UNIVERSIDADE CATÓLICA PORTUGUESA

The Hybrid Approach in Non-Software Environments

A Framework to Evaluate Hybrid Adoption

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Writing a master's dissertation can be compared to the final stage of an enriching journey. It is the most challenging stage, but which give us the greatest sense of accomplishment. Although we think that this is a path that we will travel alone, the truth is that we take it with persons who fully believe in our success.

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Abstract

Agile methodologies have taken a prominent role in software development industries. However, its recognition in non-software environments of new product development has been slower, instigated by serious challenges such as the strong presence of traditional approaches. Stage-Gate methodology asserts itself as well-suited and popular due mainly to its clear structure and milestones. Still, it limits a competitive response to meet (internal and external) pressures from a mounting complexity of new-product projects, faced by contemporary businesses. This dissertation replies to the potential of a hybrid approach to capitalize on the judicious strengths of both Stage-Gate and tailored agile components.

Little literature has focused on the practicability of developing a pilot tool to cope with erroneous conceptions about agile and lack of focus on envisioning the process itself, which makes management doubtful and sceptical to hybrid transformation. We follow prescriptive analytics on recent research of hybrid models performance in real-life companies, in order to predict the dominant prerequisites to adopt agile in non-software companies with deep-rooted traditions.

As result, we describe a four-phase framework to determine the decision on the adoption of a hybrid approach. It captures four main interrelated fields: 1) evaluation of the project's potential complexity; 2) identification of project's critical factors; 3) selection and fitting of tailored agile practices/tools; 4) definition of strategies to achieve agility. The designed solution, although limited to a systematic review, might persuade, assist and guide practitioners in deciding and preparing the integration of agility. Meanwhile, it uncovers patterns that motivate a hybrid adoption, encouraging researchers to empirically explore the magnitude/value of such tool in the decision-making process and the strategic and tactical benefits delivered by it.

Keywords: New product development, agile, Stage-Gate, hybrid, project complexity
Words: 9 979

Resumo

As metodologias *agile* têm assumido um papel proeminente nas indústrias de desenvolvimento de software. Todavia, o seu reconhecimento em ambientes de desenvolvimento de novos produtos não baseados em software tem sido mais lento, instigado por diversos desafios tais como a forte presença de abordagens tradicionais. A metodologia *Stage-Gate* exibe popularidade devido, sobretudo, à sua clara estrutura e *milestones*. Contudo, limita uma resposta competitiva às pressões contemporâneas (internas e externas) da crescente complexidade em projetos de novos produtos. Esta dissertação foca no potencial da abordagem híbrida para capitalizar os pontos fortes judiciosos do *Stage-Gate* e das componentes *agile* personalizadas.

Diminuta parte da literatura se concentra na praticabilidade de desenvolver uma ferramenta piloto para lidar com conceções erróneas sobre a agilidade e falta de foco na visão do próprio processo, o que torna a gestão duvidosa e cética quanto à transformação híbrida. Seguimos uma análise prescritiva de pesquisas sobre modelos híbridos em contexto real para prever os pré-requisitos dominantes para adotar *agile* em empresas não baseadas em software com tradições profundamente enraizadas.

Como resultado, descrevemos um *framework* de quatro fases para decidir quanto à adoção de uma abordagem híbrida. Este implica quatro áreas interrelacionadas: 1) avaliação da potencial complexidade do projeto; 2) identificação dos fatores críticos do projeto; 3) seleção e encaixe de práticas/ferramentas *agile* adaptadas; 4) definição de estratégias para alcançar a agilidade. Esta solução, embora limitada a uma revisão sistemática, poderá persuadir, suportar e orientar os profissionais na decisão e preparação da integração de agilidade. Enquanto isso, revelam-se padrões motivadores da adoção híbrida, encorajando à investigação empírica da magnitude/valor de tal ferramenta no processo de tomada de decisão e os benefícios estratégicos e táticos por ela proporcionados.

Palavras-chave: Desenvolvimento de novos produtos, *agile*, *Stage-Gate*, híbrido, complexidade do projeto
Palavras: 9 979

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Introduction

In the globalized 21st century, successful new product development (NPD) arises as a priority factor for business survival. Across all industries, both business environments and projects are changing progressively their complexity and dynamics. The wide range of interrelations and tasks, urgency of reduced product lifecycles and increasingly (un)expected changes are challenging to NPD approaches and models, even when the core business does not involve complex technology (Williams, 2005; Collyer et al., 2010; Ciric et al., 2018).

In companies beyond software industry, the traditional reactive and linear project management (PM) approaches to run NPD, such as the dominant Stage-Gate methodology, remains fundamental to sustain the structure of the planning/execution activity-cycles and control over work progress - gate decisions - (Cooper and Sommer, 2018). However, in its pure form, Stage-Gate exhibits relative shortcomings and may inhibit a proactive and strategic response to address adjustments during the process. The long-term horizon, lack of adaptability to sustain experimentation (Cooper, 2014) and rigid maneuvering space given to teams (Cooper and Sommer, 2018) restrict actions to a standard operating procedure, incompatible with high-level uncertainties.

Many authors devised the benefit of supporting the NPD in an incremental, iterative and experimental process that follows an agile philosophy. This refers to a set of methodologies - also deemed as *lightweight* -, sharing common values and principles outlined in the *Agile Manifesto* (Beck et al. 2001). The application of agile practices has been exhibiting potential to be scaled and individually customized among industries and projects (Cooper, 2014; Conforto et al., 2014; Hilt et al., 2016; Niederman et al., 2018; Brandl et al., 2021). Unfortunately, they still face high reluctance because implies a holistic transformation hindering internal/external factors and time/resources (human and monetary) investment.

In this respect, non-software companies face nowadays the dilemma: maintain their tried-and-proven Stage-Gate models or shift to a new agile approach? Recent literature mentions a reasonable alternative, that is a so-called hybrid PM approach, on a project-by-project basis. It arises as a natural evolution in the expanding range of challenges in traditional methodologies (Gemino et al., 2021), and allow to enhance the project performance from blending both approaches (Cram and Marabelli, 2018). Nevertheless, this can be a daunting journey.

Although research on this subject has been taking its roots, there is a literature gap concerning the development of procedural recommendations ("how") for the adoption of a hybrid approach in new-product projects. This study's impetus was, in fact, to help non-software companies overcome the mistrust and lack of coherent understanding and instruction about the introduction of a suitable degree of agility. In turn, that avoids blocking the agile integration into a new desirable hybrid approach (Ciric et al., 2018). Therefore, the objectives are to understand and critically examine real-world case research on the application of Agile-Stage-Gate models, identifying the determinants which work as enablers for this hybridization and enlightening the translation of agile concepts to non-software environments.

From this, the aim is to propose a framework for hybrid implementation that conducts the decision-making and business processes of these companies with pure Stage-Gate models.

This dissertation is structured into five chapters. The first chapter refers to a literature review that enunciates relevant aspects of differentiation amongst traditional, agile and hybrid approaches. The second chapter provides the research methodology. The third chapter outlines the results describing in detail the framework for the adoption of hybrid models. The fourth and final chapter discusses conclusions, main research contributions, limitations and suggestions for future work.

Chapter 1
Literature Review

1.1. The Traditional Approach

Initially, the common basis for managing NPD was the conventional Waterfall model, formally introduced in the 70s (Royce, 1970). Such approach arose from the need to gain control in managing large and unstructured development projects (MacCormack and Verganti, 2003). The model's concept associates with the visual cascading effect created by its sequencing process. Given the ineffective absence of revisiting conditions, Royce (1970) added the feedback factor to enable narrow interactions of the current stage with the immediately preceding stage.

Since the late 80s, came to light the Stage-Gate model (Cooper, 1990) as an evolution of the Waterfall model, with prevailing similarities between both traditional methodologies - figure 1.

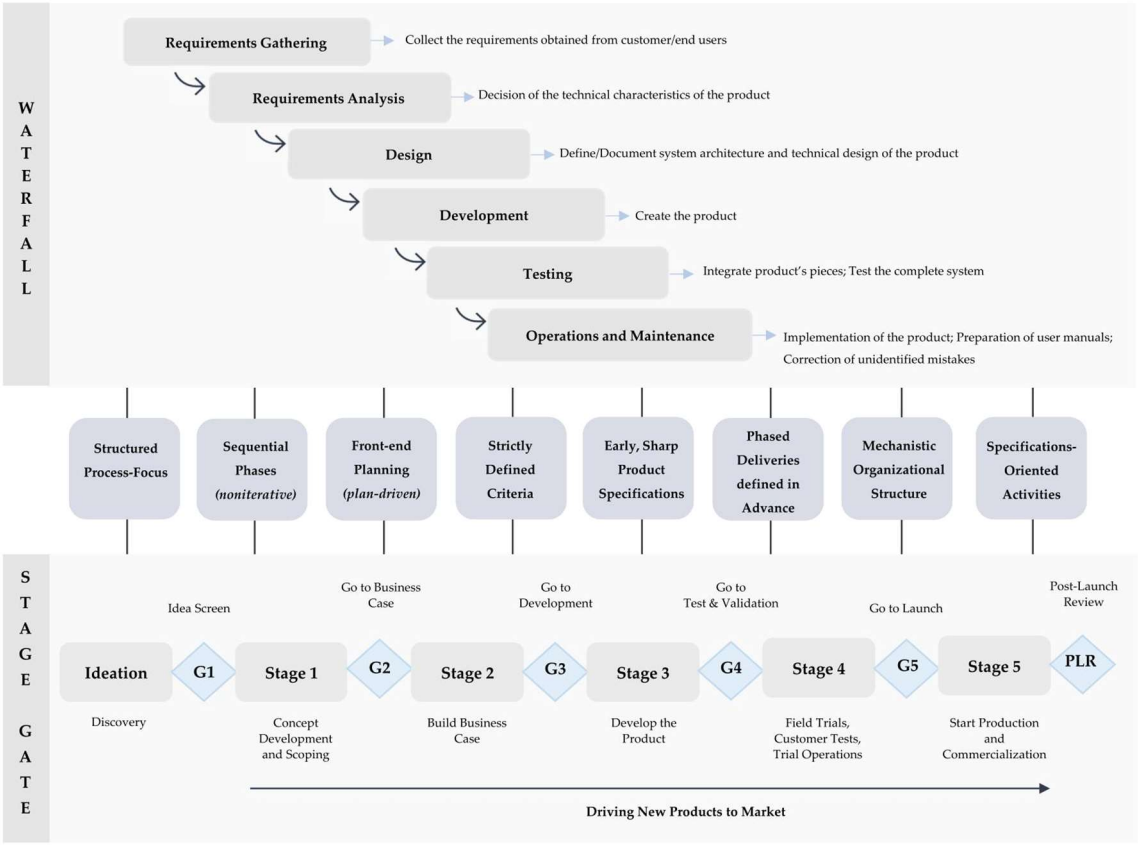

Figure 1: Waterfall, Stage-Gate models and common-points

Source: Adapted from Royce (1970) and Cooper (2014)

A typical gated model prescribes a division of the NPD process into five or six discrete stages (depending on project duration), from "Ideation" to "Launch", interspersed with gate marks.

