Stage-Gate Hybridization Beyond Agile: Conceptual Review, Synthesis, and Research Agenda

Stage-Gate hybridization beyond Agile. Conceptual review, synthesis, and research agenda

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Abstract: This paper addresses the complex implementation of Stage-Gate hybrid models in new product development (NPD) processes. The existing literature provides fragmented insights into the implementation of hybrid models and this systematic literature review offers a more holistic understanding of the Stage-Gate hybridization phenomenon. Our findings (i) reveal three iterative methodologies (Agile, Design Thinking, and Lean Startup) that are integrated into the Stage-Gate process in either a nested or handed-over hybridization form; (ii) identify the stages of the NPD process that are best suited for the integration of these methodologies; (iii) show and describe three types of hybrid models (Agile/Stage-Gate, Design Thinking/Stage-Gate, and Design Thinking and Lean Startup/Stage-Gate); (iv) identify four aggregated dimensions (project type, market, technology, and learning gap) that R&D managers should consider when deciding to activate a hybrid model for a specific project. This study contributes to innovation and project management research by advancing the Stage-Gate hybridization phenomenon's conceptualization beyond the Agile/Stage-Gate model, addressing the calls for contingency studies in the domain of hybrid models, providing managerial guidance on the activation of these models, and identifying future research directions. The study is supplemented by a description of how and when four manufacturers have successfully employed hybrid models.

Keywords: New Product Development, Hybrid Models, Stage-Gate, Agile, Design Thinking, Lean Startup

1. Introduction

Research on new product development (NPD) has experienced a significant increase in interest and scholarly attention during the past three decades, making this field an independent and well-established area of academic inquiry [1]. The academic discourse surrounding NPD has placed great emphasis on the NPD process, from Utterback, who pioneered the modeling of innovation as a managerial process comprising idea generation, problem-solving, implementation, and diffusion phases [2], through the contributions in the 1990s and early 2000s that conceptualized innovation as a funnel process represented by different stages and gates [3]–[9], to the recent debate on hybrid models that looks at the integration of linear Stage-Gate processes with iterative methodologies of product development [10]–[13]. Throughout the years, scholars have been investigating how to develop new products quickly, effectively, and efficiently, and how to manage the NPD process accordingly.

In 1990, Cooper introduced a conceptualization of the NPD process as a series of stages and gates, with each stage consisting of defined tasks and deliverables and each gate serving as a decision point for investment go/kill decisions [9]. Over the years, the Stage-Gate process has become the dominant and most influential model for NPD [11], [14]–[16], and it remains the most widely adopted NPD process among manufacturing organizations [17], [18]. The literature has extensively documented a positive impact of the initial planning advocated by the Stage-Gate process on various project success metrics, including speed, cost, and quality [9], [19], [20]. The underlying assumption of the Stage-Gate process is that reducing uncertainty during the front-end phases (i.e., ideation, concept, and business case) would result in fewer deviations during the back-end phases (i.e., development, testing, launch) of project execution [21]. However, in the face of increasingly complex and unpredictable business environments, scholars have questioned the planning rationale and have contended that the ability of iterative NPD approaches to quickly react to changes and adapt to uncertainty may lead to enhanced NPD process performances [11], [13]–[15]. Therefore, scholars have increasingly devoted their

attention to more flexible and iterative approaches and, by leveraging the processes, tools, and principles of iterative methodologies, conceptualized hybrid models of product development [1], [10], [11], [22]. The phenomenon of Stage-Gate hybridization is becoming progressively popular among manufacturing organizations that are integrating iterative methodologies such as Agile into the linear Stage-Gate process to create hybrid NPD models and face higher levels of uncertainty [13], [17], [23]–[27].

Although literature broadly supports the theoretical and practical needs of these hybrid models and indicates them to have the potential to be the most significant change about how NPD should be done since the introduction of the Stage-Gate, their identification, implementation, and activation need to be further investigated [14]. Hybrid models represent a departure from traditional organizational practices and demand distinct innovation competencies and capabilities compared to conventional Stage-Gate processes [28]. Implementing them can thus be challenging, and recent studies call for further research on ***how*** companies using linear NPD models can evolve their processes and design hybrid models [1]. In particular, research should investigate which iterative methodologies are suitable to hybridize Stage-Gate and in which process phases it is appropriate to do so [17], [29]. Moreover, as hybrid models may require specialized competencies and incur additional costs for companies, firms must carefully assess ***when*** to employ them [10], [17]. The '*one size does not fit all*' perspective has largely been employed in contingency studies of NPD and proved that different NPD projects require different NPD processes [30]–[34]. However, this perspective has scantly been applied to the Stage-Gate hybridization phenomenon despite the phenomenon's relevance and resonance in the managerial world. To address these gaps, this paper aims to answer the following research question: *how and when is it beneficial to improve the Stage-Gate process with iterative methodologies?*

The rest of the paper is structured as follows. In Section 2, we provide a theoretical foundation for Stage-Gate hybrid models. Next, we detail the methodology employed to address the research question in Section 3. We then present the findings of our study in Section 4. In Section 5, we supplement our findings by describing how four manufacturing organizations are using Stage-Gate hybrid models. Finally, we discuss our findings and outline potential avenues for future research in Section 6.

2. Theoretical background

The Stage-Gate process has been the predominant model employed by manufacturing organizations for the development of new products over the past 30 years [10]. Most firms adopt at least a version of the Stage-Gate process [22], [35], [36] and high-performing businesses usually implement a scalable and context-based Stage-Gate process [22], [37], [38]. That is, such companies employ a '*full*' Stage-Gate with all six stages and gates for major projects, a Stage-Gate '*lite*' that combines some stages and gates for moderate risk projects, and an '*Xpress*' Stage-Gate with only one gate for minor projects. Stage-Gate has been the backbone of NPD for many years because it offers a disciplined approach that ensures control over the quality of the products being developed and enhances the effectiveness and efficiency of project execution [39], [40]. The Stage-Gate model involves the division of the NPD process into distinct stages and gates, starting from idea generation to market launch [9]. Each stage has specific tasks and deliverables, and each gate marks a decision point for investment [5]. Stage-Gate presents several advantages such as discipline [41], high-quality products [42], and coordination of innovation activities [4], but also has limitations such as rigidity [13],

bureaucracy [43], and excessive linearity [18].

In the late 20th century, various manufacturing firms attempted to apply alternative approaches to NPD coming from the software industry, known as Agile methodologies [24], [26], [27], [44]. Agile is "*a set of recommendations for a more adaptive and efficient approach to software production that now enjoys widespread use beyond its original software development context*" [45] (p.62). The Agile field came together in 2001 when the Agile Manifesto [46] introduced Agile as a set of principles and a flexible process able to improve the rate of success of software innovation projects [47]. Its success has attracted the attention of manufacturing organizations as most of their NPD projects fell short of their time, cost, and quality goals [48]–[50]. As such, Agile has been increasingly adopted by manufacturing organizations. Currently, there are at least nine different Agile methodologies available that can support NPD (each characterized by its principles and tools) and, among them, the Agile scrum framework stands out [13]-[15]. Agile scrum breaks the development process of physical products into a series of build-test-revise iterations to incrementally develop the final product [18]. This approach looks at NPD as an adjustable process that iteratively adapts solutions' requirements to the identified customers' preferences. The Agile approach thus contrasts the Stage-Gate, which conceptualizes NPD as a planned process characterized by predetermined activities and well-defined progress metrics [12]. However, over the years, this Agile approach has been integrated with the Stage-Gate process by manufacturers to develop a hybrid model that combines the best features of both methodologies [14]. The Agile/Stage-Gate hybrid model represents a blend of Stage-Gate and Agile implementations [13], which is framed by a model that relies on Agile scrum cycles within a strategic Stage-Gate process [15]. The success of the Agile/Stage-Gate approach hinges upon its ability to reconcile two distinct logics of NPD in effectively managing uncertainty, specifications, and how to address users' needs [51]. On one hand, it leverages the upfront investments and project stability inherent in the Stage-Gate process. On the other hand, it incorporates deferred investments and decision-making practices that provide the NPD team with greater flexibility. Agile/Stage-Gate is thus recognized as a promising solution to mitigate the challenges associated with the over-featuring phenomenon and to strike a balance between stability and flexibility in NPD processes [51].

Additionally, a novel category of hybrid models is being developed. Some organizations have recognized that the iterative principles of Agile fit well with that of other iterative methodologies, such as Design Thinking [52] and Lean Startup [53]. Design Thinking is "*a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity*" [52] (p.2). Design Thinking is characterized by ten main attributes, among which are user-centeredness and abductive reasoning, and related tools [54]. Design thinkers approach innovation as a learning process [55] and engage in iterative cycles of user research, generation of multiple ideas, and prototyping and testing of such ideas [56]. The mindset includes dealing with uncertainty and risk, empathy, holistic thinking, collaboration and diversity, learning-oriented, experimentation, critical questioning, abduction, creative confidence, and optimism to create value [57]. Introduced as a new way of entrepreneurship [53], the Lean Startup approach has gained significant potential for driving product innovation as a methodology that "*favours experimentation over elaborate planning, customer feedback over intuition, and iterative design over traditional 'big design up front' development*" [58] (p.4). The Lean Startup methodology follows a structured process to identify the primary value drivers for customers, establish a market for the product, and scale the business upon validation of business hypotheses [59]. Recent studies indicate that these methodologies can be

assimilated into the Stage-Gate process to integrate the voice of the customer [18], [22], ensure responsiveness to customer needs, and embrace continuous experimentation [17]. Scholars have explored the coexistence of Design Thinking, Lean Startup, and Stage-Gate within the same organizational context [60]–[62]. Although many manufacturers adopt these methodologies in addition to their established gating systems [63], some firms have effectively integrated them into the gating system [17].

The existing literature on hybrid models predominantly comprises case studies of organizations that have implemented a Stage-Gate hybrid approach [10], documenting their integration strategies [14], achieved benefits [13], and encountered challenges [24]. Notably, manufacturers have been the focus of several studies, which have provided detailed accounts of the operationalization of Stage-Gate hybrids within these firms. For instance, Cooper and Sommer reported on a global manufacturer of B2B valves and sensors, describing how the Agile/Stage-Gate hybrid model was implemented within the organization [14]. Concerning the achieved benefits, hybrids that combine Agile and Stage-Gate approaches have been shown to reduce development time [11] and increase quality performance [23], the ability to quickly respond to changes [26], flexibility [27], productivity in R&D [64], and team morale [13]. Nonetheless, implementing hybrid models is a challenge for firms. Indeed, the traditional Stage-Gate process has become deeply ingrained in the practices of many organizations, making it difficult for senior managers to consider alternative product development approaches [65]. Scholars have identified several reasons for this hesitancy, including tensions that arise between Stage-Gate and Agile [66], Design Thinking [67], and Lean Startup [58] in terms of process scope (i.e., idea-to-launch process vs. methodology for specific phases only), organization involved (i.e., cross-functional team vs. technical team), and decision model (i.e., investment model with go/kill decisions from top management vs. tactical model with decisions self-managed by the NPD team). Additionally, these methodologies have a different philosophy than the Stage-Gate process and can create a cultural conflict within organizations [68], [69]. Finally, integrating other methodologies in the Stage-Gate process might require additional resources and result in resource inefficiency [23]. Despite the potential performance improvements associated with hybrid models, these challenges present a significant barrier to their adoption [24], [70].

