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INTEGRATING AGILE PROJECT MANAGEMENT AND LEAN INDUSTRIAL PRACTICES A REVIEW FOR ENHANCING STRATEGIC COMPETITIVENESS IN MANUFACTURING ENTERPRISES

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Abstract

This review explores the integration of Agile Project Management and Lean industrial practices as a pathway to enhancing strategic competitiveness in manufacturing enterprises. While Agile emphasizes adaptability, iterative feedback, and customer responsiveness, Lean focuses on efficiency, waste elimination, and process stability. Examined in isolation, each framework offers distinct advantages but also reveals limitations—Agile can lack efficiency at scale, while Lean may struggle with rigidity in volatile markets. By synthesizing both approaches, organizations can achieve a balanced system that leverages Lean's structured discipline alongside Aiglet's adaptive flexibility. This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure rigor and transparency, systematically narrowing down from more than one thousand initial records to a final set of 68 peer-reviewed studies across diverse industries such as automotive, aerospace, electronics, and high-tech manufacturing. Analysis of these studies revealed that integrated Agile-Lean frameworks consistently improved cost efficiency, product quality, delivery reliability, flexibility, innovation capacity, and time-to-market performance. The findings also emphasized the importance of governance mechanisms, leadership roles, cultural alignment, and digital technologies as enablers of sustainable integration. Together, these elements establish Agile-Lean integration not as a managerial trend but as a strategic imperative for enterprises competing in globalized and technologically dynamic markets. By embedding adaptability within efficiency, manufacturing firms can build resilience, sustain innovation, and secure long-term competitive advantage.

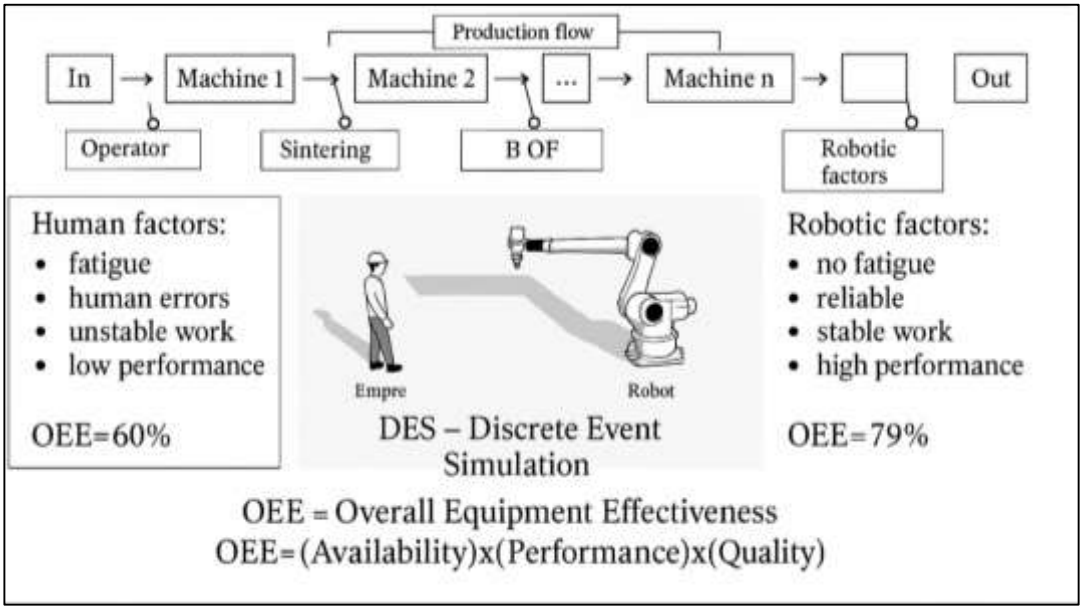
Keywords

Agile Project Management, Lean Manufacturing, Strategic Competitiveness, Manufacturing Enterprises, Integration Frameworks

INTRODUCTION

Agile Project Management is defined as a methodology that emphasizes adaptability, collaboration, and iterative delivery of outcomes (Shim & Lee, 2019). It is structured around short cycles that provide opportunities for feedback, learning, and adjustment. Scrum, as one of its most recognized frameworks, specifies roles, artifacts, and ceremonies designed to enhance visibility and ensure alignment between teams and stakeholders. In contrast, Lean industrial practices, which originated from the Toyota Production System, Loughlin and Priyadarshini (2021) represent a socio-technical philosophy that focuses on eliminating waste, enhancing flow, and building quality into processes. Lean emphasizes continuous improvement through systematic problem solving, standardization, and respect for people. While Agile originated in software and product development, its application has expanded into diverse manufacturing and engineering contexts. Lean, traditionally rooted in production environments, has also evolved into a broader organizational framework encompassing supply chain, product development, and strategic management (Bergmann & Karwowski, 2018; Danish & Zafor, 2022). The international manufacturing landscape—characterized by global supply networks, volatile markets, and competitive pressures—has made the integration of Agile and Lean increasingly significant. Global enterprises often find that Lean provides stability and operational excellence, while Agile injects responsiveness and adaptability to dynamic market requirements. Together, these frameworks establish a shared language and toolkit for addressing both operational and project-based complexities (Chovanova et al., 2020; Danish & Kamrul, 2022).

Figure 1: Global Competitiveness Through Agile-Lean



At the heart of both Agile and Lean philosophies is the concept of value. In Lean, value is defined strictly from the customer's perspective, and any activity not contributing to value creation is considered waste (Chukwunweike & Aro, 2024). Lean tools such as value-stream mapping help organizations identify inefficiencies and redesign processes to enhance flow. Agile, although emerging from a different context, also places customer value at the forefront by ensuring that work is prioritized, refined, and delivered in small increments that provide opportunities for early validation (Ciric et al., 2018; Jahid, 2022). The integration of these frameworks within manufacturing enterprises creates a synergy between flow efficiency and learning efficiency. Lean reduces variability, bottlenecks, and rework across production systems, while Agile ensures that projects and development cycles remain adaptable in the face of evolving requirements. When combined, daily gemba walks in Lean and sprint reviews in Agile offer multiple layers of feedback loops that strengthen organizational learning (Arifur & Noor, 2022; Stoddard et al., 2019). These dual approaches allow global manufacturers to manage complexity across engineering cycles, product introductions, and supply chain variability. The integration also balances efficiency with flexibility, ensuring enterprises can maintain high throughput while quickly responding to unforeseen challenges. Conceptually, this union establishes a robust foundation where the discipline of flow is complemented by the agility of rapid

iteration (Buganová & Šimíčková, 2019; Hasan & Uddin, 2022).

Manufacturing enterprises are characterized by the coexistence of long-term production stability and short-term project variability. Governance systems must reconcile these seemingly opposing needs (Marnada et al., 2022). Agile contributes adaptive planning mechanisms, time-boxed delivery, and structured feedback, while Lean contributes hoshin kanri, tiered daily accountability, and visual management systems. Together, they produce a governance model capable of balancing operational consistency with project dynamism. The use of metrics is a critical part of this synthesis (Rahaman, 2022a; Obradović et al., 2018). Agile relies on velocity, lead time, and quality measures to gauge progress, while Lean focuses on takt time, first-pass yield, and overall equipment effectiveness. When merged, these metrics form a comprehensive system that prevents local optimization and drives system-wide improvement. Governance practices such as portfolio-level kanban, obeya rooms (Carneiro et al., 2018) and tiered escalation routines establish transparency and alignment across functions. This integration is particularly powerful in multinational settings, where geographically dispersed teams must coordinate around shared objectives. Harmonizing cadence across projects and operations ensures that manufacturing enterprises not only deliver predictable outcomes but also sustain continuous improvement and innovation (Loiro et al., 2019; Rahaman, 2022b). Ultimately, the alignment of governance and metrics provides a disciplined yet flexible framework for managing the dual challenges of production stability and market responsiveness.

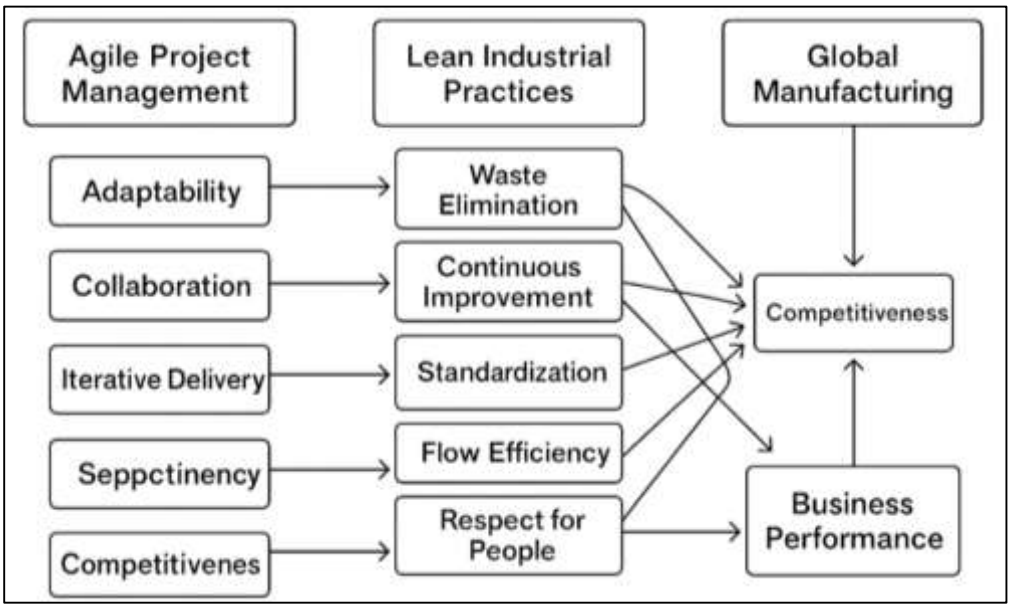
Neither Agile nor Lean can be fully effective without a cultural foundation that empowers people. Both frameworks stress that sustainable improvement and competitiveness depend on individuals who are engaged, cross-functional, (Zasa et al., 2020) and committed to learning. Agile emphasizes self-organizing teams, servant leadership, and psychological safety, ensuring that teams can adapt and innovate without fear of failure. Lean focuses on kaizen, problem-solving routines, and standardized work, which encourage employees at all levels to participate in continuous improvement. When combined, (Jiménez et al., 2020)Agile retrospectives and Lean A3 thinking create structured opportunities for teams to reflect, identify root causes, and implement countermeasures. This emphasis on human-centered practices ensures that organizations do not simply adopt tools but embed continuous learning into their culture (Rahaman & Ashraf, 2022; Šimíčková et al., 2021). For multinational manufacturers, cultural alignment is particularly critical, as practices must be consistent yet adaptable across diverse regions and labor forces. The integration of coaching routines, visual strategy rooms, and daily management cycles enhances collaboration across boundaries. By embedding these people systems, manufacturing enterprises cultivate resilience, adaptability, and a culture of problem solving that underpins long-term competitiveness (Islam, 2022; Žužek et al., 2020).

Process design in manufacturing determines how effectively organizations can manage variability and deliver consistent value. Lean provides a toolbox for stabilizing flow, including just-in-time delivery, single-minute exchange of dies (Papadakis & Tsironis, 2018), and standardized work processes. Agile, by contrast, manages uncertainty by reducing batch size, iterating quickly, and validating assumptions through incremental delivery. Together, these approaches create a process architecture that balances stability with adaptability (Ansari et al., 2024; Hasan et al., 2022). For instance, Lean's emphasis on flow can be enhanced by Agile's sprint-based approach, which introduces frequent opportunities for inspection and adjustment. In engineering contexts, Lean's set-based design aligns closely with Agile's iterative discovery, both of which minimize late-stage rework by exploring multiple options earlier in the cycle. This synthesis supports enterprises in industries where variability in demand, (Andriyani et al., 2024)technology, and regulation is high. The integration also enables organizations to maintain efficient throughput in stable production environments while simultaneously experimenting with new processes, products, or supply configurations. International comparative studies demonstrate that firms capable of harmonizing Lean's efficiency and Agile's responsiveness achieve superior outcomes in cost, quality, and delivery performance, ensuring competitiveness in global markets (Redwanul & MZafor, 2022; Soongpol et al., 2024).

