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Managing the Lean–Agile Paradox in Complex Environments

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Abstract: The decision to incrementally improve existing processes and products or introduce breakthrough innovations depends on the context a company is facing. In situations where problems are known, it is better to incrementally improve, while in complex situations where problems are not known, a probe-sense-respond approach based on experimentation and the exploration of new solutions is preferable. Lean management adapts well to the first type of context, while agile management fits the second type of context. However, organizations must increasingly consider both approaches and become ambidextrous by introducing incremental improvements and breakthrough innovations simultaneously. This requires embracing the paradox between exploiting and exploring, adopting a new leadership mindset, and dual strategic, organizational, and behavioral models. This paper proposed a framework to implement lean and agile approaches simultaneously using the paradox theory to justify and manage this co-existence. This framework is threefold. First, managers need to differentiate between lean and agile, finding ways of keeping the two approaches separated. Second, lean and agile should be integrated so that synergies between the two approaches can be generated. Finally, managers need to achieve a dynamic equilibrium over time between lean and agile. Contributions to the theory and practice of this approach were discussed.

Keywords: complexity; exploration; exploitation; ambidexterity; paradox; lean; agile

1. Introduction

Should firms improve the existing processes and products incrementally or introduce breakthrough innovations? This is the question that companies must often answer. When developing a new product, should one leverage the existing technological platforms or introduce a new technology that is not compatible with the current one but potentially better performing? To increase the productivity of factories, should existing processes be improved or new technologies guided by the introduction of artificial intelligence algorithms? To increase the efficiency and robustness of the supply chains, should one work with current suppliers or explore new sources of supply and redesign the supply chains, even geographically? The list goes on.

The most appropriate answer to these questions is "it depends". It depends on the context that the company is facing [1]. In situations where the problems are defined, easily identifiable, or catalogued and the answers to these problems are known, it is better to adopt the first approach: improve what already exists.

In "complex" situations where problems are not known (unknown unknowns), the uncertainty is profound, the relationships of cause and effect and therefore possible solutions to the problems do not yet exist, it is preferable to adopt a "probe-sense-respond" approach based on experimentation and exploration of new solutions [1,2].

The ability of a leader is, first and foremost, to understand the characteristics of the decision-making context to avoid an excessive response (i.e., exploring in contexts in which problems are defined and require improvement of existing solutions) or too timid (i.e., improving when the context requires innovation and adaptation).

Lean management adapts well to the first type of context. The Toyota Production System (TPS), the quintessence of lean management, is based on continuous improvement and kaizen. The backbone of TPS is "Genchi Genbutsu" (go and see the problem in the gemba, the place where value is created) coupled with kaizen (continuously improving processes and the value delivery system) [3]. The problems typically faced with lean management are known, analyzable, and experimentation leads to finding the best countermeasures and standardizing them.

Conversely, agile management (understood as a strategic/organizational approach and not as a simple project management tool) was born precisely to deal with situations of the second type. In complex contexts it is not possible to start with the analysis since the problem to be addressed is not even known [4]. There are only "weak signals" which are the first symptoms of change. The first thing is therefore to know how to grasp these weak signals in order to start experimenting as soon as possible by "throwing" solutions on the market and learning in an adaptive way (and with frequent interactions) thanks to feedback from customers, employees or other stakeholders.

A third approach can be considered with respect to the dilemma between improving the existing (through lean) or exploring the new (through agile): Do both. Organizations facing complex environments need to become ambidextrous, i.e., they need to introduce both incremental improvements and breakthrough innovations. The dichotomy between lean and agile becomes a paradox, from an either/or approach to a both/and approach. This path requires fueling tensions in the company by making the conflict between exploiting and exploring (which always exists at least latently) explicit. A new leadership mindset and dual strategic, organizational and behavioral models must be adopted that embrace the paradox rather than reject it.