Overall, the literature on Stage-Gate hybrid models has documented the experiences of leading companies in integrating Stage-Gate with iterative methodologies, revealing how organizations have developed hybrid solutions. However, to date, scholars have mainly reported '*a la carte implementations*' of hybrid models without providing an overall picture regarding the different hybrid models available [10], the specific NPD phases that would benefit from the integration of iterative methodologies with Stage-Gate [29], and the NPD projects that would require additional methodological competencies beyond those provided by the Stage-Gate process in isolation [31]. In this context, it is apparent that there is a pressing need to assist manufacturers in determining ***how*** to properly deploy hybrid models and ***when*** it is worthwhile to adopt them in place of the Stage-Gate process [17]. Therefore, we have employed a systematic review of the literature on NPD hybrid approaches to offer a comprehensive understanding of the Stage-Gate hybridization phenomenon.

3. Methodology

We conducted a systematic review of the literature to assess the progress of Stage-Gate hybrids [71]. A systematic literature review requires the search and selection of relevant literature on a

given subject and consists of three main phases: preliminary analysis of the literature, data collection, and data analysis [72].

3.1 Preliminary analysis of the literature

In the first phase, in December 2021, we analyzed the literature on Stage-Gate hybrid models to gain an updated overview of the research topic, define a comprehensive list of keywords to employ in the data collection phase, and establish a set of inclusion criteria before starting the data gathering phase [72].

To conduct this preliminary analysis of the literature, we selected Scopus as a bibliometric database because it has the largest journal coverage in all fields, especially in Business and Management, and Social Sciences [73], and defined the keywords to employ in this phase based on a recent literature review on NPD management [1]. These keywords included: '*Stage-Gate*', '*Stage and Gate*', '*Hybrid model*', '*Hybrid models*', '*New product development*', and '*Product Innovation*'.

Next, to identify the methodologies that have been hybridized with Stage-Gate, we performed the boolean combination *'["Stage-Gate" OR "Stage and Gate"] AND ["Hybrid model" OR "Hybrid Models" OR "New Product Development" OR "Product Innovation"]*' within article title, abstract, and keywords, limited to the subject areas '*Business, Management, and Accounting*', '*Engineering*', and '*Social Sciences*' and journal articles. We read all 106 resulting papers and identified 3 methodologies Stage-Gate has been hybridized with: Agile, Design Thinking, and Lean Startup. Accordingly, we added '*Agile*', '*Design Thinking*', '*Lean Startup*', and '*Lean Start up*' to the set of keywords to be used during the data collection phase.

Based on the readings of the 106 papers, we decided to also include conference papers in the subsequent data collection process. We decided to do so because conference papers can provide valuable insights into emerging or rapidly changing topics as they often reflect the most current research and developments in a field [74] and can offer early insight into emerging research topics that may not yet have been published in journal articles [75]. This is particularly important in the context of Stage-Gate hybrids, which is a relatively new and rapidly evolving area of research [10]. Additionally, conference papers can offer a more diverse range of perspectives and approaches than journal articles alone, as they are often authored by practitioners from different fields and backgrounds who attend conferences to showcase their organizational experimentations. This can help us to develop a more comprehensive understanding of the phenomenon and understand practices as they are enacted [76]. Therefore, we decided to include conference papers in our data collection phase so that we could capture the latest research on Stage-Gate hybrids and provide a comprehensive overview of the current state of the field.

Finally, we defined the inclusion criteria. Given that this study focuses on the Stage-Gate hybridization, we decided to retain all the documents that **(i)** mentioned the hybridization of Stage-Gate and - at least - one of the identified methodologies. Additionally, given that contributions dealing with the '*coexistence*' (i.e., the simultaneous presence of Stage-Gate and - at least - another iterative methodology) and '*fit*' (i.e., conditions under which it is better to use Stage-Gate or - at least - another iterative methodology) might contain vital insights for understanding how (i.e., in which phases) and when (i.e., for which projects) it is better to

activate a hybrid model, we decided to retain also all the documents that **(ii)** studied and referred to the use of different approaches for the same NPD project (e.g., Franchini, Dosi, and Vignoli, who studied the '*coexistence*' of Stage-Gate and Design Thinking within the same organizational context [60]); and **(iii)** questioned when to activate Stage-Gate or another iterative methodology for a specific NPD project (e.g., MacCormack et al., who investigated when it was better to pursue Stage-Gate or Agile for a specific NPD project and discussed their '*fit*' [31]).

3.2 Data collection

Data collection involves four main steps: initial search, initial screening, final screening, and complementing with other sources [54]. We adopted this multistep approach, as shown in Figure 1.

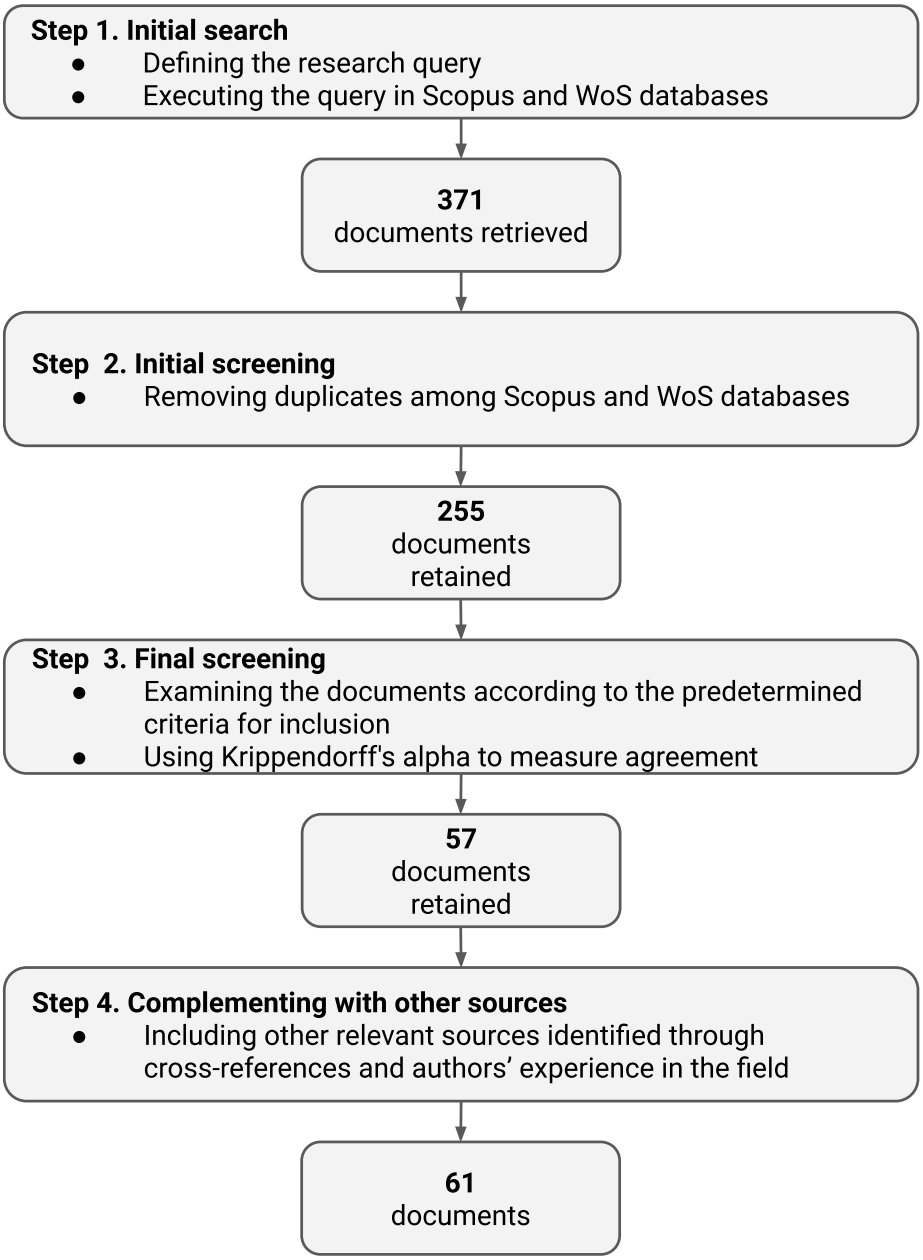

Figure 1: The data collection process

In the initial search step, we first defined the research query: *'["Stage-Gate" OR "Stage and Gate"] AND ["Agile" OR "Design Thinking" OR "Lean Startup" OR "Lean Start Up" OR "Hybrid model" OR "Hybrid Models" OR "New Product Development" OR "Product Innovation"]*'. Next, on the 21st of February 2023[1], we carried out the research query in **(i) Scopus database**, within article title, abstract, and keywords, and limited to the subject areas '*Business, Management, and Accounting*', '*Engineering*', and '*Social Sciences*' (198 documents) and in **(ii) Web of Science database (WoS)**, within article title or abstract, and limited to '*Management*', '*Business*', '*Engineering**', and '*Economics*'(173 documents). This initial search activity returned a total of **371** documents. We constructed a database with Microsoft Excel reporting for all the 371 documents: Author(s) – Document title – Year – Source title – Volume – Issue – Abstract – Document type.

In the initial screening step, we removed 116 duplicates between the Scopus and WoS databases. To accomplish this task, we created a copy of the Microsoft Excel database and used the '*remove duplicates*' function of the software to eliminate redundancies among documents with identical titles and abstracts. This initial screening activity led to the retention of **255** documents (81 from Scopus, 58 from WoS, and 116 from both Scopus and WoS databases).

In the final screening step, we examined the titles and abstracts of the remaining 255 documents and compared them to the inclusion criteria that we had established in the preliminary analysis of the literature. During this activity, we independently assigned to each document a dichotomous value of either 1 or 0, indicating whether a document should be retained or excluded, respectively. We then used Krippendorff's alpha coefficient to measure the agreement achieved between the authors [77]. Specifically, we calculated the coefficient using the SPSS kalpha macro function [78] for nominal data (syntax: "*kalpha judges = rater1 rater2 rater3/level = 1/detail = 0/boot = 10000*"). The resulting coefficient ($k_\alpha = 0.854$) was greater than the threshold of 0.8, indicating a reliable convergence and inter-reliability of the selection [79]. Out of the 255 documents, 69 were deemed relevant by at least one of the authors: 49 documents were considered to satisfy the inclusion criteria by all three authors, 12 by two authors, and 8 by one author. To refine our selection further, we reviewed the 20 documents that had been flagged for potential exclusion by at least one author. We conducted a meeting to decide which of these 20 documents should be retained based on the predetermined inclusion criteria. This final screening step yielded **57** documents that met our inclusion criteria.

Finally, as is common in a systematic literature review, we complemented the 57 documents with other sources that might provide further insights into Stage-Gate hybrids. We selected the sources considering cross-references and relying on our experience in this field [54], [71]. This activity led to adding 4 relevant sources [1], [26], [27], [29] in the final sample of documents.

The final dataset contains **61** documents (43 journal articles and 18 conference papers, as shown in the Appendix) published from 2005 to 2022 (Figure 2) in 21 different journals (Figure 3).