To avoid delays in the sequence of stages, the beginning is determined by an exhaustive top-down, front-end planning. It is based on the identification *a priori* of a customer requirements package, which is fixed, and posterior time estimation to complete those by the project manager (Boehm, 2002). The uncertainty regarding the understanding of requirements by the project team is reduced with market analysis. Indeed, a large desk research investment allows to evaluate distinct alternatives preventing and reducing causes of deviation when development begins.

Each stage contains success drivers, a checklist of prescribed deliverables and a predefined set of tasks on which gates are based (Cooper and Sommer, 2016b). Such progress strategy allows proven results and best practices acknowledgment conferring scalability to this methodology. Besides that, it can help gatekeepers simplifying the decision to *Go*/*Kill* the project occurring at each gate. The process involves decisions of investment, go-forward and resources prioritization and commitment to high-promising NPD projects (Cooper and Sommer, 2016a). To ensure a smooth transition between stages, thereby of the responsibility over activities, companies formalize knowledge through standard and comprehensive documentation - *heavyweight methodology* (Dybå and Dingsøyr 2008).

Hereupon, the basic principle relies on oversight and foreseeable development activity, so on the existence of knowable sources of variation which are eradicated by uninterruptedly measuring and refining of processes (Cockburn and Highsmith, 2001). Accordingly, the development lifecycle presents a low level of uncertainty. The essence is that projects being relatively simple and predictable have well-defined boundaries and low-expected requirements change rate, which facilitates planning practices to be designed in advance (Boehm, 2002; Boehm and Turner, 2003). Further, the customer feedback is often differed for the final stage, which should allow focusing on the design to be launched and saving on expensive, long prototyping tasks (Bianchi et al., 2020). Developers need to have the capability to make judgments about the benefits (value) and related costs behind the implementation of each requirement.

So, the ultimate objective of all these primary focuses is accomplishing a high optimization of activities and performance efficiency in order for the project to comply with the premeditated time, budget and scope, attaining quality outcomes (Špundak, 2014).

In literature raised the debate contesting the robustness and applicability of the Stage-Gate to all projects, which had been highlighted as one of its advantages. Špundak (2014) reenforced the idea proposed by other authors emphasizing that *one size does not fit all* (e.g., MacCormack et al., 2012). On the one hand, previous studies had acknowledged positive performance effects from the use of traditional methodologies such as NPD effectiveness, project execution success and speed-to-market (Bianchi et al., 2020). Indeed, in stable, predictable business contexts with little or no platform and market uncertainty - that is, the technology base and the amount of new design work being developed are well-known and understood -, requirements are clear-cut and final, and the product definition stable, thus traditional methodologies remain likely to be effective (MacCormack and Verganti, 2003; Schmidt et al., 2018; Bianchi et al., 2020).

Nonetheless, most companies no longer face highly deterministic (non-dynamic) environments with accurate information (Port and Bui, 2009; Collyer et al., 2010). That devoid traditional methodologies of suitability for the purpose. Forecasting on product specifications and committing, in an early-stage, with large number of resources and criteria, and strictly planning presupposes final concessions. In today's technology-driven, financially unstable, faster-paced and disruptively competitive environments, the fast-changing of customer needs/expectations and project requirements tend to invalidate pre-negotiated aspects by the project conclusion. The gathered requirements can change radically or become obsolete (Lee and Xia, 2010; Petersen and Wohlin, 2010; Serrador and Pinto, 2015; Sithambaram et al., 2021). So, the assumption of predictable, optimal solutions to specifiable problems as development proceeds becomes totally untenable.

Also worth noting is that this *slave-like* alignment to current market and customer needs constraints and biases the innovation's scope and capability to explore emerging/potential demands (Granato et al., 2021).

According to the proponents of *front-end freezing*, deviations on the actual plan are undesired and should not be accommodated. Hereafter, testing is concentrated at the end. In volatile environments is crucial not to obtain feedback just at the end-stage. As Petersen and Wohlin (2010) argued, non-continuous testing - thus, minimal user/customer involvement into process activities -, imply limited communication between Development and Testing, faults perpetuity and difficulties fixing late discovered issues. Therefore, the project quality is compromised until shortly before launch as the detection of market-ready product incompatibility with the initially validated concept is hindered. We must not forget the consequential design loopbacks and interrelated unplanned resources allocation - "it's hard to alter course when you're being swept down a large waterfall" (Reagan, 2012, as cited in Bianchi et al., 2020).

Criticisms emphasize as main weaknesses the too much-specialized competence of teams, late/heavy testing (Petersen and Wohlin, 2010), excessive formal paperwork and control, non-value-added work, scope inflexibility, uniform workload distribution, unnecessary bureaucracy, process design too sequential and too linear, and gates are too structured or too financially-based (Lenfle and Loch, 2010; Cooper, 2014). Further, due to the irreversibility of an early selection, decision-making process becomes longer slowing the development cycle, and the implementation of the majority of high-leverage requirements is restricted (Port and Bui, 2009).

In this vein, many problems could emerge from the application of Stage-Gate as overruns in project delivery, increased costs, blown budgets (Boehm and Turner 2004; Cooper, 2014), lack of results until the end, late communication to stakeholders, wasted efforts (e.g., rework/replanning), design instability, employees' lack of confidence (Petersen and Wohlin, 2010) and useless final product (Collyer et al., 2010). Lastly, such methodological rigidity can trigger pathologic behaviours on developers such as over-specification of product features, incurring in *gold plating*.

1.2. The Agile Approach

Agile has been asserting an innovative paradigm in NPD. Although it was first explored in the software/IT development domain, to which is typically associated (Dybå and Dingsøyr 2008), its current application can be extended to any other scope. As Dingsøyr et al. (2012) reflected in their explanation toward a decade of agile methodologies, these have become an asset in the process portfolios of several companies and not followed only by *Agilists*.

The first steps of agile started with the *Agile Manifesto*[1]. It defines four core values on which developers should concentrate, and twelve principles (Beck et al., 2001) which originate an instructive background to numerous practices able of complying with agile values and delivering superior value to customers and businesses (Dingsøyr et al., 2012) – appendices 1.

Since the *Manifesto*, practitioners and researchers have been defining agility through distinct angles as the enunciated principles do not formally define agility, but just later agile started to be conceptualized looking at manufacturing and PM.

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[1] In February 2001, a group of renowned software methodologists met to discuss the reasons why projects succeed or fail. They advocated and created an emerging movement officially contemplated in the form of the *Manifesto for Agile Software Development* (Beck et al., 2001), posted on the Agile Manifesto website (*http://agilemanifesto.org/*). The majority of principles were not novel in software community. Indeed, they had been used in methodologies that can be thought of predecessors of agile. Despite the variety of literature treatments to this subject, this dissertation follows the logic of some authors (e.g., Cram and Marabelli, 2018; Gemino et al., 2021). We consider that, an agile approach comprises the high-level principles/guidelines/goals of a project management and development. Thus, the agile approach encompasses several methodologies, with each consisting in a set of low-level, operational guiding practices that methodically support project managers during the project lifecycle. Accordingly, Scrum is considered an agile methodology although it had been in place before the *Manifesto* (in 1995). Scrum practices align with the agile principles, for instance daily meetings enable knowledge sharing within the team.

> "Agility is the project team's ability to quickly change the project plan as a response to customer or stakeholders needs, market or technology demands in order to achieve better project and product performance in an innovative and dynamic project environment." (Conforto et al., 2016, 667)

The agile approach does not concentrate on process rigor, instead it is practice-led and people-oriented (Nerur et al., 2005). Through this iterative approach, the NPD process is broken into regular short-term development cycles, named interactions or sprints (Scrum terminology that will be used). These are signalized a mainstream strength of agile methodologies (Cockburn and Highsmith, 2001). Sprints generate business value by helping developers to continuously identify changing requirements and plan's deviations, and promptly embody this fluid information into an evolving concept (Lee and Xia, 2010) - product requirements may be less than 50% defined on entering the Development (MacCormack et al., 2012), the definition solidifies thru process.

Furthermore, confronting misalignments with the *status-quo*, improve the capacity to create meaningful innovations (Granato et al., 2021). In its turn, that is reinforced by the focus on social capital, and hence the enhancement of goodwill to sustain resource/knowledge exchange (Baxter and Turner, 2021) and a work pace to creativity and productivity (Dingsøyr et al., 2012).

As the discover, the validation of requirements occurs across the project chronology - requirements existing outset are not fixed in preference of being undetermined. Thus, the product is incrementally developed considering that each interaction enables to refine specifications and faster create and deliver intermediate outputs (e.g., new feature; prototypes), which can be demonstrated to stakeholders, often to customers (Cooper and Sommer, 2016a). From here emerge three main advantages. Firstly, requirements coming into the process are

shorter and more specific and stable, so activities are performed in a compressed way (smaller packages) reducing the resources investment compared to Stage-Gate (Bianchi et al., 2020). Secondly, the scope of work tolerates requirements emerging locally in each sprint to be implemented as much as possible, and the unfulfilled can be conveyed to upcoming sprints to be reprioritized (Port and Bui, 2009). Third, as customer/user feedback loops on important features occur earlier and often, down rework can be saved (Boehm, 2002). Hence, it makes possible staying on schedule and optimizing commercial success.

Recognizing the infeasibility of an one-off robust planning, agile proponents emphasize on project execution (Chin, 2004, as cited in Špundak, 2014). Nevertheless, front-end planning should not be excluded since working customer-close is vital to gather requirements for the first release (Serrador and Pinto, 2015). Rather, the process comes up with an adaptative, high-level planning and regular test-basis - *plan and built on the fly* (Boehm and Turner, 2004; Cooper, 2016). Thus, teams fail earlier, cheaply and learn faster, collecting NPD strategic insights (Bianchi et al., 2020). Eventually, the substantial planning spread through sprints running, entitled backlog, leads to an overall planning superior to traditional methodologies (Dybå and Dingsøyr 2008).

Unlike traditional methodologies, the agile methodologies comply with the uncertainty/turbulence in business and technical domains, stating that change during the ongoing development besides inevitable is needed and must be accommodated. Therefore, it is mainly oriented to problem-solving projects (Chin, 2004, as cited in Ciric et al., 2018) as innovative NPD projects. Those involve a growing complexity which makes traditional static tools (e.g., Gantt charts) a burden. It is vital adopting dynamic tools (e.g., Scrum board) through which info updating is guaranteed for the process itself (Sommer et al., 2015). Further, by combining team's diverse backgrounds, expertise, competencies and

experience, agile methodologies can support an increased ability to understand multiple contexts of change and to engage problems complexity (Lee and Xia, 2010; Baxter and Turner, 2021).

The project team and the customer experience an active communication. That drives collective action in a social inquiry environment and fosters a learning culture built under thought-action-reflection cycles (Nerur et al., 2005). In this regard, agile methodologies differ from formal processes such as contracts and negotiations, opting for minimize them and engage higher direct communication - knowledge is mostly tacit, embodied in the team (Boehm, 2002). The shared and decentralized decision-making and self-management empower team members but impose challenges, in particular, aligning strategic product plans with iteration plans (Moe et al., 2012).

Concluding, the agile approach as the traditional produces good results (Macias et al., 2003). Serrador and Pinto (2015) highlighted in their empirical findings the positive impact of agile methodologies on project success dimensions: efficiency (on-time, on-budget, on-scope) and overall stakeholder satisfaction. Also, the agile use positively relates to the project performance.