There are several papers that have studied whether or not lean and agile can be implemented together [5–8]. For example, Krishnamurthy and Yauch [7] maintain that it is possible for a firm "to simultaneously pursue both lean and agile manufacturing strategies by adopting a leagile infrastructure" (p. 588). A decoupling point separates the agile, market-focused, part of the corporation from the lean, production-focused, part of the corporation. Quite differently, Hallgren and Olhager [6] find that the drivers and outcomes of lean and agile manufacturing are different. Their research revealed that the competitive intensity of the industry serves as a driver of lean manufacturing, which is completely mediated by the adoption of a cost-leadership strategy. In contrast, agile manufacturing is directly influenced by both internal and external drivers, such as a differentiation strategy and the competitive intensity of the industry. Notably, the adoption of a cost-leadership strategy is negatively associated with agile manufacturing, highlighting the contrast between lean and agile manufacturing.

To the best of our knowledge, however, no scholar has interpreted lean and agile as representative of the dichotomy between exploration and exploitation. Our paper is therefore the first attempt to propose a framework to simultaneously implement lean and agile approaches using the paradox theory to justify and manage this co-existence.

The paper is organized as follows. First, we review the theory of environmental complexity and interpret organizational ambidexterity as a manifestation of the complexity that firms need to deal with. Second, we use the paradox lens to frame the concept of organizational ambidexterity. Combing exploitation and exploration is a paradox that need to be managed using a paradoxical lens. Third, we interpret lean as a way to exploit, i.e., introduce small and frequent improvements of existing products and existing processes while agile is interpreted as an explorative approach aimed at introducing breakthrough innovations that break from existing products and processes. In today's competitive environments, firms need to do both, they need to become ambidextrous. Simultaneously managing lean and agile becomes a paradox. In the final part of the chapter, we advance a framework that draws on the paradox theory to simultaneously manage lean and agile approaches. In Section 6, we discuss our framework in light of the current literature and outline some opportunities for future research.

2. Environmental Complexity and Organizational Ambidexterity

A wide range of complexity theories have been developed in different disciplinary fields and at distinct times since the years straddling the Second World War, when, for example, Shannon [9] formulated his mathematical theory of communication. The existence of different approaches to complexity—complexity versus complexities [10]—requires a premise to our analysis: the complexity we are dealing with refers to the competitive environment by taking on the viewpoint of the firm, and in particular, of the managers who are tasked with coping with it. Of course, firms are part of the competitive environment and interact with other parts of it, as emphasized by the ecosystem perspective that has attracted increasing attention from management scholars over the past decade [11].

A review of management studies leads to identifying three dimensions or even components of environmental complexity [1,12–16], which we could label as:

- static complexity;
- systemic complexity;
- dynamic complexity.

The first component of complexity concerns the number of elements in the environment that can affect the focal organization. This is the number of variables in play (variety) and the number of values in which each occurs (variability in the statistical sense). The higher the number of environmental elements that must be taken into account increases the complexity. For example, a product market is more complex the greater the number of product attributes relevant to consumers' purchase choices, and the more segmented they are in relation to the importance given to different attributes. Attempts to identify a synthetic measure of environmental complexity refer to static complexity [13].

A second source of complexity is associated with the systemic nature of the competitive environment, or ecosystem, if one accepts the definition of business ecosystem proposed by Teece [17] according to whom it includes all "organizations, institutions, and individuals that impact the enterprise and the enterprise's customers and suppliers" (p. 1325). A higher number of relationships between environmental elements increases complexity. This aspect has been particularly emphasized by the theoretical perspective of the market as a network where "no business is an island" [18,19].

Both the first and second components of complexity can undergo changes over time (variability not in the statistical sense). This static-dynamic dimension in the words of Duncan [20] adds complexity even when the changes turn out to be predictable because of the knowledge and instrumentation required to make the predictions. But it is the emergence of unpredictable events and processes that makes dynamic complexity the most drastic generator of uncertainty burdening business decisions [21–23]. The COVID-19 pandemic offers a recent and dramatic example of this dimension of environmental complexity [24].