[1] This data collection follows a first data collection that was performed in December 2021

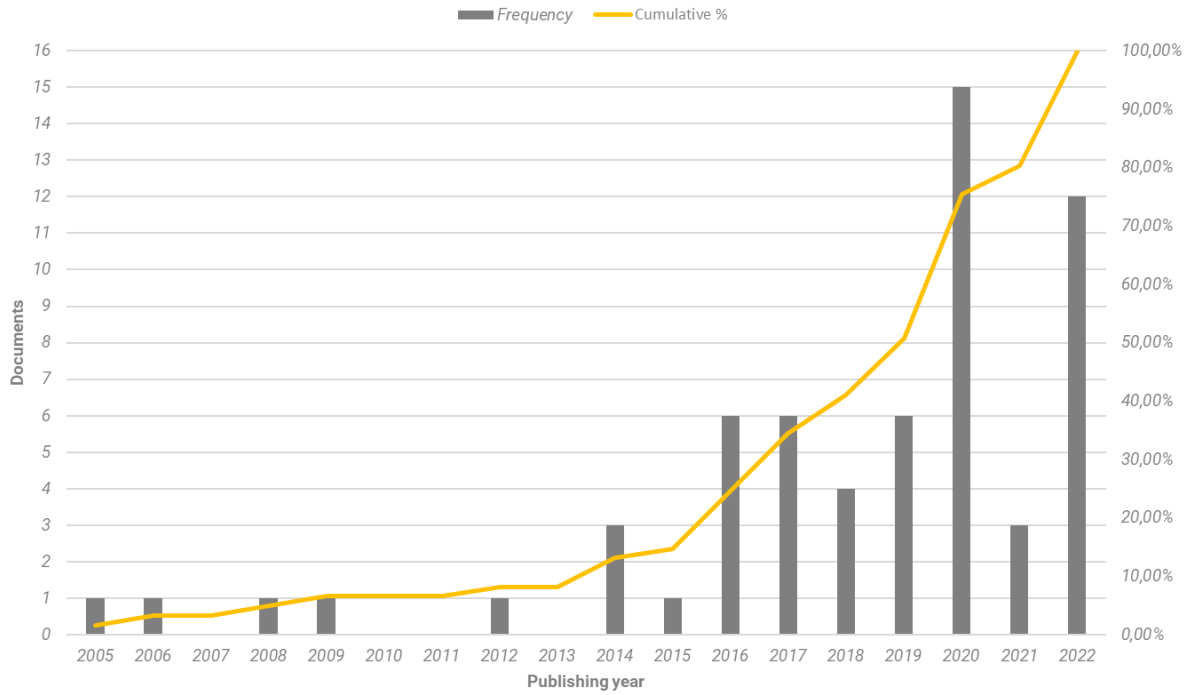

Figure 2: Year of publication of the selected documents

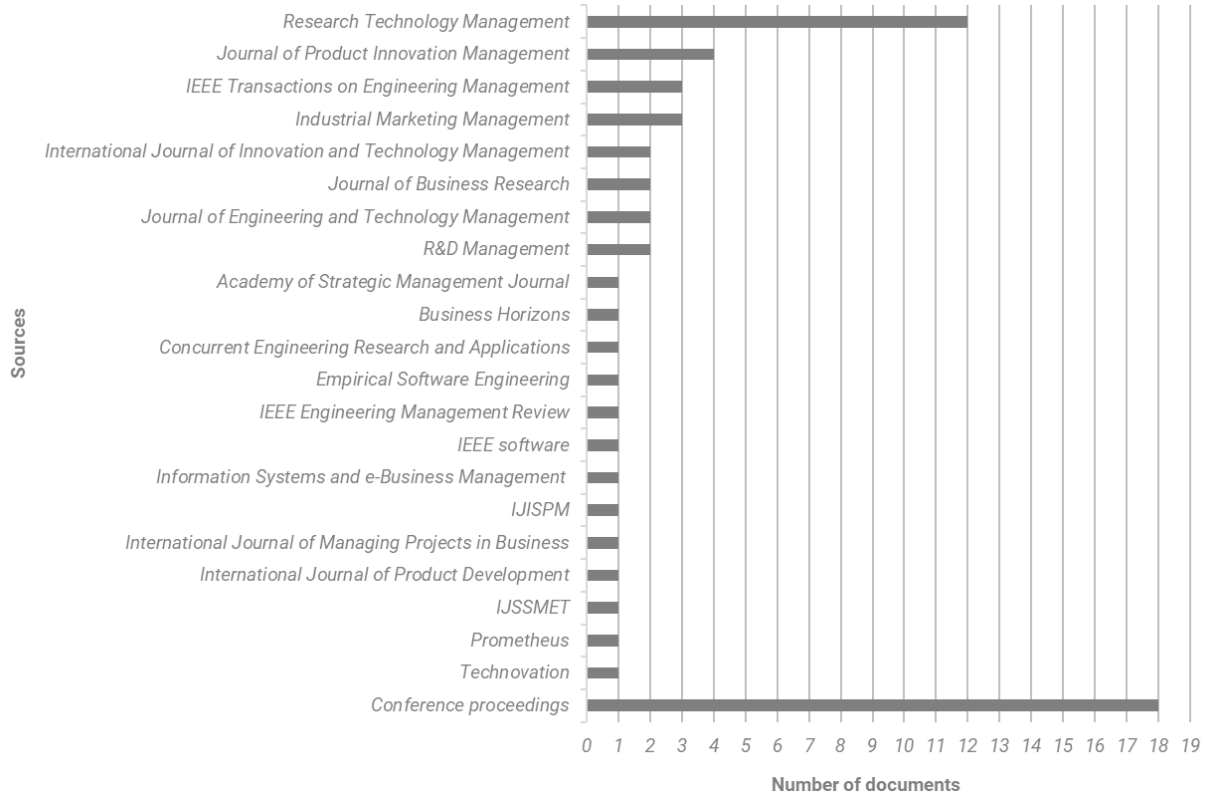

Figure 3: Sources where the selected documents were published

3.3 Data analysis

We reviewed the 61 selected documents in decreasing order of citations as a general guiding principle [72]. We divided the data analysis into four stages.

In the first stage, we examined the extent to which Agile, Design Thinking, and Lean Startup have been investigated in relation to the Stage-Gate process. To accomplish this task, we assigned each document a code based on the methodology investigated in relation to the Stage-Gate process. Specifically, we used the code '*Agile*' if only Agile was studied, the code '*Design Thinking*' if only Design Thinking was studied, and the code '*Lean Startup*' if only Lean Startup was studied. We also assigned multiple codes to some documents, as some of them examined Agile, Design Thinking, and/or Lean Startup simultaneously in relation to the Stage-Gate process. For example, the paper by Cocchi, Dosi, and Vignoli titled "*The Hybrid Model Matrix: Enhancing Stage-Gate with Design Thinking, Lean Startup, and Agile*" examined all three methodologies in relation to the Stage-Gate process [17]. Additionally, we also examined the degree to which the hybridization between the Stage-Gate process and the iterative methodologies has been addressed in a nested form, wherein one or more methodologies are integrated within the stages, or in a handed-over form, wherein one methodology is implemented before or after the Stage-Gate process. For the former scenario, we assigned the code *'Nested hybridization*', whereas, for the latter scenario, we assigned the code '*Handed-over hybridization*'. We used a Microsoft Excel spreadsheet to map the assigned codes for each of the 61 documents.

In the second stage, we aimed to identify the NPD process phases in which the hybridization of the iterative methodologies with Stage-Gate was carried out. To achieve this goal, we selected all the passages in which authors mentioned the specific phases in which they found appropriate to leverage the methodologies and assigned them a code. For instance, we coded '*ideation*' when the document suggested embedding the methodology in the ideation phase, '*concept*' when the document suggested embedding the methodology in the concept phase, and so on for all other phases. We used the code '*all*' when the document suggested embedding the methodology in all stages. For example, we assigned the code '*all*' to this passage of Salvato and Laplume [23] "*Which stages of a project? All. Cases used Agile/Stage-Gate throughout development, although one could sense a 'degree' of agility in-play. Early in development teams were very Agile and open to learning, as commercialization came closer, they were less Agile*" (p.643). We used a Microsoft Excel spreadsheet to map the assigned codes for each passage and methodology under investigation.

In the third stage, we aimed to identify all the different kinds of hybrid models that rely on the integration between Stage-Gate and Agile, Design Thinking, and Lean Startup methodologies. We analyzed all the documents to identify all the possible combinations according to which the selected methodologies were hybridized with the Stage-Gate (i.e., Agile only, Design Thinking only, Lean Startup only, and different combinations among the three).

The last phase involved figuring out the decision variables R&D managers should consider in determining the most suitable hybrid model for a given project. To tackle this stage, we adopted a coding process [80]. As a first step, we applied open coding to the passages in which the authors mentioned variables according to which it was worth activating a hybrid model. For instance, we applied the code '*radical innovation*' to this passage: "*that is, for more radical new-product projects, Agile/Stage-Gate offers the additional benefits of managing high uncertainty*" [15] (p.12). Recurrent codes mentioned for instance '*larger projects*', '*major revenue generator projects*', '*radical innovation*', '*incremental innovation*', '*innovativeness*', '*complex projects*', '*project uniqueness*', '*complexity*', '*higher risk projects*', '*more ambiguous projects*', '*high uncertainty projects'*, '*moderate task uncertainty*'. Next, we aggregated into second order themes a set of more abstract categories going back and forth

from literature [81]. For example, we considered '*higher risk projects*', '*more ambiguous projects*', '*high uncertainty projects*', and '*moderate task uncertainty*' to belong to the same category because throughout our dataset the concept of ambiguity and uncertainty have been treated as synonymous and related to the concept of risk. For instance, Edwards et al. [82] stated: "*Agile is usually reserved for larger projects that are more ambiguous (higher uncertainty) and risky*" (pp. 8-9). According to this perspective, which is consistent with that of Ward and Chapman [83] that suggest dealing with project risk management as project uncertainty management, we clustered them as '*project uncertainty*'. Finally, we identified the level of analysis that can drive the different choices and identified 4 level constructs (i.e., '*project type*', '*market*', '*technology*', and '*learning gap*'). This last phase resulted in a data structure that is reported in Figure 4.[2]

[2] Due to the inclusion of conference papers in the final dataset, we conducted a replication of the data analysis using a sample that exclusively comprised the 43 journal articles selected. This replication aimed to determine whether the findings were consistent and reliable. The check confirmed the internal validity of our study, as there were no significant differences between the outcomes provided by the two samples.