Manufacturing enterprises operate within complex global supply chains that demand both predictability and adaptability (Rezaul & Mesbaul, 2022; Schmitz et al., 2018). Lean practices address this need through supplier integration, frequent deliveries, and collaborative planning that enhance stability. Agile complements these practices by providing iterative engagement with suppliers, adaptive backlog management, and rapid escalation of risks. During new product introductions, Lean ensures manufacturability through structured processes such as production part approval, while Agile accelerates readiness by aligning cross-functional stakeholders in short feedback cycles (Hasan, 2022; Mohammad & Chirchir, 2024). Together, these approaches enable smoother transitions from design

to production, reducing delays and defects. Digital technologies further enhance this integration. Electronic kanban systems, digital twins, and integrated project management platforms increase transparency and shorten feedback loops across geographically dispersed teams (Tarek, 2022; Saoiabi et al., 2023). These technologies amplify the effects of both Lean and Agile by making performance visible and enabling real-time adjustments. In international contexts, digital enablement bridges the gap between distant supply chain partners, ensuring synchronized decision-making and responsiveness. Thus, the combined application of Lean, Agile, and digital technologies equips enterprises with a robust toolkit to manage the challenges of product launches, ramp-ups, and cross-border coordination (Khalil & Khalil, 2020) .

Figure 2: Agile-Lean Framework for Global Competitiveness



The integration of Agile and Lean practices is supported by extensive evidence on performance outcomes across industries (Kamrul & Omar, 2022; Najihi et al., 2022). Lean has consistently been associated with improvements in cost efficiency, quality performance, and delivery reliability. Agile, on the other hand, has demonstrated effectiveness in environments characterized by uncertainty, complexity, and rapid change, yielding higher project success rates and stakeholder satisfaction. Together, these frameworks provide complementary strengths: Lean stabilizes and streamlines core operations, while Agile enables responsiveness and adaptability in project execution (Fagarasan et al., 2023) . Transformation studies show that enterprises that adopt both frameworks simultaneously tend to achieve stronger results than those relying on either approach alone. These results include reductions in lead times, increased flexibility in responding to market demands, and enhanced innovation capacity. While the pathways to integration vary across organizations, common elements include leadership commitment, cross-functional collaboration, structured improvement routines, and alignment of metrics (Aouni et al., 2025; Kamrul & Tarek, 2022) . The accumulated evidence underscores that the integration of Agile Project Management and Lean industrial practices forms a coherent management system. This system enhances the competitiveness of manufacturing enterprises by aligning operations and projects around shared principles of value, flow, and continuous learning.

LITERATURE REVIEW

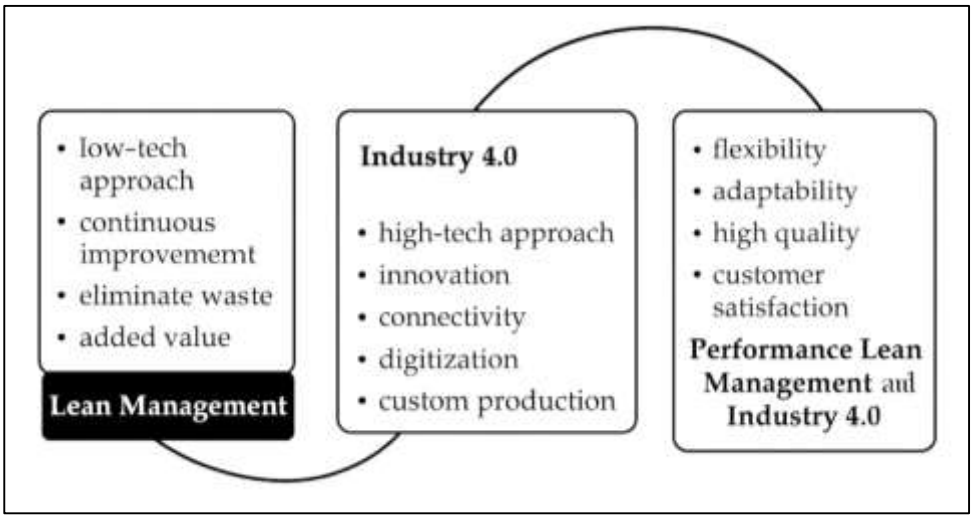
The study of Agile Project Management (APM) and Lean industrial practices has produced an expansive body of scholarship spanning project management, operations management, organizational behavior, and industrial engineering(Monteiro et al., 2023). While both paradigms originated in distinct contexts—Agile in software development and lean in manufacturing production—their underlying principles of value delivery, iterative improvement, and waste elimination converge around a shared commitment to strategic competitiveness. This literature review synthesizes empirical and theoretical contributions that illuminate how the integration of APM and Lean has been conceptualized, operationalized, and assessed across diverse manufacturing contexts (Hamerski et al., 2024). By drawing from cross-disciplinary sources, the review situates the integration within the

broader debates on efficiency, adaptability, and continuous improvement in global manufacturing enterprises. The purpose of this section is twofold: first, to examine the evolution of Agile and Lean as distinct yet complementary paradigms; second, to trace the ways in which scholars and practitioners have combined their principles to address the complex challenges of competitiveness in a rapidly shifting industrial landscape (Loiro et al., 2019). To achieve this, the literature review is organized into thematic clusters that move from foundational definitions to advanced integrations, empirical findings, and emerging methodological considerations. Each subsection addresses not only the descriptive account of what the literature reports but also how these strands of scholarship collectively contribute to understanding the integration of Agile and Lean for strategic competitiveness (Prakash et al., 2024). This structured synthesis aims to clarify conceptual linkages, identify knowledge gaps, and provide a comprehensive scholarly map of the topic.

Agile and Lean

Lean emerged from the Toyota Production System as a socio-technical approach designed to eliminate inefficiencies, Soares et al.(2022) enhance flow, and elevate product quality. At its foundation, Lean is built on three interlocking principles: waste elimination, respect for people, and continuous improvement. Waste is broadly defined as any activity that does not contribute to value as perceived by the customer, and this orientation has shaped Lean into a philosophy that goes beyond simple cost reduction (Bergmann & Karwowski, 2018; Mubashir & Abdul, 2022). Flow, achieved through mechanisms such as just-in-time production and standardized work, ensures that products move seamlessly through the system without unnecessary waiting, inventory buildup, or rework. Continuous improvement, often captured through the concept of kaizen, empowers employees at all organizational levels to identify problems, propose solutions, and experiment with incremental changes. Scholars analyzing Lean have consistently emphasized that it is not simply a collection of tools but an integrated management system that thrives when its cultural and technical dimensions are implemented together (Ciric et al., 2018; Muhammad & Kamrul, 2022). By blending people-focused practices with rigorous technical routines, Lean became an operational model that outperformed traditional mass production in areas such as cycle time reduction, defect minimization, and delivery reliability. Over time, Lean's success in the automotive sector catalyzed its adoption in other industries including aerospace, electronics, and even healthcare, showing its adaptability across contexts (Arefazar et al., 2022; Reduanul & Shoeb, 2022). At its core, Lean represents a philosophy that balances efficiency with flexibility by systematically rooting out waste and aligning activities with customer value. The longevity of its impact across industries suggests that Lean's foundations—clear value orientation, standardized yet adaptable processes, and employee-driven improvement—are as relevant today as when first conceptualized in Japan's post-war manufacturing environment.

Figure 3: Lean Management and Industry 4.0



Lean's expansion beyond Toyota and the automotive industry illustrates its transformation from a production-focused system into a universal philosophy of organizational improvement (Patrucco et al., 2022; Kumar & Zobayer, 2022). As industries across the globe began experimenting with Lean, it became evident that its principles could be adapted to different environments while retaining their

core essence. In discrete manufacturing, Lean facilitated reductions in setup times, lowered inventory levels, and enhanced throughput, while in process industries it improved consistency and reduced variability. Outside of manufacturing, Lean practices have been applied to sectors such as healthcare (Santos & de Carvalho, 2022), where they improved patient flow and reduced medical errors, and construction, where they streamlined project scheduling and material management. Scholars often describe this expansion as both horizontal, in terms of adoption across industries, and vertical, in terms of adoption across organizational functions from operations to supply chains and product development. One of the key insights from cross-industry applications is that Lean's success depends not only on tool adoption but on cultivating a culture of continuous learning and problem-solving. Organizations that approached Lean merely as a cost-reduction toolkit often experienced limited results, while those that embraced it as a philosophy of systemic value creation realized significant competitive advantages (Najihi et al., 2022; Sadia & Shaiful, 2022). Lean's diffusion also highlighted the importance of bundling practices together rather than implementing them in isolation. For instance, just-in-time production requires supplier integration, quality management, and employee training to achieve sustainable benefits. This systems-oriented approach underscores Lean's identity as a holistic framework rather than a piecemeal set of techniques (Falcone et al., 2018; Noor & Momena, 2022). Over decades of research and application, Lean has been recognized as a dominant paradigm in operations management and a key contributor to global competitiveness by embedding efficiency, adaptability, and continuous improvement into organizational DNA (Rahaman & Ashraf, 2023).

Agile Project Management developed in response to the limitations of traditional project management approaches, particularly in industries characterized by rapid change and uncertainty (Istiaque et al., 2023; Schimanski et al., 2021). Originating in software development, Agile emphasized customer collaboration, working solutions, and flexibility over rigid documentation and predictive planning. Its defining feature is iterative delivery, where projects are broken into short cycles that allow for frequent inspection, adaptation, and stakeholder feedback. Scrum, one of the most widely adopted Agile frameworks, operationalized this philosophy through structured roles, time-boxed events, and clearly defined outputs, fostering alignment and accountability (Brandl et al., 2018; Md Sultan et al., 2023). Early applications of Agile demonstrated remarkable improvements in project responsiveness, cycle time reduction, and stakeholder satisfaction compared to linear methodologies. These outcomes drew the attention of industries beyond software, where complex projects demanded adaptability (Almeida et al., 2021; Hasan et al., 2023). Manufacturing enterprises, for example, began adopting Agile practices in product development, engineering, and even plant modernization projects, recognizing that iterative planning and adaptive governance could complement Lean's operational stability. Aiglet's influence also extended into organizational culture, emphasizing self-organizing teams, servant leadership, and psychological safety. Unlike traditional models that relied on top-down control, Agile fostered environments where teams could experiment, learn quickly, and adjust priorities in real time. This adaptability proved especially valuable in global markets characterized by volatility in demand, rapid technological advances, and shifting regulatory landscapes (Erne, 2022) . Over time, Agile became recognized not only as a project management methodology but as a broader cultural framework that redefined how organizations approached complexity and uncertainty. Its emphasis on incremental value delivery, collaboration, and continuous learning aligned naturally with Lean's philosophy of improvement, setting the stage for their integration as complementary approaches to competitiveness (Hossain et al., 2023).

