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MSc in Engineering and Management



**A Survey on Agile Discontinuity Between
Theory and Practice in Systems-Intensive
Industries**

Supervisor

Prof. Filippo Maria Ottaviani

Candidate

Teresa Carotenuto

s331437

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Abstract

Agile methods were developed for small, co-located software teams, yet they are increasingly adopted in systems-intensive industries such as aerospace, automotive, defense, and medical technology, where development is shaped by scale, regulation, long lead times, and tightly coupled hardware-software dependencies. This thesis investigates the resulting discontinuity between Agile theory and Agile practice by measuring, for each of the twelve principles of the Agile Manifesto, both the importance practitioners attribute to the principle and the feasibility of enacting it under real operating conditions. The study combines a structured literature review with a cross-sectional survey of 68 practitioners and operationalizes the theory-practice gap through an Importance-Performance Analysis lens, complemented by a weighted gap metric and by one-way ANOVA across experience, project-type, and Agile-familiarity subgroups. The results reveal a universal and systematic gap: every principle is rated more important than feasible, with the mean importance (3.88) exceeding the mean feasibility (3.19) across the full sample. The gap is not uniform, however; welcoming changing requirements (P2) is the only principle in the *Challenge* quadrant and carries the largest weighted gap, whereas six relational, technical, and reflective principles fall in the *Leverage* quadrant and are perceived as both valuable and achievable. Perceived obstacles concentrate in the organizational and environmental dimensions of the Technology-Organization-Environment framework, with rigid culture and bureaucratic governance rated as more severe than technical system complexity. Crucially, 62 of the 68 ANOVA tests are non-significant, indicating that the gap structure is shared across subgroups and is therefore structural and sector-wide rather than an artifact of any particular professional profile. The thesis concludes that Agile development in systems-intensive industries is not a failure of principle but a failure of conditions, and it argues that adoption in these sectors requires governance and cultural transformation before, and more urgently than, methodological change.

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Chapter 1

Introduction

1.1 Problem Existence

Agile methods emerged in software development as a response to plan-driven approaches that struggled with uncertainty and changing requirements (Boehm & Turner, 2005; Dybå & Dingsøyr, 2008). The original setting involved small, co-located teams that could iterate quickly without strict governance or long integration cycles (Dingsøyr et al., 2012). In this context, Agile offered a credible answer to developing under uncertainty without excessive upfront planning.

Agile has since moved far beyond software and is now applied in large organizations, multi-team programs, and product development where software is only one part of a broader system (Dikert et al., 2016; Conforto et al., 2014). A method built around speed, adaptability, and local decision making is increasingly introduced into settings that are structurally very different from those in which it was developed. This expansion raises a central question: do Agile principles remain equally applicable when development is shaped by scale, formal coordination, compliance requirements, and heterogeneous engineering dependencies?

The problem is not Agile itself, but the growing distance between Agile assumptions and the realities of many industrial environments. Principles such as frequent delivery, continuous prioritization, and self-organizing teams become difficult to realize when projects involve long lead times, shared architectures, fixed milestones, and formal reviews (Nerur et al., 2005; Hobbs & Petit, 2017). Organizations are drawn to Agile precisely because they want adaptability, faster learning, and better alignment with customer needs, but these goals must be pursued inside systems built around stability, predictability, and control.

The problem is practical because many organizations try to become more adaptive while

maintaining reliability, traceability, integration discipline, and managerial control. The problem is also theoretical because existing research has discussed Agile benefits and challenges, but has rarely examined the specific gap between the perceived value of Agile principles and their perceived feasibility in practice. This thesis takes that gap as its starting point and treats it as a distinct phenomenon to be measured rather than as a vague impression that Agile is hard in complex settings.

1.2 Relevance of the Problem in Systems-Intensive Industries

The expression *systems-intensive industries* refers to sectors in which organizations develop, integrate, and operate complex engineered systems rather than stand-alone software products. Typical examples include aerospace, automotive, defense, rail, healthcare technology, and energy (Walden et al., 2023; SEBoK Editorial Board, 2022). These settings combine hardware, software, electronics, mechanics, testing, and external suppliers under strict traceability, compliance, and quality requirements. A detailed characterization of these industries is developed in Chapter 2.

Digitalization, connected products, and Industry 4.0 transformations increase the need for faster learning and continuous evolution in traditionally structured industrial environments (Nakagawa et al., 2021). Organizations in these sectors must therefore support both rigorous system integration and continuous change. If this tension is not addressed, companies risk pursuing Agile rhetorically while leaving unchanged the structural conditions that prevent it from working in practice.

For practitioners, managers and engineers must make decisions about planning, coordination, documentation, architecture, and compliance under uncertainty. For researchers, the existing evidence is dominated by experience reports and case studies, with limited survey-based data on how practitioners perceive Agile principles in their context (Dikert et al., 2016). For regulators and governance actors, successful adoption depends on substantial adaptation rather than the direct transfer of textbook practices (Fitzgerald et al., 2013; Baxter et al., 2023).

1.3 Research Gap

Existing research has identified implementation challenges, success factors, and context-specific adaptations in large organizations, regulated environments, and complex engineering settings

(Dikert et al., 2016; Kasauli et al., 2021; Uludağ et al., 2022). However, the literature does not yet provide a clear empirical understanding of how practitioners experience the distance between Agile as a set of theoretical principles and Agile as something to be enacted under real constraints. Most studies describe the conditions that make Agile difficult, but do not show whether practitioners simultaneously view Agile principles as valuable in theory and difficult to realize in practice.

A substantial part of the evidence base relies on case studies and experience reports (Paasivaara et al., 2018). These designs explain how transformations unfold, but they are less suited to showing in a comparable way which principles are most valued, which are least feasible, and where misalignment is strongest across respondents and contexts. A principle-level, survey-based perspective is therefore needed to complement the existing qualitative evidence.

Where survey-based evidence does exist, it has typically measured adoption rates, perceived success, or the relative weight of success factors, rather than the dual perception of each principle's value and enactability (Dybå & Dingsøyr, 2008; Serrador & Pinto, 2015). Large practitioner surveys have established that Agile adoption is widespread and that contextual factors moderate its effectiveness, but they treat Agile as an aggregate construct and do not decompose it into its constituent principles (Serrador & Pinto, 2015). As a result, the field knows that Agile tends to perform less well under high complexity and external constraints, yet it lacks a principle-level map of where, within the Agile value system, the theory-practice tension is concentrated. The present study is designed to fill precisely this descriptive gap by pairing an importance rating and a feasibility rating for every principle, an instrument structure that prior surveys have not systematically adopted.

This thesis addresses the gap by adopting a principle-centered and quantitative perspective. It examines whether Agile principles are considered important, whether they are considered feasible in current practice, and how perceived obstacles help explain the distance between the two. The detailed literature foundations supporting this design are developed in Chapter 2.

1.4 Research Objectives and Research Questions

This thesis investigates the discontinuity between Agile theory and Agile practice in systems-intensive industries. The study combines a structured analysis of existing literature with an empirical survey of practitioners. It focuses on the challenges associated with implementing

Agile project management frameworks in engineering contexts, and on the extent to which these challenges translate into a perceived gap between principles and feasibility.

The first objective identifies the main problems related to the implementation of Agile approaches in systems-intensive and engineering-driven environments. The second objective assesses how Agile principles are perceived in practice, in terms of both importance and feasibility. The third objective provides an interpretation of the observed results, reflecting on why certain principles are perceived as more difficult to implement.

In line with these objectives, the thesis addresses the following research questions:

- **RQ1.** What are the main problems associated with the implementation of Agile project management frameworks in systems-intensive engineering contexts, and to what extent are they supported by theoretical versus empirical evidence in the literature?
- **RQ2.** To what extent are Agile principles and related challenges perceived as important and feasible by practitioners across different systems-intensive contexts?
- **RQ3.** How can the observed perceptions and gaps between importance and feasibility be interpreted in light of the contextual constraints faced by practitioners?

1.5 Structure of the Thesis

The remainder of this thesis unfolds across six chapters that follow the natural progression of the research, moving from the framing of the problem to the interpretation of the empirical findings. Chapter 1 introduces the problem, discusses its relevance for systems-intensive industries, and defines the research gap together with the research questions that guide the study. Building on this foundation, Chapter 2 reviews the literature on systems-intensive industries, the principles of the Agile Manifesto, and the organizational barriers that hinder Agile adoption, in order to establish the theoretical baseline against which the empirical investigation is positioned. Chapter 3 then describes the research design, motivating the choice of a survey-based approach, detailing the construction of the questionnaire, and explaining the data collection and analysis procedures. The empirical core of the work is presented in Chapter 4, which reports the sample characteristics and the importance-feasibility gaps observed across Agile principles and development obstacles, and also includes the reliability analysis of the survey instrument carried out in Stata to assess the robustness of the findings. Chapter 5 interprets these results in light of the literature, drawing both theoretical and practical implications for organizations operating

in systems-intensive contexts. Finally, Chapter 6 brings the thesis to a close by summarizing the main findings, acknowledging the limitations of the study, and suggesting directions for future research that may extend the contributions of this work. Two appendices complete the document: Appendix A reproduces the full survey questionnaire, and Appendix B documents the structure and contents of the analysis workbook used to produce all empirical results reported in Chapter 4.

Chapter 2

Literature Review

2.1 Characteristics of Systems-Intensive and Regulated Industries

Systems-intensive industries differ from conventional mass-production contexts because they develop high-cost, highly customized, and engineering-intensive products (Hobday, 1998). The focal artefact is not a standalone product but a complex socio-technical system, often composed of tightly coupled hardware, software, electronics, mechanics, and service elements. Development is usually organized through one-off or small-batch projects, with a strong emphasis on systems engineering, integration, and ex-ante coordination among customers, suppliers, regulators, and professional bodies. Typical examples include aerospace and defense systems, avionics, rail infrastructure, medical devices, and other large-scale embedded or safety-critical solutions.

A central feature of systems-intensive industries is the centrality of the project as the main unit of coordination. Innovation in complex products is shaped by high uncertainty, strong customer involvement, and limited market contestability, which make project-based forms of organization particularly relevant (Hobday, 2000). This form enables the temporary integration of diverse expertise around a specific system objective, but it also limits cross-project learning, economies of scale, and the retention of knowledge beyond individual projects.

Competitiveness in complex product systems does not depend only on technological expertise. Davies & Brady (2000) show that firms must develop organizational capabilities to repeatedly manage bids, execute projects, integrate heterogeneous knowledge, and transform

project experience into more repeatable solutions. Such capabilities are especially important where system architectures evolve over long time horizons and where product development must balance customization, reliability, and integration.

These features become more pronounced in regulated industries. Product development is constrained not only by technological complexity but also by formal requirements related to safety, certification, quality assurance, traceability, and compliance (Fitzgerald et al., 2013). Regulated environments impose extensive documentation, auditable development processes, and rigorous verification and validation activities, all of which reduce process flexibility and make rapid change harder to accommodate. As a result, regulated and safety-critical sectors tend to rely on stable governance structures, formal decision gates, and documentation-intensive practices that are only partially compatible with iterative approaches.

The challenge is amplified in large-scale system development settings, where different engineering domains operate on different cadences. Companies developing systems that combine hardware and software must synchronize long hardware lead times with faster software iterations (Kasauli et al., 2021). Dikert et al. (2016) report that such environments are frequently affected by requirements management difficulties, tensions between long-term and short-term planning, coordination problems across teams, and resistance from non-development functions.

A further defining feature of systems-intensive industries is the length of the product lifecycle and the persistence of the installed base. Engineered systems such as aircraft, rolling stock, and medical devices are designed for service lives that span decades, during which they must be maintained, re-certified, and upgraded against configurations frozen long before any new change is requested (Walden et al., 2023). Development is therefore organized around the management of a baseline that becomes progressively more expensive to alter as the system moves through definition, integration, and verification. This temporal asymmetry means that the cost of absorbing a late change does not grow linearly but rises sharply once design freezes, supplier commitments, and certification evidence are in place. The long-horizon nature of these industries thus creates a structural tension with the Agile expectation that requirements can be welcomed continuously, a tension examined empirically in Chapter 4.

Overall, the literature suggests that systems-intensive and regulated industries share four recurring traits:

- high system complexity;
- strong interdependence across technical domains;

- project-based and knowledge-intensive organizational forms;
- stringent regulatory and assurance requirements.

These characteristics shape the conditions under which Agile must operate. Implementing Agile in these contexts is therefore not a matter of transferring software-originated practices, but of adapting them to structural industrial constraints.

2.2 The Emergence of Agile: From Plan-Driven Models to the Manifesto

Agile did not appear in a vacuum but emerged as a reaction to the dominant software engineering paradigm of the preceding decades. Through the 1980s and 1990s, software development was largely organized around sequential, plan-driven models that separated requirements, design, implementation, and testing into distinct and ordered phases (Boehm & Turner, 2005). These models assumed that requirements could be specified comprehensively at the outset and that change during development was a deviation to be controlled rather than an expected condition. In practice, this assumption proved fragile in environments characterized by volatile requirements and rapid technological change, where extensive upfront specification frequently produced systems that no longer matched user needs by the time they were delivered (Boehm & Turner, 2005; Dybå & Dingsøyr, 2008).

During the 1990s a number of lightweight, iterative methods developed independently as alternatives to heavyweight plan-driven processes, emphasizing short cycles, close customer involvement, and continuous feedback. These approaches were consolidated in 2001, when seventeen practitioners met and articulated a shared set of values and principles that became the Agile Manifesto (Beck, Beedle, Bennekum, Cockburn, Cunningham, Fowler, Grenning, et al., 2001; Highsmith & Cockburn, 2001). Rather than prescribing a single methodology, the manifesto codified a common philosophy that already underpinned methods such as Scrum and Extreme Programming, giving them a unified normative vocabulary (Dingsøyr et al., 2012). The significance of this moment lay less in the invention of new techniques than in the explicit statement of the value system those techniques were meant to serve.

In the decade that followed, Agile spread from co-located software teams to large programs and to non-software domains, becoming a broad management philosophy rather than a bounded set of techniques (Dingsøyr et al., 2012; Conboy, 2009). This diffusion broadened the meaning

of the term and raised the question that motivates the rest of this review: whether a value system formulated for small software teams retains its applicability once it is transferred into large, regulated, and engineering-intensive settings (Abrahamsson et al., 2009). The following section examines the twelve principles that express this value system, which serve as the theoretical benchmark for the empirical analysis.

2.3 Agile Principles and the Agile Manifesto

As the previous section described, the Agile Manifesto emerged in 2001 as the conceptual foundation of Agile development; this section turns from its origin to the normative content it codified (Beck, Beedle, Bennekum, Cockburn, Cunningham, Fowler, Grenning, et al., 2001; Highsmith & Cockburn, 2001). Rather than proposing a single prescriptive methodology, the manifesto introduced a value-oriented perspective on software development, emphasizing adaptability, collaboration, continuous learning, and frequent delivery of value.

The manifesto prioritizes human interaction over procedural formalism, working outcomes over extensive upfront documentation, customer collaboration over purely contractual relationships, and adaptation over strict adherence to an initial plan (Beck, Beedle, Bennekum, Cockburn, Cunningham, Fowler, Grenning, et al., 2001). These value statements are complemented by twelve principles that stress early and continuous delivery, openness to changing requirements, frequent releases, close collaboration between business and development, motivated and self-organizing teams, direct communication, technical excellence, simplicity, sustainable pace, and regular reflection (Beck, Beedle, Bennekum, Cockburn, Cunningham, Fowler, Martin, et al., 2001). The manifesto should therefore be interpreted as a normative framework that guides development choices and organizational behavior, not as a detailed operating model. Table 2.1 summarizes the twelve principles, their managerial interpretation, and their relevance for this study.