It has been widely pointed out that the complexity of the competitive environment or external complexity has grown considerably in all three dimensions—variety, connectedness, and uncertainty. The main forces pushing in this direction are globalization and the increasing problems of environmental sustainability [23,25,26]. These two forces operate synergistically: in a global competitive environment, where everything is connected—as the physicist Barabási explained in his celebrated book *Linked* [27]—the rapid propagation on a global scale of unforeseen shocks that can arise anywhere (e.g., an epidemic started in China or an earthquake in Japan), often have dramatic global effects [28]. A third trend that today's discourse on the complexity of the competitive environment must necessarily take into account is related to the fourth industrial revolution or digital transition: on the one hand, technologies such as artificial intelligence and the Internet of Things are creating new and powerful tools to cope with environmental complexity [15,29]; on the other hand, they represent a factor of complexity due to the problems of selection, integration, and optimal use that they pose [30].

Firms that live in complex competitive environments respond by developing internal complexity that is both cognitive and organizational [14,31,32]. In general terms, internal

complexity can be defined in a mirror-image fashion to external complexity. As Simon [33] argued in his essay on the architecture of complexity: a complex system is defined as "one made up of a large number of parts that interact in a nonsimple way. In such systems, the whole is more than the sum of the parts, not in an ultimate, metaphysical sense, but in the important pragmatic sense that, given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole" (p. 468).

The growth in external complexity that characterizes the historical phase in which we live should not lead one to believe that complexity should be treated as an attribute pertaining to the environment tout court. A complex environment symmetrically finds a unique response in the organization in terms of internal complexity. However, many firms deal with a plurality of distinct (however connected they may prove to be) environments–contexts characterized by different levels of external complexity. An example that has received recent attention is that of BtoB manufacturing firms developing an advanced digital servitization strategy by building a new business model (to work in a complex context) alongside the traditional, established one (working in a relatively simpler context) [34,35]. Situations such as this are not uncommon. In the era of the fourth industrial revolution, incumbent firms in all sectors are wondering how to simultaneously manage existing business models that still perform well with new business models that are yet to be fully understood.

One approach that grasps the multi-context characteristic of the competitive environment and its implications for strategic decision-making is the Cynefin framework first proposed by Kurtz and Snowden [2] and later taken up by Snowden and Boone [1] in an article published in the *Harvard Business Review*. The framework identifies four contexts or domains: simple (known knowns) where the relationships between cause and effect are clear; complicated (known unknowns) where the cause–effect relationships allow for a range of right answers; complex (unknown unknowns) where it is possible to understand why things happen only in retrospect; chaotic (unknowables) where "the relationships between cause and effect are impossible to determine because they shift constantly and no manageable patterns exist—only turbulence" [1] (p. 5). Although critical remarks have been raised on the specific typology of contexts proposed by Snowden and colleagues [36], what can be taken for granted is the variety of contexts in relation to their knowability. Even more interesting from the perspective of our analysis is the fact that firms may be simultaneously operating in multiple contexts because their strategic leaders must make, in the same circumstance, decisions pertaining to different contexts [1], or because—as has been proposed in the field of project management [37]—the firm develops simple, complicated, and complex projects simultaneously.

A polarity included in the Cynefin framework is the one between complex and simple contexts. Any firm that has gained a strong competitive position in a certain market, where ecosystem relationships are stable and product and process innovations are incremental and easily imitated, works in a context that has become simple; however, when the firm decides to seize the opportunities brought by a technological discontinuity and to develop an offering system (for its most advanced customers) completely different from the established one (as in the case of the digital servitization strategies mentioned above), it enters an unknown, uncertain context, i.e., a complex context. A firm facing a competitive environment characterized by this duality or polarity must develop internally differentiated solutions that are suitable for the two types of contexts.