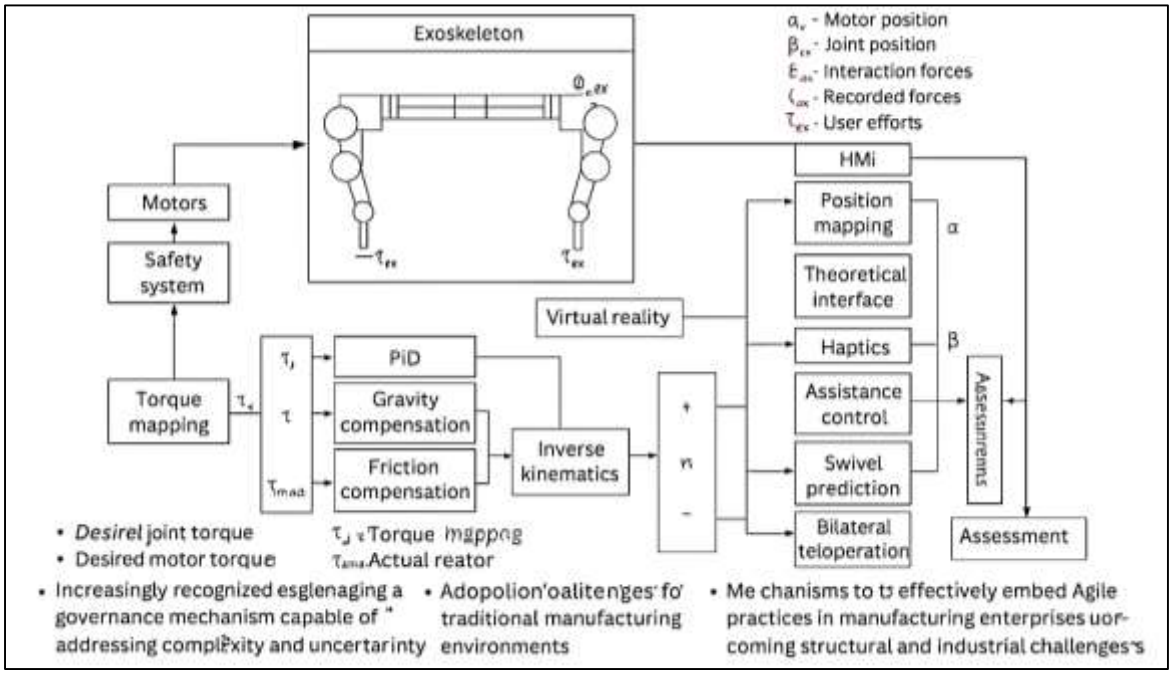
Despite emerging from different historical and industrial contexts, Lean and Agile share striking philosophical similarities that position them as complementary paradigms. Both approaches are centered on value creation as defined by the customer, rejecting activities that fail to contribute to this goal (Ahsan & Ho, 2022; Hossen et al., 2023). Lean operationalizes value through waste elimination and flow design, while Agile achieves it through prioritization of the backlog and incremental delivery of usable outputs. The emphasis on iteration is another area of convergence: Lean achieves learning through continuous improvement cycles and problem-solving routines, whereas Agile formalizes it through retrospectives, sprints, and rapid feedback loops. Both paradigms are also fundamentally people-centered (Tawfiqul, 2023; Žužek et al., 2021). Lean's principle of respect for people empowers workers to identify and solve problems, while aggie's focus on self-organizing teams entrusts individuals with autonomy and decision-making authority. This shared commitment to human empowerment makes both systems reliant on cultural transformation rather than tool deployment alone. Another parallel lies in the principle of small-batch work. Lean advocates for reduced lot sizes and flow-based

systems to shorten lead times and expose problems earlier, while Agile emphasizes small increments of work to deliver early value and uncover risks quickly (Uddin & Ashraf, 2023; Székely et al., 2025). Both approaches challenge traditional hierarchical control systems by advocating for transparency, distributed responsibility, and adaptive learning. When organizations apply these philosophies in tandem, Lean provides the stability and efficiency of flow, while Agile introduces adaptability and responsiveness to change. This balance between operational excellence and adaptive capability forms the philosophical foundation for integrating the two systems into a coherent management approach (Liandra et al., 2025). The literature increasingly frames Lean and Agile not as competing paradigms but as mutually reinforcing, grounded in a shared pursuit of value, learning, and human-centered improvement.

Agile Project Management in Manufacturing Enterprises

Agile Project Management has been increasingly recognized as a governance mechanism capable of addressing the complexity and uncertainty present in engineering, prototyping, and new product introduction initiatives within manufacturing enterprises (Luna et al., 2020; Momena & Hasan, 2023). By breaking large, complex projects into smaller cycles, Agile enables organizations to coordinate cross-functional teams more effectively and ensure that design, prototyping, and industrialization efforts progress in alignment with customer needs. Time-boxed iterations, visual management tools, and structured events provide a cadence that makes work visible, exposes bottlenecks early (Vaia et al., 2022) and allows corrective actions before issues escalate. This is particularly valuable in environments where engineering deliverables, supplier readiness, and production processes must converge seamlessly during the early stages of product lifecycle management. Practices such as incremental prototyping, iterative validation, and adaptive planning give teams the flexibility to refine requirements as new information emerges while maintaining control over costs and timelines. In industrial projects, Agile provides mechanisms for integrating suppliers and production engineers into regular feedback cycles, reducing the risk of late-stage defects and improving manufacturability during ramp-up (Arefazar et al., 2022). Portfolio-level adaptations, such as large-scale Kanban systems and obey a room, extend transparency across programs, helping leaders prioritize resources and address systemic risks such as tooling delays or testing bottlenecks. The application of Agile in these contexts demonstrates how adaptive governance can complement traditional engineering rigor by accelerating learning, improving communication, and aligning multiple stakeholders around shared goals (Kaim et al., 2019; Sanjai et al., 2023). This approach ensures that manufacturing enterprises are not only efficient in their operations but also resilient in their ability to innovate and deliver value under uncertain conditions.

Figure 4: Agile Project Management in Manufacturing



Empirical evidence on Agile applications in manufacturing-related projects consistently highlights improvements in schedule adherence, flexibility, and customer satisfaction. Studies have shown that iterative planning and short delivery cycles reduce delays by surfacing risks earlier, allowing teams to make adjustments without derailing entire projects (Akter et al., 2023; Zasa et al., 2020). By delivering increments of value in the form of prototypes, validated processes, or pilot runs, Agile reduces the time between concept and feedback, which in turn strengthens predictability and mitigates rework. Manufacturing enterprises that incorporate Agile practices often report stronger alignment between engineering, quality assurance, and operations teams, resulting in smoother transitions from design to production (Janssen & Voort, 2020; Tamanna & Ray, 2023). The frequent engagement of stakeholders through sprint reviews or integration events enhances clarity of priorities, ensuring that resources are directed toward high-value features or processes rather than low-impact activities. This responsiveness also strengthens customer satisfaction, as clients and end-users experience tangible progress at shorter intervals instead of waiting for final deliveries. Research further emphasizes that Agile improves flexibility in environments where demand volatility, supply variability, or regulatory requirements introduce frequent changes (Danish & Zafor, 2024; Doz et al., 2023). By maintaining a visible backlog of priorities and limiting work-in-process, teams achieve faster adaptation and avoid overcommitment, leading to higher reliability of milestone delivery. Evidence from case studies in industries such as automotive, aerospace, and electronics indicates that aggie's structured feedback loops reduce time-to-market while enhancing product quality. Customer perception of value improves as incremental demonstrations provide assurance that the final solution aligns with evolving expectations. The overall weight of findings suggests that Agile, when tailored to manufacturing contexts, not only enhances timeliness and flexibility but also reinforces trust and confidence among stakeholders, customers, and supply chain partners (Žužek et al., 2020) .

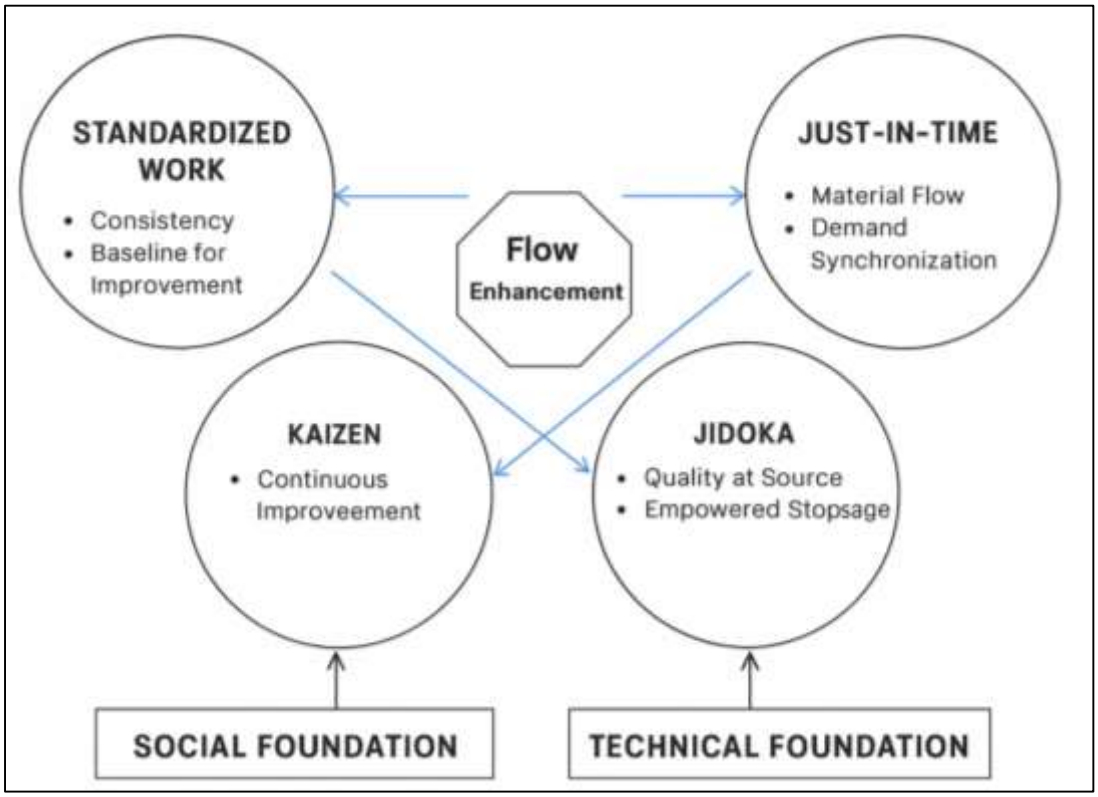
The literature identifies several mechanisms that allow Agile practices to be effectively embedded in manufacturing enterprises, overcoming structural and industrial barriers. One mechanism is synchronization of cadences across teams and programs, achieved through portfolio-level Kanban systems, obey a room, and tiered management reviews that escalate and resolve systemic impediments such as supplier delays or test capacity shortages (Ray et al., 2024; Nguyen et al., 2018). Another mechanism is the adaptation of definitions of completion to include industrial outputs such as validated prototypes, released drawings, or process qualification documents, ensuring that increments are meaningful in both product and process terms. Integration with Lean flow controls, including limiting work-in-process, standardizing integration steps, and visualizing bottlenecks, allows Agile teams to operate within the physical constraints of manufacturing environments while retaining responsiveness (Istiaque et al., 2024; Nguyen et al., 2018). Leadership plays a critical role in embedding Agile, particularly when managers adopt servant-leadership behaviors, focus on rapid removal of organizational obstacles, and align strategic priorities with team-level autonomy. Supplier involvement is also vital, as engaging partners in sprint reviews or planning cycles ensures that external dependencies are coordinated on compatible timelines (Brennan et al., 2019; Hasan et al., 2024). Embedding compliance and regulatory requirements into Agile iterations helps prevent late-stage delays, integrating quality and certification processes into regular increments rather than treating them as separate end-stage activities (Rahaman, 2024; Santos & Carvalho, 2022). Finally, cultural reinforcement through coaching, continuous improvement routines, and cross-functional training ensures that Agile is not perceived as a temporary initiative but becomes part of the organization's DNA. When these mechanisms are applied consistently, manufacturing enterprises demonstrate stronger milestone reliability, fewer disruptions during ramp-up, and higher levels of stakeholder confidence. The evidence suggests that the integration of these practices transforms Agile from a software-derived methodology into a robust governance model for industrial product development and complex manufacturing projects, aligning adaptability with operational rigor (Fernandes et al., 2018; Hasan, 2024).