Agile principle	Managerial meaning	Relevance for this thesis
Early and continuous delivery	Deliver customer value early and repeatedly, not only at the end.	Tests whether customer responsiveness is valued when delivery cycles are long.
Welcoming changing requirements	Treat change as a source of value rather than a disruption.	Relevant where regulation, architecture, and contracts limit responsiveness.
Frequent delivery of working outputs	Use short cycles and regular releases to support feedback.	Tests whether iterative delivery is viable in certification-heavy cycles.
Business-developer collaboration	Promote continuous interaction between technical and business actors.	Reveals whether collaboration is valued or hindered by organizational silos.
Motivated individuals	Support and trust people so they can perform effectively.	Linked to empowerment, management support, and organizational culture.
Face-to-face communication	Direct exchange improves clarity, speed, and shared understanding.	Tests feasibility of direct communication in large or formalized settings.
Working outcomes as progress measure	Assess progress through results, not only through reporting.	Especially relevant where reporting and documentation dominate.
Sustainable pace	Organize work so teams can sustain performance over time.	Tests whether industrial settings support sustainable work or reinforce overload.
Technical excellence and good design	Use strong design and discipline to improve adaptability and quality.	Highly relevant where robustness and maintainability matter.
Simplicity	Focus on value and reduce avoidable complexity and waste.	Tests whether simplification is desirable in documentation-heavy contexts.
Self-organizing teams	Give teams autonomy to organize work and solve problems.	Central to this study, as self-organization often conflicts with formal governance.
Regular reflection and adaptation	Review and adjust work practices to improve effectiveness.	Tests whether continuous improvement is feasible in rigid environments.

Table 2.1: Agile Manifesto principles and their relevance for the thesis.

On this basis, Agile evolved into an umbrella concept that includes methods such as Scrum, Extreme Programming, Crystal, and Lean Software Development. Although these approaches differ in terminology, roles, and mechanisms, they share a common orientation rooted in the manifesto's values and principles (Dingsøyr et al., 2012). The literature increasingly treats Agile less as a fixed method and more as a broader development philosophy that can be instantiated in different ways depending on context, scale, and organizational needs (Conboy, 2009; Abrahamsson et al., 2009).

The diffusion of Agile has generated conceptual ambiguity, since the term now refers simultaneously to a mindset, a set of principles, a family of methods, and a collection of practices. Conboy (2009) argues that agility should be understood as the ability to create and respond to change while contributing to customer value, rather than as mere speed or informality. Agile is therefore not the rejection of planning or documentation, but an alternative logic of organizing work under uncertainty, in which learning, iteration, and responsiveness are central.

In this thesis, the Agile Manifesto is treated as an analytical benchmark rather than as a universally transferable recipe. Its principles provide the theoretical reference point for understanding what Agile development is expected to promote in ideal terms. The gap between this normative content and its enactment in industrial settings is the central object of the empirical investigation that follows.

2.4 Organizational and Structural Barriers to Agile Adoption

The adoption of Agile is rarely hindered only by methodological or technical issues. A substantial body of literature shows that the main obstacles are organizational and structural, since Agile requires changes in decision-making structures, coordination mechanisms, governance arrangements, and culture (Dikert et al., 2016; Mishra et al., 2021). Agile adoption should therefore be understood not as the introduction of a new method, but as a broader organizational transformation that challenges established roles and control systems.

A first major barrier concerns organizational culture. Agile is based on collaboration, transparency, distributed responsibility, and continuous adaptation, all of which are difficult to implement in bureaucratic, hierarchical, and command-and-control organizations (Nerur et al., 2005; N. Iivari & J. Iivari, 2011; Mishra et al., 2021). Empirical studies show that culture shapes decision-making processes, planning habits, communication flows, and the degree to

which teams are allowed to self-organize. Resistance to Agile therefore often stems less from the principles themselves than from the incompatibility between Agile values and pre-existing organizational behaviors.

Closely related to culture is the issue of management support. The literature consistently identifies leadership commitment as a critical enabling condition, particularly in large organizations where structural change cannot be sustained by teams alone (Dikert et al., 2016; Hoda et al., 2011). Executive and middle management support is necessary to legitimize new ways of working, allocate resources, and align surrounding functions with Agile practices. Without such support, Agile initiatives often remain isolated at team level while the rest of the organization continues to operate according to traditional routines.

A second set of barriers is structural. Agile presupposes autonomous, cross-functional, and collaborative teams, yet many large organizations remain organized around functional specialization, centralized control, and fragmented responsibilities (Lindvall et al., 2004; Mishra et al., 2021). Team autonomy may conflict with architectural governance, centralized testing and quality assurance, or formal change control boards. Dikert et al. (2016) show that large-scale Agile transformations are frequently challenged by inter-team dependencies and difficulties in aligning local team goals with broader organizational objectives.

These issues become more pronounced in systems-intensive environments, where product development involves strong technical interdependencies across hardware, software, and other engineering domains. Kasauli et al. (2021) argue that large-scale system development introduces extraordinary demands on long-term maintenance, cross-domain synchronization, and shared knowledge integration. Organizational and structural barriers in these settings are therefore rooted not only in culture or hierarchy, but also in the technical architecture of the product and in the coordination burden created by system complexity.

A further obstacle concerns governance and institutional constraints, especially in public-sector and regulated environments. Agile adoption in these settings may be hindered by procurement rules, formal approvals, compliance requirements, and reporting systems designed around predictability rather than adaptability (Lappi & Aaltonen, 2017; Baxter et al., 2023). Baxter et al. (2023) show that Agile in public-sector IT projects faces persistent tensions related to governance, policy, project approval, and culture. Applying Agile flexibly in these settings often requires substantial changes in how projects are contracted, negotiated, managed, and overseen.

A frequently underestimated barrier concerns the distribution of Agile knowledge within

the organization. Mishra et al. (2021) find that in large, multi-disciplinary organizations, Agile expertise is often concentrated in software-oriented teams and does not diffuse naturally to hardware, systems engineering, or procurement functions. This uneven distribution means that even when management endorses an Agile transformation, the non-software parts of the organization may lack the conceptual vocabulary, tooling familiarity, and process experience needed to participate constructively. The result is a partial adoption that mirrors Agile at the team level while preserving predictive logic at the program level, a condition that Dikert et al. (2016) describe as “water-Scrum-fall”, in which Agile sprints are embedded within a traditionally managed project without genuine iterative feedback loops.

The literature suggests that organizational and structural barriers to Agile adoption can be grouped into four broad areas:

- cultural misalignment;
- insufficient management support;
- structural incompatibilities in large or functionally divided organizations;
- governance and institutional rigidities.

These barriers are particularly relevant in systems-intensive and regulated industries, where complexity, formalization, and cross-functional interdependence are especially high. Agile adoption in such contexts is therefore a problem of organizational redesign and institutional adaptation, not a purely methodological challenge.

2.5 Agile Scaling Frameworks and Their Limits in Systems-Intensive Contexts

The recognition that Agile as originally conceived operates at the level of a single co-located team led to the development of scaling frameworks designed to extend Agile principles to large-scale, multi-team program environments. The Scaled Agile Framework (SAFe), Large-Scale Scrum (LeSS), and the Spotify model are among the most widely adopted, each offering a different interpretation of how Agile values can be instantiated at program and portfolio level (Dingsøyr et al., 2012; Hobbs & Petit, 2017). These frameworks introduce coordination layers (such as Program Increments, Agile Release Trains, or Communities of Practice) that are intended to preserve iterative delivery while managing the dependencies and planning horizons that single-team Agile ignores.

The three frameworks differ markedly in how much additional structure they impose, and this variation matters for systems-intensive adoption. SAFe is the most prescriptive, layering portfolio, program, and team levels with synchronized planning cadences that appeal to organizations accustomed to formal governance, but that also reintroduce much of the planning overhead Agile sought to remove (Hobbs & Petit, 2017). LeSS takes the opposite stance, deliberately minimizing additional roles and artifacts so that a single product backlog and a shared cadence coordinate many teams, which preserves Agile minimalism but presumes a degree of architectural and organizational uniformity that systems-intensive programs rarely possess. The Spotify model emphasizes autonomous squads and cultural alignment rather than formal process, which scales engagement effectively but offers little of the explicit dependency management that hardware lead times and certification gates demand. Across all three, the coordination primitives were conceived for software-centric work, so their fit with multi-disciplinary, long-horizon engineering remains partial (Dingsøyr et al., 2012).

Despite their adoption in industry, scaling frameworks have been criticized for reintroducing precisely the planning overhead and governance structures that single-team Agile sought to dismantle (Hobbs & Petit, 2017). In systems-intensive settings, the tension is particularly visible: program-level planning events require early integration of hardware, software, and systems engineering timelines that may not fit into a common iteration cadence. Kasauli et al. (2021) document that large-scale system development introduces requirements management, cross-domain synchronization, and interface management challenges that scaling frameworks address only partially, since their coordination primitives were designed with software in mind. The result is that organizations in aerospace, automotive, and defense sectors often hybridize scaling frameworks with traditional stage-gate or milestone-driven governance, producing mixed models whose coherence and effectiveness are difficult to evaluate systematically.

Hybridization, the combination of Agile and predictive elements within the same project management approach, is increasingly recognized as the de facto standard for complex product development rather than as a transitional phase (Conforto et al., 2014; Hobbs & Petit, 2017). Conforto et al. (2014) show that hybrid approaches dominate in product innovation contexts, particularly in industries where customer uncertainty and technical complexity coexist with stable regulatory frameworks. However, hybrid models currently lack a shared theoretical foundation that specifies which principles should be retained, adapted, or suspended depending on context. This absence makes it difficult to evaluate whether specific hybrid configurations

genuinely preserve Agile’s value proposition or merely maintain the appearance of Agile while operating predictively in practice.

This thesis contributes to the hybridization debate by providing principle-level evidence on what practitioners in systems-intensive industries value and what they find feasible under real operating conditions. Rather than prescribing a hybrid model, the study uses the importance-feasibility gap as an empirical indicator of where the boundaries of Agile applicability actually lie. The principles that fall in the *Leverage* quadrant (high importance, high feasibility) can inform the Agile core of a hybrid approach; those in the *Challenge* quadrant identify the points where governance innovation is most urgently needed.

2.6 Importance-Performance Analysis as a Theoretical Lens

Importance-Performance Analysis (IPA) was introduced by Martilla & James (1977) as a practical tool for identifying where managerial attention and resources should be directed. The framework plots two dimensions, the perceived importance of an attribute and the perceived performance on that attribute, onto a two-by-two matrix, producing four quadrants that carry distinct strategic implications. Attributes rated as highly important but poorly performed signal areas requiring concentrated improvement effort; those rated as both important and well performed represent strengths to be maintained; those rated as low in importance but well performed suggest possible over-investment; and those rated as low on both dimensions warrant deprioritization. Originally developed for market research, IPA has since been applied in service quality assessment, customer satisfaction research, educational evaluation, and project management.

The application of IPA to Agile principle assessment is conceptually well-grounded. The Agile Manifesto defines a set of normative claims about how software (and, by extension, product) development should be organized. Each principle carries an implicit value judgment, making it natural to ask both how important practitioners consider it to be and how feasible they find it in their actual context. Importance in this study corresponds to the normative desirability of the principle; feasibility, used in place of the performance dimension, corresponds to the degree to which the principle can be enacted under prevailing organizational and technical constraints. This reframing preserves the strategic logic of IPA while making it applicable to a regulatory and engineering-intensive context where “performance” on an Agile principle is not

directly observable but must be inferred from perceived enactability.

A limitation of standard IPA is that it treats all high-importance, low-performance attributes as equally urgent. To address this, this study employs a weighted gap metric $\Delta' = (I - F) \times I$, which amplifies the gap for principles that are both highly valued and poorly enacted. This metric, adapted from the management literature on importance-weighted performance gaps (Martilla & James, 1977), ensures that strategic priorities are assigned not only on the basis of the gap magnitude but also in proportion to the normative weight practitioners themselves assign to each principle. Principles with a large gap but low perceived importance receive a lower strategic weight than principles with a comparable gap but high importance, reflecting the idea that not all theory-practice misalignments are equally costly from an organizational perspective.

A second methodological consideration in IPA concerns where the crosshairs separating the four quadrants are placed. The literature distinguishes a scale-centered approach, which fixes the dividing lines at the midpoint of the rating scale, from a data-centered approach, which places them at the observed means of importance and feasibility. The scale-centered convention is simpler but tends to collapse most attributes into a single quadrant when ratings are skewed toward one end, whereas the data-centered convention preserves the relative position of each attribute within the specific sample and is generally preferred when the aim is prioritization rather than absolute benchmarking. This study adopts the data-centered convention, locating the dividing lines at the sample means of importance and feasibility, so that each principle is positioned relative to how the surveyed practitioners rate the set as a whole rather than against an abstract scale midpoint.

2.7 Open Issues for Empirical Investigation

The literature reviewed in the previous sections leaves three open issues that motivate the empirical part of this thesis. First, much of the Agile literature is still software-centric and only partially addresses the characteristics of systems-intensive sectors (Dingsøyr et al., 2012; Hobbs & Petit, 2017). Second, many studies focus on Agile methods, transformations, or success factors, rather than on the individual principles of the Agile Manifesto as the normative core of Agile theory. Third, evidence in regulated and systems-intensive environments is dominated by case studies and experience reports, with limited survey-based data on how practitioners perceive Agile principles (Fitzgerald et al., 2013; Kasauli et al., 2021; Baxter et al., 2023).

A principle-level, survey-based investigation is therefore needed. The empirical study described in Chapter 3 addresses these issues by measuring, for each Agile principle, both its perceived importance and its perceived feasibility in systems-intensive contexts. This approach turns literature insights into a structured, comparable, and quantitative basis for analyzing the discontinuity between Agile theory and Agile practice.

Chapter 3

Research Design and Methods

3.1 Research Design and Quantitative Approach

A cross-sectional online survey fits the thesis goal because it captures how practitioners currently perceive Agile principles under real constraints, without requiring access to confidential project artifacts or long observation periods (Dillman et al., 2014). Perception data matter here because adoption decisions, implementation choices, and reported barriers depend on what professionals believe is feasible within governance, compliance, and coordination conditions, not only on what frameworks prescribe. An online survey also supports coverage across roles and industries, which helps to test whether discontinuity concentrates in specific profiles or appears broadly across systems-intensive settings. This approach therefore prioritizes breadth and comparability over deep causal explanation, which remains outside the scope of a master's-level empirical study.

The study narrows its analysis to systems-intensive and regulated contexts, characterized by the integration of software, hardware, and heterogeneous engineering disciplines, and by complex processes of integration, verification, and governance. In such environments, technical and organizational constraints directly affect the applicability of Agile practices, particularly when interface dependencies, traceability requirements, and distributed decision-making chains are present. The scope delimitation is functional to the research questions because it increases the likelihood of observing a discontinuity between Agile principles and real operating conditions.

Agile discontinuity is operationalized through two separate ratings for each principle: how important the principle is considered and how feasible it is in the current work context. *Importance* captures the value attributed to the principle and the extent to which it is considered useful

for achieving outcomes. *Feasibility* captures how achievable the same principle appears under concrete constraints such as inter-team dependencies, distributed decision-making, traceability requirements, compliance, or limited stakeholder availability. These paired measures distinguish what is considered desirable in theory from what is implementable in practice, avoiding confusion between preferences and operational possibilities.

Discontinuity is summarized in a gap score, computed as the difference between importance and feasibility for each principle (Martilla & James, 1977). A large gap indicates that the principle is perceived as valuable but difficult to apply, signaling misalignment between Agile orientation and organizational or technical conditions. A small gap admits two interpretations: either the principle is both important and feasible (consistency between theory and practice), or it is of low importance and low feasibility (perceived low priority). For this reason, the gap is always read jointly with both ratings rather than as a stand-alone indicator.

Perceived implementation obstacles are measured separately to explain why feasibility may remain limited in specific contexts. This separation allows the Results chapter to link low feasibility scores to specific perceived constraints rather than to treat feasibility as an unexplained outcome. The combination of gap patterns and obstacle patterns produces clear, traceable, and replicable outputs for the analysis that follows.

3.2 Survey Design for Assessing Agile Perceptions

3.2.1 Selection of Agile Principles

The questionnaire adopts the twelve principles behind the Agile Manifesto as the reference for Agile theory because they provide a framework-independent statement of Agile's intended values and behaviors (Beck, Beedle, Bennekum, Cockburn, Cunningham, Fowler, Martin, et al., 2001). A fixed set of principles improves comparability because all respondents evaluate the same normative baseline, and the analysis avoids mixing interpretations that depend on local practices or branded frameworks. A theory-practice discontinuity requires a stable theoretical target, and principles offer a clearer reference point than practices that vary with maturity and organizational constraints.