So, for non-software companies it is time to acknowledge the necessity of practices from the methodologies proposed over the years, with special attention to the Scrum methodology. Scrum has the higher popularity, with 66% of utilization (Digital.ai, 2021), and exhibits a wide scope of application in these environments. Ultimately, this can relate to being a well-documented and straightforward methodology in PM.

1.3. The Hybrid Approach

Most practitioners and academics recognize the advantages and context-dependent limitations of both traditional and agile approaches, not being uniformly better than another but each being appropriate to a particular type of project (Boehm, 2002; Boehm and Turner, 2004). Most of real-life projects diverge to fit in 100% either agile or traditional home grounds (Port and Bui, 2009). Thus, there is a *sweet spot* where the amount of time/effort invested in initial planning result in a mixed-methodology (Boehm, 2002). This is widely denominated as a hybrid approach which might outperform existing gated processes (Cooper, 2014) and offset project's success.

Yet to avoid management/organization inertia, the migration to agile does not need to be completely radical when the Stage-Gate PM methodology is well-consolidated (Zasa et al., 2020). Indeed, agile adoption may be struggled by serious challenges/barriers (Schmidt et al., 2018; Sithambaram et al., 2021; Patrucco et al., 2022). It typically requires reconfiguration in four dimensions (see appendices 2): organizational, technical, people, and process (Nerur et al., 2005; Chow and Cao, 2008).

According to Kuhrmann et al. (2017, 30-31), the hybrid approach is defined as:

> "(...) any combination of agile and traditional approaches that an organizational unit adopts and customizes to its own context needs (e.g., application domain, culture, processes, project, organizational structure, techniques, technologies, etc.)."

Several hybrid frameworks were proposed in the literature during the years. An early framework stated the feasibility of integrating agile methodologies within a Stage-Gate context, showing benefits in terms of defects reported and quality improvements, in larger software developers (Karlström and Runeson,

2005, 2006). At the microplanning-level, agile helps shortening the development time, critical for competitive advantage, and brings to Stage-Gate effective planning, day-to-day operational control and progress monitoring. At the macro-level, Stage-Gate works as means to agile methodologies to plan ahead (beyond the sprints) and supports a simplified coordination across stakeholders - whom sponsor the project or acquire the outcome is supported just like the communication within the project team.

More recently, appeared the Agile-Stage-Gate Model - figure 2 - (Cooper, 2016; Cooper and Sommer, 2016a, 2016b, 2018) which has increasingly been adopted by manufacturers. It brings Scrum in certain stages into the traditional Stage-Gate process design - the main-use focus are technical stages, corresponding to "Development" and "Testing" -, in order to improve NPD performance.

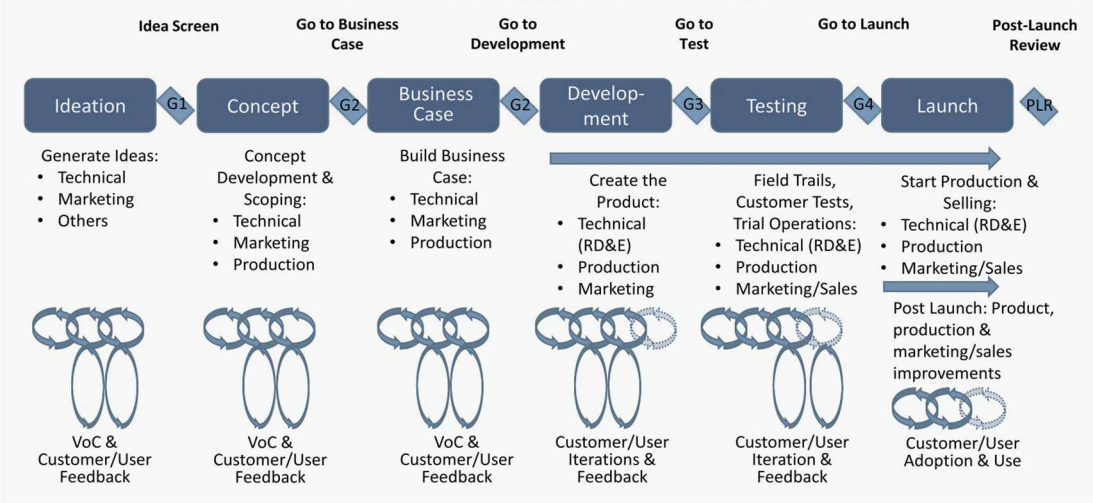

Figure 2: The integrative Agile-Stage-Gate Model
Note: The model supports a seamless movement among different planning levels
Source: Cooper and Sommer (2016a)

In parallel, Conforto and Amaral (2010) - Iterative and Visual PM framework (IVPM2) – and Sommer et al. (2015) – Industrial PM framework - observed the implementation of agile and Stage-Gate in different planning and controlling

levels, a finding corroborated later by Cooper and Sommer (2018). Stage-Gate was kept for structuring the project at the strategical management level, whereas Scrum was introduced at the operational level within the day-to-day of development teams, increasing agility on the production of continuous work outputs. The tactical level (resource planning) worked as an integration facilitator. The studies highlighted improvements from the bottom-up hybrid response such as: increased flexibility (responsiveness to change); improved team communication; better focus on the project (prioritization of tasks); bolster of employees' productivity, morale and motivation; and better fit process-tools.

Prior to Scrum implementation, companies must attend to dissimilarities between software and non-software products and conduct adjustments to avoid potential conflicts between both development practices, creating process harmony (Cooper and Sommer, 2018). First, the "definition of a done sprint" (DoD) differs from a software/IT development in which multiple features can be divided into small subprojects to be progressively completed in the form of functional products. Likewise, defining/coordinating sprint's length in short time frames can be challenging, indeed in non-software companies sprints although not variable, are typically longer (Ahmed-Kristensen and Faria, 2018; Edwards et al., 2019) which disagrees with agile principles.

Furthermore, drop out largely technical team and secure dedicated, co-located resources from a cross-functional team can be hard. Many projects are often underway thus most team members have other obligations and there are waiting times (e.g., waiting for field-trial results) (Cooper and Sommer, 2016b).

Therefore, to create the conditions for an effective combination, hybrid adopters may tailor the agile methodologies to suit the company's or project's nature/characteristics in order to apply the hybrid process that best solves each problem and is coherent with organizational processes (Serrador and Pinto, 2015;

Špundak, 2014; Ciric et al., 2018). It is not required a whole reorganization of the NPD model, in its place companies can adopt individual agile practices (Hilt et al., 2016; Brandl et al., 2021; Žužek et al., 2020).

Recent studies indicate the impacts of a hybrid approach on project outcomes. Earlier, Port and Bui (2009) stated that a hybrid strategy, adaptable to any dynamism, outweighs additional efforts required to add agile tactics (e.g., increased costs and complexity) and yield better performance result. Quantitative analysis came to demonstrate the potential to achieve Pareto improvements - that is, hybrid can provide the same budget, time, scope and quality outcomes commensurate with traditional approaches, while accomplishing the superior levels of stakeholder success that agile delivers (Gemino et al., 2021). Additionally, founded results validate the widespread of a *hybridized* version of agile in the PM field, as discussed by Serrador and Pinto (2015) based on a survey of diverse industries. Batra et al. (2010, 391) argued that "a disciplined organizational infrastructure is necessary for agile to be effective (…) agile, with iterative and fast turnaround cycles, enabled the structured planning and control process to learn and adapt efficiently to changing conditions". This view supports the sight that hybrid is not a mindset, it arises driven by the need to balance agility needs and challenges accompanying the agile transition (Cooper, 2014).

1.3.1. Complexity as a Driver to Hybrid Implementation

Agile methodologies have been widely recommended at small-scale projects (Boehm and Turner, 2005), in unstable, unpredictable (MacCormack and Verganti, 2003) and/or turbulent environments (Conforto et al. 2016; Cooper and Sommer 2016a). Nevertheless, its adoption might be a highly beneficial way of working within low-turbulence but complex NPD projects (Baxter and Turner, 2021). Therefore, the anticipatory assessment of the complexity in a project becomes particularly important to determine if the hybrid approach will cope with the conditions introduced by the type of complexity observed.

The perception of complexity in this dissertation follows the managerial perspective of Kim and Wilemon (2003). It is not limited to project size, also captures the difficulties and uncertainties imposed by diverse and/or new components in development efforts, the sensitivity to environmental factors and the nature of organizational and interorganizational tasks and relationships.

A relevant response is pursuing an ambidextrous strategy – that is, balancing exploitation (what can we re-use/avoid from the existing process?) and exploration (what we need to develop/do different?) (Turner et al., 2014). This supports management to make trade-offs and reconciliate the conflicting desires of aligning internal development efforts and adaptability to changing demands (Ramesh et al., 2012). In non-software contexts, the paradoxical forces consist in simultaneously maintaining structural stability, familiarity and discipline provided by traditional methodologies, while embracing speed, social dynamics and responsiveness through agile practices (appendices 3).

Software industry findings (appendices 4) already outlined complexity factors as drivers to the implementation of a hybrid model, introducing tensions for adopting pure-agile methodologies (Batra et al., 2010; Barlow et al., 2011).

In non-software industries, projects commonly require longer development cycles (Cooper, 2014) and further disciplines are involved. It originates more robust stakeholder networks and supply chain processes (Schuh et al., 2018). Hence, the hybrid approach is highlighted as "more effective in complex projects, that is, large projects with a focus on the development of innovative applications" (Copola Azenha et al., 2021, 106).

The complexity factors and sources can be categorized in different project dimensions that various researchers have proposed as appropriate conceptual frameworks. A comprehensive, reliable three-level hierarchical model (TOE – technical, organizational, and environmental) emerged to characterize project complexity allowing a better adaptation of the front–end development phases, so the project becomes more manageable (Bosch-Rekveldt et al., 2011). Vidal et al. (2011) proposed a refined multi-criteria framework that comprised four families of complexity drivers: interdependencies; context-dependence, variety, and size. Later, Maylor et al. (2013) synthetized in a straightforward tool three categories of complexities: structural, socio-political and emergent.

Somehow, most of the literature has been concentrating on design distinct hybrid models without understanding why and when - design parameters - a hybrid configuration is the right choice (de Vasconcelos Gomes et al., 2022). The few constructs focusing this purpose (appendices 5) fail to unveil details and holistic analysis on how companies in non-software environments can bring concurrently structure to factors that indicate when they may undertake *hybridization* and mechanisms to benefit from it (Cram and Marabell, 2018).

Chapter 2
Methodology

2.1. Research Question and Methodology

Based on a thorough literature review, it is precepted that the adoption of agile based on a hybrid approach represents an emerging and controversial topic in non-software environments of NPD (Schuh et al., 2018). Further issues arise from the fact that agile should not be forced into all spaces, rather it must be logical and consistent with conditions whereby their productivity is explored.

So, practitioners may be reluctant and indisposed to invest in the implementation of that new approach over the mature Stage-Gate model. There is no evidence, in practice, of a generally applicable instrument that mitigates technical issues internally and allows to evaluate, quickly and explicitly, the necessity of integrating agile and assist in its operation. Accordingly, concrete, practical decision-making guidance for managers to follow at the time of ensuring when optimal conditions (prerequisites) are met to implement a hybrid model for new projects is lacking. To address that gap, we focus on the following research question (RQ). Considering the complexity and pragmatism of the RQ, it was broken down into three derived RQs.