We find the same polarity (i.e., simple vs. complex contexts) at the heart of the studies on organizational ambidexterity [38]. More specifically, we are referring to those studies—prevalent in the literature on organizational ambidexterity [39,40]—that closely associate this ability or better dynamic capability [41] with the classic dichotomy proposed by March [42] between exploration (coupled with complex contexts) and exploitation (coupled with simple contexts). In line with March's original definition, exploitation means not only exploitation of already available knowledge, but also incremental improvements and innovations [43].

March [42] concludes his essay by arguing that exploitation is about the refinement and extension of existing knowledge (e.g., competences, technologies, and paradigms) while exploration is about experimentation with new alternatives. Returns on exploitation are predictable, while returns on explorations are uncertain. Therefore, the distance in time and space between the locus of learning and the locus of returns is generally greater for exploration than for exploitation. These considerations have led several scholars to question how an organization can behave ambidextrously while remaining competitive. Table 1 summarizes the main contributions that have offered answers to this question. In particular, some studies have treated organizational ambidexterity as a dilemma whose solution requires separating exploration and exploitation into different time periods (sequential or temporal ambidexterity) or into different structures (structural ambidexterity) wherein exploration is delegated to a specific corporate venture or division, often newly formed [44,45]. Markides [46], drawing on case studies with a focus on disruptive business model innovation, highlighted a variant of structural ambidexterity (temporal separation), in which the new business model is developed in a separate organization unit (in order to mitigate conflicts with the existing business model) and then reintegrated into the main business.

The idea that the firm can, and indeed should, do exploration and exploitation simultaneously was proposed in a different version of structural ambidexterity by Gibson and Birkinshaw [47], who introduced the concept of contextual ambidexterity. According to these authors, and others who have followed, ambidexterity is achieved "by building a set of processes or systems that enable and encourage individuals to make their own judgments about how to divide their time between conflicting demands for alignment and adaptability" (p. 211), i.e., between exploitation and exploration. In this case, every individual working in a given organization should be ambidextrous. But the concept of contextual ambidexterity has not only been used in this way, that is "within" individuals [48]. For example, one should refer to contextual ambidexterity also in cases where some employees manage the relationships with demanding clients whose complex needs require a superior exploration investment [49,50]. Other authors [51,52] propose to extend the concept of contextual ambidexterity from the individual level (within or between individuals) to the level of groups of individuals, such as project teams (between teams).

Table 1. Selected Contributions on Organizational Ambidexterity.

Authors (Year)	Type of Contribution	Key Findings
Markides (2013) [46]	Theoretical	Simultaneously managing an existing business model and a new, disruptive one is framed as an ambidexterity challenge. This challenge can be met through temporal separation, where the firm puts the new business model: in a separate unit but reintegrating it in the main business over time (a variant of structural ambidexterity); or within the existing business but separating it over time (a variant of contextual ambidexterity).
Gibson and Birkinshaw (2004) [47]	Empirical (quantitative)	In an ambidextrous organization individuals divide their time between conflicting demands for exploration and exploitation. This contextual ambidexterity is positively associated with the performance of the organization.
Bednarek et al. (2016) [49]	Empirical (qualitative)	Client portfolios are seen as a source of ambidexterity for knowledge-intensive firms. These firms can attain knowledge by segmenting their client portfolios, use that knowledge to explore and exploit within and across client relationships, and adjust their portfolios over time.

Table 1. *Cont.*

Authors (Year)	Type of Contribution	Key Findings
Im and Rai (2008) [50]	Empirical (quantitative)	Both exploratory and exploitative knowledge sharing lead to better performing inter-organizational relationships; such sharing is enabled by the ambidextrous management of the relationships.
Lavie et al. (2010) [52]	Theoretical	Alternative modes of balancing exploration and exploitation are identified. In the contextual ambidexterity mode, balancing takes place at the individual and group level.