Each principle is translated into a short survey statement that preserves its original intent while using plain language interpretable across roles. The wording avoids references to specific tools, ceremonies, or branded methods, so that responses reflect the feasibility of the underlying

principle rather than familiarity with a particular implementation. Consistent phrasing across items reduces wording-driven variation and supports direct comparisons of importance and feasibility across principles.

All twelve principles are retained to avoid selective emphasis and to keep the instrument aligned with the original theoretical source. Complete coverage enables identification of which parts of Agile's normative foundation show the largest importance-feasibility gaps in systems-intensive contexts. Principle-level patterns can then be compared across industries and roles without altering the theoretical benchmark.

3.2.2 Selection of Development Obstacles

The obstacle set derives from the evidence base identified through the literature review, which followed an identification, screening, and inclusion logic aligned with PRISMA reporting principles (Page et al., 2021). During full-text screening, the extraction focused on statements describing factors that hinder Agile adoption or limit Agile implementation in complex and systems-intensive settings. Obstacles were treated as recurring barriers reported at team, program, organizational, or external levels, rather than as isolated project-specific issues.

Figure 3.1 summarizes the identification, screening, and inclusion process used to build the evidence base for obstacle extraction.

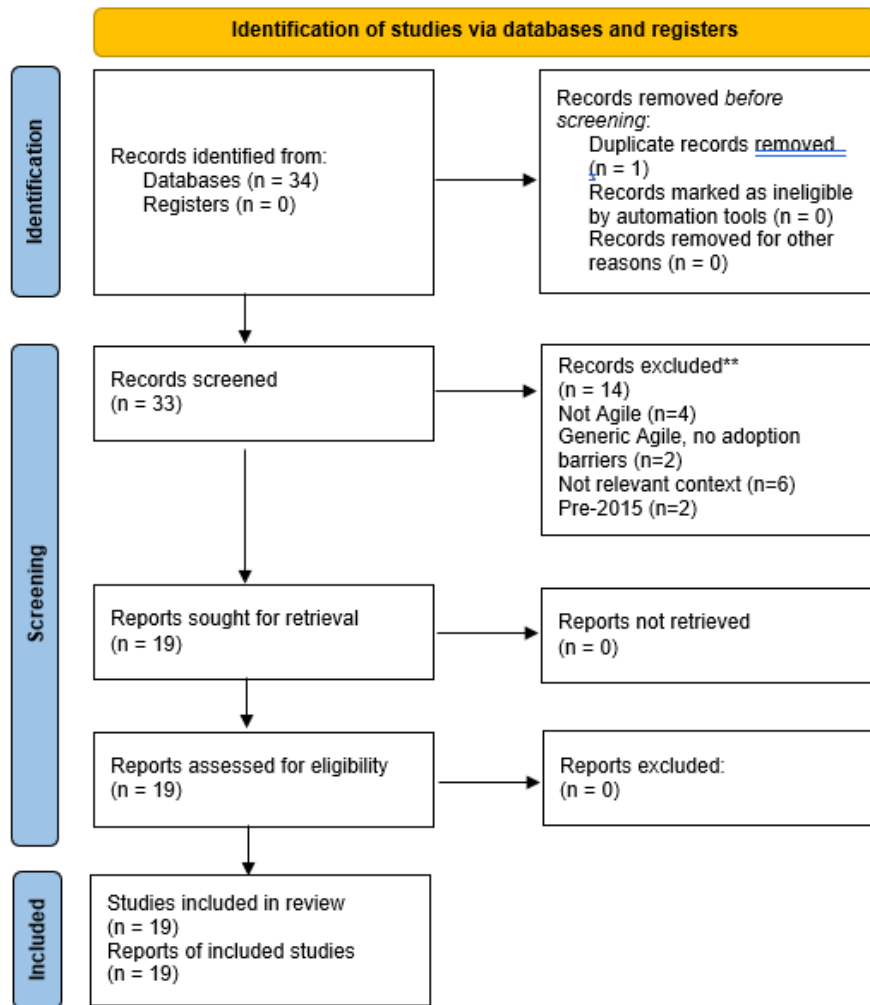


Figure 3.1: PRISMA flow diagram of the literature search and obstacle selection.

The consolidation step merged synonyms and overlapping labels into a smaller number of distinct obstacle categories. This step reduced redundancy, kept categories conceptually clear, and ensured that each obstacle could be rated without ambiguity. The final list matches the seven obstacles used in the survey instrument, so the literature synthesis and the empirical measurement remain consistent.

An article-obstacle matrix supported the coding process, with rows representing the included studies and columns representing the obstacle categories. A binary coding rule kept the matrix consistent: an obstacle is marked as present when the study explicitly describes it as a constraint, impediment, or limiting condition for Agile, and as absent otherwise. Short evidence notes were stored for traceability, so that each coded obstacle can be traced back to the underlying text.

The final obstacle categories were classified using the Technology-Organization-Environment (TOE) framework (Tornatzky et al., 1990). TOE groups barriers according to their primary source of constraint, distinguishing technology-related, organizational, and environmental conditions. This classification turns an obstacle ranking into a structured explanation of why feasibility remains limited across different contexts, and supports discussion because each TOE dimension implies different levers for change. Table 3.1 reports the development obstacles used in the survey and their TOE classification.

ID	Obstacle statement	TOE dimension
1	Rigid organizational culture and resistance to change.	Organizational
2	Lack of leadership for Agile adoption.	Organizational
3	Heavy formal processes that conflict with Agile practices.	Environmental
4	High system complexity and long development cycles that hinder short Agile iterations.	Technological
5	Insufficient Agile knowledge and training within the organization.	Organizational
6	Difficulties in coordinating many teams and limited cross-functional collaboration between departments.	Organizational
7	Geographically dispersed teams that hinder communication.	Organizational

Table 3.1: Development obstacles and TOE classification.

3.2.3 Questionnaire Structure and Measurement Scales

The questionnaire is organized into sequential blocks to move respondents from descriptive questions to more evaluative judgments, while keeping completion effort manageable. The opening part clarifies purpose, confidentiality, and voluntary participation, which supports transparent and ethically sound data collection in an online setting (Dillman et al., 2014). Background questions precede perception questions because they describe the setting in which feasibility judgments form, and because this order helps reduce response bias by anchoring stable context features before evaluative items.

Likert-type scales measure importance, feasibility, and obstacle severity because they offer a well-established way to collect perceptions through ordered categories (Likert, 1932). A 5-point scale balances detail and ease of response: it provides enough variation to reflect different

positions, but avoids overly fine distinctions that can increase uncertainty and inconsistency in self-administered questionnaires (Dillman et al., 2014). The same 1-5 structure is used across blocks, which reduces scale switching, keeps completion smooth, and supports simple analyses such as averages, rankings, and group comparisons.

Background and context questions mainly use multiple-choice formats because they standardize responses and reduce ambiguity during coding and analysis (Dillman et al., 2014). A multi-select format is used when respondents can realistically match more than one category, which avoids forced labeling and reflects hybrid roles that are common in complex settings. Category-based answers are preferred for organizational size and similar descriptors, since respondents can report a reliable range more easily than an exact number while still enabling subgroup comparisons.

The predictive-Agile measure uses an ordered 5-point continuum because it captures methodological orientation as a graded position rather than a binary choice. This format supports the analysis of perceived misalignment by comparing the current approach with the approach perceived as most appropriate for maximizing performance in the same context. It also enables exploration of whether a larger distance between current and best-fit approach associates with larger importance-feasibility gaps.

Block	Content	Measurement scale	Items
Introduction and consent	Purpose of the study, voluntary participation, confidentiality statement.	n/a	1
Demographic profile	Job role, total professional experience, years of experience with Agile approaches.	Multiple choice / ordinal	3
Organizational context	Industry sector, organizational size, project type, geographical dispersion of the team.	Multiple choice	4
Methodology orientation	Current development approach and approach perceived as most appropriate for the same context.	5-point ordinal continuum (predictive-Agile)	2
Agile familiarity	Self-reported exposure to Agile principles and practices.	5-point ordinal	1
Agile principles, importance	Perceived importance of each of the twelve Agile Manifesto principles.	5-point Likert	12
Agile principles, feasibility	Perceived feasibility of each of the twelve Agile Manifesto principles in the current context.	5-point Likert	12
Development obstacles	Severity of the seven obstacles identified in Section 3.2.2.	5-point Likert	7
Optional follow-up	E-mail address for receiving the study results.	Open text	1
Total items			43

Table 3.2: Survey questionnaire structure, scales, and item counts.

3.2.4 Demographic and Context Variables

Demographic and professional questions describe the sample and support the interpretation of differences in perceived feasibility across respondent profiles. The instrument collects role or job position, total years of professional experience, and years of experience with Agile approaches, because decision authority and exposure to governance constraints vary substantially across

these dimensions (Dikert et al., 2016). These variables do not represent study outcomes; instead, they provide context that helps interpret results without over-generalizing from a heterogeneous pool of respondents.

Organizational and project-level variables capture the setting in which Agile is applied. The questionnaire records industry sector, organizational size, project type, and the degree of geographical dispersion of the team, since these features shape coordination demands, cross-team dependencies, and external constraints. Industry and project type are particularly informative in systems-intensive settings, where the balance between hardware, software, and integration activities differs across sectors and directly affects feasibility judgments (Kasauli et al., 2021).

The instrument also includes a measure of Agile familiarity and a measure of methodology orientation, because adoption outcomes depend not only on attitudes toward Agile but also on direct exposure and current ways of working. Familiarity provides a practical indicator of judgment quality, since it distinguishes respondents who rate principles based on real experience from those with limited contact. Methodology orientation places the current approach on a predictive-Agile continuum and captures the approach perceived as most appropriate for the same context, which is especially relevant in settings where Agile often coexists with predictive governance elements.

Together, demographic and contextual variables enable structured comparisons of perception data across subgroups, while keeping the analytical scope coherent with the exploratory nature of the survey. The Results chapter uses them to detect systematic differences in importance-feasibility gaps by role, industry, and methodological orientation. Patterns observed across these subgroups support interpretation but are reported as descriptive evidence rather than as causal explanations.

3.3 Validity, Reliability, and Ethical Considerations

Content validity refers to the extent to which the measurement instrument covers the conceptual domain it intends to assess (Dillman et al., 2014). In this study, content validity was pursued by deriving both the principle set and the obstacle set directly from the Agile literature: the twelve Agile Manifesto principles provide a framework-independent and exhaustive coverage of Agile’s normative content, while the seven obstacles were extracted and consolidated from peer-reviewed evidence through a PRISMA-aligned screening process. The item wording was kept

framework-neutral and plain to ensure that ratings reflect genuine principle-level perceptions rather than familiarity with specific Agile tool sets.

Construct validity was supported by the Importance-Performance Analysis operationalization (Martilla & James, 1977). Measuring importance and feasibility as two separate constructs for each principle prevents the conflation of desirability and enactability, which are conceptually distinct. The paired structure also enables the computation of a gap score that directly quantifies the theory-practice discontinuity, which is the central construct of the study. The instrument structure is consistent with validated practice in applied Agile surveys, where separate perceptual dimensions have been used to detect adoption tensions (Serrador & Pinto, 2015).

Reliability refers to the consistency of the measurement instrument across items and respondents. The use of a uniform 5-point Likert scale across all principle and obstacle items reduces scale-switching effects and supports direct comparisons. Internal consistency was evaluated using Cronbach's alpha in Stata after data collection, computed separately for the twelve importance items, the twelve feasibility items, and the seven obstacle-severity items. All three blocks meet or exceed the conventional threshold of $\alpha > 0.70$, with $\alpha = 0.854$ for principle importance, $\alpha = 0.873$ for principle feasibility, and $\alpha = 0.760$ for obstacle severity. These coefficients indicate acceptable to good reliability of the composite measures, and the full results are reported in Section 4.5. The consistency of findings across unweighted and industry-weighted analyses provides an additional indicator of result stability.

Ethical considerations were addressed at the design stage. Participation was entirely voluntary and the survey instrument included an explicit statement of purpose, a description of how data would be used, and a confirmation of anonymity. No personally identifiable information was required beyond an optional email address for respondents who wished to receive the study results. The study does not involve vulnerable populations, experiments, or interventions; it is based exclusively on self-reported professional perceptions collected in a low-risk online format. These features position the study within the ethical conventions standard for academic survey research in management and organizational studies.

3.4 Data Collection Procedure

The questionnaire was administered as a self-administered online form through Google Forms, without researcher intervention during completion. This format ensures standardized expo-

sure to question wording across all respondents, eliminates interviewer effects, and allows asynchronous participation, which is necessary when targeting professionals distributed across organizations, roles, and geographic locations (Dillman et al., 2014). The survey remained open for approximately ten weeks, from March to May 2026, providing sufficient time for responses to accumulate through heterogeneous distribution channels while keeping the data collection window tight enough to limit contextual drift.

Participant recruitment followed a purposive multi-channel strategy aimed at reaching practitioners with direct exposure to Agile in complex, systems-intensive, or regulated environments. The survey link was distributed across LinkedIn communities focused on Agile and project management, where members self-identify as practitioners in engineering-intensive sectors. Direct outreach was also conducted toward authors of peer-reviewed publications on Agile adoption and scaling, representing a population with both domain knowledge and practical perspective. Additional dissemination targeted student groups at Politecnico di Torino with professional backgrounds in engineering or management, as well as faculty members with documented industry experience in Agile or project-intensive settings who were asked to relay the invitation to eligible professional contacts. This multi-channel approach combines professional and academic networks to maximize variation in organizational context, role, and industry while maintaining relevance to the research focus.

Probability sampling was not feasible given the absence of a complete sampling frame for Agile practitioners in systems-intensive industries. A purposive approach was therefore adopted, consistent with survey-based research in emerging and specialized professional domains (Dikert et al., 2016; Serrador & Pinto, 2015). Respondents were not offered incentives, and participation was framed as a voluntary contribution to academic research. All data were collected anonymously; no personally identifiable information beyond an optional email address for result notifications was requested or stored.

Figure 3.3 summarizes the distribution strategy and the relative contribution of each recruitment channel to the final sample of 68 responses.

Recruitment channel	Approx. <i>n</i>	Share (%)	Target profile
LinkedIn Agile communities	21	31%	Agile practitioners, PM professionals
Faculty and professional contacts	29	43%	Engineers and managers with systems-intensive experience
Paper authors (direct e-mail)	8	12%	Academic and industry researchers on Agile
Polito student groups	10	15%	Engineering and management students with professional backgrounds
Total	68	100%	

Table 3.3: Recruitment channels and their contribution to the sample ($n = 68$).

Eligibility was defined implicitly through channel selection rather than through a formal inclusion question, a practice common in professional surveys where self-selection into domain-specific communities serves as a first-stage filter (Dillman et al., 2014). All responses that passed the minimum completion threshold, defined as providing ratings for all twelve importance items and all twelve feasibility items, were retained for analysis. Incomplete records limited to background questions were excluded prior to analysis. The final dataset comprises 68 valid responses, collected across manufacturing, aerospace, automotive, defense, telecommunications, and software sectors, as detailed in Chapter 4.

3.5 Data Extraction and Data Preparation

Raw responses were exported from Google Forms as a structured spreadsheet, producing a unified file of 68 rows and 44 variables. A dedicated tab in the analysis workbook records each preparation decision, so the complete provenance chain from raw export to analysis-ready file remains auditable and replicable.

Obstacle severity items used labeled response options (e.g., *1 (Very low)*, *4 (High)*) stored as

character strings in a subset of records. All obstacle columns were normalized to numeric values by extracting the leading digit from string entries, which preserves the ordinal meaning of the original response while enabling arithmetic computation. Importance and feasibility items were integer-coded throughout and required no additional transformation.

The industry and project-type fields allowed free-text input in addition to predefined categories, producing responses that required manual harmonization before subgroup analysis. Each non-standard entry was reviewed individually and mapped to a standardized category following a decision rule documented in the dedicated preparation tab; for example, *Heating, ventilation and air conditioning* was reclassified as *Industrial / HVAC / Equipment*, *Oil & Gas* as *Energy / Utilities*, and mixed-industry entries with a clear primary affiliation were assigned to that primary category. One respondent listed *Community Operations* alongside *Automotive*: the entry was classified under *Automotive* as the primary sector, with a note that community operations likely refers to an internal business function rather than a separate industry vertical. Project-type responses combining multiple predefined categories were assigned to a *Mixed / Multiple* category when no single type was dominant. Table 3.4 summarizes the principal harmonization decisions applied during preparation.