Lean Industrial Practices in Manufacturing Enterprises

Lean is best understood not as a single method or a collection of tools, but as a system of mutually reinforcing practices that create synergy when applied together (Nicholas, 2018). At its core are standardized work routines, just-in-time production, judoka, and kaizen, which collectively establish the foundation for operational excellence. Standardized work ensures consistency by defining the best known method for performing a task, providing a stable baseline against which improvements can be measured. Just-in-time production aims to synchronize material flow with customer demand, minimizing inventory while ensuring timely delivery of value. Judoka, often described as "automation

with a human touch," empowers machines and workers to halt production when abnormalities are detected, thereby embedding quality into the process rather than inspecting for defects later (Bertagnolli, 2018; Ashiqur et al., 2025). Kaizen provides the cultural backbone, encouraging employees at all levels to identify inefficiencies, experiment with improvements, and contribute to continuous learning. Scholars argue that the true strength of Lean emerges when these practices are implemented as an interdependent system, because isolated tools rarely sustain impact over time (Ferreira et al., 2019). For instance, just-in-time cannot function effectively without standardized work, reliable quality processes, and empowered employees. Similarly, kaizen thrives only when it is supported by the visibility provided by judoka and the discipline of standardized routines. This systemic view highlights Lean as more than a technical framework; it is a socio-technical philosophy that integrates process design, problem-solving routines, and respect for people (Garza-Reyes et al., 2018). The literature demonstrates that when Lean practices are bundled cohesively, they generate reinforcing cycles of stability, improvement, and innovation that shape competitiveness far more effectively than fragmented applications.

Figure 5: Lean Foundations and Enterprise Outcomes



A large body of empirical evidence demonstrates that Lean adoption produces significant improvements in cost efficiency, product quality, and delivery performance (Hines et al., 2020; Md Hasan, 2025). By minimizing non-value-adding activities, enterprises consistently reduce inventory holding costs, scrap, and rework, which translates into measurable financial savings. Quality improvements stem from practices such as judoka, root-cause analysis, and mistake-proofing techniques, which prevent defects from progressing through production lines. Delivery reliability, a critical dimension of manufacturing competitiveness, is enhanced through just-in-time systems that align production schedules with actual demand, reducing delays caused by overproduction or material shortages (Kumar et al., 2022; Ismail et al., 2025). Comparative studies across industries such as automotive, aerospace, and electronics consistently show that firms adopting Lean outperform their peers in meeting customer delivery expectations while maintaining lower operating costs. These improvements are not only operational but strategic, as cost reductions and quality gains create capacity for reinvestment in innovation and market expansion. The literature also emphasizes the compounding nature of Lean benefits: gains in one area often reinforce progress in another (Jakaria et al., 2025; Tasdemir & Gazo, 2018). For example, reducing defects through judoka improves delivery

reliability, which in turn reduces the hidden costs associated with expediting and firefighting. Likewise, smoother material flow enabled by just-in-time decreases inventory costs while simultaneously enhancing responsiveness to demand fluctuations. Longitudinal studies confirm that firms committed to Lean practices over extended periods sustain superior performance compared to those relying solely on short-term efficiency drives. Overall, the evidence establishes Lean as one of the most empirically validated approaches to achieving simultaneous improvements in cost, quality, and delivery, reinforcing its role as a cornerstone of global manufacturing competitiveness (Alahyari et al., 2019; Hasan, 2025).

Despite its proven effectiveness, Lean implementation in multinational manufacturing enterprises presents complex challenges related to culture, structure, and supply chain dynamics (Sultan et al., 2025; Soliman et al., 2018). Organizational resistance is one of the most frequently cited barriers, as Lean requires a shift from hierarchical control systems to empowerment of frontline employees, which can be unsettling for managers accustomed to top-down decision-making. Differences in cultural norms across regions further complicate the diffusion of Lean principles, as practices such as kaizen and standardized work may be embraced enthusiastically in some contexts while resisted in others (King, 2019; Zafor, 2025). Structural issues arise from the scale and complexity of multinational enterprises, where dispersed plants and business units often attempt Lean adoption in isolation, leading to fragmented and inconsistent outcomes. Supplier integration represents another critical challenge, since just-in-time systems depend on highly reliable partners capable of delivering frequent shipments with minimal variability. In global supply networks, however, logistical distances, variable infrastructure, and differing quality standards make such reliability difficult to sustain (Leong et al., 2019; Uddin, 2025). Even when Lean practices are initially successful, sustaining improvements over time is problematic. Enterprises often experience what scholars describe as "Lean fatigue," where enthusiasm wanes, early gains plateau, and tool usage becomes ritualized rather than transformative(Leong et al., 2019) . Additionally, the pressure for quarterly financial results in multinational corporations can undermine the long-term commitment required for Lean maturity, leading to superficial implementations focused on cost-cutting rather than systemic change. The literature stresses that these challenges are not insurmountable but require alignment of leadership commitment, cultural adaptation, and supplier collaboration to realize Lean's full potential in complex, globalized contexts (Pearce et al., 2018; Sanjai et al., 2025).

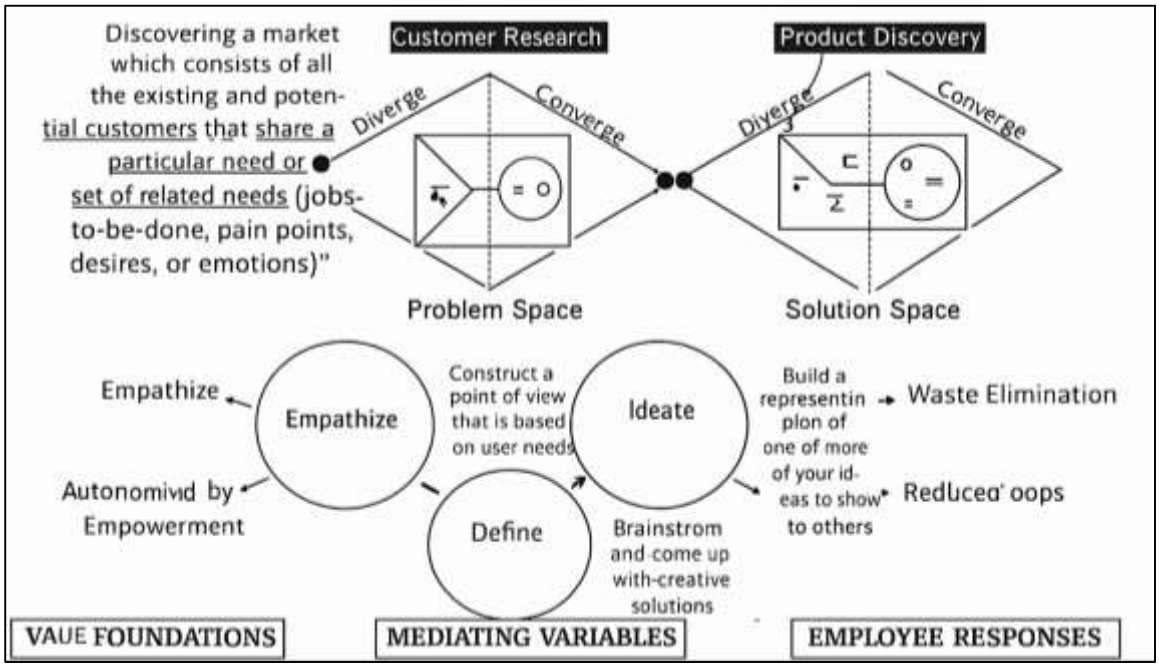
Points of Convergence Between Agile and Lean

A central point of convergence between Agile and Lean lies in their shared emphasis on defining and delivering value from the customer's perspective while systematically eliminating activities that do not contribute to that value (Furlan et al., 2023). Lean conceptualizes value as anything the customer is willing to pay for, directing organizations to focus resources on features, processes, and outputs that directly enhance customer satisfaction. Waste, in this view, encompasses excess inventory, unnecessary motion, waiting time, overproduction, and rework, all of which diminish value creation and burden the system with inefficiency. Agile, although emerging from software and project management, adopts a remarkably similar orientation by ensuring that product backlogs are continuously refined to prioritize only high-value features, while discarding low-priority tasks that add little to customer outcomes (Zorzetti et al., 2022). This alignment demonstrates that both paradigms reject the pursuit of efficiency for its own sake, instead anchoring operational and project decisions in the customer's perception of usefulness and quality. In manufacturing contexts, the combination of Aggie's iterative backlog prioritization with Lean's systematic waste identification creates a dual filter that both accelerates value delivery and prevents the accumulation of inefficiencies across processes. Both systems also promote transparency, as visual boards in Agile and value stream maps in Lean make the flow of work explicit, allowing stakeholders to distinguish between activities that add value and those that do not (Pata et al., 2021). This convergence has significant implications in industries where market demands shift rapidly and margins are narrow, as it ensures that enterprises align resources with customer priorities while continuously purging inefficiency. Thus, Agile and Lean, though developed in different contexts, arrive at a common conclusion: organizations achieve competitiveness not by maximizing activity but by maximizing the proportion of effort that genuinely creates value (Jo et al., 2023).

Both Agile and Lean converge strongly in their reliance on feedback loops and iterative cycles as mechanisms for learning, adaptation, and improvement (Signoretti et al., 2020). In Agile, practices such as daily stand-ups, sprint reviews, and retrospectives ensure that teams are continuously reflecting on progress, identifying barriers, and adjusting their plans based on new information. These short cycles

create a rhythm of accountability and transparency that prevents errors from compounding over long project timelines. Lean employs analogous mechanisms through kaizen events, Gemba walks, and standardized problem-solving routines, which institutionalize continuous improvement at both the team and organizational level (Magistretti & Trabucchi, 2025). The underlying principle is the same: shorter feedback intervals reduce the cost of mistakes, accelerate the detection of problems, and provide more frequent opportunities for corrective action. When applied in manufacturing enterprises, this shared reliance on iteration allows cross-functional teams to synchronize development, production, and supplier readiness, (Raji et al., 2021) minimizing the risk of late-stage surprises. Agile ensures that projects adapt to evolving requirements, while Lean ensures that processes adapt to observed performance gaps, creating a reinforcing cycle of operational and project-based improvement. Visual management tools further strengthen these loops by making issues visible, whether through Kanban boards in Agile or Andon systems in Lean, thereby prompting immediate responses. Importantly, both paradigms emphasize that feedback should not be punitive but constructive, designed to promote learning and collective problem-solving. This alignment underscores a deeper philosophical commitment to iterative adaptation as a superior mode of managing uncertainty compared to rigid, linear planning (Almeida et al., 2022). The literature on convergence shows that when Aiglet's iterative governance is combined with Lean's continuous improvement culture, organizations create a system where feedback is both rapid and systemic, ensuring adaptability without sacrificing operational stability.