RQ: How to support and guide practitioners into determining the suitability to implement a hybrid approach to achieve best potential outcomes of new NPD projects?

- **RQ_1:** What are the driving forces whether to adopt tailored elements of agile within current traditional NPD approaches?
- **RQ_2:** What are the appropriate dimensions to be considered when tailoring agile towards a hybrid perspective?
- **RQ_3:** How can companies overcome the actual challenges seen in the hybrid model implementation cases?

This dissertation conducts a prescriptive research whose guidelines focus on building an architectural template in the form of a framework that works as a solution for the problem stated. This work was performed through an inductive qualitative approach based on a systematic review methodology. The objective is not at testing hypothesis based on current theoretical perspectives - the actual deployment of a hybrid model indeed remains theoretically limited (Gemino et al., 2021) -, rather acknowledging individual variables from data analysis and bringing them together into a final *roadmap* that works as a supporting system.

Systematic reviews, and associated process of meta-synthesis, have been regarded as transparent, reproducible, and methodical procedures (Cook et al, 1997). By helping disseminate high-quality evidence-aware approaches in a research (sub)field, systematic reviews provide practitioners a reliable basis to support and improve optimized decision-making (Tranfield et al., 2003). This is particularly pertinent when considering that NPD projects compete in increasingly fast-paced environments where speed is essential, so management needs to take decisions/actions in shorter time cycles. Indeed, despite its origin in medical science, this research methodology has been extended to the "pragmatic" management field (Tranfield et al., 2003; Dybå and Dingsøyr, 2008).

In this way, it is an appropriate methodology to address the RQ, since we seek to summarize the current state-of-the-art concerning empirical studies on hybrid applications in companies outside software industry, conduct comparisons and reach collective insights. That enables to examine certain aspects - context, successes, challenges, patterns of practices, casual relationships - of this phenomenon with the reliability of cross-case analyses unavailable from a single study. The use of secondary data for the development of a reliable knowledge-descriptive base, alongside prescriptive work, will lie at the heart of a generic conceptual framework and its levels - research product -, which aims to work as a reference assisting both academics and practitioners (Tranfield et al., 2003).

Ultimately, the objectives that support this dissertation's contribution are demonstrated in figure 3.

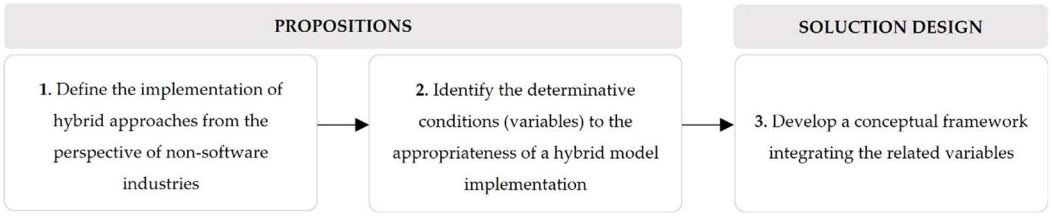

Figure 3: Research objectives

It is important to mention the limitations with regard to the use of systematic review and framework development. In the management field, there is not a specific roadmap model/technique for rigorously conducting this research methodology (Conforto et al., 2011). Also, conducting a systematic review does not overcome problems intrinsic to the primary studies selected, or avoid biases in study selection. Second, prescriptive research can lead to inaccurate predictions, if incorrect or missing data is used or changes over time invalidate the prescriptive result. Moreover, the prescriptive result does not consider the contingencies in the usage environment, thereby the organization's willingness to adopt it is uncertain (Ahlemann et al., 2013).

2.2. Data Collection and Analysis

A systematic review includes analysing, gathering, and synthesizing data. Specifically, using empirical data allows an improved problem-understanding, so to achieve a concrete fitting solution-problem pattern (Ahlemann et al., 2013). Considering the only now investigated pioneering adoption of hybrid approaches, data were collected from diverse databases to obtain more information from different circumstances of agile's adaptation as a complementary methodology to Stage-Gate. First, it was used the MDPI, Taylor & Francis and ScienceDirect multi-disciplinary databases, as these represent online sources of peer-reviewed research articles from prestigious academic journals and book chapters. Second, were identified pertinent case studies in DTU database.

Table 1 provides the synthesis of the literature analysed. It is perceptible that, independently from the company size, multiple complexity factors - internal and external to the project - are transversal to the implementation of a hybrid model. The agile methodology was broken in practices that were slightly modified to suit the differentiating requirements of non-software development and the project contingencies. Furthermore, the cross-analysis reveals common challenges when running the hybrid transformation, most of those corresponding to the barriers to agile PM.

In the light of these observations, we propose four variables associated with hybrid adoption:

- Project complexity
- NPD critical factors
- Tailored agile practices/tools
- Hybrid challenges

Authors	Industry	Size	Project Conditions to Hybrid Implementation	Benefits	Challenges
Conforto and Amaral (2016)	Technology-Based	25	The hybrid framework (IVPM2) is implemented for a single project which involves hardware and software components. It is innovative, high risk and concerns a unique superior product facing uncertain conditions and limited structures/resources.	▪ More effective absorption of changes ▪ Greater flexibility in design process and of the product design ▪ Projects' documentation standardization ▪ Better overall project development performance (information accuracy, commitment, and leadership) and product performance	Properly diagnose the critical conditions in the organization, project and team to adapt these practices for different types of portfolio's projects (*sweet spot*, as discussed in Conforto et al. (2014))
Ahmed-Kristensen and Faria (2018)	Automotive	>120000	The hybrid model is implemented for the majority of NPD projects which include distributed teams and, in one case, an external company. All manufacturers integrate agile principles/tools in the Development stage and most cases also in the Definition and Testing stages.	▪ Better information structuring, exchange, and alignment ▪ Increased control over the project ▪ Improved handling of requirements changes ▪ Better at handling uncertainty ▪ Higher innovation/ creativity levels	▪ Levels of stress of the team members when working with multiple projects ▪ Lack of teams coordination ▪ Difficulties in integrating agile elements within hardware development ▪ Lack of scalability
	Consumer and Healthcare	>100000			
	Hearing Devices	>500			
	Audio Solutions	>5000			
	Audio Solutions	>500			
	Medical Devices	> 2700			
	Industrial Valves	> 24000			
Cooper and Sommer (2018)	Remote Control Equipment	>5000	The hybrid model is applied in the larger, riskier, more transformational and more ambiguous/ uncertain projects (about 20% of the projects). Although most manufacturers implemented Agile in the technical stages, Danfoss and LEGO found that hybrid can work well in earlier stages.	▪ 30% reduction in time-to-market ▪ 30% improvement in productivity ▪ Reduced cycle time ▪ Faster development time ▪ Faster response to market conditions and customer needs ▪ Exceed market success expectations ▪ Higher team independence ▪ Raised project team morale/motivation ▪ Stronger new offerings ▪ Better customer collaboration/feedback ▪ Better fit work process-method ▪ Improved prioritizing of time/tasks	▪ Systems' Inconsistencies (short-term vs long-term planning) ▪ Managing leadership scepticism ▪ Lack of resources to support the dedication of full-time teams ▪ Defining each sprint's deliverables ▪ Levels of frustration during the team's learning curve ▪ Matching Projects to Processes
	Packaging	>24000			
	Aviation	>300000			
	Process Control	>130000			
	Toys	>14000			
	Industrial Valves	>27000			
Edwards et al. (2019)	B2B Convenience Food	142	The hybrid model is implemented for a single project. The SMEs use Stage-Gate gate meetings with no financially-based decisions.	▪ Shorter development times (20% reduction) ▪ Faster response to market ▪ Higher success rates ▪ Improved NPD/innovation process ▪ Improved process visibility	▪ Finding dedicated teams ▪ Co-locating teams ▪ Evolving product's design, using the product backlog ▪ Certify active participation of members in daily scrums
	B2B Audio Equipment	155			
	B2B Radar Systems	98			
Žužek et al. (2020)	Automotive - Wire Harness	200	The hybrid model is applied in an international, high-risk project (no previous collaboration with either customer, toolmaker, or equipment supplier; several new materials and technologies).	▪ Improved communication ▪ Faster discrepancies detection ▪ More effective problem-solving ▪ Additional know-how provided by external stakeholders ▪ Faster response to changes ▪ Greater flexibility ▪ Positive impact on project success ▪ Empowered project team	▪ Ensure dedicated teams ▪ Coordinate work on multiple projects ▪ Defining each sprint's deliverables ▪ Teams' learning time to get used to a higher intensity of work and collaboration

Table 1: Adopting agile in non-software development

Source: Own elaboration

Chapter 3
Results

3.1. Framework to Adopt a Hybrid Model in Non-Software Environments

The proposed four-phase framework is briefly illustrated in figure 5 and, posteriorly, each phase is discussed in detail. It conceptually designs a sequence of phases, so that by running through these management combines information about the variables outlined. The last phase accompanied by recommendations signals strategies to take advantage of agility without related challenges.

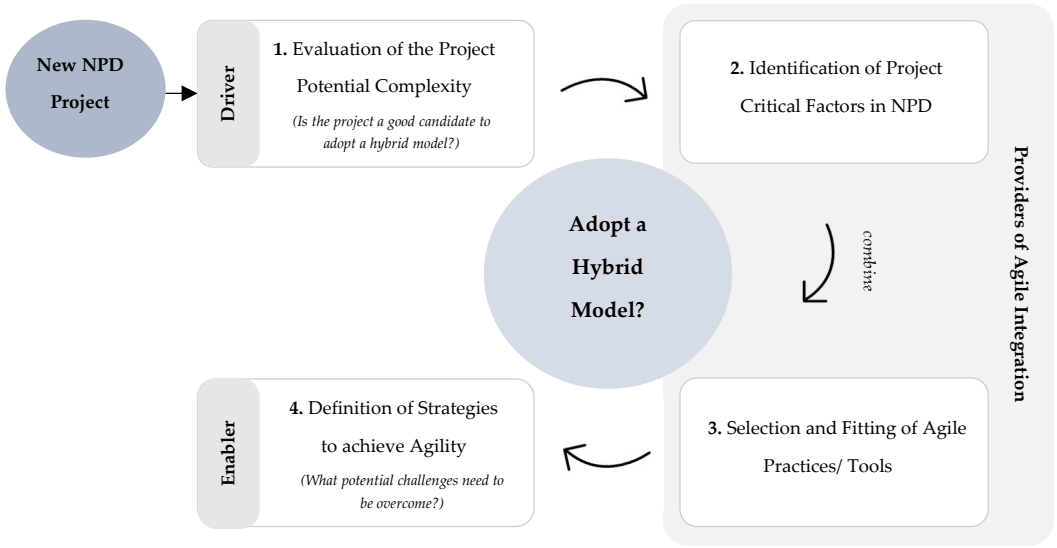

Figure 4: Framework to decide to adopt a hybrid model in non-software environments
Source: Own elaboration

3.1.1. Evaluation of the Project Potential Complexity

Project complexity, which is interpreted as a cause of facing uncertainties during the project lifecycle, is a key driver in the decision whether to adopt agile methodologies (MacCormack et al., 2012) tailored in a hybrid model. In other words, agile provides practices/tools to complement the current use of a traditional development process and handle project complexity, and to convert that into added value for customers. Thereby, the first phase consists of the prior assessment of complexity through an evaluation table - table 2.