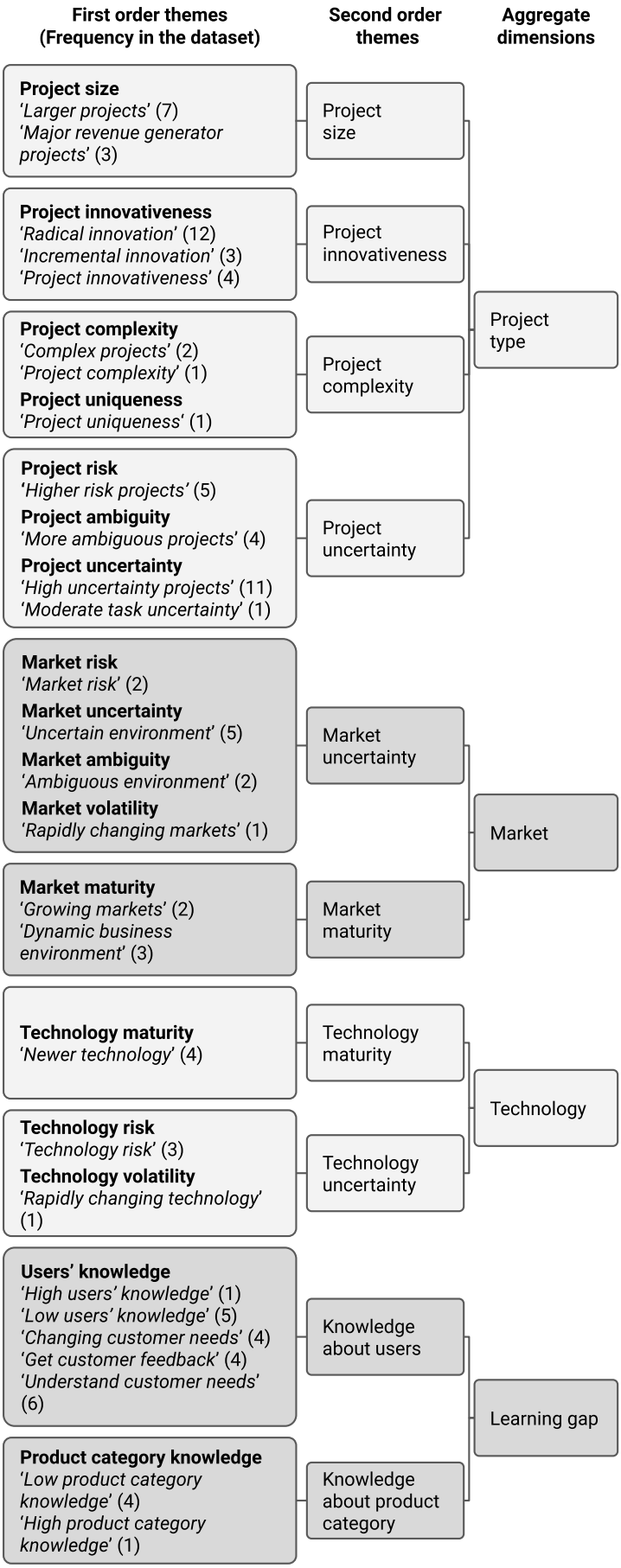

Figure 4: Data structure

4. Results

Our results reveal (i) the existence of three methodologies that have been integrated into the Stage-Gate process, namely Agile, Design Thinking, and Lean Startup, and two types of hybridization, that we called nested and handed-over; (ii) a wide consensus among scholars about the NPD process phases where Agile, Design Thinking, and Lean Startup methods are most appropriate; (iii) three distinct hybrid models, namely Agile/Stage-Gate, Design Thinking/Stage-Gate, and Design Thinking and Lean Startup/Stage-Gate, which have varying degrees of popularity in the literature; (iv) four aggregated dimensions that R&D managers should consider when selecting the most appropriate NPD process for a specific project: project type, market, technology, and learning gap.

4.1 Beyond Agile/Stage-Gate

4.1.1 Agile, Design Thinking, and Lean Startup hybridize Stage-Gate—Table 1 presents the frequency with which Agile, Design Thinking, and Lean Startup have been studied in relation to the Stage-Gate process in our dataset. Agile is the most investigated methodology (77,8%). Our findings show that also Design Thinking (11,1%) and Lean Startup (9,7%) are valuable methodologies for improving the Stage-Gate process and thus it's necessary to explore hybrid approaches to NPD beyond the traditional Agile/Stage-Gate hybrid model. Additionally, we identified two kinds of hybridization, which we referred to as '*nested*' and '*handed-over*'.

Table 1: Frequency of iterative methodologies and types of hybridization in Stage-Gate studies

Methodologies / Types of hybridization	Agile	Design Thinking	Lean Startup	Total
Nested hybridization	77,8 % (56)	6,9 % (5)	8,3 % (6)	**93 % (67)**
Handed-over hybridization	1,4 % (1)	4,2 % (3)	1,4 % (1)	**7 % (5)**
Total	**79,2 % (57)**	**11,1 % (8)**	**9,7% (7)**	**100% (72)**
Type of hybrid model(s) connected	Agile/Stage-Gate	Design Thinking/Stage-Gate Design Thinking and Lean Startup/Stage-Gate	Design Thinking and Lean Startup/Stage-Gate	**3 kinds of hybrid models**

This table shows the percentage of codes assigned to documents, with the absolute count of codes provided in brackets. The number of codes (72) is greater than the number of documents (61) because some documents evaluated multiple methodology/hybridization types and obtained more than one code.

4.1.2 Forms of hybridization: nested and handed-over—The prevailing perspective considers Stage-Gate as a general framework upon which specific methodologies can be embedded, resulting in a nested hybrid form, wherein Agile, Design Thinking or Lean Startup are injected into specific stages of the process (93%). In the nested hybridization form, scholars refer to Stage-Gate as a '*macro-level framework*' [12], or a '*macro-level planning*' process [10] that operates at the strategic level with a macroplanning horizon [84]. Iterative methodologies work at the execution level as '*micro-planning project management*' methodologies [66] for '*task execution*' [85]. The use of Stage-Gate as a scaffolding for hybrid forms of NPD is not an obvious outcome. Indeed, we identified some contributions dealing with a different form of hybridization, which we called handed-over (7%). Handed-over hybridization entails alternating Stage-Gate with diverse methodologies along the NPD process, namely substituting

some stages (and related gates) of the Stage-Gate with that of the iterative methodologies, so that Design Thinking handovers the outcome to Stage-Gate or Stage-Gate handovers the outcome to Agile. For example, Franchini, Dosi, and Vignoli [60] showcased a leading food and beverage firm where Design Thinking is initially activated as a stand-alone process, followed by the activation of Stage-Gate in its classical form from stages 2 or 3 based on the outcome of Design Thinking. Nakata [86] reported a similar model whereby Design Thinking is used at the front-end, and Stage-Gate is used at the back-end of the innovation process to minimize conflicts between the two. Lichtenthaler [63] also presented a conceptual framework whereby Agile can be employed before and after gating in addition to Agile within and alongside gating. Although not explicitly referring to handed-over hybridization, de Vasconcelos Gomes et al. [10] recommended that "*a hybrid approach should be adopted by skipping or combining the stages and decision points to allow for the tailoring of the product development process*" (p. 10), thus questioning the predominance of the Stage-Gate structure as the most appropriate scaffold for every project. Figure 5 visually represents the different forms of hybridization.

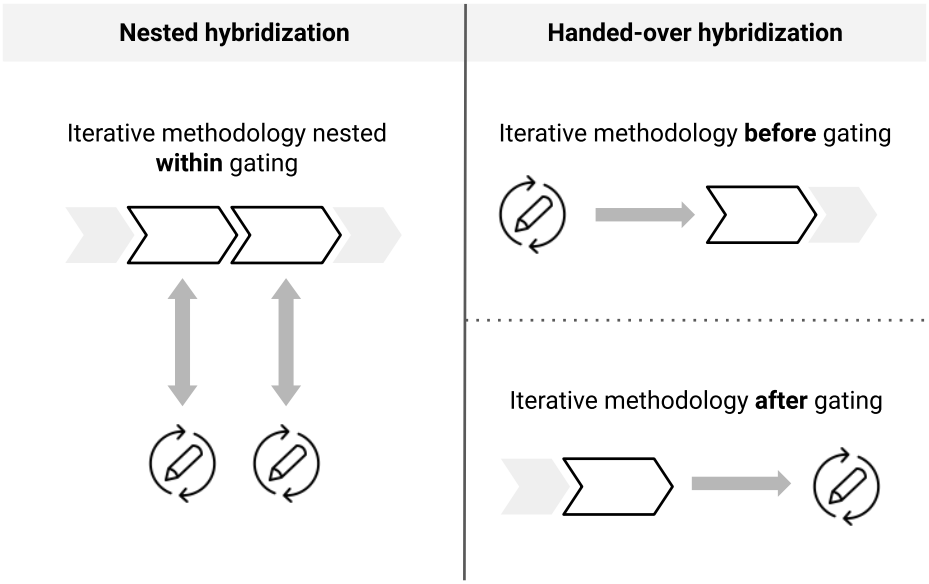

Figure 5: Nested and handed-over hybridizations

4.2 Stages of hybridization

Table 2 reports the phases of the Stage-Gate in which Agile, Design Thinking, and Lean Startup were hybridized.

Table 2: NPD process phases in which Agile, Design Thinking, and Lean Startup were integrated in the Stage-Gate process

NPD phases / Methodologies	Ideation	Concept	Business case	Development	Testing	Launch
Agile	X	X	X	X	X	X
Design Thinking	X	X				
Lean Startup			X			

4.2.1 Agile—Our findings show that Agile was initially employed during the development and testing phases, where "*uncertainty is lower, and environments are easier to control*" [87] (p.7). Organizations began experimenting with Agile during these technical phases [26], which were "*divided into a series of sprints*" [11] (p.229) that consisted of "*time boxed iterations with physical deliverables*" [88] (p.26). Subsequently, Agile methodologies have also been integrated into the ideation, concept, business case, and launch phases. According to Cooper and Sommer [14], "*early adopters report that this new approach [i.e., Agile/Stage-Gate] should be applied across the entire project in order to achieve maximum benefit including the earlier stages, ideation, concept and business case, and even for the launch stage*" (p.10). Brock et al. [87] also showed that the application of Agile has been extended "*in the front-end of innovation, as this is where digital innovations emanate from and where the foundation is laid for corporate renewal in the era of digitization*" (p.7). This evidence is also presented by Edwards et al. [82] who reported that "*with maturity, manufacturing firms used Agile/Stage-Gate for more than just these two technical stages [i.e., development and testing], namely, in the pre-development stages, for example to develop the concept and to assess feasibility*" (p.8). Furthermore, Salvato and Laplume [23] conducted a study of five distinct business units and found that "*all cases used Agile in all stages of a project. Cases used Agile/Stage-Gate throughout development, although one could sense a degree of agility in-play. Early in development teams were very Agile and open to learning, as commercialization came closer, they were less Agile*" (p. 643). Nevertheless, embedding Agile in the early NPD process phases poses more challenges, as "*more adjustments are required for these earlier stages (e.g., defining a done sprint and securing dedicated resources in the concept stage or business case stage)*" [15] (p.9).

4.2.2 Design Thinking— The studies investigating Design Thinking and Stage-Gate unanimously recommend the use of Design Thinking in the initial stages of NPD. It is important to clarify that these initial stages do not refer to the '*fuzzy-front-end*' phases preceding the start of the Stage-Gate process [89], but rather to the first stages of NPD, specifically the ideation and concept phases. Lichtenthaler [90] asserts that Design Thinking is a useful methodology "*to generate promising new ideas and concepts*" (p.158). Cooper [22] and Cooper and Sommer [18] emphasize Design Thinking as a useful methodology to build the voice of the customer into the earliest stages of the idea-to-launch system to understand users' needs, generate great ideas, and test with users a series of product versions. Franchini, Dosi, and Vignoli [60] and Cocchi, Dosi, and Vignoli [17] describe how a leading food and beverage manufacturer uses Design Thinking during the ideation phase of the Stage-Gate process: "*during the ideation phase, the company uses the Design Thinking methodology to support the Stage-Gate process*" [17] (p.22). Design Thinking can also be employed in the concept stage to create innovative concepts [17], [18], [86]. As Nakata [86] explicitly notes, Design Thinking is well-suited for '*identifying the market, generating ideas, developing the concept, and articulating the initial product or service*' (p.770).

4.2.3 Lean Startup—Cocchi, Dosi, and Vignoli [17], and Lichtenthaler [63], [90] suggest the integration of the Lean Startup methodology during the business case stage to achieve the alignment between the product and the market, namely the product-market fit, as originally proposed by Ries [53]. Indeed, many large companies rely on the Lean Startup methodology to "*enable entrepreneurial processes*" [63] (p. 43). Cocchi, Dosi, and Vignoli [17] presented a case study of a multinational corporation that employed Lean Startup to define the components of the business model. That company turns the business idea into a product and then tests assumptions related to the business model during the business case stage. As they reported: "*at*

the end of the concept phase, [...] the company turns [...] a minimum viable product (MVP) to kick off the business case phase with the Lean Startup methodology. In this phase, the team launches the MVP on the market to experiment with unclear business decisions" (p.23). Similarly, Lichtenthaler [90] reported that "*Lean Startup has a strong focus on the business model*" (p.160) since "*the strengths of Lean Startup will be particularly pronounced if it builds on a proficient and systematic initial ideation stage* [...] *because initial ideation is not the focus of Lean Startup"* (p.162).