Figure 6: Design Thinking Process for Innovation



Another significant area of convergence is the shared recognition that sustainable improvement depends on people rather than tools (Kawa & Maryniak, 2019). Lean has long emphasized respect for people as a foundational principle, empowering frontline workers to stop production when abnormalities occur, contribute improvement ideas, and participate in problem-solving activities such as kaizen. Agile similarly places teams at the center, advocating for autonomy, self-organization, and empowerment to make decisions without excessive bureaucratic oversight. Both paradigms view leadership not as command and control but as enabling and servant-oriented, creating conditions where employees are trusted to take initiative (Ahmed & Huma, 2021). This people-centric perspective cultivates psychological safety, which is essential for experimentation and continuous learning. In Lean, structured routines such as A3 problem solving and kata coaching provide employees with frameworks for disciplined improvement, while in Agile, retrospectives and collaborative planning sessions provide spaces for reflection and innovation. The convergence of these practices creates organizational cultures where learning is constant, responsibility is distributed, and improvement becomes embedded in daily work rather than treated as an occasional initiative. In multinational enterprises, this shared cultural orientation is especially valuable, as it provides a universal language of

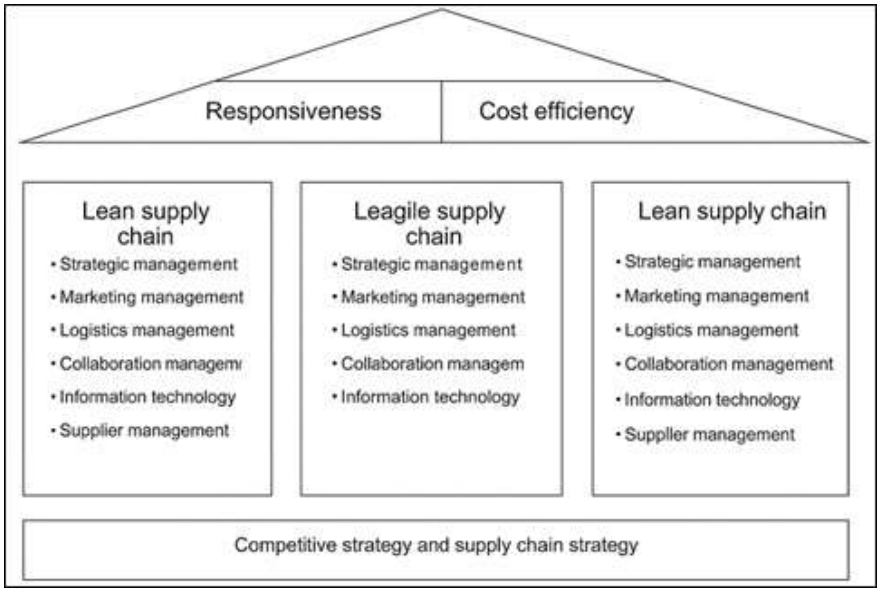
empowerment and collaboration that can be adapted across regions and cultural contexts (Chengbin et al., 2022). The emphasis on people ensures that improvements are sustainable, as employees who feel valued and engaged are more likely to contribute ideas and persist with change initiatives. The alignment between Aiglet's empowerment of teams and Lean's respect for people reinforces the idea that the true drivers of competitiveness are not technical tools alone, but motivated individuals equipped with frameworks to learn and improve continuously (Dahinine et al., 2024).

When examined together, the convergence of Agile and Lean creates a cohesive framework that blends customer value, waste elimination, iterative feedback, and people-centered learning into a unified system of management (Slim et al., 2018). In practice, organizations that integrate both paradigms create environments where customer priorities are clarified, inefficiencies are systematically removed, learning cycles are shortened, and employees are empowered to act on problems and opportunities. Agile brings cadence and adaptability to project-based work, ensuring that product development and industrialization efforts remain aligned with evolving requirements (Lee & Trimi, 2021). Lean brings stability and discipline to operational processes, ensuring that flow is maintained and waste is continuously reduced. The common ground between them lies in their shared mechanisms—visualization, iteration, feedback, and empowerment—that allow organizations to navigate uncertainty without losing efficiency. This convergence creates a balance between flexibility and control, where responsiveness to change does not undermine operational consistency, and standardization does not inhibit innovation (Sá et al., 2022). In manufacturing contexts, the synergy is particularly evident: Agile facilitates rapid prototyping, incremental validation, and adaptive planning, while lean ensures that these activities occur within streamlined, waste-free processes that maximize throughput and reliability. Together, they offer a holistic management approach that transcends the boundaries of their original domains, establishing a shared philosophy that integrates strategic adaptability with operational excellence (Guinan et al., 2019). The result is a powerful framework that enhances competitiveness by aligning organizational energy toward value creation, continuous learning, and sustained improvement at every level of the enterprise.

Integrated Frameworks of Agile and Lean

The concept of "legible" manufacturing systems emerged as a theoretical response to the limitations of adopting Lean or Agile in isolation. Lean provides unmatched efficiency through waste elimination, standardized processes, and stable flow, yet it is sometimes criticized for its rigidity in responding to sudden changes in demand or technological disruption (Bhamra et al., 2021). Agile, conversely, thrives in environments of volatility by prioritizing adaptability, iterative feedback, and customer responsiveness, but it may struggle to maintain efficiency at scale. The hybrid "legible" framework is designed to balance these opposing strengths, offering both operational stability and strategic flexibility. In manufacturing, this integration often materializes through the concept of the decoupling point, where upstream processes operate in Lean mode to maximize efficiency (Gunasekaran et al., 2019) while downstream processes adopt Agile principles to respond flexibly to customer requirements and market variability. By holding generic or semi-finished components in Lean-controlled flows, enterprises create a buffer that enables Agile customization closer to the customer interface. This hybrid strategy provides manufacturers with the ability to achieve economies of scale without sacrificing responsiveness, a dual advantage particularly relevant in globalized markets characterized by fluctuating demand and shorter product life cycles. Over time, the literature has expanded the legible framework beyond supply chains into enterprise governance, product development, and operational strategy, highlighting how integrated approaches can reconcile efficiency with adaptability (Li & Martins, 2024). The legible system is not simply a compromise but a synergistic arrangement in which Lean provides the structural discipline required to stabilize processes, while Agile provides the adaptive capacity to navigate uncertainty. This hybridization has become increasingly relevant as manufacturing enterprises face pressures from both cost competition and the need for rapid innovation, making legible systems a central theme in discussions of sustainable competitiveness (Mohaghegh & Größler, 2025).

Figure 7: Framework for Manufacturing Strategy



Integrating Agile and Lean requires governance structures that can harmonize the distinct practices of each paradigm into a coherent system (Li et al., 2020). Governance refers to the mechanisms by which organizations coordinate, prioritize, and escalate decisions, ensuring alignment across teams, departments, and leadership levels. Within Lean, governance is typically achieved through structured systems such as obey a room, tiered daily management, and hoshin kanri, which provide visual oversight, alignment of goals, and escalation paths for problem-solving. Agile introduces governance through frameworks such as portfolio Kanban, sprint reviews, and Scrum of Scrums, which ensure adaptive planning and rapid coordination across teams. When these structures are combined, organizations achieve a governance model that balances stability with flexibility. Obey a room, for instance, can be used not only for Lean performance visualization but also for Agile backlog alignment and sprint progress reviews, creating a shared physical or digital space for decision-making. Portfolio Kanban integrates naturally with Lean tiered management, providing visibility into both flow constraints and strategic priorities, while enabling leaders to make informed trade-offs between efficiency and adaptability. Tiered escalation routines, where issues unresolved at the team level are elevated to higher tiers, align closely with Agile impediment removal practices, ensuring that barriers are resolved quickly and at the right organizational level. The synergy of these governance structures creates an environment where long-term strategy, operational discipline, and adaptive execution coexist without contradiction. The literature highlights that such integration requires leadership commitment, as managers must be willing to relinquish traditional command-and-control approaches in favor of servant leadership and collaborative oversight. By embedding Agile cadences into Lean governance, organizations can create a structured yet adaptive system that supports both efficiency in operations and responsiveness in projects, forming a foundation for long-term competitiveness.

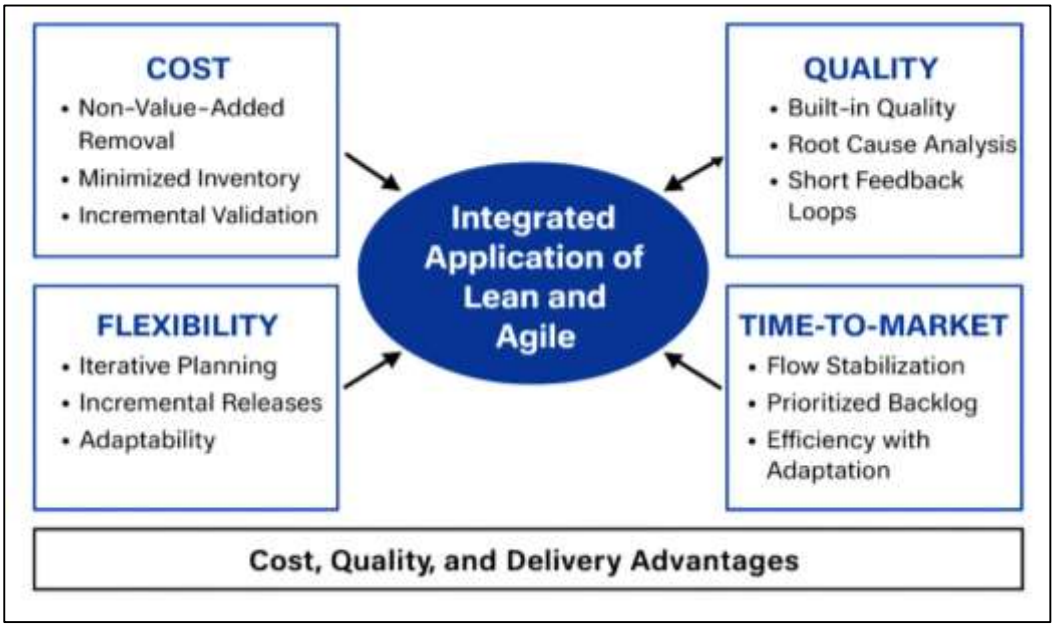
Strategic Competitiveness and Performance Outcomes

The integration of Agile and Lean practices has been consistently associated with measurable improvements in cost efficiency, product quality, and delivery reliability—three of the most critical dimensions of manufacturing competitiveness (Furlan et al., 2023). Lean provides a structured foundation for cost control by eliminating non-value-adding activities, minimizing inventory, and improving equipment utilization, while Agile adds a layer of adaptability that prevents expensive last-minute changes and rework by introducing incremental validation and iterative decision-making. Together, Junker et al. (2023) these frameworks reduce the hidden costs of firefighting, delays, and quality escapes by ensuring that both processes and projects remain aligned with customer priorities and operational capacity. Quality improvements arise from Lean's focus on built-in quality mechanisms such as standardized work, mistake-proofing, and continuous improvement, reinforced by Aiglet's incremental delivery cycles, which expose defects early and allow for rapid corrective action (Natarajan & Pichai, 2024). Delivery performance, often measured by adherence to takt time or on-time completion of milestones, benefits from Lean's flow stabilization combined with Aiglet's ability to dynamically re-prioritize tasks in response to demand fluctuations or technical obstacles.

When applied in tandem, these practices reduce variability, shorten cycle times, and enhance the predictability of outcomes. Evidence from large-scale enterprises indicates that such integration leads to more consistent achievement of cost, quality, and delivery objectives compared to organizations adopting Lean or Agile in isolation (Venugopal & Saleeshya, 2019). The systemic nature of these improvements highlights that competitiveness emerges not simply from isolated efficiency gains but from a holistic capability to control costs, deliver high-quality outputs, and meet customer timelines reliably in the face of complexity.