Original free-text entry	Harmonized category	Decision rule
Heating, ventilation and air conditioning	Industrial / HVAC / Equipment	Sector inference
Oil & Gas	Energy / Utilities	Sector mapping
Insurance	Financial Services / Insurance	Sector mapping
Consultancy	Consulting / Professional Services	Activity-based
Luxury / Luxury (trailing space)	Luxury / Fashion	Deduplication
Consumer goods	Retail / Consumer Goods	Sector mapping
Software Products	Software	Subsector merge
Automotive, Community Operations	Automotive	Primary sector rule
Construction / Civil, Defense	Construction / Civil Engineering	Primary sector rule

Table 3.4: Industry harmonization decisions applied during data preparation.

Derived categorical variables were computed from continuous fields to support group-level comparisons. Work experience was binned into four groups (0-5, 6-10, 11-20, and 20+ years) following thresholds commonly used in practitioner surveys (Dikert et al., 2016). Age was similarly binned (under 30, 30-39, 40-49, and 50+) using a label that avoids Excel's operator-parsing ambiguity (*Under 30* instead of <30). Project type and industry were assigned using the harmonized classification described above. All derived variables are stored in dedicated helper columns appended to the right of the main dataset, keeping raw and derived fields visually and logically separated.

Industry-weighted means were computed to correct for the overrepresentation of the Aerospace/Maritime sector, which accounts for approximately 51% of the sample. Each respondent was assigned a weight equal to the inverse of their industry's sample count, normalized so that the sum of weights equals $n = 68$:

$$w_i = \frac{1}{n_{\text{industry}}}, \quad (3.1)$$

where w_i denotes the weight assigned to respondent i and n_{industry} is the number of respondents belonging to the same industry sector. This post-stratification approach gives each represented industry equal aggregate influence on mean scores, consistent with survey weighting practice (Kish, 1965; Valliant & Dever, 2018). Weighted and unweighted means are reported in parallel in the Results chapter, allowing the reader to assess the sensitivity of findings to this correction.

A weighted gap metric was computed for each principle to complement the simple difference score:

$$\Delta' = (I - F) \times I, \quad (3.2)$$

where I denotes the mean importance score and F denotes the mean feasibility score for a given principle. This measure amplifies gaps that occur on high-importance principles, reflecting the intuition that a feasibility shortfall is more consequential when the principle at stake is considered highly valuable. The formulation is consistent with the Importance-Performance Analysis approach introduced by Martilla & James (1977), in which performance deficits are penalized in proportion to the stated importance of the attribute.

A methodological note is warranted on the treatment of the Likert-type ratings as interval-level data for the purpose of computing means, gaps, and ANOVA. Likert responses are strictly ordinal, and equal spacing between adjacent categories cannot be assumed a priori (Likert,

1932). This study nonetheless computes arithmetic means and applies parametric comparisons, following the established convention that five-point scales with balanced and clearly labeled categories can be treated as approximately interval when the analytical goal is comparison rather than precise measurement (Field, 2013). The risk introduced by this assumption is mitigated by reporting medians and interquartile ranges alongside the means, so that the central tendency and the dispersion of each item can be judged without relying solely on the interval interpretation.

One-way analysis of variance (ANOVA) was applied to test whether mean importance, feasibility, and obstacle scores differ significantly across work experience groups, project types, and Agile familiarity levels. The test statistic F and the associated p -value were computed using `scipy.stats.f_oneway` in Python. Effect size was quantified using eta-squared:

$$\eta^2 = \frac{SS_{\text{between}}}{SS_{\text{total}}}, \quad (3.3)$$

where SS_{between} is the sum of squares between groups and SS_{total} is the total sum of squares. Thresholds of 0.01 (small), 0.06 (medium), and 0.14 (large) follow Cohen (1988). A significance threshold of $\alpha = 0.05$ was applied across all tests; results are reported with explicit p -values and effect sizes to support transparent interpretation. Post-hoc comparisons were not computed within this study but are recommended in future work where ANOVA yields significant results, as they would identify which specific group pairs drive the observed differences.

All data preparation and analysis steps were implemented in Python using the `pandas`, `numpy`, `scipy`, and `openpyxl` libraries. A dedicated script (`anova_analysis.py`) reads the combined dataset directly from the DATA tab of the analysis workbook, recomputes all derived variables and test statistics, and writes the results back to a dedicated worksheet. This end-to-end pipeline ensures full reproducibility: any update to the raw response file propagates automatically to all summary tables, gap metrics, and ANOVA outputs upon re-execution of the script.

The analytical strategy combines descriptive gap analysis with one-way ANOVA rather than multivariate modeling, and this choice follows directly from the exploratory objective and the size of the sample. With 68 respondents distributed across several unequal subgroups, regression or structural-equation models would have been over-parameterized and would have produced unstable coefficients that could not be interpreted with confidence. One-way ANOVA, by contrast, answers the precise question the research design poses, whether perceptions differ systematically across well-defined practitioner groups, while remaining robust and transparent

at this sample size (Field, 2013). Reporting effect sizes alongside significance values further ensures that the magnitude of any group difference can be judged independently of the sample size, which is the dimension most likely to constrain statistical power in a study of this scale.

3.6 Methodological Limitations

The sample was assembled through purposive and convenience-based recruitment rather than probability sampling, which limits the ability to make formal statistical inferences about a well-defined population. Professionals who engage with Agile communities on LinkedIn, respond to academic outreach, or have direct institutional contacts with the research team may differ systematically from the broader population of practitioners in systems-intensive industries. Results should therefore be interpreted as characterizing the perceptions of an informed, self-selected segment of the practitioner community rather than as representative estimates of sector-wide views.

One industry sector, Aerospace/Maritime, accounts for approximately 51% of the combined sample. This concentration limits the statistical power of cross-industry comparisons and means that unweighted means are substantially influenced by aerospace practitioners' perceptions. Industry-weighted means are reported alongside unweighted figures to mitigate this limitation, but the correction does not substitute for a more balanced industry distribution. Future studies should explicitly stratify recruitment to achieve broader sector coverage.

All constructs (importance, feasibility, obstacle severity, methodology orientation, and Agile familiarity) were collected through self-report from the same respondents using the same online form, which introduces the risk of common method bias (Podsakoff et al., 2003). Respondents may have been inclined to report higher importance scores for Agile principles than their actual operational judgments would warrant, particularly given that the survey was visibly positioned as an Agile research instrument. A temporal or procedural separation between importance and feasibility measurement, as well as the inclusion of objective performance indicators, could reduce this bias in future replications.

The cross-sectional design provides a snapshot of current perceptions but cannot capture how importance-feasibility gaps evolve over time as organizations mature their Agile practices. A longitudinal study or a repeated cross-section would be required to assess whether observed gaps narrow, widen, or shift across principles as adoption progresses. This constraint is inherent

in any one-round survey design and is acknowledged as a boundary condition of the findings.

The one-way ANOVA tests were applied across subgroups of unequal and sometimes small size, which reduces statistical power and the ability to detect true differences. Normality assumptions cannot be formally verified for small groups, though ANOVA is generally considered robust to moderate violations when sample sizes are balanced (Field, 2013). All reported ANOVA results include explicit p -values and effect sizes (η^2) so that readers can assess the practical significance of findings independently of the significance threshold. Post-hoc pairwise tests were not performed because the primary research objective is exploratory, and the sample size does not support the correction overhead required for multiple comparisons.

The study does not include objective measures of organizational maturity, project performance, or compliance requirements, relying instead on self-reported categorical descriptors. Respondents' assessments of feasibility may therefore reflect individual perceptions shaped by local experience rather than objective operating conditions. Richer organizational-level data, such as maturity assessment scores or regulatory classification, would strengthen causal interpretability in future research.

#	Phase	Activities	Output
1	Survey design	Instrument construction from Agile Manifesto principles and PRISMA-derived obstacles; 5-point Likert scale selection	Google Forms questionnaire
2	Data collection	Multi-channel distribution (LinkedIn, email outreach, university networks); 10-week window	68 valid responses
3	Data preparation	Text normalization, free-text harmonization, derived variables (Exp_Bin, Age_Bin, Project_Cat)	Unified dataset, 68 rows
4	Descriptive analysis	Means, medians, IQR, frequency tables; importance-feasibility gap (Δ , Δ'); quadrant matrix	Tables in Ch. 4
5	Industry weighting	Inverse-frequency weights per sector; weighted means vs. unweighted	Sensitivity check
6	ANOVA	One-way tests across experience, project type, Agile familiarity; F-statistic, p -value, η^2	6 significant results
7	Interpretation	Findings mapped to RQ1-RQ3; IPA quadrant framing; TOE classification	Ch. 5 discussion

Table 3.5: Research design pipeline.

Chapter 4

Results

This chapter reports the empirical results of the cross-sectional survey described in Chapter 3. The presentation follows the structure of the research questions: Section 4.1 describes the sample; Section 4.2 reports importance and feasibility scores for the twelve Agile principles and the corresponding gap analysis; Section 4.4 reports perceived obstacle severity; and Section 4.6 synthesizes the main patterns. All figures are based on a final sample of $n = 68$ valid responses. Unless otherwise stated, values are unweighted means on a 1-5 scale.

4.1 Sample Characteristics

The final sample comprises 68 respondents drawn from systems-intensive and related engineering sectors. Respondents are distributed across experience levels, industries, project types, and organizational sizes, providing variation along all dimensions used in the subgroup analyses. Table 4.1 summarizes the main socio-demographic and professional characteristics of the sample.

Variable	Category	<i>n</i>	%
Age group	Under 30	21	30.9
	30-39	18	26.5
	40-49	16	23.5
	50+	13	19.1
Work experience (total)	0-5 years	24	35.3
	6-10 years	11	16.2
	11-20 years	15	22.1
	20+ years	18	26.5
Education level	Master's degree	55	80.9
	Bachelor's degree	9	13.2
	Doctoral degree	3	4.4
	Postgraduate diploma	1	1.5
Agile familiarity (1-5)	1: Very low	1	1.5
	2	1	1.5
	3	22	32.4
	4	32	47.1
	5: Expert	12	17.6
Project type	Cyber-physical (HW+SW)	23	33.8
	Hardware-intensive	17	25.0
	Software-intensive	15	22.1
	Mixed / Multiple	8	11.8
	Systems integration	5	7.4
Industry (top four)	Aerospace / Maritime	35	51.5
	Automotive	7	10.3
	Software	6	8.8
	Other sectors	20	29.4

Table 4.1: Sample profile (n = 68).

The mean respondent age is 38.5 years ($SD = 12.3$; range 23-70), and the mean total professional experience is 14.4 years ($SD = 12.6$). Mean tenure within the current organization is 7.7 years ($SD = 8.0$). The distribution across experience groups is broadly balanced: the largest group is early-career respondents with 0-5 years of experience (35.3%), followed by senior respondents with more than 20 years (26.5%).

The sample is highly educated: 80.9% hold a Master's degree and a further 4.4% hold a Doctoral degree, reflecting the academic and engineering background typical of systems-intensive organizations and of recruitment channels that included university networks.

Self-reported Agile familiarity is concentrated at levels 3 and 4, with a combined share of 79.4% of the sample (mean = 3.78, $SD = 0.81$). Only two respondents (2.9%) report minimal familiarity (levels 1-2), while 12 (17.6%) rate themselves as highly expert (level 5). This distribution indicates that the majority of respondents have meaningful, direct exposure to Agile principles and are therefore well-positioned to provide informed feasibility judgments.

The Aerospace/Maritime sector is the most represented with 35 respondents (51.5%), followed by Automotive (10.3%) and Software (8.8%). This concentration is expected given the recruitment channels and the survey focus on systems-intensive industries; industry-weighted means are reported alongside unweighted values in the following sections to account for it. In terms of project type, nearly one-third of respondents (33.8%) work on integrated hardware-software (cyber-physical) projects, followed by hardware-intensive (25.0%) and software-intensive (22.1%) contexts.

Half of the respondents (50.0%) belong to organizations with 1,000-4,999 employees, consistent with medium-to-large engineering companies typical of aerospace and automotive supply chains. On the methodology orientation continuum, respondents rate their current practice at a mean of 2.84 (on a 1=Predictive, 5=Agile scale), while the mean perceived ideal approach is 3.56, a gap of +0.72 toward more Agile practices. Among the 68 respondents, 61 (89.7%) prefer a score of 3 or higher as the ideal, with scores 3 and 4 together accounting for 76.5% of all responses. Figure 4.1 shows the full distribution of current and preferred orientation scores.

The distribution of ideal PM scores is notably concentrated at 3 (Hybrid, $n = 26$, 38.2%) and 4 ($n = 26$, 38.2%), with only 9 respondents (13.2%) selecting 5 (Fully Agile). This distribution rejects both the fully predictive and the fully Agile extremes: respondents do not aspire to full Agile adoption, but clearly seek greater adaptability than their current practice affords. The pattern is consistent with the hybridization literature (Conforto et al., 2014; Hobbs & Petit, 2017)

and suggests that practitioners in systems-intensive settings have already converged on hybrid as the perceived optimum. The operative implication is that transformation targets in these sectors should be set at hybrid rather than fully Agile levels, a point developed further in Chapter 5.

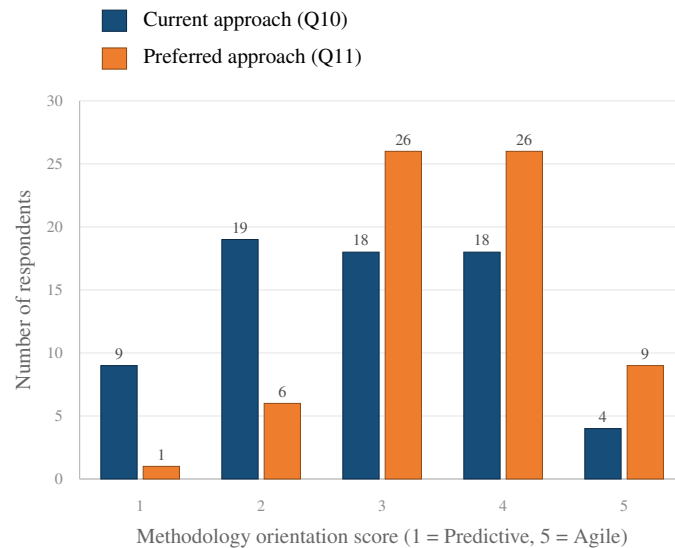


Figure 4.1: Distribution of current (Q10) and preferred (Q11) project management orientation scores across the 68 respondents. The current approach has a mean of 2.84 and the preferred approach a mean of 3.56, a shift of +0.72 toward greater adaptability. Both distributions reject the fully predictive and fully Agile extremes and concentrate on hybrid positions.

4.2 Importance and Feasibility of Agile Principles

Table 4.2 reports the mean importance score, mean feasibility score, simple gap ($\Delta = I - F$), and weighted gap ($\Delta' = \Delta \times I$) for each of the twelve Agile Manifesto principles. Across all principles, importance consistently exceeds feasibility, yielding a positive gap for every item. The mean importance across all principles is 3.884 and the mean feasibility is 3.188, producing a sample-level mean gap of 0.696.

Principle	Imp.	Imp. ^w	Feas.	Feas. ^w	Δ	Δ'	Rank Δ'
P1: Customer delivery	4.13	4.07	3.19	3.26	0.94	3.89	2
P2: Welcome change	3.96	3.93	2.88	2.96	1.07	4.25	1
P3: Frequent delivery	3.63	3.70	3.06	3.31	0.57	2.08	11
P4: Biz-dev collab.	3.85	3.89	3.24	3.39	0.62	2.38	8
P5: Motivated indiv.	4.29	4.22	3.51	3.60	0.78	3.35	3
P6: Face-to-face comm.	3.91	4.06	3.34	3.40	0.57	2.24	9
P7: Working software	3.50	3.72	3.18	3.39	0.32	1.13	12
P8: Sustainable dev.	3.71	3.65	2.91	2.96	0.79	2.94	5
P9: Tech. excellence	4.09	4.18	3.47	3.57	0.62	2.53	7
P10: Simplicity	3.91	3.93	3.22	3.36	0.69	2.70	6
P11: Self-organizing	3.43	3.51	2.79	2.92	0.63	2.17	10
P12: Regular reflection	4.19	4.13	3.46	3.53	0.74	3.08	4
Mean	3.88		3.19		0.70	2.73	

Table 4.2: Mean importance, feasibility, Δ , and weighted Δ' for each Agile principle.