Overall, our results indicate that the Agile methodology has been integrated into all stages of the Stage-Gate process [23], [91]. While initially Agile was only used in the development and testing phases, some organizations have now extended its use to all other phases of the Stage-Gate system [87]. Design Thinking has been integrated into the ideation and/or concept stages [17], [86]. Differently, Lean Startup methodologies are integrated into the business case stage [17], [90].

4.3 Three hybrid models

Table 3 summarizes the characteristics of three different hybrid models resulting from our data analysis. It is worth noting that the relationship between the identified methodologies and the hybrid models is not necessarily one-to-one. For instance, while this systematic literature review identified a unique model of Stage-Gate hybridization with Agile (i.e., Agile/Stage-Gate), our results show two possible models of Stage-Gate hybridization with Design Thinking (i.e., Design Thinking/Stage-Gate and Design Thinking and Lean Startup/Stage-Gate).

Table 3: Three kinds of hybrid models

Characteristics	Agile/Stage-Gate	Design Thinking/Stage-Gate	Design Thinking and Lean Startup/Stage-Gate
Type	Nested or handed-over hybridization	Nested or handed-over hybridization	Nested or handed-over hybridization
Starting point	Product backlog	Product vision	Opportunity area to be explored
Build	Protocepts	Pretotypes	Pretotypes and MVP
Measure	Test of protocepts	Test of pretotypes	Test of pretotypes and MVP
Learn	Incorporate new requirements and knowledge in the product backlog until customers' expectations are met	Incorporate new needs and learnings into the product vision until the product idea is standing	Incorporate how customers responds to the pretotypes and MVP and learn whether to pivot or persevere

4.3.1 Agile/Stage-Gate—The Agile/Stage-Gate hybrid model has challenged the notion that Agile methodologies are exclusively suitable for software projects and has proven that manufacturers can use such models to develop physical products [10]. This model has gained widespread acceptance in the literature, to the extent that even the most advanced studies on Stage-Gate hybrids tend to consider it as the sole form of hybrid approach. This model deals with mixed implementations of Stage-Gate and Agile methodologies [13] and is usually studied and implemented in a nested hybridization form. The hybrid model encompasses both Agile scrum cycles and a strategic Stage-Gate process, which allows for greater flexibility and faster execution at lower levels while still providing a clear strategic roadmap [12]. Agile tools such as scrum boards, daily sprints, sprints, and burn-down charts replace traditional project

management tools (e.g., Gantt charts and milestones) and are applied in each stage of the product development process [51], [92]. Each phase is made up of a series of sprints with predetermined timeframes [66]. Planning for each sprint is done in real-time, resulting in a tangible outcome that can be either a prototype or a physical model (in Cooper's words, a '*protocept*'), which is shared with stakeholders to obtain feedback and identify any required changes [14]. All relevant feedback is integrated into the next sprint [15]. This iterative approach to work enables the project to move from ideation to launch by aligning the product with the customers' feedback. The front-end tasks entail initial assumptions about customer value (i.e., ideation and concept) and market acceptance and manufacturing costs (i.e., business case) [64]. As the product evolves, each Agile iteration generates more tangible versions of it, moving from rapid prototypes to working prototypes. Each version is closer to the final product and is tested with customers [11]. The testing phase is conducted with the product created during the development stage and offers insights into customer reactions and delivery costs [64]. Stages and gates remain in the model [88]. Stages provide an overview of the main phases of the project and recommend activities and expected deliverables for each phase, while gates separate each stage and mark investment decision points [18]. This structure enables top management to review projects at key transition points.

4.3.2 Design Thinking/Stage-Gate— The Design Thinking/Stage-Gate hybrid model uses Design Thinking in the ideation phase of the Stage-Gate process [17]. It allows the design team to make different versions of the product idea tangible through '*pretotypes*', which are artifacts such as sketches, storyboards, and physical models that are developed and tested with customers [17]. Through analysis of user interaction with the pretotypes, the design team iteratively refines the product's idea [60]. This use of Design Thinking represents its sprint execution version [93], namely an inside-out model whereby the original product vision, based on the company's knowledge of the market, remains intact, but the company recognizes that the required knowledge to build the idea can only be obtained through users' interactions with different pretotypes. Cocchi, Dosi, and Vignoli [17] reported an example of a project developed with this model where a company sought to develop a cookie with dried fruits. The firm leveraged Design Thinking to understand how users would react to different combinations of dried fruits with a cookie, leading to the definition of the final product idea based on the learnings gained through the test of the pretotypes. The final product concept has then been developed by following the classical Stage-Gate process.

4.3.3 Design Thinking and Lean Startup/Stage-Gate— This hybrid model incorporates Design Thinking during the ideation and concept phases, and the Lean Startup methodology during the business case phase of the Stage-Gate process [17]. In this hybrid model, Design Thinking is used as a creative problem-solving methodology [93] as it reframes the initial product idea, defines the design principles of the product, and develops a solution concept [17]. Ethnographic research techniques such as user interviews and observations are used during the ideation phase to identify user needs and design a product idea based on the newly uncovered needs. The team then iteratively develops and tests pretotypes to identify the design principles of the product (i.e., the product attributes) during the concept phase. Once the design principles are established, the team uses the Lean Startup methodology to create an MVP and initiate the business case phase. The MVP is launched into the market to test various business hypotheses, but it should be noted that this launch does not correspond to the product's official launch. For example, in the case presented by Cocchi, Dosi, and Vignoli [17], the company that uses this model does not invest in a production line to commercialize the product but instead employs alternative methods to deliver the product to the market, such as co-packers. Based on the

MVP's outcomes, the company iterates and validates business assumptions to determine whether a market launch should be pursued. This hybrid model leverages the complementarities between Design Thinking and Lean Startup methodologies to generate innovative solutions and successful business outcomes [90].

Although theoretically other combinations are possible (e.g., a full hybrid model that integrates all three methodologies into the gating system), our systematic literature review did not discover other kinds of hybrid models, namely other combinations according to which the Stage-Gate process was hybridized with Agile, Design Thinking, or Lean Startup.

4.4 Decision variables to select hybrid models

4.4.1. Four macro-variables— In order to determine decision variables, we conducted an open coding activity on those passages where scholars referred to circumstances under which a hybrid model would be beneficial. Table 4 illustrates examples of those passages corresponding to first-order themes.

Table 4: First order themes

First order theme	Example quote	Reference
Project size	**[Larger projects]** "*Project teams have 100% dedicated team members for each project; but given that dedicated teams are not feasible for every project, the firm only uses this Agile/Stage-Gate approach for about 20% of their projects, specifically the* ***larger****, major revenue generator* ***projects***"	[11], p.229
	[Major revenue generator projects] "*For example, one U.S. manufacturer of residential remote controlled devices reserves its Agile/Stage-Gate system for about 20% of development projects, namely only the larger,* ***major revenue-generating****, higher risk* ***projects***"	[14], p.12
Project innovativeness	**[Radical innovation]** "*One thorny question concerns whether or not Agile/Stage-Gate is suitable for both radical and for incremental new product developments. In theory, it is suitable for both, but Agile/Stage-Gate adds the most value when there is high uncertainty and a great need for experimentation and failing fast […]. That is, for* ***more radical new-product projects****, Agile/Stage-Gate offers the additional benefits of managing high uncertainty*"	[14], p.12
	[Incremental innovation] "***When products to be developed are more incremental*** *in nature, iterative, yet time-boxed cycles (hybrid Agile/Stage-Gate) processes may provide the best of both worlds*"	[94], p.496
	[Project innovativeness] "*Stage-Gate is useful for projects that do not need to fulfill a significant learning in terms of users or category knowledge. […] also suggest* ***Stage-Gate for incremental innovation and not for extreme or radical innovation****. For innovations that require a significant learning effort, the matrix proposes ways to embed other methodologies within Stage-Gate*"	[17], p.28
Project complexity	**[Complex projects]** "*These points capture a shift in values based on a different understanding of what is important to manage. An expression of Agile values can be seen in the tool set evolved to manage* ***complex*** *product development* ***projects****. As complexity increases, static tools (like Gantt charts and project plans, documentation, and task specifications) become a burden to maintain*"	[13], p.41
	[Project complexity] "*Complexity – is a measure of the project scope, reflected in characteristics such as the number of tasks and the degree of interdependency […] project novelty, and* ***project complexity*** *have a statistically significant moderating effect that differentiates impact on the team concerning the project management approach applied*"	[95], p. 511
Project uniqueness	**[Project uniqueness]** "*If the NPD process must be defined in a situation where each project is* ***unique*** *and has its own routing, a hybrid approach should be adopted*"	[10], p. 10

First order theme	Example quote	Reference
Project risk	**[Higher risk projects]** "*Innovation: bigger, bolder, more venturesome project. **Higher-risk initiative***"	[88], p.29
Project ambiguity	**[More ambiguous projects]** "*Although in theory, the Agile/Stage-Gate hybrid is suitable for all development projects, in practice the greatest advantages may be reaped in **more ambiguous** and uncertain initiatives*"	[18], p.25
Project uncertainty	**[High uncertainty projects]** "*Many have found that for **high-uncertainty projects**, implementing Agile methods alongside traditional Stage-Gate processes to create an Agile/Stage-Gate hybrid yields faster response to change and higher R&D productivity*"	[66], p.29
	[Moderate task uncertainty] "*With **moderate levels of task uncertainty** and degrees of innovation firms would fare better with Agile/Stage-Gate approaches*"	[94], p.497
Market risk	**[Market risk]** "*At HP, managers are asked to select a style based on a detailed assessment of both the technical and **market risks** present in the business context. When risk is high along both dimensions, an emergent style is best; where risk is low on both dimensions, an efficient style typically works well. When the context entails an intermediate level of risk, an agile style is often chosen for the task*"	[31], p.42
Market uncertainty	**[Uncertain environment]** "*If the NPD process must be defined in a situation with a fast-changing and **uncertain environment**, a hybrid approach should be adopted*"	[10], p. 10
Market ambiguity	**[Ambiguous environment]** "*Design Thinking also builds an organizational capacity for rapid learning and for taking action in volatile, uncertain, complex, and **ambiguous environments***"	[86], p.764
Market volatility	**[Rapidly changing markets]** "***Rapidly changing market** and technology environments --> Agile/Stage-Gate*"	[96], p.210
Market maturity	**[Growing markets]** "*But the newer process [i.e., Agile/Stage-Gate] is designed for more innovative and bolder projects targeted at less well defined but **growing markets***"	[88], p.28
	[Dynamic business environment] "*Therefore, with the aim of integrating characteristics of both Stage-Gate and Agile methods in a single approach, well equipped for the dynamism of the current market and applicable in a wider context, recent research has increasingly turned its attention on hybrid methods*"	[97], p.2
Technology maturity	**[Newer technology]** "*Technology maturity: **newer technology**, but largely existing. May be new to the company, but familiar*"	[88], p.29
Technology risk	**[Technology risk]** "***Technical risks**: Some risks and technical hurdles; hurdles can likely be overcome. Technical solution largely envisioned*"	[88], p.29
Technology volatility	**[Rapidly changing technology]** "***Rapidly changing** market and **technology** environments --> Agile/Stage-Gate*"	[96], p.210
Users' knowledge	**[High users' knowledge]** "***High Knowledge about Users**/Low Category Knowledge—In this case, the Agile–Stage-Gate hybrid model seems to fit the company's lessons learned. This model enters when the company determines the product-market fit settled, but the company still needs to learn about category rules*"	[17], p.26
	[Low users' knowledge] "*Design Thinking is useful when the goal is to learn about users' habits and needs […]. The Hybrid Model Matrix suggests that use of hybrids with Design Thinking are best in situations of limited user knowledge*"	[17], p.28
	[Changing customer needs and requirements] "*If the NPD process must be defined in a situation where the relevant external project aspects are unpredictable (e.g., **customer requirements**), a hybrid approach must be adopted*"	[10], p. 10
	[Getting user feedback] "*The Design Thinking methodology develops the product vision by generating different coherent ideas, making them tangible through rough prototypes, and **gathering user feedback**. Users' interactions with prototypes provide priceless reactions that the company analyzes to design around them*"	[17], p.23