The table was based on three dimensions and its interrelation (appendices 6): Characteristics of complexity in software/IT development (A) and non-software development (B); Project complexity taxonomy (C).

In software/IT projects **(A)**, the hybrid implementation occurs under characteristics such as number/variety of interdependencies, project size, scope ambiguities, global development environment, activities outsourcing, distinct stakeholders perspectives, time-sensivity, requirements volatility, limited competences/skills/resources, design and technology novelty and level of customer involvement. In non-software industries **(B)**, projects reveal similar characteristics (as previously seen in table 1) along product's distinct components and high innovation, and uncertainty/high-risk conditions. Moreover, there is a discussion concerning how complexity relates to risk: higher complexity as a source of higher risk (Vidal et al., 2011) or growing number/probability of risks as a contributor of complexity (Bosch-Rekveldt et al., 2011)? We consider that one of risk's dimensions besides the consequences is the uncertainty (Kim and Wilemon, 2003), which drives high complexity since more interactions and dynamics are expected.

Complexity Category	Subcategory	Evaluating/Reflection Questions	Classification *(1-very low; 5-very high)*
Technical	**Scope**	Is the project scope large? Are there ambiguities in the scope (e.g., non-confidence in technology)? Are there strict quality requirements? What development effort is conducted in-house and outsourced?	12345
	Tasks	Are there novel project tasks? Does the team clearly know the process technology to accomplish these tasks? Does the project have a diversity of tasks? What is the number and nature of dependencies between the tasks?	12345
	Goals	What is the number/criticalness of strategic project goals? Do team members understand and have competences to achieve the project goals? Are there aggressive time-to-market goals/innovation speed?	12345
	Product	What is the number of components and the extent of their interaction? What is the number of functions that the product must perform? What is the degree of innovation (architectural, incremental, radical)?	12345
	Technology	Is there technology newness? Does the project have high technology interdependence? Are the members familiar with the technologies used to implement the designs (e.g., technology users maturity)?	12345
	Risk	Do the project have high technical risks (e.g., dynamism such as changing information and specifications)?	12345
Environmental	**Marketplace**	Is the project environment unstable and unpredictable? Are there high levels of competition?	12345
	Stakeholders	How many and which stakeholders participate? Do different stakeholders have different perspectives? Is there internal (management) support for the project? What is the number/nature of dependencies on other stakeholders? Is the degree of clients involvement uniform throughout the project?	12345
	Risk	Do the project have high environmental risks (e.g., misalignment of interests, changes in market conditions, management's inflexibility)?	12345
Organizational	**Resources**	Is there unforeseeable demand for resources? Do management have experience/knowledge in agile? Do company have previous experience with parties involved? Are there multiple contract types involved? Is there strong project drive (cost, quality, schedule)?	12345
	Size	What is the planned duration for the project? How many members include the project team? How many locations/time-zones are involved?	12345
	Risk	Do the project have high organizational risks (e.g., availability of the required bundle of resources/competences/skills)?	12345
			Overall Classification (average)

Table 2: Project complexity evaluation table
Source: Own elaboration

(C) After determining the complexity factors transversal to software/IT and non-software environments, and that triggered a hybrid approach adoption, the last step was to determine a taxonomy that enables a common-shared understanding/language in terms of complexity evaluation for practitioners (Williams, 2005). Regardless of subcategories for the different complexity categories, the evaluation table relies on Bosch-Rekveldt et al.'s (2011) clustering - TOE - and strengthening the model's scope combining additional aspects from the NPD perspective. For instance, product's high complexity, especially in multitechnology-based products, is a critical determinant to contemplate in project's complexity analysis.

For each subcategory was assigned a set of questions based on the insights gathered from both, complexity assessment frameworks (chapter 1.3.1.) and dimensions (A) and (B). Since the complexity of projects can be built on subjective interpretation (Maylor et al., 2013), the classification attributed to each subcategory, on a qualitative scale, will rely on the individual lived experience of managers, that is on their perception of complexity. The assumption under this evaluation is that the presence of complexity (overall classification equal/superior to three-point) negatively affects the determinants of project success (Gemino et al., 2021), so it is a demanding condition to introduce agile and go straight to a hybrid a model. In the case of small projects with low complexity scopes, that is seemingly simple and predictable contexts, the traditional NPD approach appears to be more suitable to achieve better performance. That decision follows the idea that "agile development is not a silver bullet" (Schmidt et al. 2018, 2130).

3.1.2. Critical Factors in NPD

The proficiency in making new products requires accomplishing a set of critical factors (Cooper, 2019) concerning the project/product itself and both organizational and development processes. The second phase of the framework thus comprises the identification of those in order to translate each, in the third phase, into appropriate agile practices/tools whereby the factors can be operationally addressed:

- **(CF1)** Clearly Target Market
- **(CF2)** Customer Centricity (VoC)
- **(CF3)** Pre-development Homework
- **(CF4)** Evolutionary, Fact-based Product Definition
- **(CF5)** Iterative, Spiral Development
- **(CF6)** Progress Testing/Review
- **(CF7)** Clear Understanding/Vision of Project Operations
- **(CF8)** Internal Within-Team Communication
- **(CF9)** External Communication
- **(CF10)** Cross-functional Co-operation
- **(CF11)** Strict Monitoring
- **(CF12)** Speed on Development Time
- **(CF13)** Consistency into Product Deliveries
- **(CF14)** Building Confidence/Transparency
- **(CF15)** Differentiated Superior Ideas
- **(CF16)** Knowledge Transfers
- **(CF17)** Quality Standards
- **(CF18)** Planning and Resourcing the Launch
- **(CF19)** Top Management Support

3.1.3. Selecting and Fitting Agile Practices/Tools

The next step is to determine the practices/tools that will provide means for project managers to react to research and/or minimize known inefficiencies under their Stage-Gate methodology. The construction of this phase contemplates two considerations: (A) Selection of agile practices/tools; (B) Fitting agile in the development process.

(A) The complexity determines the need for flexibility on the agile methodology. Hence, there is greater potential of improved control, visibility and transparency in using Scrum practices, as Scrum can be tailored to effectively fit the project contextual factors (Hossain et al., 2009), specially to handle global team distribution and innovation. The application of Scrum's micro-management practices/tools, not by-the-book, to start adopting agile is reenforced by literature findings on chapter 1.2. and table 1. Though per se Scrum do not deem project chartering (Rasmusson, 2010), it can represent one important initial element to cope with the complexity of the project. Perhaps, an inception event might set foundations to the alignment between stakeholders perspectives, self-organization in a new team, mitigation of risks, understanding novelties (technology/design/tasks) and obtainment of funding.

Hereupon, was chosen a set of practices/tools - table 3 - in accordance with their feasibility to be employed in non-software contexts and to operate separately, that is they do not exhibit interdependences relationships between each other as fragments of a structured methodology (Hitl et al., 2016; Gemino et al., 2021), so can be combined in harmony with the traditional means in order to suit the project unique characteristics. Scrum concepts do not follow the software version as it is, rather they have a non-software nature interpretation. In order to clarify them was added a description about how each concept is transposed and designed to be consistent with the differences in the environment in analysis. There is not an universal set of agile practices to match every project/company.

Practices/Tools	Description	References
Sprint (P1)	Stages are broken into short-time development-and-test iterations that can be run in parallel or subsequently. Its length is non-variable and typically about 2-4 weeks or longer, depending on project size/complexity.	Cooper and Sommer (2018); Edwards et al. (2019)
Time-Boxing (P2)	Up-front definition of fixed and maximum time periods for the project events (tasks, sprints), each having its well-defined objectives and constraints.	Gemino et al. (2021); Žužek et al. (2020)
Inception Deck (P3)	Kick-off meeting that put together stakeholders to address 10 tough questions, which enable the project rationale and contextualization, and the communication of goals/visions.	Rasmusson (2010)
Sprint Planning Meeting (P4)	At the beginning of each sprint, the team meet, lasting up to 8 hours, to collaborate on the planning of the sprint goal to be accomplished and the work to be performed (task plan). Following sprints are taking in care as drafts.	Conforto and Amaral (2016); Cooper and Sommer (2018); Edwards et al. (2019); Briatore and Golkar (2021)
Task Efforts Definition (P5)	Initial estimation about the necessary and feasible development efforts (task workload) by considering different parameters (e.g., prototyping). This should be updated based on the time data collected from the executed tasks and extra-task required, in order to provide accurate estimates for next sprints (team-based estimations).	Briatore and Golkar (2021); Hilt et al. (2016)
Stand-up Meeting (P6)	During the sprint, autonomous team members meet regularly (not necessarily daily, but 1-3 times a week) to report and discuss progress, review the current status of achievements and expectations on what need to be accomplished today, synchronize tasks, resolve issues, and foresee challenges.	Hilt et al. (2016); Edwards et al. (2019)
Sprint Review (P7)	At the end of each sprint, the sprint's outcome is presented and demonstrated to stakeholders (management and customer), in order to get their feedback and validation, and to identify required rectifications.	Ahmed-Kristensen and Faria (2018); Edwards et al. (2019)
Retrospective Meeting (P8)	The sprint is followed by a project team meeting to review and discuss the work progress and to identify lessons learn on the previous sprint and potential improvements for the subsequent sprint.	Hilt et al. (2016); Cooper and Sommer (2018); Ahmed-Kristensen and Faria (2018)
Backlog (P9)	Dynamic document with an up-to-date requirements/needs list (of product features in which user stories are the prevailing component - product backlog - and of sprint activities/tasks - sprint backlog - with acceptance criteria aligned with the DoD) and its (re)prioritization, evolving through project lifecycle as data becomes available.	Hilt et al. (2016); Conforto and Amaral (2016); Cooper and Sommer (2018); Edwards et al. (2019)
DoD (P10)	Understanding and common sense of what signalizes the completion of a sprint or product feature. It comprises technical and business quality requirements.	Hilt et al. (2016); Cooper and Sommer (2018); Edwards et al. (2019)
Increment (P11)	Meaningful value created by each sprint's deliverable/result which correspond to a chunk of performed tasks that take many formats, not necessarily physical/ tangible (short-list of ideas, protocepts, prototype, market study, business model canvas, technical feasibility analysis, product maturity model, etc). They are available to be presented, verified/integrated and validated through appropriate mechanisms (customer feedback, market-hypothesis-test) in order to reduce the risk of develop the wrong product.	Cooper and Sommer (2018); Edwards et al. (2019); Žužek et al. (2020)
Stable Core Team (P12)	There is a careful capacity planning. The composition of the core project team[2] is permanent from the beginning to the project ending (varying role intensity across stages), while individual members with specific skills integrate the team for the sprint concerned and leave after the increment accomplishment.	Cooper and Sommer (2016b, 2018); Edwards et al. (2019)

[2] The core team is composed by the core team leader, project manager and representatives of functional areas.