Figure 4.2 visualizes the importance-feasibility gap for every principle, ordered from the widest to the narrowest.

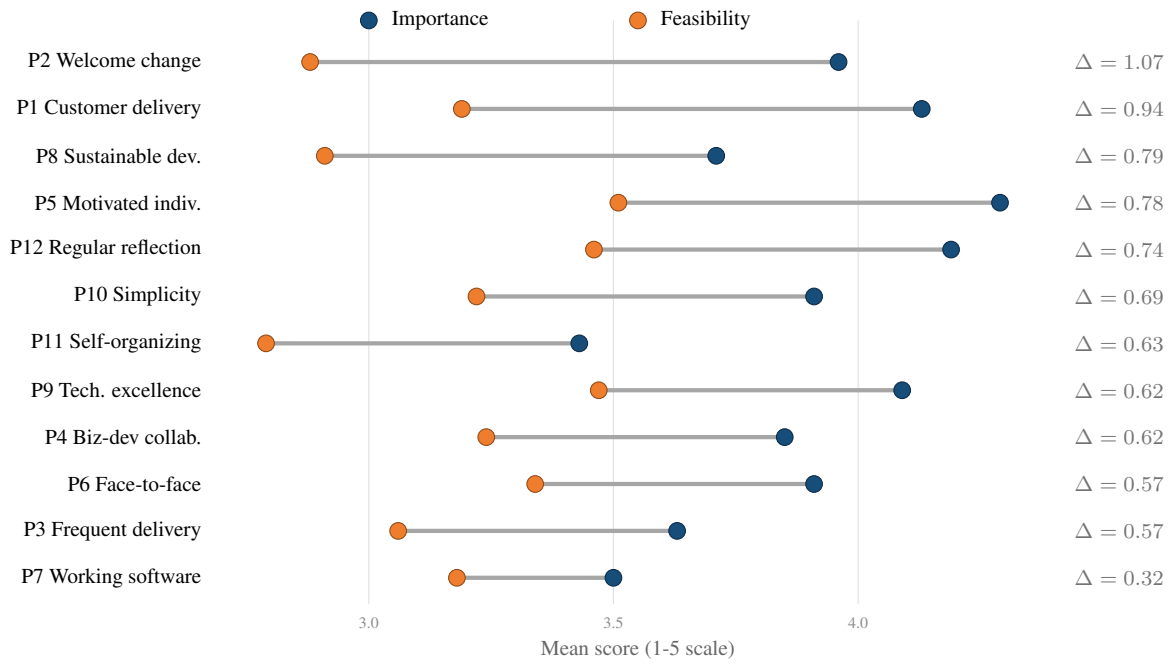


Figure 4.2: Mean importance and feasibility for each Agile principle, ordered by the importance-feasibility gap Δ . Every principle is rated more important than feasible.

Before examining the gaps, it is useful to consider the dispersion of scores. The interquartile ranges (IQR) for importance scores are generally narrow, most principles have $IQR = 1$, indicating relatively broad consensus on what is considered important. By contrast, feasibility IQRs are wider ($IQR = 2$ for P2, P4, P5, P8, P11), signaling greater disagreement among respondents about what is achievable in practice. This asymmetry is theoretically informative: practitioners broadly agree on the value of Agile principles but disagree substantially on their enactability, suggesting that perceived feasibility is more context-sensitive than perceived importance. The IQR pattern is consistent with the view that feasibility is shaped by local governance, team structure, and contractual conditions that vary across organizations, while importance reflects a more widely shared professional judgment.

P2 (Welcome changing requirements) shows the largest simple gap ($\Delta = 1.07$) and the largest weighted gap ($\Delta' = 4.25$), making it the principle with the most severe theory-practice misalignment. Feasibility for P2 (mean = 2.88, Mdn = 3, $IQR = 2$) is the second lowest in the dataset, while its importance rating (mean = 3.96) places it above the sample average, reflecting that practitioners value adaptability in principle but find it particularly difficult to enact under long planning cycles and contractual constraints typical of systems-intensive projects. P1 (Customer delivery, $\Delta' = 3.89$) and P5 (Motivated individuals, $\Delta' = 3.35$) rank second and

third on the weighted metric, confirming that the most strategically critical gaps are concentrated on relational and adaptive principles.

P7 (Working software as primary measure of progress) produces the smallest gap in both metrics ($\Delta = 0.32$, $\Delta' = 1.13$). This result does not indicate strong alignment between theory and practice; rather, it reflects that both importance (mean = 3.50) and feasibility (mean = 3.18) are among the lowest in the dataset, suggesting that this principle is perceived as less central in hardware-intensive and cyber-physical contexts where progress metrics extend beyond software delivery alone. P3 (Frequent delivery) and P6 (Face-to-face communication) also show small gaps ($\Delta = 0.57$ each), though for different reasons: frequent delivery is rated moderately on both dimensions, while face-to-face communication is considered important but adapted to dispersed team realities.

Figure 4.6 maps each principle onto an importance-feasibility quadrant defined by the sample averages (mean importance = 3.88; mean feasibility = 3.19) as threshold lines. Six principles fall in the *Leverage* quadrant (high importance, high feasibility): P1, P5, P6, P9, P10, and P12. One principle, P2, occupies the *Challenge* quadrant (high importance, low feasibility), confirming it as the single most critical gap. One principle (P4) falls in *Quick Win* (low importance, high feasibility), while four (P3, P7, P8, and P11) fall in *Low Priority* (low importance, low feasibility).

Industry-weighted means are generally close to their unweighted counterparts, suggesting that the dominance of Aerospace/Maritime respondents does not materially distort the overall pattern. The largest divergence appears on P8 (Sustainable development): the unweighted gap is 0.79 but the industry-weighted gap narrows to 0.44, indicating that the aerospace subsample perceives this principle as slightly more feasible than the remaining industries do. P2 remains the highest-gap principle under both weighting schemes ($\Delta_{uw} = 1.07$, $\Delta_w = 0.98$), confirming the robustness of this finding.

4.3 ANOVA: Variation in Principle Scores Across Subgroups

One-way ANOVA tests were used to examine whether mean scores for importance, feasibility, and obstacle severity differ significantly across three grouping variables: work experience (four bins), project type (five categories), and Agile familiarity level (1-5 scale). In total, 68 separate ANOVA tests were conducted across these combinations. The full p-value heatmap and effect

size matrix are reported in the analysis workbook (Sheet E. ANOVA Visualization); this section presents and interprets the six statistically significant results ($p < .05$) in detail. The general non-significance of most tests is itself a finding, discussed at the end of this section.

Table 4.3 summarizes all six significant results, providing F-statistics, p-values, and effect sizes to allow direct comparison across analyses.

Item	Grouping variable	F	p	η^2	Effect size
P5: Motivated individuals	Work experience	3.02	.036*	0.124	Medium-large
P3: Frequent delivery	Agile familiarity	4.56	.014*	0.126	Medium-large
P7: Working software	Agile familiarity	6.00	.004**	0.159	Large
P11: Self-organizing teams	Agile familiarity	4.74	.012*	0.126	Medium-large
O2: Lack of leadership	Project type	2.69	.039*	0.146	Large
O7: Dispersed teams	Project type	3.10	.022*	0.164	Large

Table 4.3: Statistically significant ANOVA results ($p < .05$). Effect sizes follow Cohen (1988).

P5 (Motivated individuals) $\times$ Work experience. Importance scores for P5 differ significantly across work experience groups ($F(3, 64) = 3.02, p = .036, \eta^2 = 0.124$). The group means are: 0-5 years = 3.83 ($n = 24$); 6-10 years = 4.09 ($n = 11$); 11-20 years = 4.33 ($n = 15$); 20+ years = 4.67 ($n = 18$). The monotonically increasing pattern, where every additional experience group assigns higher importance to motivation, is theoretically significant. It suggests that the appreciation of intrinsic motivation as a productivity driver is not innate but experiential: practitioners who have observed teams across multiple project cycles and organizational contexts develop a stronger conviction that motivated individuals outperform those working under directive management. This finding is consistent with self-determination theory (Dybå & Dingsøyr, 2008) and with the practitioner literature on high-performance Agile teams, where autonomy and intrinsic motivation are repeatedly identified as key performance differentiators. The implication for organizations is that senior practitioners and team leads, who score motivation highest, may be more effective advocates for creating psychologically safe and autonomous working environments than management hierarchies that have not experienced the performance difference first-hand.

P3, P7, and P11 $\times$ Agile familiarity. Three principles show significant variation across

Agile familiarity levels, all in the same direction: importance scores rise as familiarity increases. P7 (Working software as primary measure of progress) shows the largest effect ($F(4, 63) = 6.00, p = .004, \eta^2 = 0.159$), with group means of 4.00 (Fam=1), 3.00 (Fam=2), 2.86 (Fam=3), 3.78 (Fam=4), and 3.92 (Fam=5). The non-monotonic pattern at levels 2 and 3 reflects small group sizes (Fam=1: $n = 1$; Fam=2: $n = 1$) that introduce instability at the extremes, but the overall trend from low-familiarity to high-familiarity groups is clearly upward. P3 (Frequent delivery) and P11 (Self-organizing teams) show the same directional pattern with effect sizes of $\eta^2 = 0.126$ for both. These three principles share a common characteristic: they are the principles that most directly challenge traditional engineering conventions. Frequent delivery conflicts with milestone-based scheduling; working software as a metric conflicts with stage-gate progress indicators; self-organizing teams conflict with hierarchical project governance. The fact that only practitioners with higher Agile familiarity recognize the importance of these principles suggests that their value is not self-evident to practitioners operating primarily within predictive frameworks. Structured Agile exposure, through training, pilot projects, or cross-functional collaboration with software-native Agile teams, appears to be a necessary precondition for these principles to be recognized as relevant rather than disruptive.

Table 4.4 reports the group means by familiarity level that underlie this pattern. Read across the five levels, the three principles whose perceived importance grows with familiarity are precisely those tied to iterative delivery and team autonomy, which points to internalization through exposure rather than to an intrinsic property of the principles themselves.

Principle	F	p	η^2	Fam=1	Fam=2	Fam=3	Fam=4	Fam=5
P3: Frequent delivery	4.56	.014*	0.126	3.00	3.00	3.09	3.88	4.08
P7: Working software	6.00	.004**	0.159	4.00	3.00	2.86	3.78	3.92
P11: Self-organizing	4.74	.012*	0.126	2.00	4.00	2.95	3.59	3.92

Table 4.4: ANOVA results for principles with significant variation by Agile familiarity level.

Figure 4.3 plots the corresponding trend in perceived importance across familiarity levels.

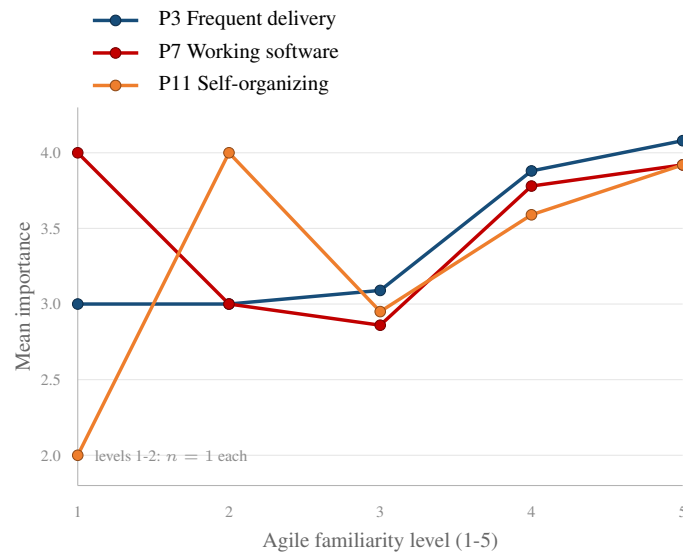


Figure 4.3: Mean importance assigned to P3, P7, and P11 across Agile familiarity levels. Perceived importance rises with familiarity for all three principles (small groups at levels 1-2).

4.4 Perceived Severity of Development Obstacles

Table 4.5 reports the mean threat score, median, interquartile range, and percentage of respondents who rated each obstacle at 4 or 5 (High or Very High threat) for the seven obstacles identified in Section 3.2.2. Obstacle scores are generally concentrated in the 2.7-3.5 range, with no obstacle approaching the maximum of 5, indicating a pattern of moderate-to-high perceived threat rather than extreme ratings.

#	Obstacle	Mean	Mdn	IQR	% ≥ 4	TOE
1	Rigid culture & resistance to change	3.47	4	1	54.4%	Org.
2	Lack of leadership support	3.12	3	2	38.2%	Org.
3	Bureaucratic governance & heavy processes	3.29	3	1	45.6%	Env.
4	High system complexity	2.88	3	2	27.9%	Tech.
5	Insufficient Agile knowledge & training	3.00	3	2	26.5%	Org.
6	Coordination difficulties	3.28	3	2	45.6%	Org.
7	Geographically dispersed teams	2.68	3	1	25.0%	Org.
Mean across all obstacles		3.10				

Table 4.5: Perceived severity of the seven development obstacles (n = 68) and TOE classification.

Figure 4.4 presents these severities ranked and grouped by their Technology-Organization-Environment dimension.

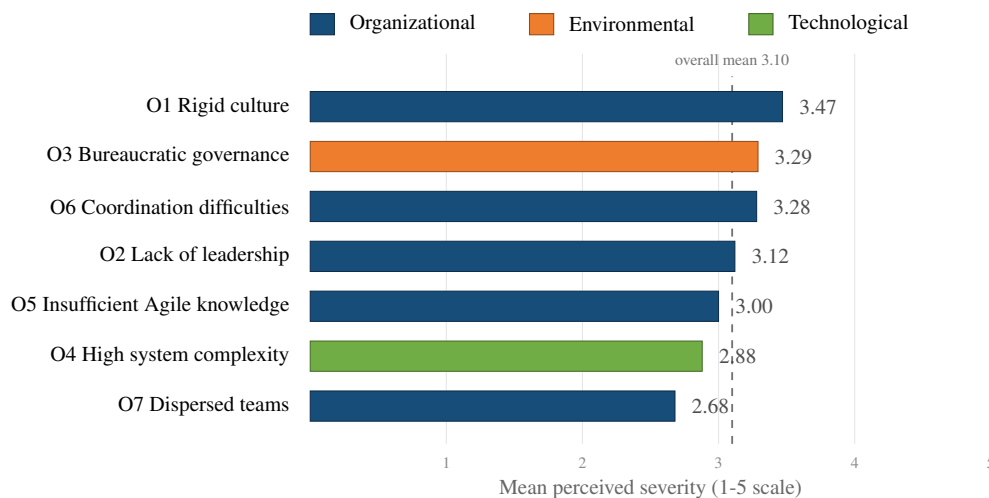


Figure 4.4: Mean perceived severity of the seven development obstacles, ranked and colored by Technology-Organization-Environment dimension. Organizational and environmental barriers dominate over the single technological one.

The Technology-Organization-Environment (TOE) framework (Tornatzky et al., 1990) provides a useful lens for interpreting the obstacle rankings. In TOE terms, the technology dimension covers factors intrinsic to the Agile method itself and to its technical implementation; the organization dimension covers structural, cultural, and managerial factors; and the environ-

ment dimension covers external governance, regulatory, and institutional factors. Of the seven obstacles included in the survey, five belong to the organization or environment dimensions (rigid culture, lack of leadership, bureaucratic governance, insufficient knowledge, and coordination difficulties), while only one is primarily technological (high system complexity). Dispersed teams can be classified under either the organization or environment dimension depending on whether they reflect a deliberate organizational design or an externally imposed constraint. The concentration of high-severity scores in the organizational and environmental dimensions, with mean scores consistently above those for system complexity, suggests that Agile discontinuity in systems-intensive industries is driven primarily by structural and cultural barriers rather than by the technical demands of system integration.

Rigid organizational culture and resistance to change is the most severe perceived obstacle (mean = 3.47, Mdn = 4, IQR = 1), and the only item for which more than half of respondents (54.4%) assign a rating of 4 or above. Bureaucratic governance and heavy processes (mean = 3.29) and coordination difficulties in scaled Agile (mean = 3.28) rank second and third, both with 45.6% of respondents rating them at High or Very High severity. All three belong to the organizational and environmental dimensions of the TOE framework, suggesting that the primary barriers to Agile adoption in systems-intensive settings are governance and cultural constraints rather than purely technical ones.