First order theme	Example quote	Reference
	[Understand customer needs] "*Customer feedback was another perceived driver toward Agile/Stage-Gate, to benefit from an increased **understanding of customer needs** and wants and to update product specifications*"	[23], p.641
Product category knowledge	**[Low product category knowledge]** "*For those companies looking to design a product for a **new category** in which only limited knowledge about users exists, the Hybrid Model Matrix suggests using Lean Startup to define the business model elements. In the Hybrid Model Matrix, Lean Startup builds on the knowledge gained through the Design Thinking that occurs in lieu of the classical Lean Startup phase of product-solution fit*"	[17], p.28
	[High product category knowledge] "*Low Knowledge about Users/**High Category Knowledge**—In this case, the Design Thinking/Stage-Gate hybrid model enables the company to learn about users*"	[17], p.26

We identified four major decision variables that emerged as significant dimensions in determining the activation of hybrid models: *project type*, *market*, *technology*, and *learning gap*.

1) ***Project type*** includes all the recurrent variables that define the characteristics of a project, such as project size, innovativeness, complexity, and uncertainty. *Project size* reflects the largeness of capital investments and the number of activities, decisions, stakeholders, and objectives that characterize a large project [98]. *Project complexity* involves the number of tasks, the degree of interdependency between tasks, and the extent to which the project is unique [98]. *Project uncertainty* refers to the degree of ambiguity, uncertainty, and risk inherent in the project, with these constructs being treated synonymously in our dataset consistently with the perspective of handling project risk management as project uncertainty management [83]. Finally, *project innovativeness* refers to the degree of innovativeness, whether it is more radical or incremental [99].
2) ***Market*** includes market uncertainty and market maturity. *Market uncertainty* refers to the extent to which the market is uncertain, ambiguous, and risky and thus includes the degree to which customer needs and wants are clear, the interaction between the customer and the product is understood, and conventional business models and application markets are appropriate [100]. *Market maturity* refers to the degree to which the market is growing, and the business environment is dynamic [88].
3) ***Technology*** encompasses contingencies that pertain to technology uncertainty and maturity, which relate to technical hurdles in the R&D process and the selected technical solutions. *Technology uncertainty* and *technology maturity* refer to the degree to which the technology is new, familiar, or largely existing [88] (p.29).
4) ***Learning gap*** considers the gaps the company needs to fill with the NPD process. It is strictly related to the idea of innovation as a learning process [55]. Specifically, the learning gap encompasses knowledge about product categories and users. According to Cocchi, Dosi, and Vignoli [17], the *knowledge about users* and *knowledge about product category* dimensions represent crucial variables that must be considered while deciding on the appropriate methodology to support the Stage-Gate process.

It is worth noting that these four macro-variables can be viewed from two perspectives with respect to the organization implementing the NPD: internal and external. Both ***market*** and ***technology*** dimensions bring an external point of view, pushing managers to develop an

absolute perspective that starts from the market/technology assessment and develops evaluation based on those absolute reference points. Conversely, the ***learning gap*** dimension has an internal perspective which includes those learning gaps that the organization needs to fill within the NPD process. ***Project type*** has mainly an internal perspective, considering factors such as project size, complexity, uncertainty, and innovativeness. Nevertheless, managers may encounter challenges in assessing each of these aggregated dimensions. For instance, concerning project type, an organization may face difficulties in relying on financial elements, such as CapEx, for those projects that lack a solution at the outset of the process [17].

4.4.2. When to activate a hybrid model—Table 5 presents a comparison of variables across various hybrid models and provides an overview of the recommendations made by scholars for the activation of such models. It should be noted that most of the reviewed documents investigate one hybrid model at a time (e.g., Agile/Stage-Gate only) and, with a few exceptions, do not compare different hybrids. Therefore, the identified variables suggest when to activate a hybrid model, but do not provide guidance on which hybrid model to choose over others (e.g., Agile/Stage-Gate vs. Design Thinking/Stage-Gate). Hence, it is interesting to compare what we know about the role that those variables play across different Stage-Gate hybrids.

Table 5: Decision variables to implement hybrid models

Second order theme (Frequency in the dataset)	Agile/Stage-Gate	Design Thinking/Stage-Gate	Design Thinking and Lean Startup/Stage-Gate
Dimension #1: Project type			
Project size (10)	Larger projects (10/10)	/	/
Project innovativeness (19)	Incremental (3/19) vs. Radical (11/19)	Radical (1/1)	/
Project complexity (4)	High complexity (4/4)	/	/
Project uncertainty (21)	High uncertainty (17/18) vs. Moderate uncertainty (1/18)	High uncertainty (2/2)	High uncertainty (1/1)
Dimension #2: Market			
Market uncertainty (10)	High uncertainty (5/5)	High uncertainty (4/4)	High uncertainty (1/1)
Market maturity (5)	Growing markets (5/5)	/	/
Dimension #3: Technology			
Technology maturity (3)	Newer for the company (3/3)	/	/
Technology uncertainty (4)	High uncertainty (4/4)	/	/
Dimension #4: Learning gap			
Knowledge about users (20)	High (1/7) vs Moderate (4/7) vs Low (2/7)	Low (8/8)	Low (5/5)
Knowledge about product category (5)	Low (2/2)	High (2/2)	Low (2/2)

Even though the studies mostly developed independently, it is noteworthy that three out of four aggregated dimensions have relevance in selecting all three identified hybrid models. Agile/Stage-Gate, being the most studied and developed hybrid, exhibits more articulated visions of the second order themes. Design Thinking/Stage-Gate and Design Thinking and Lean Startup/Stage-Gate are still emergent hybrid models and thus present fewer contributions from second order themes. Project and market uncertainties, as well as knowledge about users and categories, are present in all the hybrids. We report and discuss the results for each aggregated dimension below.

1) **Project type.** Scholars concur that the Agile/Stage-Gate hybrid model is best suited for large projects with a high potential for generating substantial revenue streams (i.e., ***project size***). For instance, Cooper [11] presented a case study of a firm where "*project teams have 100% dedicated team members for each project; but given that dedicated teams are not feasible for every project, the firm only uses this Agile/Stage-Gate approach for about 20% of their projects, specifically the larger, major revenue generator projects*" (p.229). Agile/Stage-Gate hybrid models are well-suited to highly complex projects (i.e., ***project complexity***). For example, Sommer at al. [13] noted that "*an expression of Agile values can be seen in the tool set evolved to manage complex product development projects. As complexity increases, static tools (like Gantt charts and project plans, documentation, and task specifications) become a burden to maintain*" (pp.36-37). For what concerns the fit of Agile/Stage-Gate approaches with ***project uncertainty***, evidence is mixed. Most scholars recommend Agile/Stage-Gate hybrid models for those projects that are more uncertain, ambiguous, and risky. For instance, Cooper and Sommer [15] stated: "*Agile/Stage-Gate adds the most value when there is high uncertainty and a great need for experimentation and failing fast*" (p.12). However, Paluch et al. [94] questioned the effectiveness of such models for highly uncertain projects. They rather suggest a pure Agile approach for such initiatives: "*Agile methods work best if task uncertainty […] is high, but […] with moderate levels of task uncertainty […] firms would fare better with Agile/Stage-Gate approaches*" (p.497). Design Thinking/Stage-Gate and the Design Thinking and Lean Startup/Stage-Gate hybrid models seem to be suitable for NPD projects with a high degree of project uncertainty. For instance, Cocchi, Dosi, and Vignoli [17] suggest that managers might delay uncertain projects if the underlying process structure is the one provided by Stage-Gate and recommend "*to embed other methodologies [i.e., Agile, Design Thinking, Lean Startup] within Stage-Gate*" (p. 28) for such projects. Regarding ***project innovativeness***, it remains unclear whether the Agile/Stage-Gate hybrid model best fits incremental or radical innovation efforts. Literature reports mixed evidence in this regard. Most scholars suggest this hybrid model for more radical new product projects. For instance, Cooper and Sommer [15] stated: "*for more radical new-product projects, Agile/Stage-Gate offers the additional benefits of managing high uncertainty through incremental product versions (protocepts), quick learning cycles, and frequent customer involvement*" (p.12). However, on the other hand, Paluch et al. [94] argued the opposite, namely that Agile/Stage-Gate is more appealing for managing incremental innovation initiatives. As they reported "*Agile/Stage-Gate hybrids, in turn, are a particularly attractive form of organizing incremental innovation initiatives*" (p.497). Although scholars agree that Stage-Gate is better suited for incremental innovation initiatives, it remains an open question whether Stage-Gate hybrid models are more suitable for radical or incremental innovation projects [17].
2) **Market.** Scholars concur in recommending the use of hybrid models for those markets that are uncertain, risky, and ambiguous (i.e., ***market uncertainty***). For instance,

Cooper and Sommer [14] reported that "*Agile/Stage-Gate is designed to handle more dynamic development projects, facing fluid markets and changing customer needs and requirements*" (p.10). As de Vasconcelos Gomes et al. [10] highlighted: "*if the NPD process must be defined in a situation with a fast-changing and uncertain environment, a hybrid approach should be adopted*" (p.10). Besides, scholars suggest employing the Agile/Stage-Gate hybrid model for those markets that are experiencing rapid growth (i.e., ***market maturity***). In this regard, Cooper [88] reported that Agile/Stage-Gate suits those markets characterized by *"a growth phase of the product life cycle*" (p.29) because it is designed for *"projects targeted at less well defined but growing markets*" (p.28).

3) **Technology.** Scholars recommend employing the Agile/Stage-Gate hybrid model for projects characterized by high levels of technology uncertainty and risk (i.e., ***technology uncertainty***). As reported by Cooper [88], Agile/Stage-Gate has been specifically designed to manage projects that encounter '*technical hurdles*', which involve a "*newer technology with technology risks*" (pp.28-29). This hybrid model is particularly well-suited to technologies that are new to the company, even if they are largely existing (i.e., ***technology maturity***). As noted by Schuh et al. [101], "*technology […] still evolves during the process […]. This is opposed to the traditional process that assumes […] proven technology solutions*" (p.725).
4) **Learning gap.** ***Knowledge about product category*** and ***knowledge about users*** are critical dimensions for selecting an appropriate hybrid model for a given project. Scholars suggest employing the Design Thinking/Stage-Gate hybrid model when there is limited user knowledge within a well-known product category "*to learn about users needs and habits […] and embed new users' needs in the original product vision*" [17] (p.28), and the Design Thinking and Lean Startup/Stage-Gate hybrid model in situations in which also the company's knowledge about the product category is low "*to build on the knowledge gained through the Design Thinking […] and define the business model elements*" [17] (p.28). For what concerns the Agile/Stage-Gate hybrid model, scholars agree in suggesting it when the company has a low knowledge of the product category, as "*this model enters when the company determines the product-market fit settled, but the company still needs to learn about category rule*" [17] (p.26). However, evidence is mixed for what concerns knowledge about users. Some scholars suggest that the Agile/Stage-Gate works well when the customer needs and requirements are unpredictable [10], [14], some others when some of those needs and requirements are known and some are unarticulated [23], [88], [101], and others when the customer needs and requirements are known [17].