Figure 1 shows the conceptual framework that, based on the relevant literature, describes the link between the complexity of the competitive environment and organizational ambidexterity. Consider a firm that must deal simultaneously with a simple context and a complex context, that is, using the Cynefin language, one context in which the relationships between cause and effect are clear, and another for which it is possible to understand why things happen only in retrospect. The ambidextrous organization is characterized by its ability to effectively manage the two key processes that mark these two contexts—exploration and exploitation. The exploration–exploitation duality can be located at different levels of analysis, which correspond to alternative ways of conceptualizing organizing ambidexterity. The first (within individuals), represented on the right hand-side of Figure 1, is the one corresponding to Gibson and Birkinshaw's view of contextual ambidexterity. The second (between individuals) and third (between teams) are hybrid forms (for the sake of simplicity, Figure 1 shows only the "between teams" solution). The second and third solutions can be seen as versions of contextual ambidexterity based on organizational differentiation within the same organizational context, but also as versions of structural ambidexterity based on the structural division of exploitative and exploratory tasks between individuals/teems [47]. Lastly, the fourth level (between organizational units) marks the transition from contextual to structural ambidexterity. In any case, it should be kept in mind that the separation of exploration and exploitation into distinct entities (individuals, teams, organizations) must be matched by identifying and managing the possible interdependencies between them [46].

A particularly complex multi-unit firm could also house all three of the alternative solutions depicted in Figure 1. For example, in studying a large European multi-unit research firm, Güttel and Konlechner [53] were able to distinguish between: monodextrous organizational units dedicated only to exploitation or exploration (structural ambidexterity in Figure 1); organizational units in which specific individuals or teams were dedicated to exploitation or exploration (central contextual ambidexterity in Figure 1); and ambidextrous organizational units in which all or most individuals were ambidextrous (right contextual ambidexterity in Figure 1). The authors studied in depth only the latter units, finding that in them "fluid project structures and semistructures, as well as commonly shared cultural values and norms, provided stability for a concurrent performance of exploration and exploitation" (p. 165).

Whatever form ambidexterity—intended as coping with simultaneous exploration and exploitation—takes, the conceptual approach that has proven most successful in interpreting it is the one based on paradoxes [45,54].
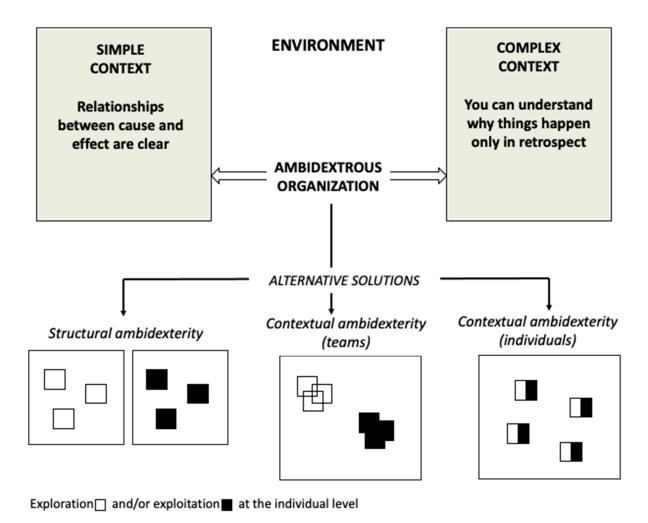
Figure 1. Ambidextrous organizations in complex environments.

3. Organizational Ambidexterity through the Lens of Paradox Theory

Drawing on the seminal contribution made by Lewis [55], Smith and Lewis [45] define paradox as two contradictory but interdependent elements that exist simultaneously and persist over time. This definition identifies two components of the paradox: (1) underlying tensions, i.e., elements that are logical and consistent when considered individually but become inconsistent and even absurd when juxtaposed; and (2) the simultaneous and persistent existence of the elements in tension.