High system complexity (mean = 2.88) and geographically dispersed teams (mean = 2.68) receive the lowest scores, with fewer than 28% of respondents rating them at High or Very High. The relatively moderate rating of system complexity is notable given the profile of the sample: respondents working on hardware-intensive and cyber-physical projects might be expected to rate technical complexity more severely, yet organizational factors consistently dominate their responses. The low score for dispersed teams (IQR = 1, reflecting low variability) suggests broad agreement that this obstacle is present but manageable, at least for the majority of the sample.

One-way ANOVA tests were also conducted on obstacle severity scores across work experience groups and project types. No significant variation was found across experience groups for any of the seven obstacles, confirming that perceived severity of organizational barriers is independent of how long practitioners have been working: junior and senior practitioners agree on which barriers are most problematic. By contrast, two significant results emerge from the project-type analysis, both with large effect sizes.

O2 (Lack of leadership support) $\times$ Project type. The ANOVA yields $F(4, 63) = 2.69$, $p = .039$, $\eta^2 = 0.146$ (large effect). Group means are reported in Table 4.6. The range of means spans from 2.40 (Systems integration, $n = 5$) to 4.25 (Mixed/Multiple, $n = 8$), a difference of 1.85 points on the 1-5 scale. This is a substantively large difference: practitioners managing mixed or multiple project types perceive the absence of leadership support as nearly a full scale point more severe than any other group. The interpretation is structurally plausible: when a practitioner must simultaneously manage across project types with different governance logics, delivery cadences, and stakeholder expectations, the absence of leadership direction creates a vacuum that cannot be filled by cross-project coordination alone. Leadership support functions as a source of priority arbitration and resource allocation authority; its absence is disproportionately felt in mixed-portfolio contexts where competing demands are highest. By contrast, hardware-intensive (2.82) and systems integration (2.40) practitioners (who operate within more established and structured governance frameworks) may have clearer escalation paths and decision authority, reducing their dependence on active management support for Agile adoption.

O7 (Geographically dispersed teams) $\times$ Project type. The ANOVA yields $F(4, 63) = 3.10$, $p = .022$, $\eta^2 = 0.164$ (large effect). Group means range from 1.80 (Systems integration, $n = 5$) to 3.17 (Cyber-physical, $n = 23$) and 3.12 (Mixed/Multiple, $n = 8$). The concentration of high scores among cyber-physical and mixed-context practitioners is consistent with the nature of these project types: integrated hardware-software development typically requires co-design across mechanical, electrical, embedded software, and systems engineering disciplines, which are frequently distributed across multiple sites, departments, or supplier organizations. The low score for systems integration practitioners (1.80) is initially counterintuitive, since systems integration also involves multi-team coordination; however, systems integration projects often operate under well-defined interface specifications and integration protocols that reduce the need for continuous face-to-face collaboration, partially insulating them from the coordination overhead that dispersed teams impose on Agile's communication-intensive working style.

Obstacle	HW-int. (n=17)	SW-int. (n=15)	Cyber-phys. (n=23)	Sys. int. (n=5)	Mixed (n=8)
O2: Lack of leadership support	2.82	2.93	3.22	2.40	4.25
O7: Dispersed teams	2.53	2.13	3.17	1.80	3.12

Table 4.6: Group means for O2 and O7 by project type (significant ANOVA results).

Figure 4.5 provides a visual comparison of the group means for the two significant obstacle findings.

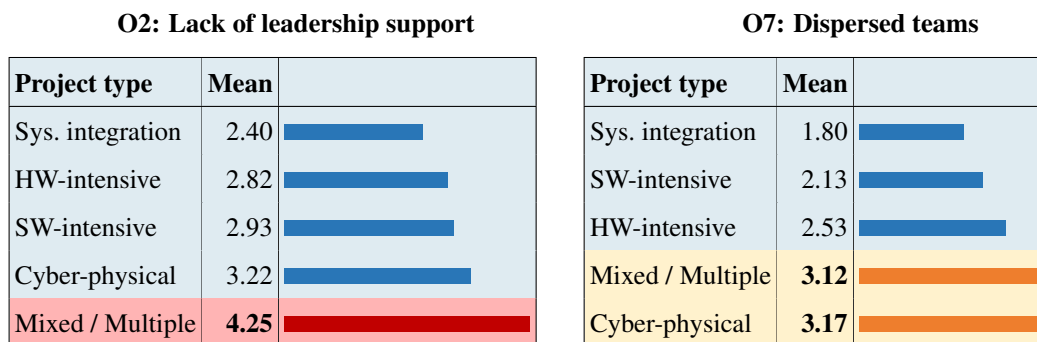


Figure 4.5: Group means for O2 and O7 by project type (sorted ascending).

Interpreting the non-significant results. The overwhelming majority of ANOVA tests (62 out of 68) are non-significant. This result is not a null finding in the conventional sense; it carries substantive theoretical content. It means that the importance-feasibility gap structure documented in Section 4.2 is consistent across experience levels, project types, and Agile familiarity groups for all but a handful of principles. Practitioners with two years of experience and those with twenty years agree on the ranking of principles; hardware-intensive and software-intensive practitioners agree on which obstacles are most severe; low-familiarity and high-familiarity respondents agree on the importance of the majority of Agile principles. This homogeneity strengthens the generalizability of the study's main findings: the theory-practice gap is not an artifact of a particular subgroup's perspective but a broadly shared perception across the systems-intensive practitioner community. The six significant results, in this context, identify specific conditions under which individual variation does occur and where targeted organizational intervention may therefore be most effective.

4.5 Instrument Reliability

The internal consistency of the three multi-item rating blocks was assessed with Cronbach's alpha, following the reliability procedure introduced in Section 3.3. Table 4.7 reports the alpha coefficient and the number of items for each block. The importance block ($\alpha = 0.854$) and the feasibility block ($\alpha = 0.873$) both reach good internal consistency, while the obstacle-severity block ($\alpha = 0.760$) reaches acceptable consistency. These values confirm that the items within each block measure a coherent underlying construct, which supports the use of block-level means and the comparisons reported in the preceding sections. The slightly lower coefficient for obstacle severity is expected, because that block deliberately spans distinct organizational, environmental, and technological barriers rather than a single homogeneous dimension.

Rating block	Items	Cronbach's α	Interpretation
Agile principle importance	12	0.854	Good
Agile principle feasibility	12	0.873	Good
Obstacle severity	7	0.760	Acceptable

Table 4.7: Internal consistency (Cronbach's alpha) of the three multi-item rating blocks (n = 68).

4.6 Summary: Ranking of Gaps and Key Patterns

Table 4.8 synthesizes the main results by ranking all twelve principles by weighted gap Δ' and indicating quadrant assignment and ANOVA significance. Three consistent patterns emerge from the data.

Rank	Principle	Imp.	Feas.	Δ'	Quadrant
1	P2: Welcome change	3.96	2.88	4.25	(!) Challenge
2	P1: Customer delivery	4.13	3.19	3.89	★ Leverage
3	P5: Motivated individuals	4.29	3.51	3.35	★ Leverage
4	P12: Regular reflection	4.19	3.46	3.08	★ Leverage
5	P8: Sustainable dev.	3.71	2.91	2.94	↓ Low priority
6	P10: Simplicity	3.91	3.22	2.70	★ Leverage
7	P9: Technical excellence	4.09	3.47	2.53	★ Leverage
8	P4: Biz-dev collab.	3.85	3.24	2.38	→ Quick win
9	P6: Face-to-face comm.	3.91	3.34	2.24	★ Leverage
10	P11: Self-organizing	3.43	2.79	2.17	↓ Low priority
11	P3: Frequent delivery	3.63	3.06	2.08	↓ Low priority
12	P7: Working software	3.50	3.18	1.13	↓ Low priority

Table 4.8: Ranking of Agile principles by weighted gap Δ' and quadrant assignment.

The first pattern is universal: every principle shows a positive importance-feasibility gap. No principle reaches parity between perceived importance and perceived feasibility, confirming a systematic theory-practice discontinuity across all twelve normative claims of the Agile Manifesto. This pattern is consistent across unweighted and industry-weighted scores and is not limited to any specific principle cluster.

The second pattern concerns the distribution of gap severity. The three largest weighted gaps belong to principles governing adaptability to change (P2), customer-centricity (P1), and human motivation (P5), all relational and adaptive in nature. These principles are precisely those that require the highest degree of organizational flexibility and stakeholder alignment, conditions that are structurally constrained in systems-intensive environments by requirements traceability, contractual obligations, and review gates. By contrast, the smallest gaps cluster around principles with a more technical character (P7, P3), where hybrid execution approaches can partially satisfy the principle without requiring deep organizational transformation.

The third pattern emerges from the ANOVA analysis: Agile familiarity level is the variable most consistently associated with variation in importance scores, producing significant effects

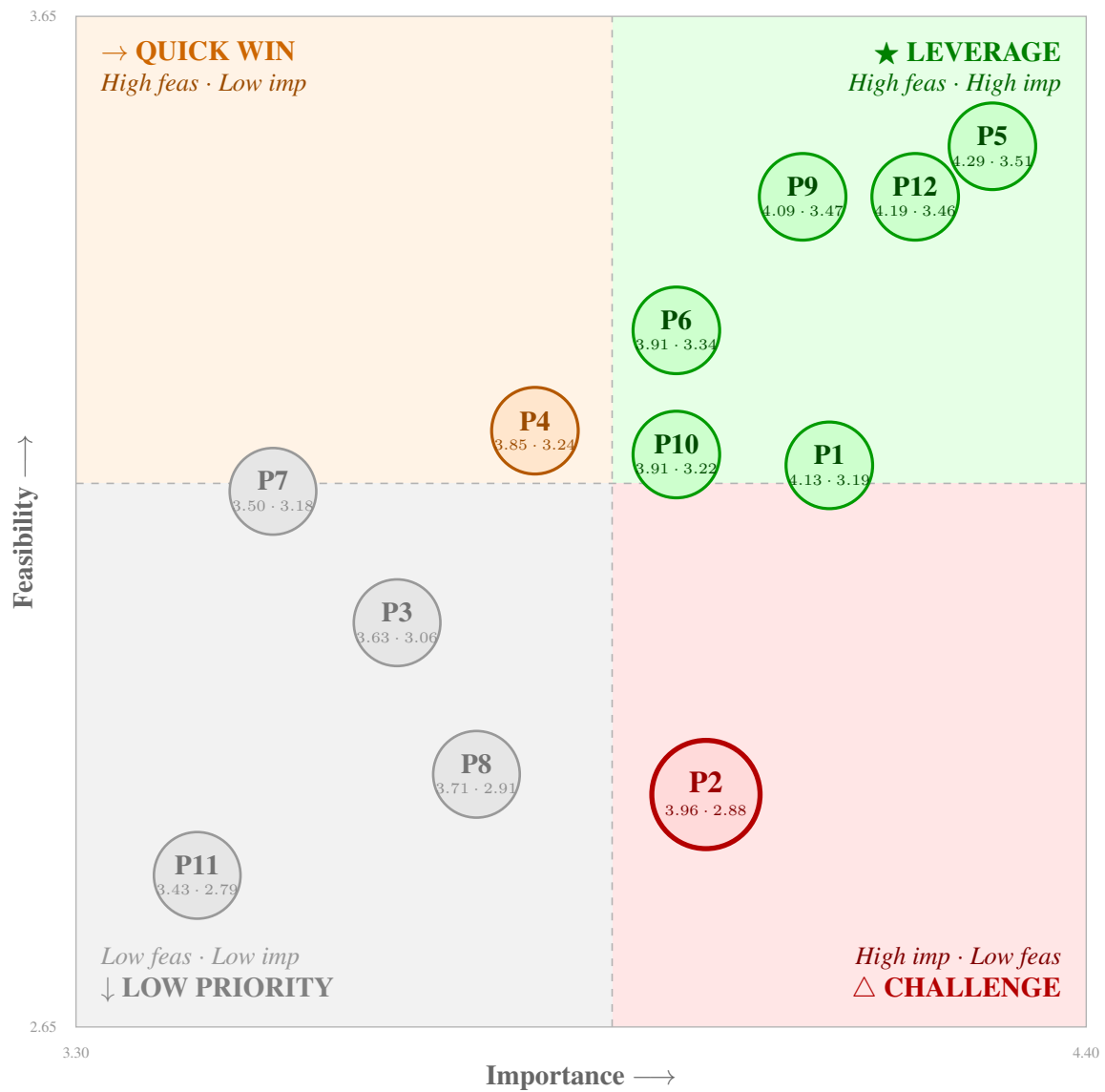


Figure 4.6: Importance-feasibility quadrant map for the twelve Agile principles. Dashed lines mark sample averages. Quadrant labels follow Martilla & James (1977).

on three principles (P3, P7, P11) with medium-to-large effect sizes ($\eta^2 = 0.126$ to 0.159). Work experience explains significant variation only for P5, while project type does not produce significant differences for any principle. For the obstacle domain, project type is the only grouping variable that yields significant effects, with Mixed/Multiple project contexts reporting higher severity for both leadership gaps and dispersed team coordination challenges.

Chapter 5

Discussion

This chapter interprets the results reported in Chapter 4 in light of the theoretical framework developed in Chapter 2 and the three research questions formulated in Chapter 1. Section 5.1 addresses each research question in turn, connecting empirical patterns to the existing literature. Sections 5.2 and 5.3 derive the theoretical and practical implications of the findings.

5.1 Interpretation of Main and Secondary Results

5.1.1 RQ1: Alignment between literature-identified barriers and perceived obstacles

RQ1 asks what problems are associated with Agile implementation in systems-intensive contexts and to what extent they are supported by theoretical versus empirical evidence. The literature review identified four families of barriers: cultural misalignment, insufficient management support, structural incompatibilities, and governance rigidities (Dikert et al., 2016; Mishra et al., 2021; Nerur et al., 2005). The survey data allow these four categories to be tested empirically by examining which obstacles practitioners rate as most severe.

The survey results confirm that organizational culture is the dominant perceived obstacle. Rigid organizational culture and resistance to change obtains the highest mean threat score (3.47) and the highest percentage of respondents rating it at High or Very High severity (54.4%). This finding aligns closely with Nerur et al. (2005) and N. Iivari & J. Iivari (2011), who characterize cultural misalignment as the most pervasive and least tractable barrier to Agile adoption, because cultural change is slow, requires sustained leadership commitment, and cannot be mandated

through process redesign alone.

Bureaucratic governance and heavy processes ranks second (mean = 3.29) and coordination difficulties third (mean = 3.28), both with 45.6% of respondents rating them as High or Very High. These results are consistent with Lappi & Aaltonen (2017) and Baxter et al. (2023), who identify governance rigidities as a structural constraint that is especially difficult to relax in publicly contracted or safety-regulated projects. The co-occurrence of high scores on governance and coordination obstacles suggests that practitioners perceive bureaucratic processes not merely as an administrative burden but also as a direct cause of cross-team alignment failures.

Lack of leadership support receives a mean score of 3.12 but shows the largest variation by project type in the ANOVA analysis ($\eta^2 = 0.146$). Respondents from Mixed/Multiple project contexts rate leadership gaps at a mean of 4.25, substantially above those from systems integration (2.40) and hardware-intensive (2.82) contexts. This pattern is consistent with Hoda et al. (2011) and Dikert et al. (2016), who argue that management support becomes especially critical when teams work across multiple project types and must navigate conflicting governance logics simultaneously. The result suggests that the literature's finding on leadership is correct in direction but insufficiently sensitive to the project-type heterogeneity that characterizes many real organizations.

High system complexity receives the second-lowest obstacle score (mean = 2.88), despite the sample being dominated by aerospace, automotive, and cyber-physical practitioners, contexts where technical interdependencies are objectively high. This result challenges a simplistic reading of the TOE framework (Tornatzky et al., 1990) in which technical barriers are expected to dominate in engineering-intensive settings. Instead, the data suggest that practitioners have largely adapted to system complexity through existing engineering practices and do not perceive it as the primary bottleneck for Agile; it is the organizational and governance context surrounding technical work that generates the most friction.