Practices/Tools	Description	References
Visual Management (P13)	Visual display/track, on digital and/or physical boards, of tasks (done, doing, to do), product backlog and the automatically project progress using a Burndown Chart, facilitating team discussion and an accessible overview.	Hilt et al. (2016)
Modular Design (P14)	The product is broken into independent modules, accommodating an evolving product design as customer feedback is received and modules face changes.	Briatore and Golkar (2021); Edwards et al. (2019)
User Integration (P15)	Seeking for a balanced participation users-team, and a meaningful interaction from the start. Users engagements rely on their personally motivated **use stories** (real use-case situations to describe functionalities and show dependencies), allowing developers a deeper understanding on requirements and to openly discuss solutions; their validations through **user tests** conducted as part of some sprints.	Briatore and Golkar (2021); Schmitz et al. (2018); Paluch et al. (2020); Cooper and Sommer (2016a)
Dedicated Resources (P16)	High dedicated resources are flexible, so secured in specific stages/sprints, not necessarily dedicated in 100% during the project but with limited maximum loads. The project team focus > 60% of their time to the project.	Cooper and Sommer (2016a, 2016b, 2018)

Table 3: Tailored agile practices/tools to develop hybrid models
Source: Own elaboration

(B) Not all development stages may be feasible to fit the agile practices, as well as the degree in which they are added may be different. So, previous to project beginning, it is important determining a strategy of integration (Lichtenthaler, 2020) under two possible scenarios. In the first one, the hybrid model crosses the entire process and the agile practices selected are iteratively combined with the traditional processes originating reciprocal interdependencies between both during the whole project – the output from an approach is the input for the other one. In the second scenario, agile focuses on the completion of specific stages (e.g., front-end innovation; technical development) to strength there the process agility. The integration of agile might be reciprocally – gates still being kept but with greater flexibility focusing on the assessment of the deliverables -, or sequentially linked to the traditional structure.

The criteria decision should depend on the complexity evaluation:

- Projects with an intermediate level of complexity (3 points) can integrate agile practices only in the technical stages;

- Projects with high complexity (>3 points), on which an *upfront freezing* is not compatible with the high levels of uncertainty and ambiguity brought by high innovation, agile practices should be applied, using agile thinking (Cooper and Sommer, 2018; Lichtenthaler, 2020) from the early stages (pre-development).

3.1.4. Definition of Strategies to achieve Agility

The fourth phase have the objective to handle in advance the potential challenges (see chapter 2.2.), formulating a responsive process to prevent an aggressive transformation.

To a better hybrid development, companies should anticipate the need to address discrepancies and mange changes in the pure Stage-Gate process based on the new conditions. Consequently, it entails pervasive resolutions mainly learning-oriented and building-up an overall alignment of objectives and vision between the project team and the organization. That encompasses a deep, but crucial reflective analysis. We clustered strategical actions, enablers of essential agile capabilities and readiness, toward the dimensions of challenge in agile diffusion - table 4. This refined the strategical areas specified in appendices 7. Management should check the most relevant for their situation.

Dimension	Proposed Strategies
Process	▪ Establish formal working agreements with specific rule sets for a defined number of sprints, which is designed by the team members to govern project's relationships on working together (Zasa et al., 2020) ▪ Adapt synchronization concepts, leaving traditional practices (e.g., business planning process) and fostering an aligned approach between front-end and development (Cooper and Sommer, 2018; Brock et al., 2020) ▪ Lock-in the project final budget in the end of the Development stage (Cooper and Sommer, 2016a) ▪ Assign pricing and payment negotiations with specialists built-on the project deliverables ▪ Gauge portfolio's health and progress with metrics which emphasize value creation as a function of time such as the Proximity Metric, Productivity Index, Expected Commercial Value (Cooper and Sommer, 2020) ▪ Give management a supply-chain-assessment with improvement opportunities and strengths/weaknesses ▪ Introduce a development *moratorium* timeframe after each sprint to best manage the time allocation of resources to both the project and other tasks responsibilities, such as another project (Edwards et al., 2019) ▪ Prioritize short-hand stories and narratives to share complex concepts on meetings (Baxter and Turner, 2021)

Dimension	Proposed Strategies
Organizational	▪ Engage *Agile Champions* (may or may not be included in the project team) to educate, motivate, drive the organizational hybrid implementation, primarily within executive and management teams ▪ Create teams based on a prior assessment of the organizational interdependencies (internal/external) and their nature (sequential/reciprocal), ensuring that the hybrid model effectively supports their coordination ▪ Remove the employer-employee demarcation between senior managers and the different functional areas, and value organizational-member relationships and networking (Crocitto and Youssef, 2003) ▪ Take advantage of organizational diversity by engaging different backgrounds on workshops of diffusion of the hybrid-agile culture (Zasa et al., 2020; Magistretti et al., 2019) ▪ Use formal/hard metrics to track and measure the project performance results (Cooper and Sommer, 2018) ▪ Conduct workshops to engage leaders to collectively discuss their project experiences and outputs, plot possible solutions to overcome identified dependencies between organizational daily processes and the development team, and assess the effects of the hybrid model against comparable projects from a management perspective (Edwards et al., 2019; Zasa et al., 2020) ▪ Training the capabilities of project managers for the multitasking characteristics of team members (Boehm and Turner, 2005) and its mentality/vision to adapt their management style to team changing conditions (progressively empower teams by supporting task autonomy, and to accept a participative/pluralist decision-making approach) ▪ Establish communication channels to enable regular and clear team connection, top management engagement toward transformation (Sithambaram et al., 2021), and faster response/decision between project's partners ▪ Certify appropriate communication media to substitute the physical co-location of team members
People/Technical	▪ Prepare management for training employees in agile awareness, as well as to retrain teams' capabilities (interpersonal/technical) to deal with distinct customers, built trust and get their active involvement/participation ▪ Create environments of psychological safety in teams where it is possible to disagree, intervene critically and question independently of the role or seniority. Mistakes are interpreted as an essential tool for learning, and the misalignments with customer are discussed from the perspective of their business potential ▪ Implement team-focused feedback and recognition/reward schemes for the learning, adaptation to changes and innovation contributions (Nerur et al., 2005; Boehm and Turner, 2005; Sommer et al., 2015) ▪ Implement learning tools (e.g., MUD method proposed by Granato et al., 2021) to manage (mis)alignments between designers' decisions and users' expectations, and put designers together reflecting on solutions to align both sides ▪ Implement modular technologies/systems, including connected platforms that facilitate an agile development of complex solutions, broking silos and connecting the pre-development and the development (Brock et al., 2020) ▪ Entrust leaders to define, with teams (team-based), appropriate team rewards, using as direction reward measures and goals that are customer value-based such as the customers' Net Promoter Score (Sommer, 2019) ▪ Establish continuous reminding sessions that alert management to support the requirements/expectations of agile ▪ Organize self-evaluation workshops for team members in order for them to identify their product domain and methodological knowledge gaps (Zasa et al., 2020). Hence create cross-skilling training sessions and fill the discrepancy in terms of competences/skills - T-shaped skills - needed for goals achievement, preventing egos (Nerur et al., 2005) on the project team ▪ Provide initial intense training courses to present agile concepts and how agile methods work and are used, as well as to give first-hand developers the experience of a heterogeneous and cross-functional teamworking environment, promoting interaction, creativity, learning share and their collaboration through workshops ▪ Mix managers assistance and team self-organization in tasks assignment and decision-making ▪ Implement collaboration meeting tools and mechanisms to ensure all members conditions to participate in the Scrum meeting, and thus the team's synchronization regarding the project progress (Hossain et al., 2009) ▪ Spread of easy-use digital means to share knowledge and promote the continuous understanding of agile and its role on the new hybrid approach along the transformation (Sommer, 2019)

Table 4: Strategies to sustain the path toward agility
Source: Own elaboration

In summary, to apply and automate all four-phases in a single representation we propose a model – figure 4 - to assist management in optimizing the findings of the developed framework.

																	Project Complexity (1)			
		Agile Practices/Tools (3)															Importance to address the complexity of the project (1 – weak; 5 – strong)			
		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	**Org**	**Tech**	**Envr**
NPD Critical Factors (2)	CF1			×				×				×			×					
	CF2			×				×		×		×				×	×			
	CF3	×		×							×	×								
	CF4	×						×								×				
	CF5	×	×		×		×	×	×	×		×				×				
	CF6	×					×	×	×											
	CF7			×	×	×	×	×	×	×	×			×		×				
	CF8			×	×		×		×	×	×			×			×			
	CF9			×				×						×	×	×	×			
	CF10				×	×	×	×	×				×				×			
	CF11						×	×	×			×								
	CF12	×	×		×	×	×		×	×			×		×					
	CF13	×	×								×	×			×					
	CF14			×				×				×		×	×	×				
	CF15	×		×				×								×				
	CF16			×	×	×	×	×	×	×						×				
	CF17	×	×		×	×	×		×	×				×		×				
	CF18				×	×			×				×				×			
	CF19			×																
Agility Strategies (4)	Potential difficulties to achieve agility (1-low; 5 – high)																			

Figure 5: Propose of decision-model based on the framework
Source: Own elaboration

Chapter 4
Conclusion

Early-adopters of hybrid approaches have been showing an informal ad-hoc decision-making to introduce agile in a given NPD project. The performance outcomes were indeed promising, at least concerning qualitative/soft factors. However, quantitatively reported benefits are scares, as well as new constraints are added to the hitherto identified in software environments. Thereafter, "build projects around motivated individuals" can be in many companies a task fraught with difficulty from top management up to downstream teams.

To achieve a concrete win-win scenario, a formalized framework was created to support and guide practitioners into determining the suitability to implement a hybrid approach to achieve best potential on new NPDs projects (RQ).

The first prerequisite motivating the adoption of tailored components of agile is mainly driven by the potential complexity of the project which can be assessed with a table of reflection questions throughout distinct determinants (RQ_1). Subsequently, it is important to check the critical factors in the NPD and select agile practices/tools reasonable to provide means to address them. This task requires agile knowledge, experience and readiness. To overcome gaps in this regard, companies can use our methodical model where reviewed combination between both are mapped based on literature (RQ_2). Furthermore, to increase

efficiency on the development of combined PM processes, management should rank the relative importance of critical factors in relation to the complexity.

We identify that the application of an ambidexterity perspective has inherent challenges. To overcome those, management should exploit the institutionalized traditional methodology, while focus on the exploration of agility alongside strategies, strongly focused on the human factor (Patrucco et al., 2022), enabling to reach a successful transition (RQ_3). To do this analysis, managers should rank the potential difficulty to accomplish each selected agile practice. Based on the rating choose among the strategies we present.

This dissertation contributes to maturing the discussion around the logic engagement of companies that detain traditional NPD approaches with new hybrid approaches. Prior work suggested that this decision should be a choice according to the project undertaken (Magistretti et al., 2019; Gemino et al., 2021) – its characteristics and settings of development. The proposed framework becomes a crucial input of the project predevelopment because to leapfrog trial-and-error, companies can early best diagnose with confidence if the integration of agile will enrich the project. In general, practitioners may use the framework as a guideline to create conditions for success without neglecting the managers' need to have freedom for reflecting, discussing and making decisions, for instance regarding strategies to sustain the agility path. The two contributions stated strengthen the literature proposals on the hybrid phenomenon relevance as they fostered the still very marginal adoption of hybrid models.