In the same article, the authors recognized that contradictory demands intensify depending on the fact that environments become more global, dynamic, and competitive, and proposed a categorization of the paradoxical tensions that may arise in organizations. These are very general categories, representing "core activities and elements of organizations" [45] (p. 382): learning paradoxes, dependent on the fact that organizations are forced to change and that changes generate a tension between the well-known past and the not-yet-known future; belonging paradoxes or tensions of identity, as individuals and groups (for instance, project teams) seek both homogeneity and distinction; organizing paradoxes, which emerge whenever the achievement of a desired outcome leads to creating competing designs and processes within the organization; and performing paradoxes, stemming from the "differing, and often conflicting, demands of varied internal and external stakeholders" [45] (p. 384). This typology offered a conceptual framework that has since been used and specified by various empirical studies on organizational paradoxes [54]. Some specific tensions are directly classifiable within one of the four categories: for example, a typical learning paradox is the tension between incremental and disrupting innovation, with the potential for "disrupting the past" associated with the latter [45] (p. 383). Other tensions operate

between two categories, for example between learning and performing that "spur tensions between building capabilities for the future while ensuring success in the present" [45] (p. 384).

The fact that paradox elements exist simultaneously over time raises a fundamental problem of paradox management. Leaders faced with paradoxical tensions can respond in two different ways [45,56,57]. They can prioritize the challenges and decide to focus on one element to the exclusion of the other (either/or logic) or they can embrace tensions trying to find the drive for excellence in the contradiction (both/and logic). The first approach interprets each contradiction as a dilemma. This approach can be represented with a scale in which the benefits and costs of each alternative are weighed and the most convenient one is chosen. There is therefore a trade-off between the alternatives: one excludes the other, if one is correct the other cannot be correct. The dilemma has ancient roots being inherited in Western countries from Aristotelian teachings and in particular from the principle of non-contradiction, which establishes that if a given proposition A is true, then its negation, i.e., the proposition "not A", cannot be true. However, in organizational and strategic fields, the alternatives are hardly truly mutually exclusive and contain elements of contradiction together with the constraints of complementarity. Operational efficiency allows companies to generate the resources for innovation, and innovation allows companies to achieve operational excellence. This interdependence makes alternatives paradoxical and requires leaders to switch from an either/or approach (we need to invest in A or B) to a both/and approach (how can we do A and B simultaneously). We find relatively more recent traces of this solution in the history of Western thought than the previous one, precisely in the search for synthesis generated by the Hegelian dichotomy between thesis and antithesis. In the current situation, several authors see both/and logic as a necessary, albeit fraught with difficulties (internal complexity) way to deal with environmental complexity [58].

Smith and Lewis' idea is to exploit the interdependence/complementarity among the opposing elements in the paradox in order to construct a dynamic equilibrium. Their paradox theory, refined in subsequent contributions, has moved in this direction [45,54,55,59]. To frame the dynamic equilibrium that is the objective of paradox management, the authors resorted to the metaphor of the Taoist duality between the two contradictory elements of yin and yang [60].

In light of the early work produced by research on ambidexterity associated with innovation [38,41,47], Smith and Lewis [45] found an apparent connection between this strand of study and their paradox theory. This convergence seems almost taken for granted in the case of structural or contextual ambidexterity and is recognized by scholars from both fields [44,61]. Indeed, on the one hand, exploration and exploitation are perfect examples of two contradictory but interdependent elements that exist simultaneously and persist over time. On the other hand, as March [42] (p. 71) already reminded us, "both exploration and exploitation are essential for organizations, but they compete for scarce resources"; consequently, managing the exploration-exploitation paradox must necessarily take on the form both/and, with the resulting complexity facing the ambidextrous organization. Considering the paradox theory as a metatheoretical perspective [62], the exploration–exploitation dilemma—as well as the local–global dilemma [63]—offer a privileged ground for the application of the paradox metatheory.