Drawing on the results gleaned from our investigation, we devised a conceptual representation designated as "*The Hybrid Model Radar*". The Hybrid Model Radar expounds on the ten second order dimensions identified as part of the study, supports managers in evaluating each dimension, and thus might inform their decisions regarding the activation of hybrid models.

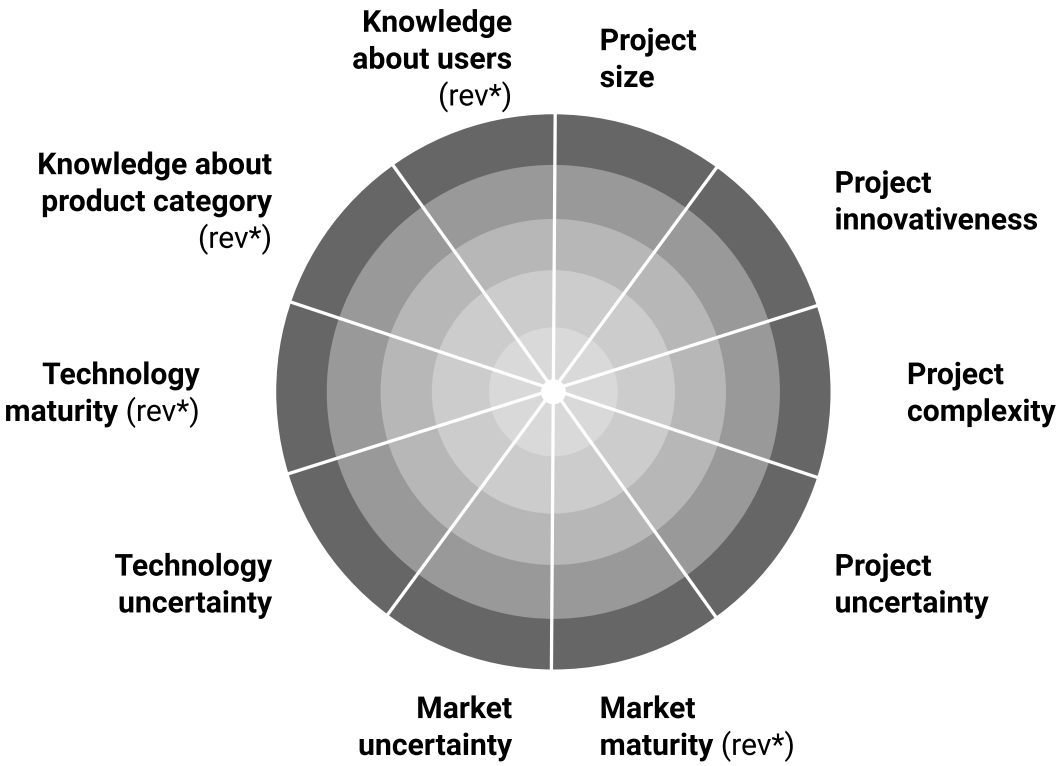

Figure 6: The Hybrid Model Radar

5. Hybrid models in practice

To supplement the findings of our literature review, we looked at the experiences of four multinational companies that are using Stage-Gate hybrid models. We selected four representative organizations that have been using Stage-Gate for over a decade and that are employing Agile, Design Thinking, and/or Lean Startup to support NPD [102]. These organizations include a consumer goods corporation, a multinational beauty company, a multinational food and beverage company, and a world leader in the woodworking machinery industry. Two firms have their headquarters in Europe, and the other two in North America. Prior to adopting Stage-Gate hybrid models, all four manufacturers had used a traditional, scalable idea-to-launch Stage-Gate system for more than a decade with highly satisfactory results. These companies began to adopt Stage-Gate hybrid to accelerate their NPD processes and meet evolving customer needs. During the transition to Stage-Gate hybrids, these organizations retained their conventional Stage-Gate processes and integrated Agile, Design Thinking, and/or Lean Startup methodologies within certain or all stages of the process, thereby establishing nested hybridizations of different approaches Alternatively, they created handed-over hybridizations by alternating between Stage-Gate and Agile, Design Thinking, and/or Lean Startup throughout the NPD process. These companies still use Stage-Gate processes for most of their NPD projects and deploy Stage-Gate hybrid models solely for a minority of projects based on specific contingencies. We interviewed a senior R&D manager from each company (average time length 90 minutes) by following a semi-structured interview protocol that aimed to understand (i) how these companies implemented the Stage-Gate process and the iterative methodologies, (ii) how they managed to structure Stage-Gate hybrid models, and (iii) for which NPD projects they use such hybrids. We then used the results that emerged from the literature review to classify the data collected from the interviews (Table 6). Below, we report how and when these organizations enacted Stage-Gate hybrid models.

5.1 Global consumer goods corporation

This company uses the Design Thinking/Stage-Gate model to handle larger, major revenue generators, and more innovative NPD projects. The firm has been using Design Thinking techniques and principles extensively in the ideation phase since 2006. Currently, experts in Design Thinking assist Stage-Gate teams to generate ideas and acquire knowledge during the ideation phase of the product development process. The duration of this methodological support is dependent on the project's specific requirements, lasting between 12 to 16 months. Design Thinking is founded on key principles, such as empathy, problem framing, learning through rapid prototyping, and storytelling. Its application is dependent on the unique demands of each project under development. Once the methodological support of Design Thinking is completed, the company resorts to the Stage-Gate process for the remaining phases of the process.

5.2 Beauty company

For the past three years, this company has employed the Agile/Stage-Gate model to accelerate the product development process. This model was introduced when the company recognized the need for a project to be launched on the market quickly. Had they followed the traditional Stage-Gate model, the project would have been completed three years later than required. Thus, the firm created a dedicated cross-functional team comprising a senior marketing director, a brand manager, a procurement manager, a finance manager, and three R&D managers who were responsible for different aspects of the project. The team relied on weekly sprints and the scrum method to complete all NPD activities, from ideation to launch. Throughout the process, the team reported directly to the CEO of the company, making decisions promptly and efficiently. The project was a success, meeting all the requirements in terms of speed, cost, and quality, but team members were reluctant to return to traditional Stage-Gate processes, as they perceived the Agile/Stage-Gate process to be more efficient and effective. Yet, some middle management members expressed skepticism towards a complete overhaul of the NPD process, as they would no longer have had control over certain decisions. Thus, the company has formally structured the Agile/Stage-Gate process for fast time-to-market projects while using the Stage-Gate process for most other NPD projects.

5.3 Food and beverage company

This global leader manufacturer uses all three kinds of hybrid models. When an Agile/Stage-Gate model is activated, the firm employs the Agile methodology during the development and testing phases of the Stage-Gate process, resulting in a nested hybridization. The company uses this model to gain knowledge about some dynamics related to the product category. The manufacturer assembles a dedicated team of experts from different functional areas to lead the project, and the team makes independent decisions regarding critical aspects of the project such as product packaging and pricing. The team conducts user testing directly on market shelves and reports the field results to the top management during scheduled retrospective meetings. Once the testing is completed, the top management evaluates the outcomes in ad-hoc gate meetings. When the organization activates a Design Thinking/Stage-Gate model, Design Thinking is leveraged in the ideation phase, and Stage-Gate comes into play from the concept phase. The organization activates this model when the goal is to understand customers' needs and wants and involves the Design Thinking Area to support the project. The Design Thinking Area – created within the company's R&D department in 2015 – assembles a team of experts.

This team can be made up of internal employees from different functional areas who have been trained to Design Thinking methodologies, or external experts who work in universities, design studios, or other management consultancies that periodically report their research progress to the Stage-Gate team. In the Design Thinking and Lean Startup/Stage-Gate model, the company implements Design Thinking in both the ideation and concept phases and Lean Startup in the business case stage. Stage-Gate is then reserved for the final phases of development, testing, and launch. This handed-over hybridization is activated when the firm wants to acquire knowledge about the needs of the end users and the product category they are working on. In this model, the Design Thinking Area creates a team of internal or external experts dedicated to the project. The team comes up with a physical product concept. This outcome is then refined into an MVP which is tested on the market. The MVP is iteratively refined until all the unclear product attributes can be frozen into the final product specifications.

5.4 Producer of woodworking machines and systems

This firm uses the Agile/Stage-Gate hybrid model to develop software and digital services that must be integrated into the woodworking machinery. While the mechanical design and development of the machinery continue to be managed via the Stage-Gate model, the software component of the product-service system is managed via an Agile scrum methodology. Thus, Agile supports Stage-Gate to handle software development and testing. The NPD team's activities - whether conducted with Stage-Gate or Agile approach - are assessed during common gate meetings to ensure adherence to the predetermined plan.

Table 6: Hybrid models in practice

Results / Firms	Iterative methodologies	Stages (type) of hybridization	Types of hybrid models	Decision variables to implement hybrid models
Global consumer goods company	Design Thinking	Ideation (handed-over)	Design Thinking/Stage-Gate	Project size (Larger)
				Project innovativeness (Radical)
Beauty company	Agile	All (nested)	Agile/Stage-Gate	Fast time-to-market projects
Food and beverage company	Design Thinking	Ideation (handed-over or nested)	Design Thinking/Stage-Gate	Knowledge about users (Low)
				Knowledge about product category (High)
		Ideation and Concept (handed-over or nested)	Design Thinking and Lean Startup/Stage-Gate	Knowledge about users (Low)
	Lean Startup	Business case (handed-over or nested)		Knowledge about product category (Low)
	Agile	Development and Testing (nested)	Agile/Stage-Gate	Knowledge about users (High)
				Knowledge about product category (Low)
Producer of woodworking machines and systems	Agile	Development and Testing (nested)	Agile/Stage-Gate	Product category (Agile for software development, Stage-Gate for mechanical design and development)

6. Discussion

6.1 Theoretical implications

This systematic literature review significantly advances the conceptualization of Stage-Gate hybridization. In empirical terms, this research is among the first to concurrently compare various hybrid approaches (Agile/Stage-Gate, Design Thinking/Stage-Gate, Design Thinking and Lean Startup/Stage-Gate) and it contributes to theory at four main levels.

First (i), hybridization does not necessarily equal Agile/Stage-Gate, as our results strongly show that at least two other methodologies are currently hybridized with the Stage-Gate process. In fact, to date, the literature has mostly focused on the Agile/Stage-Gate hybrid model, considering it almost as the only possible hybrid model. This research adds to the literature by including Design Thinking and Lean Startup methodologies and contributes to the limited body of research that explores hybrid approaches in product development [10], [17].

Second (ii), while the existing literature has predominantly focused on a singular hybridization form (which we named nested), this study sheds light on another underexplored type of hybridization, that we called handed-over hybridization. By identifying and highlighting this distinct hybridization form, this research contributes to the existing knowledge base by providing an alternative frame to integrate iterative methodologies and structured innovation processes, in contrast to the commonly researched nested hybridization form [63]. The identification of handed-over hybridization form offers novel insights and opportunities for further investigation, enriching the scholarly discourse in the field of management.