5.1.2 RQ2: Perceived importance and feasibility of Agile principles

RQ2 asks to what extent Agile principles are perceived as important and feasible by practitioners. The clearest finding is that every one of the twelve Agile Manifesto principles shows a positive importance-feasibility gap, with not a single principle reaching parity between the two dimensions. This universal pattern confirms the existence of a systematic theory-practice discontinuity across the full normative content of Agile in systems-intensive settings, rather

than being concentrated in a subset of principles. The finding extends the evidence base of Serrador & Pinto (2015), who document lower Agile effectiveness in contexts characterized by high complexity and external constraints, by providing principle-level resolution for the source of that underperformance.

P2 (Welcome changing requirements) produces the largest gap on both the simple ($\Delta = 1.07$) and the weighted ($\Delta' = 4.25$) metric, and is the only principle classified in the *Challenge* quadrant (high importance, low feasibility). Its feasibility rating (mean = 2.88) is the second lowest in the dataset, while its importance rating (mean = 3.96) places it above the sample average. Practitioners therefore acknowledge the strategic value of responsiveness to change while simultaneously reporting that it is structurally impractical under the constraints they face. This result echoes Kasauli et al. (2021), who identify change management in large-scale systems as one of the most persistent and difficult tensions in hybrid Agile adoption, and is consistent with the well-documented difficulty of accommodating late requirement changes when hardware, regulatory, and contractual lock-in are present (Fitzgerald et al., 2013).

The finding that six principles are perceived as both important and highly feasible challenges what might be called the incompatibility thesis, the assumption, implicit in some engineering literature, that Agile values are fundamentally at odds with systems-intensive work. This thesis has sometimes been used to justify wholesale rejection of Agile in regulated or hardware-intensive contexts, rather than a principled selection of which elements to preserve. The data show that this dichotomy is too crude: Agile offers a coherent cluster of practices related to technical quality, continuous improvement, and human factors that are not only valued but are also perceived as achievable under the real constraints practitioners face.

Six principles fall in the *Leverage* quadrant (high importance, high feasibility): P1, P5, P6, P9, P10, and P12. Their presence indicates that practitioners do not experience Agile as entirely incompatible with systems-intensive work; rather, a coherent set of principles related to customer orientation (P1), human factors (P5, P6), technical quality (P9), frugality (P10), and continuous improvement (P12) are perceived as both valuable and achievable. This finding qualifies the commonly held view that Agile is fundamentally at odds with complex engineering contexts (Boehm & Turner, 2005): Agile's relational and reflective principles appear significantly more tractable than its delivery cadence and change-absorption principles.

A useful way to read the divide between the *Leverage* and *Challenge* quadrants is in terms of where the locus of control for each principle lies. The principles perceived as both important

and feasible are largely those that a team or an engineering function can enact within its own boundaries: technical excellence, simplicity, regular reflection, and respect for motivated individuals depend mainly on internal working practices and on leadership behavior. By contrast, the principles that accumulate the largest gaps require renegotiating conditions that lie outside the team, such as contractual scope, certification milestones, and customer delivery cadences that external stakeholders fix in advance. This contrast suggests that the boundary of Agile feasibility in these industries runs along the line separating what teams control internally from what is imposed externally by contracts, regulators, and customers.

P3 (Frequent delivery), P7 (Working software as primary measure of progress), P8 (Sustainable development), and P11 (Self-organizing teams) are rated below average on both importance and feasibility, placing them in the *Low Priority* quadrant. For P7, the low importance rating (mean = 3.50) is particularly revealing: in contexts where progress metrics must encompass hardware milestones, certification stages, and integration tests, the principle that working software is the primary measure of progress appears to practitioners as a poor fit rather than an aspirational goal. This suggests that the Agile Manifesto’s software-centric framing generates a more fundamental rejection in hardware-intensive settings than has been previously noted in the scaling literature (Dingsøyr et al., 2012; Hobbs & Petit, 2017).

5.1.3 RQ3: Interpretation of gaps in light of contextual constraints

RQ3 asks how the observed gaps can be interpreted in light of the contextual constraints practitioners face. A first interpretation is that the theory-practice gap is primarily structural rather than attitudinal. Practitioners do not dismiss Agile principles as wrong or irrelevant (mean importance scores lie above the scale midpoint for all twelve principles) but they rate feasibility significantly lower across all items. The gap therefore does not reflect a failure of Agile advocacy or organizational reluctance to embrace new ideas; it reflects the objective friction between Agile’s normative assumptions and the governance, integration, and coordination conditions of systems-intensive work.

The Importance-Performance Analysis (Martilla & James, 1977) framework applied through the Δ' metric sharpens this interpretation. By penalizing gaps that occur on high-importance principles, Δ' confirms that the most strategically consequential deficits are concentrated on P2 (Welcome change, $\Delta' = 4.25$), P1 (Customer delivery, $\Delta' = 3.89$), and P5 (Motivated individuals, $\Delta' = 3.35$), precisely the principles that require the highest degree of organizational

alignment with external stakeholders, adaptive planning, and intrinsic team motivation. These are also the principles most directly threatened by the governance, contractual, and cultural barriers identified in RQ1, confirming a structural coherence across the three research questions.

The gap between the mean current PM score (2.84) and the mean ideal PM score (3.56) adds a further layer of interpretation. Practitioners perceive themselves as operating under more predictive approaches than they consider optimal for their context, a misalignment of +0.72 toward more Agile practices. Taken together with the importance-feasibility gap, this finding suggests that practitioners operate in a structural tension: they recognize both the value of Agile principles and the better-fit nature of hybrid methodologies, but the organizational, contractual, and governance conditions they face prevent them from closing either gap.

The ANOVA analysis reveals that Agile familiarity is the variable most consistently associated with variation in principle importance scores. Respondents with higher Agile familiarity assign significantly greater importance to P3 (Frequent delivery), P7 (Working software), and P11 (Self-organizing teams), the same principles that are rated lowest by the full sample. This pattern suggests that deeper Agile exposure recalibrates practitioners' understanding of what these principles can offer, even in systems-intensive settings. The implication is that exposure and training may be a more effective lever for principle adoption than structural or technological changes, at least in the short term.

Project type emerges as a significant moderator for obstacle perception rather than for principle scores. The finding that Mixed/Multiple project contexts rate both leadership support deficits and team dispersion as substantially more severe aligns with the structural argument: when practitioners must simultaneously navigate multiple project governance logics, the organizational overhead intensifies and leadership alignment becomes harder to maintain. This result is theoretically consistent with Dikert et al. (2016)'s observation that inter-team dependencies and multi-governance settings amplify coordination failures, but provides quantitative, cross-industry evidence for a claim previously supported mostly by case studies.

5.2 Theoretical Implications

The first theoretical contribution of this study is the demonstration that the theory-practice gap in Agile is not uniform across principles. Prior literature has framed the gap broadly, treating Agile adoption as either largely successful (Serrador & Pinto, 2015) or as fundamentally incompatible

with complex engineering contexts (Boehm & Turner, 2005). The principle-level granularity of this study reveals a more structured picture: a cluster of relational and reflective principles is perceived as tractable even in systems-intensive settings, while a cluster of delivery-cadence and change-absorption principles faces structural barriers. This finding invites theoretical models of Agile adoption to move from a binary adoption/rejection framing to a principle-specific applicability model that accounts for the heterogeneity within the Agile Manifesto.

The application of Importance-Performance Analysis (Martilla & James, 1977) to Agile principle measurement is, to the author's knowledge, not yet established in the Agile literature as a systematic framework. The $\Delta' = \Delta \times I$ formulation adds theoretical value over the simple gap because it weights the urgency of a deficit by the strategic relevance of the attribute, enabling more precise prioritization of barriers. This methodological extension could inform future Agile readiness assessments by replacing binary adoption surveys with quadrant-based analysis tools that distinguish tractable leverage opportunities from structurally constrained challenge areas.

The TOE framework (Tornatzky et al., 1990) is validated in direction but requires re-sequencing for systems-intensive Agile contexts. The classical assumption that technology-related factors dominate in engineering-intensive settings is not supported by the data: organizational and environmental barriers rank higher than technological ones despite the sample being composed primarily of hardware-intensive and cyber-physical practitioners. Future theoretical work should treat the organizational and environmental dimensions as primary explanatory factors for Agile discontinuity in complex product systems, with the technological dimension serving as a moderator rather than as the primary driver.

The ANOVA results for Agile familiarity suggest that this variable functions as a theoretical moderator of principle internalization. Established models of technology adoption, such as TAM (Dybå & Dingsøy, 2008), typically treat familiarity as an antecedent to adoption intentions. The evidence here suggests a richer role: familiarity appears to shift the cognitive framing of what Agile principles offer, raising perceived importance for the very principles that are most unfamiliar in traditional engineering workflows. This relationship between exposure and normative internalization warrants formalization in future conceptual models of Agile diffusion.

5.3 Practical Implications

The results generate five actionable directions for practitioners and organizations operating in systems-intensive industries who are evaluating or pursuing Agile adoption.

The first implication concerns prioritization. If organizations allocate limited transformation resources, the data suggest that governance redesign and cultural change should precede method training. Rigid culture (54.4% high threat) and bureaucratic governance (45.6% high threat) rank above knowledge gaps (26.5%) as perceived barriers. This means that Agile training delivered before governance and cultural conditions are addressed is unlikely to produce lasting change at the organizational level, consistent with the *no quick fix* conclusion of Dikert et al. (2016). Transformation programs in aerospace, automotive, or defense organizations should therefore begin with leadership alignment and governance redesign, using method training as a follow-on investment once enabling conditions are in place.

The second implication concerns entry strategy. The six principles in the *Leverage* quadrant (P1, P5, P6, P9, P10, P12) represent a viable starting portfolio for Agile adoption in systems-intensive settings: they are perceived as both important and achievable without requiring deep structural transformation. Organizations that are at an early stage of Agile adoption can build credibility and internal competence by strengthening these principles first, rather than attempting to implement the full Agile Manifesto simultaneously. Practices aligned with continuous improvement (P12), technical excellence (P9), and motivated individuals (P5) are particularly well-suited to this sequenced approach, as they reinforce one another and create organizational readiness for the harder changes that P2 and P1 require.

The third implication concerns the *Challenge* quadrant. P2 (Welcome changing requirements) stands alone in this quadrant with the largest weighted gap in the dataset. Improving its feasibility does not require adopting Agile in its software-native form; instead, it requires designing mechanisms that make late-stage adaptation structurally possible within the existing governance context. Concrete interventions include the use of modular system architectures that reduce the cost of late changes, the introduction of contract clauses that allow scope evolution within agreed boundaries, and the use of rolling-wave planning techniques that defer detailed planning to later phases. These approaches draw on hybrid project management frameworks already discussed in the literature (Conforto et al., 2014; Hobbs & Petit, 2017) and can be introduced incrementally without dismantling existing predictive governance structures.

A fourth implication, derived from the ANOVA findings, concerns the design of Agile

rollouts in organizations that manage multiple project types simultaneously. Such organizations should not apply a uniform Agile adoption approach across all project streams. The data show that leadership support and team dispersion are perceived as significantly more severe obstacles in Mixed/Multiple contexts, suggesting that governance mechanisms, communication protocols, and leadership investment must be calibrated to the specific project logic rather than standardized. A portfolio-level Agile governance model, where each project stream follows an adoption roadmap appropriate to its integration requirements, certification constraints, and team geography, is more likely to succeed than a one-size-fits-all transformation.

Finally, the ANOVA results on Agile familiarity carry a concrete investment implication. The three principles where familiarity produces the largest shifts in perceived importance (P3, P7, P11) are precisely those where the sector defaults most strongly to traditional practices. Structured exposure programs, including cross-functional Agile workshops, pilot projects in lower-risk project streams, and exchange with software-native Agile practitioners, can shift practitioners' normative frames and increase the organizational recognition of iterative and autonomous working as valuable. The data suggest that this investment can produce measurable changes in how practitioners evaluate Agile principles, even before full adoption is attempted.

Chapter 6

Conclusions

This chapter closes the thesis by revisiting the three research questions, synthesizing the key findings, and drawing together the theoretical and practical contributions of the study. No new data or arguments are introduced; the chapter reflects on what the evidence collected and the analysis conducted can affirm about Agile development in systems-intensive industries.

6.1 Main Findings

This thesis set out to investigate the discontinuity between Agile theory and Agile practice in systems-intensive and regulated industries. Starting from the observation that Agile frameworks were developed in software-centric contexts and that their transfer to engineering-intensive settings is non-trivial, the study asked whether practitioners perceive a gap between the importance they attribute to Agile principles and the feasibility of enacting those principles under real operating conditions. An online survey of 68 practitioners across aerospace, automotive, defense, telecommunications, and software sectors provided the empirical basis for addressing this question.

In response to RQ1, the literature review established that the main problems associated with Agile implementation in systems-intensive contexts cluster around four families of barriers: cultural misalignment, insufficient management support, structural incompatibilities in large and functionally divided organizations, and governance and institutional rigidities. The survey data confirm this hierarchy: organizational culture is the most severe perceived obstacle (mean threat score = 3.47; 54.4% of respondents rate it as High or Very High), followed by bureaucratic governance and coordination difficulties. The finding that technical complexity ranks below or-

ganizational and governance factors, despite the sample being dominated by hardware-intensive and cyber-physical practitioners, is empirically relevant: it shifts the theoretical weight in TOE-based analyses from the technology dimension to the organization and environment dimensions, and implies that transformation efforts focused primarily on technical tooling or methodological adaptation are unlikely to resolve the root causes of Agile discontinuity.

In response to RQ2, the analysis reveals a universal and systematic theory-practice gap: every one of the twelve Agile Manifesto principles shows a positive importance-feasibility gap, with no principle reaching parity between the two dimensions. The mean importance across all principles (3.88) substantially exceeds the mean feasibility (3.19), producing a mean gap of 0.70. The distribution of gaps is, however, far from uniform. P2 (Welcome changing requirements) is the single most critical case, occupying the *Challenge* quadrant alone with a weighted gap of $\Delta' = 4.25$; its feasibility rating (2.88) is the second lowest in the dataset despite a well-above-average importance score (3.96). At the other end of the spectrum, six principles fall in the *Leverage* quadrant (high importance, high feasibility), confirming that Agile's relational, reflective, and technically oriented principles are perceived as both valuable and achievable in systems-intensive settings, even when its change-absorption and rapid-delivery principles are not.

In response to RQ3, the study interprets the observed gaps as primarily structural rather than attitudinal. Practitioners do not reject Agile principles as misguided; they value them consistently above the scale midpoint. The gap reflects the friction generated by governance constraints, contractual obligations, system architectures, and certification requirements that make enacting Agile's adaptive logic operationally difficult. The PM orientation data reinforce this reading: practitioners perceive a mismatch of +0.72 between their current methodology (mean score 2.84 on a 1-5 Predictive-Agile continuum) and what they consider optimal for their context (mean 3.56), yet remain unable to close it. The ANOVA results add important nuance: Agile familiarity is the variable most consistently associated with higher importance scores, suggesting that structured exposure to Agile can shift practitioners' normative frames toward greater appreciation of the principles most foreign to traditional engineering workflows.

Taken together, the three answers converge on a single overarching thesis: *Agile development in systems-intensive industries is not a failure of principle but a failure of conditions*. Practitioners recognize the value of Agile's normative core but operate in organizational, contractual, and technical environments that systematically prevent its full enactment. The implication is that

Agile adoption in these sectors requires organizational and governance transformation before, and more urgently than, methodological change.

6.2 Study Limitations

The study carries three categories of limitation that qualify the generalizability of its conclusions. The first concerns sampling. Participants were recruited through purposive and convenience channels, and the Aerospace/Maritime sector accounts for approximately 51% of the sample. The absence of a complete sampling frame for Agile practitioners in systems-intensive industries makes probability-based inference impossible, and the industry concentration means that unweighted means are strongly influenced by aerospace practitioners' perceptions. Industry-weighted means were reported to partially mitigate this, but the correction does not substitute for a more balanced sampling design.

The second limitation is methodological. All constructs were collected through a single self-administered questionnaire, which introduces the risk of common method bias (Podsakoff et al., 2003). Respondents may have inflated importance scores, given the visible Agile framing of the instrument. A temporal or methodological separation between importance and feasibility measurement, or the inclusion of objective organizational performance indicators, would reduce this risk in future replications.