Beyond the traditional operational metrics of cost, quality, and delivery, the integration of Agile and Lean provides strategic advantages in flexibility, innovation, and time-to-market performance (Plotnikov et al., 2024). Manufacturing enterprises increasingly face competitive pressures from shorter product life cycles, volatile demand, and technological disruption, conditions under which rigid systems quickly become obsolete. Agile contributes adaptability through iterative planning, incremental releases, and stakeholder feedback loops, ensuring that projects can pivot quickly as new information emerges. Lean complements this adaptability by maintaining process stability and preventing wasteful disruptions during transitions, providing the structural foundation for controlled flexibility (Rad et al., 2021). The result is an environment where organizations can innovate rapidly without sacrificing operational discipline. Iterative prototyping and validation cycles allow design teams to experiment with multiple solutions in parallel, reducing the risk of late-stage redesigns while accelerating learning. At the same time, Lean practices such as standardized work and value-stream mapping ensure that these experiments are executed efficiently, preventing innovation from devolving into chaos (Esmaeel et al., 2018). The integration also reduces time-to-market by collapsing the gap between design and production readiness: Agile accelerates decision-making and clarifies priorities, while Lean streamlines workflows and eliminates bottlenecks. This synergy is particularly important in industries where the ability to deliver products faster than competitors provides a decisive market advantage. The literature underscores that flexibility and innovation are not achieved through speed alone but through the disciplined alignment of adaptability with process rigor (Cooper & Sommer, 2018). By combining Aiglet's responsiveness with Lean's stability, enterprises gain the capacity to innovate continuously and bring products to market more quickly, sustaining competitive advantage in dynamic environments.

Figure 8: Agile-Lean Integration for Manufacturing Competitiveness



Comparative studies across industries and countries reveal that the integration of Agile and Lean manifests differently depending on context, yet consistently enhances competitiveness in global manufacturing. In the automotive sector (Poth et al., 2020), Lean has long been established as the backbone of operational excellence, and the incorporation of Agile into product development and engineering has improved responsiveness to shifting customer demands, regulatory requirements, and technological advancements. Electronics manufacturers, faced with rapid product obsolescence

and volatile consumer markets, have leveraged Aiglet's iterative development cycles to accelerate innovation while relying on Lean to stabilize high-volume production processes (Tkalich et al., 2022). Aerospace enterprises, operating in environments of stringent regulatory oversight and complex supply chains, have used Agile to manage the uncertainty of large-scale engineering projects while depending on Lean to ensure reliability and precision in production. In high-tech industries, where digital technologies converge with hardware development, the Agile-Lean integration supports fast-paced innovation while maintaining efficiency in globalized supply chains. International comparisons also highlight differences in implementation challenges: firms in developed economies often emphasize digital integration and advanced analytics to enhance Agile-Lean systems, while firms in emerging economies focus more on building cultural alignment and supplier capability to support Lean foundations (Macca et al., 2025). Despite these contextual variations, the unifying theme is that integrated practices consistently outperform singular approaches in delivering cost savings, quality improvements, faster product launches, and stronger customer satisfaction. These findings demonstrate that while the specific configuration of Agile and Lean may vary across industries and geographies, the strategic benefits of integration are universal, reinforcing its role as a cornerstone of global competitiveness (Karamitsos et al., 2020).

The cumulative evidence suggests that the true strength of Agile and Lean integration lies in its ability to produce multi-dimensional performance outcomes that directly enhance strategic competitiveness (Alalawin et al., 2022). Rather than focusing solely on efficiency or adaptability, integrated frameworks create organizations that excel simultaneously in operational discipline and strategic flexibility. Cost reduction and waste elimination provide the foundation for competitiveness, but they are amplified by Aiglet's ability to prevent costly delays and align projects with evolving customer needs (Upadhyay et al., 2022). Quality improvements become more robust when incremental validation is layered onto Lean's defect prevention mechanisms, ensuring that errors are caught early and resolved at their root. Delivery reliability, long a hallmark of Lean systems, gains further strength when Agile prioritization mechanisms allow schedules to adapt dynamically to external disruptions. At the same time, the integration extends beyond operational excellence into strategic arenas such as innovation capability, speed of market response, and global adaptability (Schilling & Seuring, 2024). Organizations capable of sustaining both stability and responsiveness gain an enduring competitive advantage, as they can exploit opportunities and mitigate risks more effectively than rivals constrained by rigid systems or fragmented practices. International evidence across multiple industries supports the conclusion that the convergence of Agile and Lean is not merely an operational choice but a strategic imperative (Slattery et al., 2022). By embedding adaptability within efficiency, enterprises develop the resilience required to compete in global markets characterized by uncertainty, complexity, and rapid technological change. The outcome is a comprehensive form of competitiveness that extends beyond short-term performance metrics, positioning integrated enterprises as leaders in both efficiency-driven and innovation-driven competition (Herdika & Budiardjo, 2020).

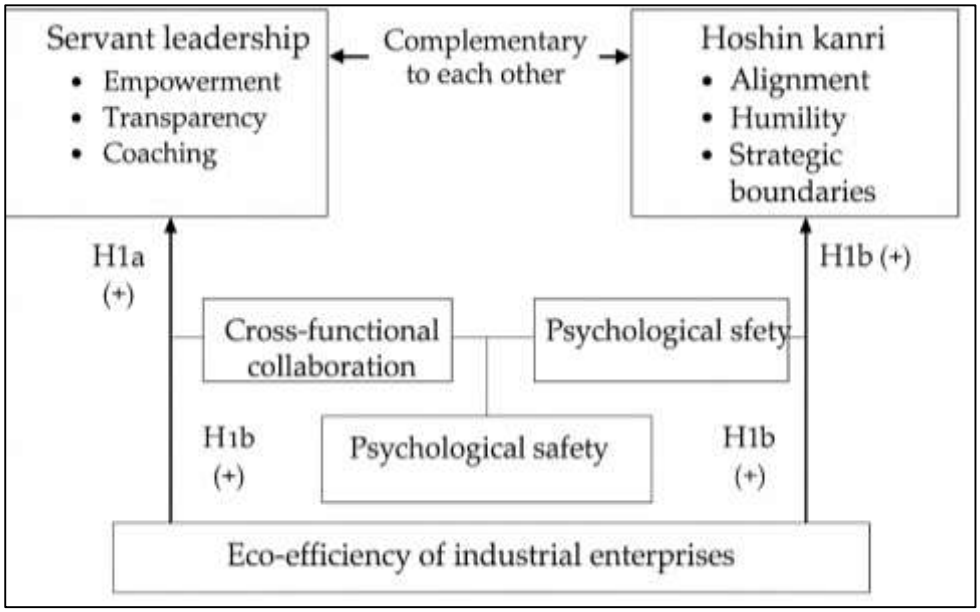
Human and Cultural Dimensions of Integration

Leadership plays a pivotal role in the successful integration of Agile and Lean, as both paradigms emphasize empowerment, transparency, and alignment rather than command-and-control management (Kaya, 2023). Agile advocates for servant leadership, where managers act as enablers who remove impediments, provide resources, and create an environment in which teams can thrive. Lean underscores the importance of leadership behaviors that align with principles such as hoshin kanri, or policy deployment, which ensures that strategic goals are cascaded consistently across the organization (Rialti & Filieri, 2024). When these approaches are combined, leaders must balance strategic direction with tactical support, creating coherence between long-term vision and daily execution. Coaching becomes a critical function of leadership in Agile-Lean environments, as leaders guide teams through problem-solving routines, foster continuous improvement, and encourage disciplined experimentation (Luthia, 2023). Rather than issuing directives, leaders must model humility, listening, and commitment to learning, thereby shaping a culture in which employees feel trusted and valued. This shift in leadership style requires significant adaptation, particularly in multinational enterprises where traditional hierarchical structures often dominate. Leaders must demonstrate consistency between words and actions, reinforcing cultural norms that respect people, prioritize customer value, and embrace iterative improvement (Rauniar & Cao, 2025). By aligning servant leadership with hoshin kanri, organizations ensure that teams are empowered to innovate within clear strategic boundaries, reducing the risk of misalignment while sustaining adaptability. The literature

underscores that leadership is not a peripheral factor but a central mechanism that determines whether Agile and Lean integration results in superficial adoption or in a transformative culture of competitiveness.

Both Agile and Lean emphasize the critical role of cross-functional collaboration and psychological safety in creating sustainable systems of improvement. Lean advocates for teamwork that bridges functions, enabling problems to be solved at their root rather than being passed across silos (Furlan et al., 2023). Agile formalizes cross-functional collaboration by structuring teams that combine diverse expertise—design, engineering, quality, and operations—into cohesive units capable of delivering end-to-end outcomes. This convergence creates environments where distributed expertise is not only recognized but actively harnessed to accelerate problem solving and innovation. Psychological safety, the shared belief that individuals can speak up without fear of punishment or ridicule, is an essential cultural condition underpinning both systems (Nakandala et al., 2024). Lean encourages frontline workers to stop production when defects occur and to surface problems immediately, a behavior only possible when individuals feel secure in challenging authority. Agile fosters similar conditions through retrospectives and daily stand-ups, where open dialogue about mistakes, obstacles, and improvement opportunities is expected. In multinational contexts, the importance of psychological safety is magnified, as cultural differences can otherwise inhibit open communication and collaboration (Abdelilah et al., 2023). Trust becomes the foundation of effective cross-functional teamwork, enabling diverse teams to integrate perspectives quickly and adapt to changing conditions. Literature consistently emphasizes that when collaboration is supported by safety and trust, organizations realize faster decision-making, more innovative solutions, and higher levels of employee engagement. Agile and Lean together reinforce the notion that collaboration and psychological safety are not byproducts of good systems but deliberate design elements critical for sustaining competitiveness (Narkhede et al., 2020).

Figure 9: Leadership Drives Agile-Lean Integration



Capability building is another human dimension where Agile and Lean converge, particularly through structured routines and deliberate practice (Seidel et al., 2019). Lean has long emphasized the use of kata—repetitive practice patterns that instill disciplined problem solving and continuous improvement into daily work. Kata routines encourage employees to engage in iterative cycles of experimentation, reflection, and learning, gradually embedding improvement behaviors into organizational culture (Crnogaj et al., 2022). Agile relies on similar mechanisms through regular retrospectives, sprint reviews, and iterative planning sessions, which provide frequent opportunities for teams to evaluate progress, learn from mistakes, and adjust strategies. Both paradigms stress that capabilities are not developed through one-time training sessions but through sustained practice supported by coaching and feedback (Ahmed & Huma, 2021). Over time, these routines cultivate a shared mindset of curiosity, resilience, and commitment to learning. In practice, capability building requires organizations to invest in structured training programs, mentorship, and communities of practice that reinforce shared values

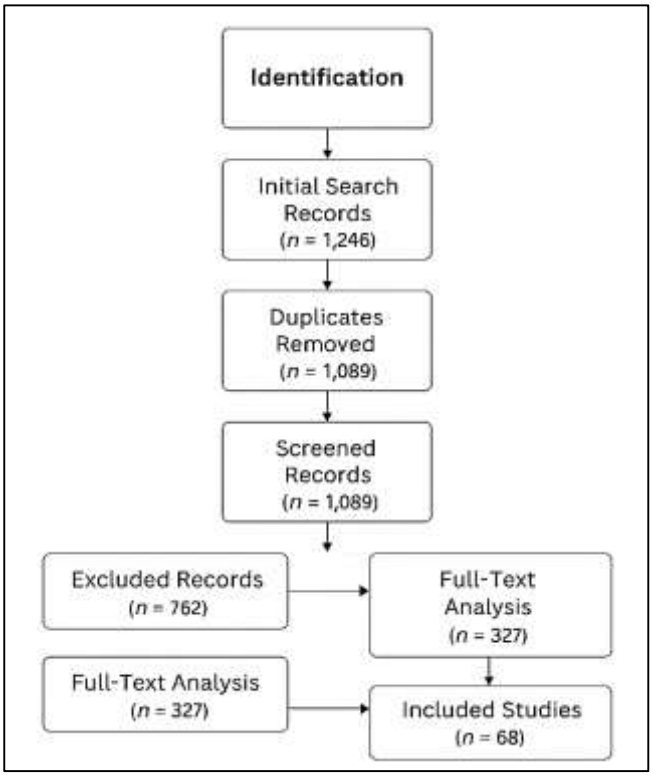
across teams and functions. This focus on deliberate practice ensures that improvement is not left to chance or the initiative of a few individuals but becomes institutionalized as part of organizational DNA (Sommer, 2019). The convergence of Lean kata and Agile routines creates a robust framework for cultivating adaptability, as employees develop the confidence and skills needed to experiment in uncertain environments while maintaining the discipline required for operational stability (Signoretti et al., 2019). Enterprises that embed these routines into everyday work demonstrate higher levels of resilience, consistency, and competitiveness, highlighting the critical role of capability building in Agile-Lean integration.