Third (iii), we identified in which phases of the Stage-Gate process Agile, Design Thinking, and Lean Startup methodologies best fit. On the one hand, our research corroborates the existing NPD literature by showing a wide consensus among scholars on the phases where iterative methodologies are best suited. On the other hand, our study emphasizes an urgency of research on what genuinely distinguishes the contributions of Agile, Design Thinking, and Lean Startup in the early stages of the Stage-Gate process. In fact, we found that both Agile and Design Thinking are well suited for the ideation and concept stages, and that both Agile and Lean Startup are well suited for the business case stage. Our results suggest that research should analyze their differences as their incorrect use may hinder the innovation process [17], [45].

Finally (iv), we identified how organizations have combined the Stage-Gate process with the Agile, Design Thinking, and Lean Startup methodologies to create three different kinds of hybrid models. This contribution is of considerable importance to innovation management theory, as it offers insights into how the build-measure-learn cycle is applied to different models, emphasizing both similarities and differences. Additionally, this contribution has practical implications for those managers who seek to design new hybrid models, as it provides valuable guidance on how these models have been effectively employed by different organizations [17].

6.2 Managerial implications

Managers are aware of the benefits associated with Stage-Gate hybrid models when facing

innovation challenges, particularly in contexts characterized by high levels of uncertainty. Nevertheless, the challenges of designing hybrid models and determining when it is worth abandoning the Stage-Gate in favour of a hybrid approach present considerable obstacles for managers. This systematic literature review offers managers two key practical implications.

First (i), through the identification and comparative analysis of the three types of hybrid models currently used, this study provides a comprehensive synthesis of the current knowledge about the existing hybrid models. By examining these models and their specific characteristics, managers can inform their strategic decisions on NPD processes, ultimately facilitating the successful design and implementation of hybrid approaches tailored to their specific innovation needs.

Second (ii), managers must understand when it is appropriate to transition from a Stage-Gate process to a hybrid approach for a given project. This decision is not taken lightly, as adopting a hybrid approach necessitates additional methodological competencies that come at a cost, both in terms of resources and mindset change. This decision-making activity requires careful consideration and analysis. This study identifies the conditions under which it is useful to rely on extra methodological competencies beyond those provided by the Stage-Gate alone. Our four aggregated dimensions not only contribute to contingency studies in innovation management [33] but also offer valuable managerial advice on which process to activate for a specific project [30].

6.3 Limitations

This study is not without its limitations.

First (i), the scope of this research is limited to Stage-Gate hybrid models, which do not account for other types of hybrid models that do not rely on Stage-Gate as their foundation. Therefore, future research could complement this study by investigating a wider range of hybrid models and including those that extend beyond the Stage-Gate process.

Additionally (ii), this research focused on understanding how and when it is beneficial to improve the Stage-Gate process with iterative methodologies primarily from the perspective of project management and contingency studies. Nevertheless, other perspectives, such as portfolio management, could also be considered to comprehensively understand the Stage-Gate hybrid models' phenomenon. Thus, future research could extend our findings to other bodies of literature and advance our understanding of Stage-Gate hybrid models.

Third (iii), the studies reviewed in this paper are not restricted to specific industries, regions, or organizational contexts (e.g., SMEs or large enterprises), potentially oversimplifying our results with respect to the complexities of the actual hybrid models' practices within those specific contexts. To address this limitation, future research could complement our results by exploring how Stage-Gate hybrid models are implemented in specific industries or organizational contexts and by empirically testing the identified decision variables in those specific settings.

Lastly (iv), we explained in the methodology how the limited number of papers and the existence of ongoing conversations with practitioners in research conferences led us to include

18 conference proceedings in the final dataset of 61 documents. To strengthen the validity of the results, we replicated the data analyses using a sample that exclusively comprised the 43 journal articles selected. Our results proved to be stable. However, due caution requires acknowledging the limitation of including documents that go through a limited review process and waiting for a richer portfolio of hybrids models' research to replicate and expand the analysis.

6.4 Future research avenues

Our study highlights questions that still need to be answered through future research.

Can iterative methodologies substitute (rather than complement) Stage-Gate? Most of the literature reviewed in this study focused on Stage-Gate hybridization within companies where the Stage-Gate model was already in place, taking the Stage-Gate process structure for granted and assuming a nested hybridization form as a desirable outcome. Some scholars argued that combining Stage-Gate at the strategic level with Agile, Design Thinking, or Lean Startup at the execution level reduces the cultural clash that arises due to the introduction of these iterative methodologies [92]. Nevertheless, a Stage-Gate hybrid form is not necessarily the best alternative to Stage-Gate. As a viable option, companies could employ iterative methodologies without relying on Stage-Gate [103]. In this vein, some scholars have begun investigating Stage-Gate, Stage-Gate hybrid models, and iterative methodologies simultaneously. For instance, Bianchi, Marzi, and Guerini [12] studied the impact of using Stage-Gate, Agile/Stage-Gate, and Agile models on performance indicators such as speed, cost, and quality. Their results suggest that "*for organizations that already employ a traditional gating system, the use of iterative, time-boxed development cycles could improve performance, and a hybrid model may therefore enable dealing with increased levels of uncertainty. However, when this is not the case, then an Agile-only approach would seem a better option*" (p.551). They recommend hybrid models for organizations that already use Stage-Gate but suggest those Stage-Gate-based companies transition towards pure Agile methodologies in a stepwise manner to improve their NPD performance. Our results reinforce this perspective and present another potential solution with a handed-over hybridization form. We thus call for further research to investigate whether and under what circumstances it is worthwhile to abandon the Stage-Gate structure in favour of iterative methodologies or combinations thereof (e.g., Gartner's approach to combining Design Thinking, Lean Startup, and Agile[3], [104], [105]).

What makes iterative methodologies in a Stage-Gate setting specific for? In the following passage, Cooper and Sommer [66] discuss the implementation of Agile in the early stages of product development. They argue that although the tasks remain the same as in the traditional gating model, their nature is different, as "*iterations and testing with customers provides feedback that is looped into the analysis and definition even as the business case is being developed; […] initial assumptions about market acceptance, customer value, and even manufacturing costs are validated often, early, and cheaply [;…] go/kill decisions can be made more frequently than in the classic gating system— potentially at the end of each iteration when results are demonstrated to management.*" (p.31). However, all the reported characteristics could also be attributed to Design Thinking and Lean Startup. As a result, the literature is fragmented in this regard. On the one hand, some scholars suggest embedding Agile in the initial phases to identify customer needs and requirements [14]. On the other hand, some scholars recommend using Design Thinking and Lean Startup in the same phases to achieve

[3] https://www.gartner.com/en/documents/3941917

the same goal [17]. Future research should compare and question the use of these methodologies in the Stage-Gate process since their misuse can be detrimental and harmful to the innovation process [45], [106]. One possible approach to address this issue is to focus on the differences between Agile, Design Thinking, and Lean Startup, rather than on their commonalities. As Cocchi, Dosi, and Vignoli [17] reported: "*Design Thinking, Lean Startup, and Agile have common pillars, including using prototypes to learn in multidisciplinary teams […], testing them with users, and iterating to define the solution progressively*. *[But] Significant differences also exist among the three methodologies.*" (p.28). Another potential approach is to employ design science research methodologies [107], to develop principles, frameworks, or solutions that provide practical and actionable knowledge for managers. For example, de Vasconcelos Gomes et al. [10] proposed a set of design principles to activate hybrid approaches, while Cocchi, Dosi, and Vignoli [17] developed a framework that recommends which hybrid to activate for each specific quadrant along a 2x2 matrix with user and category learning gaps as axes.

Which hybrid model for which project? Our findings reveal four aggregated variables that determine the best fit for hybrid models and highlight the need to adopt such models based on specific contingencies. However, our study also shows how the current literature on hybrid models is limited in this regard. First, the Design Thinking/Stage-Gate and Design Thinking and Lean Startup/Stage-Gate hybrid models are still emerging and require further investigation to fill the gaps in the second order themes that compose the aggregated decision variables. Second, while the management literature has clearly distinguished between the constructs of uncertainty and ambiguity [108], the Stage-Gate hybrid literature often uses them interchangeably. Thus, a deeper inquiry into these constructs would be of interest to both the research and practitioner community. Third, our results suggest that hybrid models are most effective in dealing with market uncertainty. However, the question of which of the three different hybrid models is best suited to address market uncertainty remains largely unexplored. Our study shows that, to date, scholars have predominantly focused on comparing a single methodology to Stage-Gate (e.g., to understand when it is worth embedding Agile or Design Thinking into Stage-Gate). Scholars appear to have a methodological-driven interest in their research, whereby they solely investigate a specific methodology (e.g., study Agile, Design Thinking, or Lean Startup) rather than considering a broader range of hybrid models [17]. Such a narrow approach can result in a limited understanding of the effectiveness of hybrid models. Indeed, comparing Stage-Gate with a more flexible and iterative model based on a single methodology will inevitably lead to the latter model being deemed more effective in managing high levels of uncertainty, regardless of whether it is built on Agile, Design Thinking, or Lean Startup principles. Hence, it is crucial to compare more than one hybrid model simultaneously to gain a better understanding of their relative strengths and weaknesses. Considering these findings, our study suggests avenues for future research focusing on the comparison of multiple hybrid models.

What are the boundary conditions under which hybrid models are more likely to result in radical (incremental) innovation? Our results show there is no clear consensus on whether hybrid models are more suitable for incremental or radical innovation efforts. Although hybrid models theoretically have the potential to be applied to both types of innovation, it is unclear whether they offer major benefits for more radical initiatives [23] or incremental ones [94] in practice. This divergence can partially be attributed to the fact that several manufacturers are still in a piloting phase, experimenting with hybrid models [18]. As such, some companies may prefer to start small with Agile/Stage-Gate for incremental innovation efforts and then scale it

up to more radical projects. In a previous study we conducted with a global manufacturer, a senior R&D manager commented on a project completed with the Agile/Stage-Gate hybrid model, stating: "*through Agile we understood that we could have sold the product at a certain price [...]. Agile proved that it works: it sped up the development process and allowed us to collect learnings directly from the shelves [...]. Nevertheless, I perfectly understand the strategic direction of the company: starting to inject Agile techniques for incremental projects and afterward scale them up for more breakthrough projects*". Rather than seeking to determine whether hybrid models are better suited for incremental or radical innovation in absolute terms, we argue that the current discourse on hybrid models lacks a perspective on boundary conditions. Indeed, there can be some conditions under which hybrid models are more likely to result in incremental innovation and some others under which they can result in radical innovation. Examining these conditions in future research may help to address the mixed evidence that has been identified.

7. Conclusions

This work started from the well-established principle that one size does not fit all: different NPD projects require different NPD processes [31]. The perspective that there is no single approach to project management that fits all cases calls for systematic contingency studies. Our study addresses this call in the field of Stage-Gate hybrid models, contributes to the innovation management and NPD literature, and provides managerial implications for understanding how and when to employ hybrid models. The adoption of Stage-Gate hybrid models is considered a major shift in the way organizations should approach the NPD process. Our contribution has provided an overall picture of hybrid models and has proposed future research directions to advance the field of hybrid models. The findings can also serve as a valuable reference for managers involved in the transition of their organizations towards hybrid models of NPD. By addressing the identified research gaps and building on our insights, scholars and practitioners can make further progress in developing effective hybrid models and enhancing their implementation. Ultimately, this can lead to more efficient and successful NPD processes and enable organizations to remain competitive in today's dynamic and complex business environment.

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