However, a first limitation concerns the use of secondary data. Besides, we are not able to refine the findings through feedback/pilot tests. So, it is important to advance studies with the inclusion of an interpretive approach with the perceptions of experts.

The framework has not been tested within the context of its application (open-testing environment in preference to simulations), which might be considered another limitation. This ultimate level of research requires a substantial timeframe for data collection and benchmarking to evaluate the usefulness, reliability and viability of the framework and its potential improvements. Since this dissertation held time restrictions the framework's consolidation embodies a further research opportunity.

It is also worth of mentioning that non-software environments of NPD involve several realities, from physical products to product-service bundles or pure services, though the designed generic framework does not capture their particularities. Therefore, further procedures can be undertaken, in a more holistic picture of practitioners' community, to investigate the implementation conditions of hybrid approaches in non-software industries and expand the framework to more detailed factors of each scenario.

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Appendices

VALUES	PRINCIPLES
Individuals and interactions over processes and tools Valuing people and promoting efficiency and effectiveness on conveying information to and within a development team **Building over comprehensive documentation** Importance of having an usable increment that works and meets the customer's needs, rather than having an extensively documented and non-functional application. **Customer collaboration over contract negotiation** Call on teamwork and foster interdisciplinary cooperation and collaboration enabling the empowerment of team members and their capacity to self-organization and alacrity response. **Responding to change over following a plan** Importance of manage and respond to change, understanding that plans get out of date quickly, so it is more important to adapt to deliver a product than persisting on planning.	**1.** Satisfy the customer through early and continuous delivery of value. **2.** Welcome changing requirements, even late in development. **3.** Deliver customer-value frequently. **4.** Business people and developers must work together daily throughout the project. **5.** Build projects around motivated individuals, who should be supported on their needs and trusted to get the job done. **6.** Facilitate efficient and effective communication through face-to-face conversation. **7.** Product increment and its customer-needs fit is the primary measure of progress. **8.** Agile processes promote sustainable development able to maintain a steady pace. **9.** Continuous attention to technical excellence and good design enhances agility. **10.** Value simplicity: the art of maximizing the amount of work not done is essential. **11.** The best architectures, requirements, and designs emerge from self-organization. **12.** Regular reflection and adaptation: team reflects on how to become more effective, then tunes and adjusts its behaviour accordingly.

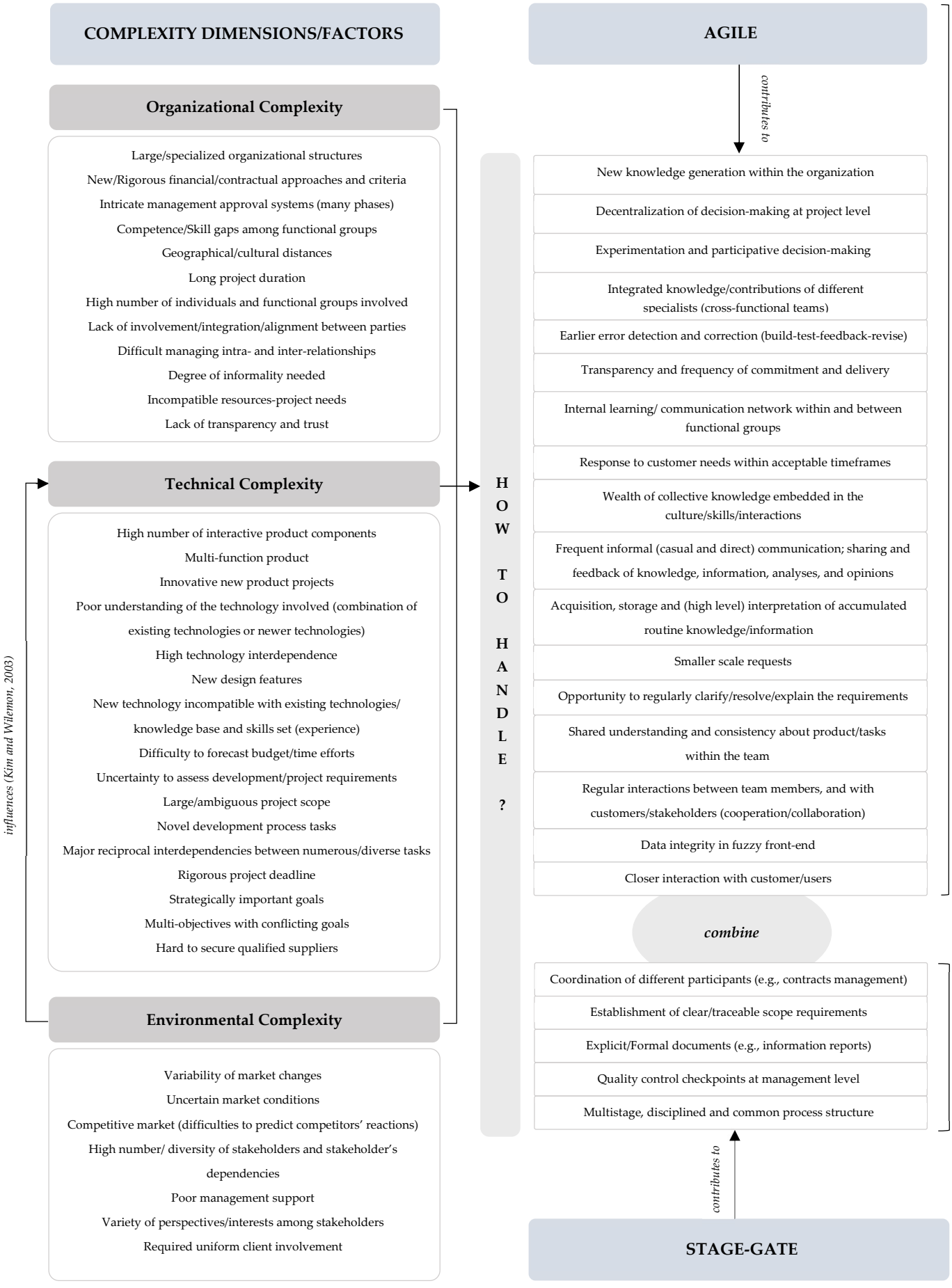
Appendices 1: Summary of the Agile Manifesto (adapted to knowledge areas outside software)
Source: Own elaboration based on Beck et al. (2001)

Organizational Challenges		
Organizational culture mismatch (too politic and too traditional)		The organizational culture as a reflection of standards, rules and principles that guide the routine conduct/operation of individuals significatively influences dimensions of development processes such as problem-solving strategies, decision-making, innovative practices, information filtering, social negotiations (Nerur et al., 2005; Pikkarainen et al., 2012). Changing a culture mindset and political control ingrained on traditional organizations may be difficult and requires time. Besides, the typical political agenda can be in interference with the concretization of agile's project objectives.
Lack of management commitment/ support	**Incorrect Balance of Authority, Autonomy and Cooperation**	Change emerges bottom-up, thus the executive reluctance to support the organizational transformation makes the extension of agile through the hierarchical structure - middle management to development team – difficult or even impossible (Dikert et al., 2016). Project manager has to let go some authority and control (Cohn and Ford, 2003), working as a *facilitator* who directs and coordinates collaborative efforts of project players (Nerur et al., 2005) and allowing the self-management of teams. It may be hard getting a command-and-control management to start accepting that changes have to be dealt through the process (flexibility) involving the team when making strategic project decisions (Moe et al., 2012).
Lack of team commitment		The individual role assignment has to be replaced by teamwork, thus agile teams depend on trust and shared tacit knowledge (Boehm and Turner, 2005). Also, they have to improve individual autonomy in assigning tasks, but it can be hard for them to balance organizational goals in detriment of focusing on their own goals (Dikert et al., 2016). When management do not define clear goals and explain potential visible benefits for using agile, team members become more sceptical toward the implementation (Dikert et al., 2016).
Poor logistical arrangements		The workplaces require key components such as layouts designed to facilitate agile processes in order to facilitate information sharing and conversation among the team members (Dikert et al., 2016), and adequate resources/equipment to support continuous integration, testing (Boehm and Turner, 2005, and self-management (Moe et al., 2012).
Global communication barriers		In distributed project environments the geographical, temporal and socio-cultural distances, and the different technologies used may restrict team collaboration, coordination, communication, and trust (Ågerfalk and Fitzgerald, 2006), especially if the agile methodology is not adapted and tailored to the work circumstances (Hossain et al., 2009; Dikert et al., 2016).
Lack of executive sponsorship		The flawed leadership understanding about the implementation of agile restricts their support on the required investments that enable the organization of exhibit a level of exposure that fits the agile methodologies - e.g., training, coaching, workload (Dikert et al., 2016).
Process Challenges		
Poor definition of requirements		Project requirements are differently performed in agile, tending to be primarily functional and reasonably informal. This might lead to requirements not properly defined if the process is not strengthening with flexibility to allow the provision of additional information and to identify mismatches in requirements/expectations (Boehm and Turner, 2005). Some problems are requirements refinement; high-level requirements management; requirements break down to effort estimations (Dikert et al., 2016).
Faulty project definition and project management/planning		Agile processes require adjustments compared to traditional longer lifecycle, so the documentation must be overcome to the test-driven development to be implemented to support work (Nerur et al., 2005). The iterative/evolutionary model entails several barriers in altering work procedures, tools and techniques, communication channels, relationships, problem-solving strategies, and planning and control mechanisms leading to uncontrolled scope creep, insufficient planning, lack of progress tracking/reporting mechanisms, poor governance, poor defined customer role (Chow and Cao, 2008), improper quality management and neglected project activities.
Inappropriate agile methodology		Select among a wide range of agile methodologies available the most compatible with the company's practices can be challenging, as despite all of them sharing common principles, they vary in teams size, duration of each iterative cycle, mechanism of change and feedback and downstream and upstream activities emphasis (Nerur et al., 2005).
People Challenges		
Discrepancy of competences/ knowledge	**Conflicts and lack of enough training, coaching and mentoring**	The required skill set of talented and high-competent individuals is hard to find. When new techniques are being learned, discrepant competences/knowledge could lead to different productivity levels among developers, slowing the entire team (Cohn and Ford, 2003), constraint the participation in shared decision-making (Moe et al., 2012), or affect the moral of who are left behind in a *culture of elitism* (Nerur et al., 2005).
Lack of project management competence		Project management cannot have or develop agile competence. That disturbs the development process given the tendency to associate employees with specific roles, which can difficult the multitasking characteristics of agile team members (Boehm and Turner, 2005).
Resistance to teamwork		Shifting to a cooperative approach of shared learning and collaborative decision making could be struggled by team developers who normally work on solitary tasks or with relatively homogeneous groups (Nerur et al., 2005). Problems can be understood as individual leading to *decision-hijacking* - make decisions individually without informing the other project team members (Moe et al., 2012). Due to stress (time pressure plus much change), misinterpretation of agile and lack of immediate benefits, team members can pull back to the old traditional way of working (Dikert et al., 2016).
Poor customer relationships		The pluralist decision-making requires a good customer relationship, however, discover knowledgeable customers with willingness to participate and actively involve themselves in the development could be difficult (Nerur et al., 2005), particularly when it is the first time that they join the team.
Technical Challenges		
Inappropriate configuration of techniques		Inappropriate technology, tools and training for their correct use do not support agile practices (timeboxing), thus complicate the assimilation of agile methodologies (Nerur et al., 2015). Also, the lack of a complete set of correct agile practices as clear prioritization of requirements or test-first and continuous integration imposes bigger challenges to the alignment with scheduling, budgeting and resources planning (Boehm and Turner, 2005).