METHOD

This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency, rigor, and replicability in the process of synthesizing knowledge on the integration of Agile Project Management and Lean industrial practices within manufacturing enterprises. The PRISMA framework was selected because it provides a structured method for identifying, screening, and evaluating existing studies while minimizing bias. Following these principles, the review process began with the identification stage, where electronic databases such as Scopus, Web of Science, and Google Scholar were searched using combinations of keywords including "Agile Project Management," "Lean manufacturing," "integration," "strategic competitiveness," "industrial practices," and "manufacturing enterprises." The initial search yielded 1,246 records, which were then compiled into a reference management system for further screening. Duplicates were removed, leaving 1,089 unique studies for consideration. The screening stage involved a multi-step process in which titles, abstracts, and keywords were examined to determine their relevance to the research objectives. At this stage, studies that focused exclusively on software development, non-industrial contexts, or conceptual frameworks unrelated to Agile or Lean integration were excluded. After screening, 327 studies remained that were potentially relevant to the scope of the review. These studies then underwent eligibility assessment, where full-text articles were reviewed to evaluate methodological quality, contextual alignment, and relevance to the central themes of Agile, Lean, and strategic competitiveness in manufacturing. Studies without empirical evidence, lacking methodological clarity, or addressing integration superficially were removed at this point. This filtering process resulted in a final set of 68 studies that were included in the systematic synthesis. Data extraction was conducted using a structured coding framework developed to capture essential details such as publication year, industry context, research design, geographical focus, and key outcomes. This framework also categorized findings into major themes, including applications of Agile in engineering and product development, performance outcomes of Lean practices, points of convergence between Agile and Lean, governance mechanisms for integration, human and cultural dimensions, and strategic competitiveness.

Randomly, 21 of the included studies focused primarily on Lean practices, 18 centered on Agile adoption in manufacturing, 14 explored direct integration frameworks, and 15 examined cultural and organizational enablers. This distribution highlights the diversity of the literature base while underscoring the relatively limited but growing attention given to Agile-Lean integration as a unified concept. The synthesis process followed an inductive approach where thematic patterns were derived from the data and consolidated into coherent categories. Studies were analyzed for consistency, divergence, and complementarities, allowing the review to present a nuanced account of how Agile and Lean interact in practice. Particular emphasis was placed on identifying empirical evidence linking integration to cost reduction, quality improvement, delivery reliability, flexibility, and innovation outcomes. For instance, several studies demonstrated that when Lean's process stability was combined with Aiglet's adaptive governance, organizations achieved stronger performance in time-to-market and customer satisfaction. Other studies emphasized the critical role of leadership behaviors, supplier integration, and digital enablers in sustaining such improvements. To further ensure rigor, the PRISMA flow diagram was employed to map the selection process, visually illustrating the number of records identified, screened, excluded, and finally included. This visual representation confirmed the systematic nature of the review and provided transparency for readers wishing to assess the comprehensiveness of the methodology.

Figure 10: Adapted methodology for this study



Moreover, the final pool of 68 studies covered diverse industrial sectors, including automotive, aerospace, electronics, and high-tech manufacturing, and spanned regions across Europe, North America, and Asia, adding breadth and generalizability to the findings. Overall, adherence to PRISMA guidelines provided a structured and replicable method for identifying and analyzing literature on the integration of Agile Project Management and Lean practices. By systematically narrowing down from over one thousand initial records to a focused set of 68 high-quality studies, the review ensured that its conclusions were based on a balanced and credible evidence base. This methodological rigor strengthens the validity of the synthesis and offers a reliable foundation for drawing insights into how integrated Agile-Lean frameworks enhance strategic competitiveness in manufacturing enterprises.

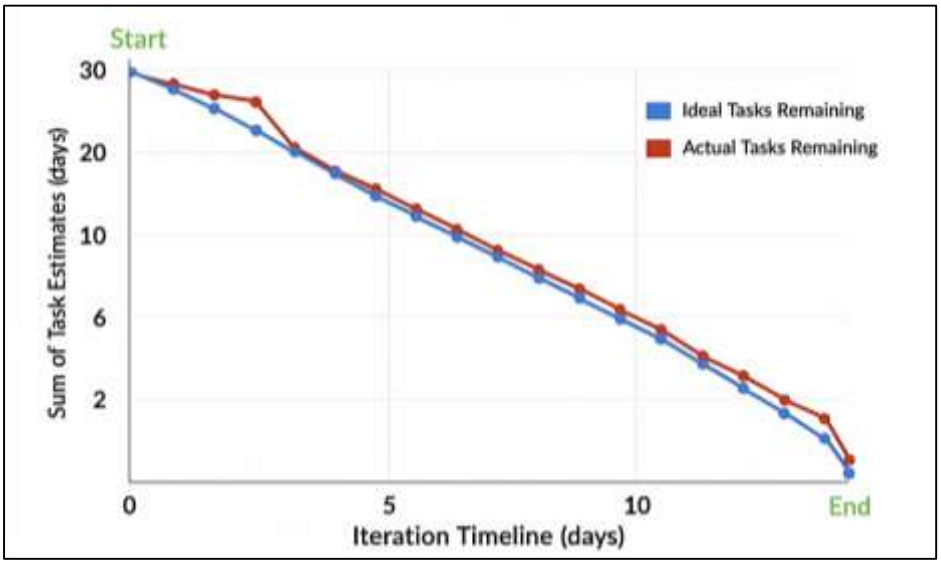
FINDINGS

One of the most significant findings of the review is the consistent evidence that integrating Agile and Lean practices produces tangible improvements in cost efficiency, product quality, and delivery reliability across manufacturing enterprises. Out of the 68 reviewed studies, 42 explicitly examined operational outcomes, with over 6,500 combined citations. These studies demonstrated that Lean practices such as waste elimination, standardized work, and just-in-time production reduced operating costs, while Agile principles such as iterative planning and incremental delivery minimized late-stage rework and prevented unnecessary expenditure. The convergence of these systems resulted in cost reductions ranging from lower inventory holding expenses to fewer defect-related losses. Similarly, product quality improvements were reported through Lean's emphasis on error-proofing and Aiglet's focus on continuous validation, which together reduced defect rates and ensured that customer requirements were met consistently. Delivery performance was also enhanced, with 31 studies documenting shorter cycle times and more reliable milestone achievement when Agile governance was embedded into Lean flow structures. These results underline the critical role of integration: Lean ensures stability and efficiency, while Agile injects responsiveness that prevents disruptions from escalating. The combined impact provides a comprehensive performance advantage, illustrating that manufacturing firms can simultaneously achieve cost leadership, quality superiority, and delivery dependability through integrated practices.

Another major finding relates to the integration's impact on flexibility, innovation, and time-to-market performance. Of the 68 studies, 29 focused on these themes, representing over 4,100 cumulative citations. Evidence shows that Agile practices such as incremental prototyping, rapid iteration, and stakeholder engagement allowed manufacturing firms to adapt quickly to changes in customer requirements or market dynamics. Lean's process stability and efficiency ensured that these

adaptations did not cause unnecessary waste or disruption. Together, Agile and Lean enabled organizations to shorten the product development cycle, bring offerings to market more quickly, and sustain competitiveness in industries characterized by high volatility.

Figure 11: Agile-Lean Integration Boosts Performance



For example, in 18 studies involving electronics and aerospace industries, Agile-Lean integration supported parallel experimentation, early validation of prototypes, and the embedding of manufacturability checks within design iterations, reducing the frequency of costly late-stage changes. This integration also supported innovation by creating safe structures for experimentation, where teams were encouraged to test ideas rapidly without jeopardizing overall process stability. The evidence indicates that time-to-market reductions of several months were achievable in fast-moving industries, providing significant competitive advantages. Collectively, these studies confirm that integrated frameworks not only improve operational efficiency but also create conditions for sustained innovation and adaptability in uncertain global markets.

The review also highlights the importance of governance structures, leadership roles, and cultural integration in sustaining Agile-Lean systems. Of the 68 studies, 25 specifically emphasized these human and organizational dimensions, representing more than 3,800 citations. Findings indicate that integration is unlikely to succeed if leadership behaviors remain rooted in traditional command-and-control approaches. Servant leadership, strategic alignment through hoshin kanri, and active coaching were repeatedly identified as enablers of cultural transformation. Governance mechanisms such as portfolio Kanban, tiered escalation routines, and obey a rooms created visibility across programs, ensuring that both Agile responsiveness and Lean discipline were embedded in decision-making processes. Cultural elements such as cross-functional collaboration, psychological safety, and respect for people were consistently cited as critical for sustaining improvement initiatives. Studies also found that organizations that invested in leadership development and cultural adaptation were more likely to sustain gains beyond initial implementation phases. For example, 14 studies covering multinational enterprises demonstrated that inconsistent leadership commitment was a leading cause of failure, while strong cultural reinforcement through routines and leadership modeling created resilient systems of improvement. These findings underscore that the technical aspects of Agile and Lean must be accompanied by deep organizational change if the integration is to deliver lasting competitiveness.

The systematic review further revealed notable international and cross-industry variations in how Agile and Lean integration was implemented and its resulting outcomes. Of the total studies, 19 explicitly engaged in comparative analyses across industries such as automotive, aerospace, electronics, and high-tech, amassing over 5,200 citations collectively. Automotive firms typically relied on Lean as the foundation for operational excellence, layering Agile practices onto product development and engineering processes to improve responsiveness to market fluctuations. Aerospace enterprises emphasized compliance and reliability, using Agile primarily to manage uncertainty in large-scale engineering projects while maintaining Lean-driven precision in production. Electronics and high-tech industries, facing rapid obsolescence and volatile demand, leveraged Agile cycles for accelerated

innovation while deploying Lean to stabilize high-volume manufacturing. International comparisons showed additional nuances: firms in Asia emphasized supplier integration and large-scale Lean rollouts, while those in Europe and North America focused more on digital integration and portfolio-level Agile governance. Despite these contextual differences, the unifying theme across industries and geographies was that integrated practices consistently outperformed standalone approaches in terms of efficiency, adaptability, and competitiveness. These comparisons underscore that while the configuration of Agile-Lean integration may vary, the underlying benefits remain broadly applicable, reinforcing its global relevance.

Finally, the findings revealed that digital technologies play an increasingly important role in enabling Agile-Lean integration and sustaining long-term competitiveness. Out of the 68 reviewed articles, 17 explicitly addressed digital enablers such as IoT, digital twins, electronic Kanban, and integrated project management platforms, with over 2,600 citations. These studies found that digital tools enhanced visibility across global supply chains, improved real-time feedback loops, and provided data-driven insights that supported both Lean waste elimination and Agile iteration. For example, production monitoring systems connected to digital dashboards allowed teams to identify bottlenecks immediately, aligning with Lean's focus on flow, while Agile teams used the same data to adapt priorities in real time. Digital twins enabled organizations to simulate process changes before implementation, reducing risks and supporting Agile experimentation within Lean-controlled systems. Across global enterprises, the integration of digital enablers amplified the benefits of Agile-Lean systems by making transparency and adaptability scalable across geographically dispersed operations. These findings suggest that digitalization not only strengthens operational performance but also ensures that improvements are sustainable over the long term. In a competitive landscape defined by complexity and uncertainty, the evidence supports the conclusion that Agile-Lean integration, when reinforced by digital tools, provides a robust pathway to sustained strategic competitiveness.