The third limitation is structural. The cross-sectional design provides a snapshot of perceptions at a single point in time and cannot capture how importance-feasibility gaps evolve as organizations mature their Agile practices. The ANOVA tests were conducted on subgroups of unequal and sometimes small size, which reduces statistical power and limits the interpretability of non-significant results. Post-hoc pairwise comparisons were not performed, meaning that the ANOVA findings identify the presence of group differences without localizing them to specific pairs.

6.3 Future Research Streams

The most direct extension of this work is a longitudinal or repeated cross-sectional study that tracks how importance-feasibility gaps evolve as organizations advance through Agile transformation programs. The cross-sectional snapshot captured here cannot determine whether

the observed gaps are narrowing, widening, or stable over time. A panel design with two or three waves, administered to practitioners in the same organizations at intervals of 18-24 months, would allow causal attribution of gap changes to specific organizational interventions and would test whether the ANOVA finding on Agile familiarity reflects a genuine learning trajectory or a selection effect.

A second stream concerns external validity. The dominance of aerospace in the current sample limits the generalizability of findings to other systems-intensive sectors. A stratified replication study that enforces balanced sampling across aerospace, automotive, defense, rail, energy, and medical device industries would test whether the principle-level gap structure observed here is sector-specific or represents a robust cross-industry pattern. Industries with different regulatory regimes and hardware-software balance ratios, such as automotive (ASPICE-governed) versus medical devices (FDA-regulated), are particularly interesting because they share the systems-intensive profile while differing in the nature of their institutional constraints.

A third stream is methodological. The ANOVA results reported here identify significant group differences but stop short of localizing them through post-hoc pairwise comparisons. A replication using Stata or R, with Tukey HSD post-hoc tests and correction for multiple comparisons, would provide the fine-grained group-level evidence needed to design targeted interventions. A confirmatory factor analysis of the obstacle items would also test the construct validity of the seven-item obstacle battery and could inform a more parsimonious measurement model for future surveys.

A fourth stream is qualitative and is specifically motivated by the P2 result. The *Challenge* quadrant finding for P2 (Welcome changing requirements) identifies the largest strategic gap but cannot explain the specific organizational, contractual, or technical mechanisms through which feasibility is constrained. A series of semi-structured interviews with project managers and systems engineers from organizations that have attempted to improve their change-absorption capacity would provide the causal texture that a survey cannot. Such interviews could also probe whether the low feasibility of P2 reflects a genuine structural barrier or whether it partially reflects cognitive anchoring to past practices that could be dislodged through targeted leadership intervention.

A fifth and more applied research stream concerns the design of hybrid governance models that improve Agile feasibility without dismantling predictive controls. The PM orientation gap (+0.72 toward more Agile practices) and the low feasibility scores on delivery-cadence principles

together suggest that practitioners are not satisfied with the status quo but see no available path to change. Research that co-designs and pilot-tests hybrid frameworks, combining Agile iteration logic with stage-gate assurance structures, in live aerospace or defense programs would provide evidence on whether the importance-feasibility gap can be materially narrowed through governance innovation. Such work would also directly inform the practical recommendations derived from this thesis and would generate the practitioner-validated artifacts that the field currently lacks.

Appendix A

Survey Questionnaire

The full questionnaire administered to respondents is reproduced below, exactly as it was delivered through the Google Forms platform. The instrument was distributed in English and structured according to the blocks described in Section 3.2.3.

Agile Development in Systems-Intensive Industries: Gaps between Theory and Practice

This survey is part of the master's thesis of **Teresa Carotenuto** (MSc student, **Politecnico di Torino** and **ESCP Business School**), supervised by **Filippo Maria Ottaviani** (Assistant Professor, Department of Management and Production Engineering, **Politecnico di Torino**). It explores the gap between Agile Development theory and its practical implementation in system-intensive industries.

Your participation is greatly appreciated and will contribute to advancing academic research on both Agile Systems Engineering and Agile Project Management.

The survey takes **less than 10 minutes**.

By proceeding, you confirm you are at least 18 years old and you consent to **anonymous data** processing for **academic research**.

~~* Indica una domanda obbligatoria~~

General Information

1. What is your **age** in years? *

2. What is your highest education **degree**? *

Contrassegna solo un ovale.

- ☐ High School
- ☐ Bachelor's degree (e.g., BA, BSc, BEng)
- ☐ Postgraduate certificate/diploma (PgCert/PgDip)
- ☐ Master's degree (e.g., MA, MSc, MEng, MBA)
- ☐ Doctoral or professional degree (e.g., PhD, EdD, DBA, MD, JD, PharmD)
- ☐ Prefer not to say
- ☐ Altro:

3. How many **years of work experience** do you have (in total)? *

4. How many **years of work experience** do you have **in your current organization**? *

5. What is your **job specialization**? *

Please select all that apply options that best describes your main role or area of expertise.

Seleziona tutte le voci applicabili.

- ☐ Project / Program / Portfolio Manager
- ☐ Product Manager / Product Owner
- ☐ Manufacturing / Industrial / Process Engineer
- ☐ Systems Engineer / Solution Architect
- ☐ Software Engineer / Developer
- ☐ Hardware Engineer (Mechanical, Electronic, etc.)
- ☐ Supply Chain / Procurement Manager
- ☐ R&D Engineer / Researcher
- ☐ Quality / Reliability / Safety Engineer
- ☐ Business Analyst
- ☐ Consultant
- ☐ Altro: _____

6. Which **industry** best represents your organization? *

Seleziona tutte le voci applicabili.

- ☐ Aerospace / Maritime
- ☐ Automotive
- ☐ Rail & Metro
- ☐ Telecommunications / Networking
- ☐ Construction / Civil
- ☐ Semiconductors / Electronics
- ☐ Oil & Gas
- ☐ Defense
- ☐ Software
- ☐ Energy / Utilities
- ☐ Industrial Automation / Robotics / Heavy Machinery / Industrial Equipment
- ☐ Manufacturing
- ☐ Altro: _____

7. How many **people** are in your **local site/business unit**? *

Select one. A best estimate is fine; count full-time equivalents (FTEs).

Contrassegna solo un ovale.

- ☐ 1–9 (micro)
- ☐ 10–49 (small)
- ☐ 50–249 (medium)
- ☐ 250–999
- ☐ 1,000–4,999
- ☐ 5,000–19,999
- ☐ 20,000+
- ☐ Not sure / Prefer not to say
- ☐ Altro: _____

8. What **type of projects** are you currently involved in? *

Choose the primary project type your organization delivers.

Seleziona tutte le voci applicabili.

- ☐ Software-intensive (applications, cloud/SaaS, enterprise IT, data/ML)
- ☐ Hardware-intensive (mechanical, electrical/electronic, physical products)
- ☐ Integrated hardware–software (cyber-physical) (embedded/firmware, mechatronics, IoT)
- ☐ Systems integration / systems-of-systems (multi-subsystem infrastructure, networks, plants)
- ☐ Altro: _____

Agile Development

9. How **familiar** are you with **Agile** methodologies? *

Please select the option that best describes your level of familiarity.

1 = I have **never heard** of Agile methodologies

2 = I have **heard** of them **but never applied** them

3 = I have **some knowledge** of Agile concepts

4 = I have **applied** Agile methods **occasionally**

5 = I have **extensive experience** with Agile methods

Contrassegna solo un ovale.

1 2 3 4 5

I have ☐ ☐ ☐ ☐ ☐ I have extensive experience with Agile methods

10. On a scale from 1 to 5, how would you rate the current **project management methodology** in your function? *

Quick definitions

- **Incremental:** delivering **new chunks of scope** each cycle.
- **Iterative:** **refining the same scope** across cycles based on feedback.

Scale anchors

- **1 - 100% Predictive:** Neither incremental nor iterative; sequential phases, fixed scope/schedule, formal change control.
- **2 - Mostly Predictive:** Occasional use of incremental **or** iterative in pockets; plan-driven gates dominate.
- **3 - Hybrid:** Regular use of **either** incremental **or** iterative (one is common), with significant predictive constraints.
- **4 - Mostly Agile:** Frequent incremental **or** iterative cycles; some fixed milestones remain (e.g., compliance dates).
- **5 - 100% Agile:** **Both** incremental **and** iterative by default; short cycles deliver new scope and continuously refine existing work.

Contrassegna solo un ovale.

1 2 3 4 5

100 ☐ ☐ ☐ ☐ ☐ 100% Agile

11. On a scale from 1 (fully Predictive) to 5 (fully Agile), how would you rate the **best project management approach for maximizing project performance in your industry context?** *

Contrassegna solo un ovale.

	1	2	3	4	5	
100	☐	☐	☐	☐	☐	100% Agile

12 Agile Principles

For each Agile principle, please rate:

- **Importance** to project performance in your industry, and
- **Feasibility** in your industry context.

Scale: 1 = Very low, 5 = Very high.

Project performance = effectiveness in delivering products within specified **cost** and **time** + **management efficiency**.

12. "Our highest priority is to satisfy the customer through the early and continuous delivery of valuable software." *

Contrassegna solo un ovale per riga.

	1	2	3	4	5
Importance	☐	☐	☐	☐	☐
Feasibility	☐	☐	☐	☐	☐

13. *"Welcome changing requirements, even late in development. **
Agile processes harness change for the customer's competitive advantage."

Contrassegna solo un ovale per riga.

	1	2	3	4	5
Importance	☐	☐	☐	☐	☐
Feasibility	☐	☐	☐	☐	☐

14. *"Deliver working software frequently, from a couple of weeks to a couple of **
months, with a preference to the shorter timescale."

Contrassegna solo un ovale per riga.

	1	2	3	4	5
Importance	☐	☐	☐	☐	☐
Feasibility	☐	☐	☐	☐	☐

15. *"Business people and developers must work together daily throughout the **
project."

Contrassegna solo un ovale per riga.

	1	2	3	4	5
Importance	☐	☐	☐	☐	☐
Feasibility	☐	☐	☐	☐	☐

16. *"Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done."* *

Contrassegna solo un ovale per riga.

	1	2	3	4	5
Importance	☐	☐	☐	☐	☐
Feasibility	☐	☐	☐	☐	☐

17. *"The most efficient and effective method of conveying information to and within a development team is face-to-face conversation."* *

Contrassegna solo un ovale per riga.

	1	2	3	4	5
Importance	☐	☐	☐	☐	☐
Feasibility	☐	☐	☐	☐	☐

18. *"Working software is the primary measure of progress."* *

Contrassegna solo un ovale per riga.

	1	2	3	4	5
Importance	☐	☐	☐	☐	☐
Feasibility	☐	☐	☐	☐	☐

19. *"Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely."* *

Contrassegna solo un ovale per riga.

	1	2	3	4	5
Importance	☐	☐	☐	☐	☐
Feasibility	☐	☐	☐	☐	☐

20. *"Continuous attention to technical excellence and good design enhances agility."* *

Contrassegna solo un ovale per riga.

	1	2	3	4	5
Importance	☐	☐	☐	☐	☐
Feasibility	☐	☐	☐	☐	☐

21. *"Simplicity—the art of maximizing the amount of work not done—is essential."* *

Contrassegna solo un ovale per riga.

	1	2	3	4	5
Importance	☐	☐	☐	☐	☐
Feasibility	☐	☐	☐	☐	☐

22. *"The best architectures, requirements, and designs emerge from self-organizing teams."* *

Contrassegna solo un ovale per riga.

	1	2	3	4	5
Importance	☐	☐	☐	☐	☐
Feasibility	☐	☐	☐	☐	☐

23. *"At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly."* *

Contrassegna solo un ovale per riga.

	1	2	3	4	5
Importance	☐	☐	☐	☐	☐
Feasibility	☐	☐	☐	☐	☐

Agile Development Implementation Obstacles

Based on a literature review, we identified several obstacles that pose a threat to Agile development practices implementation.

We clustered those obstacles into N categories:

- Rigid organizational culture and resistance to change.
- Lack of leadership for Agile adoption.
- Heavy formal processes that conflict with Agile practices.
- High system complexity and long development cycles that hinder short Agile iterations.
- Insufficient Agile knowledge and training within the organization.
- Difficulties in coordinating many teams and limited cross-functional collaboration between departments.
- Geographically dispersed teams that hinder communication.

24. Rate **how much** you think the following **obstacles** pose a **threat** within your working context. *

Contrassegna solo un ovale per riga.

	1 (Very low)	2 (Low)	3 (Medium)	4 (High)	5 (Very High)
Rigid organizational culture and resistance to change.	☐	☐	☐	☐	☐
Lack of leadership for Agile adoption.	☐	☐	☐	☐	☐
Heavy formal processes that conflict with Agile practices.	☐	☐	☐	☐	☐
High system complexity and long development cycles that hinder short Agile iterations.	☐	☐	☐	☐	☐
Insufficient Agile knowledge and training within the organization.	☐	☐	☐	☐	☐
Difficulties in coordinating many teams and limited cross-functional collaboration	☐	☐	☐	☐	☐

between
departments.

Geographically
dispersed
teams that
hinder
communication.

☐☐☐☐☐

Thank you for participating!

Your responses have been recorded.

Thank you for your time and contribution.

25. If you wish to be notified about the results of the survey, please write your email below.

Questi contenuti non sono creati né avallati da Google.

Google Moduli

Appendix B

Analysis Workbook

The empirical analysis described in this thesis was conducted using a structured Excel workbook (`agile_workbook.xlsx`) that contains the full raw dataset and all derived analytical outputs. The workbook is organized into fourteen sheets, summarized in Table B.1, and is designed so that any update to the raw response data in the `DATA` tab propagates automatically to all pivot tables, mean comparisons, gap metrics, and ANOVA results.

Sheet	Content
DATA	Raw combined dataset (68 rows, 44 survey variables + helper columns for derived groupings and normalized obstacle scores).
0. Manual Categorization	Decision log for all free-text industry and project-type responses, with harmonization rationale for each non-standard entry.
1. Sample Profile	Frequency tables for all socio-demographic and professional variables (education, age, experience, Agile familiarity, industry, project type, site size).
2. Principles I vs F	Mean importance, mean feasibility, simple gap Δ , and weighted gap Δ' for each of the twelve Agile Manifesto principles.
3. Principles by Project Type	Mean importance and feasibility broken down by project type (hardware-intensive, software-intensive, cyber-physical, systems integration, mixed).
4. Obstacles Ranking	Mean threat score, median, IQR, and % of respondents rating each obstacle at ≥ 4 , plus cross-tabulation by project type.
5. PM Methodology	Current vs. ideal PM score by industry and overall sample, with distribution of ideal scores.
6. Experience & Familiarity	Mean importance by experience group and mean feasibility by Agile familiarity level for each principle.
7. Gap Matrix (I-F)	Quadrant classification of all twelve principles with dynamic thresholds and strategic implication labels.
A. Delta' Weighted Gap	Ranking of principles by $\Delta' = (I - F) \times I$, with rank comparison against the simple gap.
B. Industry Weighting	Industry weight table (inverse frequency weighting) and comparison of unweighted vs. weighted means for each principle.
C. ANOVA Results	One-way ANOVA output for eight analyses (importance/feasibility/obstacles $\times$ experience, project type, Agile familiarity) with F-statistic, p-value, and η^2 for each item.
D. Box Plot Data	Quartile statistics (Min, Q1, Median, Q3, Max, IQR, skewness) for importance, feasibility, and obstacle scores.
E. ANOVA Visualization	Colour-coded p-value heatmap across all 68 ANOVA tests and bar charts for the six significant findings.

Table B.1: Structure of the analysis workbook.

All ANOVA analyses were computed externally to the workbook using the Python script `anova_analysis.py`, which reads the DATA tab, runs `scipy.stats.f_oneway` for each item-group combination, computes η^2 effect sizes, and writes the results back to the C. ANOVA Results and E. ANOVA Visualization sheets. The script requires Python 3 with the `pandas`, `numpy`, `scipy`, and `openpyxl` libraries and is executed from the command line as:

```
python anova_analysis.py --file agile_workbook.xlsx
```

Re-running the script after any update to the DATA tab regenerates all ANOVA outputs automatically, making the analysis fully reproducible from the raw data without manual recalculation.

The workbook and the analysis script are available from the author on request and are intended to allow full replication or extension of the study by researchers who wish to apply the same analytical pipeline to updated or enlarged datasets.

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