Delay of the NPD process → *prevent* → **Shortening of product lifecycles/innovation speed**

Appendices 2: Review of challenges/barriers to the introduction of agile

Source: Own elaboration



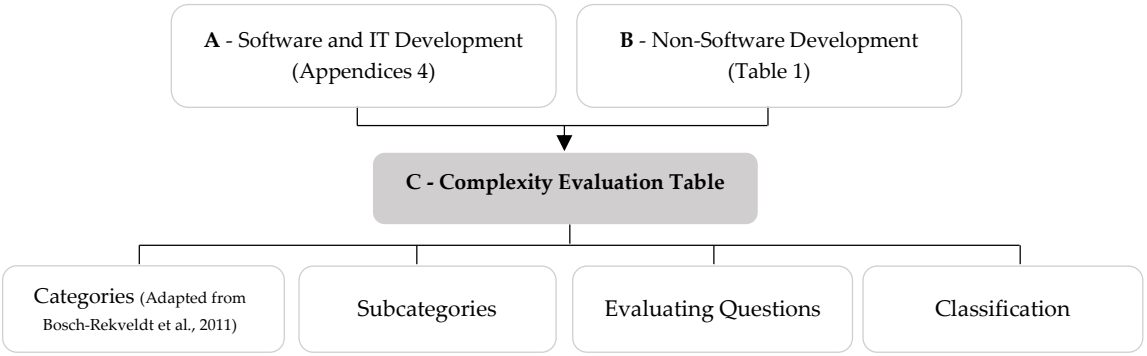
Appendices 3: Project complexity dimensions/factors
Source: Own elaboration

Authors	Study Method	Project Conditions to Hybrid Implementation	Complexity Dimensions
Batra et al. (2010)	Case Study (empirical evidence): the project was a new website for a cruise line	**Large**, **strategically important** to company's competitiveness and **strategically critical** – that is, **distributed**, and **outsourced** - projects are reasonable to harmonize the embedment of Scrum, based on the PMBOK, in traditional approaches. These projects have a clear overall objective, in particular driven by a **time-to-market goal**, but dynamic and unanticipated aspects (e.g., technology boosting new business opportunities and top management turnover) that lead to **ambiguity in scope and user requirements**. Further, **conflicting interests/perspectives** between the client and the vendor emphasize the need for a different PM. To coordinate and plan project's features across locations, and to control and contracting the outsourced development efforts, it is crucial to maintain elements of a structured approach (e.g., traceable requirements, documented decisions and parties expectations, steering committee). That works as an organizational infrastructure to manage discipline throughout the whole project. On the other hand, the learning and evolving nature of the project require sense and response capabilities such as iterative and fast-turnaround cycles, time-boxed sprints and prioritized backlogs provided by the agile approach. That enables the structured planning/control process to efficiently deal with changing circumstances.	▪ **Organizational** (size; geography; contracts; resources) ▪ **Technical** (goals; scope) ▪ **Environmental** (management support; market conditions/changes; stakeholders)
Barlow et al. (2011)	Theory-based framework: tool to select the proper methodology to organization's needs	Projects with **large team sizes**, and **mostly reciprocal interdependencies** within mature organizations should adopt a hybrid methodology. The project manager can decompose the development process into modules which are developed using a plan-driven or agile practices, but the appropriate infrastructure for supporting its coordination depends on the level of **team volatility** (turnover). With low volatility conditions, the focus should be on promoting a strong social network connectivity among the entire project team, as well as investing in the tacit knowledge and competences of project's managers. When volatility is high, the focus should be on codifying the knowledge into a knowledge management system that will support with project planning and sourcing. Alongside, hybrid focuses on traditional project planning with formalized information and knowledge transfer.	▪ **Organizational** (structure; size; resources) ▪ **Technical** (tasks) ▪ **Environmental** (stakeholders)
Goh et al. (2013)	Multiple case studies (empirical evidence): four projects for building a terminal system	The hybrid approach may be suitable in **large** projects, which involve **uncertainty** (foreseen and unforeseen), **completion urgency** and **team's inexperience** with the project's tasks and technology. The introduction of agile practices is defined by the interplay between the project team capabilities and the trust-mediated organizational control mechanisms. The project team have to develop planning and sensing capabilities to proactively identify/anticipate, accommodate and manage requirements and environment changes, behavioral conditioning capabilities in order to influence stakeholders and guarantee an alignment of interests and actions. When there are unforeseeable uncertainties, project teams develop shared ideology and learning capabilities in order to align **stakeholders expectations** and ensure a positive working relationship. The implementation of organizational control mechanisms either joint-responsibility deposit scheme and 24/7 work culture for foreseeable needs for change, or progress meetings for situations of unforeseeable change, being a crucial aspect to meet the required project timeline.	▪ **Organizational** (size; resources) ▪ **Technical** (goals; tasks; technology) ▪ **Environmental** (market changes; stakeholders)
Ramasubbu et al. (2015)	Conceptualization of process diversity (empirically tested): large, commercial projects of a multinational	As during the project's life cycle the **requirements volatility** may not occur homogenously, companies could mix plan-based and agile process frameworks in the different phases (or interactions) or software modules, according to the volatility level. Another project contingency that contributes to project complexity, thus to the use of a hybrid approach is the **design and technology novelty**, as the project team face a learning curve during the development process initially should be employed agile processes but when the members get familiar, and tasks become predictable might have a transition to a plan-driven approach. Also, the higher level of **customers involvement** in the project positively affects the simultaneous use of elements of both development frameworks, once there is the need to formal communication plans as well as to informal coordination schemes that allow active responses to evolving requirements.	▪ **Organizational** (size; resources) ▪ **Technical** (experience; scope) ▪ **Environmental** (customer)

Appendices 4: Adopting agile in software/IT development
Source: Own elaboration

Authors	Study Objective	Description (main fields/steps explored to determine hybrid feasibility)
Boehm and Turner (2003)	Risk-based Method	The authors proposed businesses to integrate a risk-based, tailored strategy. The method is based on the idea of Boehm (2002) previous work - there is established home grounds characteristics where each approach is favourable to succeed and the other will face difficulties. First, management should perform a **risk analysis**, where they determine if project features diverge to fit either agile or traditional home grounds; and subsequently define the project environment in five critical factors – size, criticality, dynamism, personnel and culture. In the case of risk presence, it is riskier to select one approach in its exact form. The second step should be a **risk comparison** between agile and plan-driven risks. In this point if neither is dominant, the combination of complementary practices from both into an hybrid approach works better. The last step focus on developing **resolution strategies** for each identified risk.
MacCormack et al. (2012)	NPD Strategy Procedure	Based on a case-study the authors design fours steps to help managers choosing and fitting the appropriate development approach in the context of their project/business. Each step has associated a set of key evaluation questions. The step 1 consists in **defining the business context** in terms of: alignment of the objectives to be achieved with the market maturity and market position; evaluation of different factors (such as team structure and organization, processes for technology development, partnering strategy, etc) that should be optimized. The step 2 concerns the **selection of development practices** to achieve each project objective by assessing technical and market risks. An intermediate level of risk raises the importance of combine complementary practices (agile and traditional). In step 3 occur the **definition and implementation of the development style** what includes a roadmap to change which comprises effective responses to handle potential conflicts of introduce agile. The last step involves **monitoring and reviewing over time**.
Schuh et al. (2016)	Highly Iterative Product Development (HIP)-Indicator Method	The authors mention the importance of classifying development scopes by the application of the HIP-Indicator. This method establishes an application-related criterion to introduce and combine agile with existing traditional methodologies. First, it is necessary to **examine internal factors** (solution space, prototype manufacturability, technology disability) **and external factors** (market relevance, market accuracy and market volatility), and how they influence uncertain project requirements/functions/components. The second step focus on the **derivation of a HIP-Indicator** and comprises sub-steps: rate each factor regarding its importance for the overall development task; evaluate each requirement's suitability for adaptive (agile) or deterministic (traditional) development; sum internal and external sides. The final step consists into the **clustering of requirements into specific development scopes** through HIP-Indicators. That structuration of the development process into scopes determine in which is favourable following agile or traditional approaches.
Cram and Marabelli (2018)	Ambidextrous Approach	Based on a case study of transition to a hybrid approach, the authors generalize on three-levels the conditions that can orient the choice to combine agile techniques alongside existing traditional techniques in knowledge-sharing processes. At the first level, **problems within the existing traditional approach** - lack of testing, limiting insights on project status, unresponsive customer, lack of management-team trust, insufficient representation of users - promote the introduction of agile techniques that assure a smooth transition, understandable and acceptable by the team. In a second level, when the **results of the traditional approach diverge from the ideal**, the decentralization of responsibilities from management to the project team is optimal decision. The third level outlines that **mid-size companies** tend to be more flexible and have a greater level of informality that drive the transition to hybrid.
Brandl et al. (2021)	Conceptual Framework	The authors propose a procedure based on three phases and four auxiliary models, that can easily be established in manufacturer's daily business routine. The first phase concerns the **awareness about the need to adapt** the current traditional modus operandi based on two tools: a checklist of critical prerequisites and a guide to evaluate the perceived environmental complexity. The following phase consists in **supplementing the current modus operandi** with the right agile practices taking in consideration to this end a linking model which comprises two matrixes: objectives-principles and principles-practices. The third phase focus on the **operationalization of the new hybrid approach** in a long-term horizon having as basis: Kotter's eight steps of successful change management.

Appendices 5: Comparison of studies focused on determining the viability of introduce hybrid models
Source: Own elaboration



Appendices 6: Chart of orientation to develop the evaluation table of project complexity
Source: Own elaboration

Dimension	General Strategic Areas	References
Organizational Challenges	▪ Install an organizational culture complementary to agile mindset ▪ Top management commitment and (visible) involvement ▪ Executive support and sponsorship ▪ Top-down approach for new culture adoption ▪ Recognition and engagement of change leaders ▪ Organization alignment toward a common goal/mission/vision ▪ Clear understanding of the agile way of work ▪ Dissemination and evidence of good outcomes	Boehm and Turner (2005); Dikert et al. (2016); Ciric et al. (2019); Sithambaram et al. (2021); Zasa et al. (2020); Patrucco et al. (2022) ; Sarangee et al. (2022)
Process Challenges	▪ Carefully customized hybrid-agile methodology ▪ Piloting to start agile introduction ▪ Learning investments on requirements management ▪ Negotiation and expectation's setting ▪ Realign/redefine traditional milestones ▪ Work modularization ▪ Spread and simplification of agile concepts	
People Challenges	▪ Awareness and *learning by doing* mode ▪ Human resources planning and skillset development ▪ Critical choices openness ▪ Collaborative working environment ▪ Team empowerment ▪ Team commitment to change ▪ Stakeholders broadly engagement ▪ Mental willingness to share knowledge ▪ Communication/Synchronization tools ▪ Efforts recognition	
Technical Challenges	▪ Team exposure to technology and tools	

Appendices 7: General strategic areas to answer the challenges of agile-hybrid introduction
Source: Own elaboration