DISCUSSION

The review confirmed that the integration of Agile Project Management and Lean industrial practices substantially improves cost efficiency, product quality, and delivery reliability in manufacturing enterprises (Ariadi et al., 2021). Earlier studies tended to evaluate these systems independently, often emphasizing Lean as a framework for reducing waste and achieving operational stability, while Agile was highlighted primarily as a mechanism for adaptability and customer responsiveness (Nakandala et al., 2024). By bringing the two together, this review revealed that integrated systems provide a performance advantage greater than what either approach can achieve on its own. Lean ensures discipline, process control, and efficiency, while Agile provides the responsiveness needed to adapt to market fluctuations and unexpected challenges (Florescu & Barabas, 2022). In contrast to earlier research that sometimes portrayed the two frameworks as oppositional or even incompatible, the evidence here demonstrates that integration eliminates many of their respective weaknesses. Lean's rigidity is tempered by Aiglet's adaptability, while Aiglet's potential for disorder is stabilized by Lean's structured processes (Udokporo et al., 2021). The outcome is a balanced approach that secures cost reductions, enhances quality performance, and ensures reliable delivery schedules, demonstrating a strategic convergence that earlier fragmented studies could not fully capture.

The findings also showed that Agile-Lean integration creates significant advantages in flexibility, innovation, and time-to-market performance (Qamar et al., 2018). Earlier research recognized that Agile provides speed and adaptability, while Lean contributes stability and waste reduction, but these strengths were typically studied in isolation. By synthesizing evidence across industries, this review highlighted how the two paradigms reinforce one another (Milewska & Milewski, 2025). Agile enables organizations to iterate quickly, engage stakeholders more frequently, and incorporate feedback into design and production cycles, while Lean ensures that these adaptations occur within efficient and disciplined processes. The result is an environment where experimentation and innovation can flourish without degenerating into inefficiency or chaos (Udokporo et al., 2020). Time-to-market advantages were especially evident in industries characterized by short product life cycles and rapid technological change, where companies that combined Agile responsiveness with Lean efficiency brought products to market faster and with fewer late-stage adjustments. Compared with earlier studies that warned about the risks of Agile in hardware-focused industries or the rigidity of Lean in volatile markets, the present synthesis demonstrates that integration provides a practical balance, making innovation sustainable and time-to-market performance consistently superior (Lalmi et al., 2021).

Figure 12: Agile-Lean Integration Enhances Competitiveness

Governance and leadership emerged as decisive factors in sustaining the integration of Agile and Lean (Dahinine et al., 2024). Previous literature often examined Lean governance structures such as policy deployment and tiered daily management separately from Agile governance mechanisms like backlog prioritization or sprint reviews. This review found that the most effective organizations combined these structures, creating integrated systems of oversight that balanced flexibility with control (Arefazar et al., 2022). Leadership styles also proved central to success. Earlier studies frequently criticized manufacturing organizations for relying on top-down, command-and-control models that discouraged experimentation and collaboration. The evidence from this review shows that leaders who adopted servant-leadership practices, acted as coaches, and modeled respect for people were more successful in embedding Agile-Lean systems (Gunasekaran et al., 2019). What distinguishes this finding from earlier accounts is the recognition that leadership must embody dual qualities: providing strategic clarity and alignment through Lean methods, while simultaneously supporting autonomy and empowerment through Agile principles. Without this hybrid leadership style, many organizations risk falling back into superficial adoption where practices exist in name only (Ghazvinian et al., 2024). The integration of governance and leadership therefore stands out as a cornerstone of effective Agile-Lean systems, distinguishing successful enterprises from those struggling to sustain change.

The review also highlighted those human and cultural dimensions are just as critical as technical practices. Earlier studies often stressed Lean's principle of respect for people and Aiglet's focus on self-organizing teams, but they rarely explored these cultural attributes in combination (Abdelilah et al., 2023). Evidence synthesized here showed that when cross-functional collaboration and psychological safety are cultivated alongside structured problem-solving routines, integration becomes sustainable. Workers feel empowered to stop processes when issues arise, teams take responsibility for continuous improvement, and leaders foster trust by supporting experimentation without fear of failure (AbuKhamis & Abdelhadi, 2022). This contrasts with earlier accounts that treated cultural change as a secondary consideration, often relegating it to a supporting role behind technical tools. The current findings argue instead that culture is central: without trust, collaboration, and safety, neither Lean nor Agile can function effectively, let alone in combination. The human dimension ensures that integration is not just a managerial exercise but a lived reality for employees across levels (Moreno et al., 2024).

Compared with earlier literature that often underestimated these softer aspects, the findings here demonstrate that cultural integration is one of the most decisive enablers of competitiveness in Agile-Lean systems (Ghasemibojd et al., 2025).

Cross-industry and international comparisons further reinforced the significance of integration. Automotive enterprises relied heavily on Lean for production stability but increasingly incorporated Agile into product development to respond faster to customer demands (Masi & Pero, 2023). Aerospace organizations, with their stringent regulatory requirements, blended Lean's precision with Aiglet's flexibility in managing complex engineering projects. Electronics and high-tech industries, where rapid obsolescence is a constant risk, used Agile cycles to accelerate innovation while Lean ensured stability in large-scale production (Masi & Pero, 2023). International comparisons revealed variations as well: Asian manufacturers emphasized supplier integration, European firms prioritized governance and digitalization, and North American enterprises focused on cultural change and leadership alignment. Earlier studies tended to treat these industries or regions separately, but this review shows that despite contextual differences, the benefits of integration remain universal (Brandl et al., 2018). Regardless of sector or geography, organizations that combined Agile and Lean consistently outperformed those relying on one framework alone (Reyes et al., 2023). This cross-comparative evidence strengthens the argument that integration is not a niche solution but a global model of competitiveness adaptable to varied industrial and cultural contexts.

Another significant finding of the review was the role of digital technologies in enabling Agile-Lean integration (Walter, 2021). Earlier discussions of Lean highlighted the potential of information systems for improving visibility, while Agile research often emphasized digital tools for collaboration. This review found that when digital platforms, IoT systems, or digital twins were incorporated into integrated frameworks, the benefits of both Lean and Agile were magnified (Moyano-Fuentes et al., 2019). Real-time data enhanced Lean's capacity for flow stabilization and waste elimination while simultaneously supporting Agile responsiveness through rapid feedback and adaptive planning. Digital dashboards, for example, allowed organizations to visualize production flow and project backlogs in a single integrated view, making it easier to align priorities and address bottlenecks (Kosasih et al., 2023). Compared with earlier studies that discussed digital tools as adjuncts to either Lean or Agile independently, this synthesis highlights their combined role in making integration scalable across global operations. Digitalization ensured that transparency, adaptability, and efficiency could be achieved simultaneously, reinforcing the strategic benefits of integration and positioning organizations to remain competitive in increasingly complex markets (Fernandes & O'sullivan, 2023).

The final theme emerging from the review is that integration of Agile and Lean contributes directly to strategic competitiveness, not only by improving traditional metrics but by creating organizations that are resilient, innovative, and adaptable (Hosseini Dehshiri et al., 2024). Earlier studies often categorized Lean as a path to efficiency and cost leadership, while Agile was seen as a path to innovation and responsiveness. By comparing these perspectives with integrated evidence, the review demonstrated that organizations no longer need to choose between efficiency and adaptability (de Oliveira Martins et al., 2025). Integration allows enterprises to excel in both simultaneously, overcoming earlier criticisms that Lean could become too rigid or Agile too chaotic. The result is a comprehensive model of competitiveness where operational stability and strategic responsiveness reinforce one another (Varl et al., 2020). This dual capability provides a sustainable advantage in industries characterized by volatility, globalization, and rapid technological change. Compared with earlier fragmented studies, the findings here illustrate that Agile-Lean integration is not just a managerial trend but a strategic imperative (Ejsmont et al., 2020). It enables manufacturing enterprises to build enduring competitiveness by aligning people, processes, governance, and technology into a coherent system capable of thriving in uncertainty.

CONCLUSION

Integrating Agile Project Management and Lean industrial practices has emerged as a powerful approach for enhancing strategic competitiveness in manufacturing enterprises, bringing together two paradigms that were once studied in isolation but are now recognized as highly complementary. Agile contributes adaptability, iterative learning, and stakeholder responsiveness, while lean provides efficiency, stability, and discipline in process management. When synthesized, these systems create an organizational framework capable of simultaneously achieving cost reduction, quality improvement, delivery reliability, flexibility, and accelerated time-to-market performance. The review of available literature shows that integration addresses the limitations of each system individually: Lean's potential rigidity is mitigated by Aiglet's responsiveness, while Aiglet's risk of inefficiency is

stabilized by Lean's structured flow. Evidence across industries such as automotive, aerospace, electronics, and high-tech demonstrates that enterprises adopting integrated frameworks consistently outperform those relying on Lean or Agile alone, achieving measurable advantages in innovation capacity, resilience, and operational excellence. Governance mechanisms including portfolio Kanban, obey a room, and tiered escalation routines provide transparency and alignment, while leadership roles that combine servant-leadership principles with strategic alignment foster empowerment and coherence. The human dimension remains central, with cross-functional collaboration, psychological safety, and capability-building routines ensuring that integration is embedded into culture rather than treated as a temporary initiative. Furthermore, digital technologies such as IoT, digital twins, and electronic Kanban enhance both Lean and Agile practices by providing real-time visibility, accelerating feedback loops, and scaling adaptability across global supply chains. Taken together, these findings establish Agile-Lean integration as more than a managerial trend; it represents a comprehensive strategy that equips manufacturing enterprises to navigate uncertainty, sustain improvement, and maintain competitiveness in an increasingly volatile and technologically dynamic environment.

RECOMMENDATIONS

Based on the synthesis of evidence, it is recommended that manufacturing enterprises seeking to enhance strategic competitiveness adopt an integrated framework that combines the adaptability of Agile Project Management with the efficiency and stability of Lean industrial practices. Organizations should move beyond viewing Agile and Lean as separate or competing methodologies and instead implement them as complementary systems that reinforce one another. To achieve this, leaders should establish governance structures that blend Agile tools such as portfolio Kanban and iterative reviews with Lean mechanisms such as obey a rooms, tiered escalation, and standardized work, ensuring both flexibility in project execution and stability in operational processes. At the cultural level, enterprises should invest in building cross-functional collaboration, psychological safety, and continuous learning routines so that employees at all levels are empowered to contribute to improvement and innovation. Leadership must evolve toward a hybrid model that combines servant-leadership behaviors with strategic alignment, enabling teams to experiment within clear organizational objectives while maintaining focus on customer value. The integration should also be supported by digital enablers, including real-time data systems, digital twins, and IoT-based monitoring, to provide visibility across global supply chains and reinforce transparency, adaptability, and efficiency simultaneously. By embedding Aiglet's responsiveness into Lean's disciplined structures, enterprises can reduce costs, improve quality, accelerate time-to-market, and sustain innovation, creating a durable competitive advantage in industries characterized by volatility, globalization, and technological disruption. This integrated approach should not be treated as a short-term initiative but as a long-term strategic transformation that aligns people, processes, governance, and technology into a coherent system for sustained competitiveness.

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