Other works have shown the usefulness of analyzing ambidexterity through the lens of paradox theory [64–66]. Table 2 lists these contributions along with the foundational one by Smith and Lewis. In particular, Andriopoulos and Lewis [64] state that between structural ambidexterity, i.e., dual structures (which they call architectural ambidexterity) and contextual ambidexterity, it is the latter that represents the elective context of the paradoxical approach. Based on a multiple case study of leading new product design consultancies engaged in radical or incremental innovation projects, the authors identified different specific tensions under the umbrella of the general one between exploration and exploitation, each with its specific managerial implications in terms of integration and differentiation tactics: the strategic intent paradox between the need to make a profit and

the need to face breakthroughs; the paradox of customer orientation, related to the need to be tightly and loosely coupled to the customer; and the paradox of personal drivers, generated by discipline and passion that simultaneously fuel individuals' innovative efforts. Interestingly, the authors find that "managing paradox does not imply resolution or eliminating the paradox, but tapping into its energizing potential" [64] (p. 702).Managing paradoxes is far from easy: as the authors pointed out in another paper, conducted on a sample of firms very similar to the first, "paradox can fuel, as well as frustrate, innovation", that is, the dark side of paradox [65] (p. 117).

Table 2. Selected contributions on managing exploration–exploitation paradox.

Authors (Year)	Type of Contribution	Key Findings
Andriopoulos and Lewis (2009) [64]	Empirical (qualitative)	Leading design firms face different exploration-exploitation tensions (strategic intent, customer orientation, personal drivers), each with its specific managerial implications in terms of integration and differentiation tactics. The use these leading firms make of both integration and differentiation approaches to managing paradoxes of innovation demonstrate managerial creativity.
Andriopoulos and Lewis (2010) [65]	Empirical (qualitative)	Leading design firms provide three lessons in ambidexterity showing the power of paradoxes: (1) they can fuel, as well as frustrate innovation; (2) innovation paradoxes require paradoxical management approaches; (3) paradoxical tensions guide a common managerial approach, but enable contextual variations.
Papachroni and Heracleous (2020) [66]	Theoretical	Individual ambidexterity can be accomplished via paradoxical practices that renegotiate or transcend boundaries of exploration and exploitation. Three such paradoxical practices are identified: engaging in "hybrid tasks" that accomplish dual types of outcomes; carrying out tasks in a way that cumulatively capitalizes on previous efforts; adopting a mindset of seeking ways to accomplish task synergies between exploration and exploitation.

In short, an ambidextrous organization simultaneously exploits existing knowledge to make incremental improvements (what is called exploitation) and creates new knowledge by generating product, process, or business model innovations that break with the past (what is called exploration). The binomial exploitation–exploration qualifies as a paradox since the two forces of exploitation and exploration are in contradiction with each other even if over time they can be synergistic. Recognizing, accepting, and managing the paradox enables the firm to move in a multi-context environment in terms of (external) complexity. At the same time, the ambidextrous firm has an internal complexity that comes not only from exploring the most challenging and risky contexts, but also from managing exploration in close association with exploitation. It is within this framework that, following Lewis, Andriopoulos, and Smith [63], we can place the lean–agile dichotomy.

4. Lean and Incremental Improvements vs. Agile and Breakthrough Innovations

4.1. Lean and Kaizen: Exploiting to Introduce Incremental Improvements

Lean was first introduced as a way to generalize the principles underlying the Toyota Production System [3]. Lean has been conceived as a management system geared towards the reduction of waste (muda in japanese) in all forms in the search for continuous flow, operational excellence, and competitive advantage. As the famous book *The Machine That Changed the World* [3] shows, lean tools and practices can be applied in different functional areas of the organization from new product development to operations, from distribution to supplier relations.

The literature on lean management is vast and, as a recent debate shows [67,68], there are different definitions of the term lean, ranging from a pure science of efficiency to a learning and education system. Regardless of the definition of lean, there is a common thread that cannot be ignored: lean rests on the practices of kaizen (loosely translated as continuous improvement).

Kaizen can be defined as the incremental improvement of processes through a constant reduction of waste in all its forms. This requires the involvement and the engagement of people at all levels, making lean a total and human-centered system [69]. Kaizen results in small and incremental changes that lead to the improvement of existing operating routines. As Imai points out [70], kaizen is about introducing small changes everyday, by everyone, and everywhere, in the organization.

Both products and processes can be the subject of kaizen. Product improvement is associated with the introduction of improvements to existing products' technologies with the purpose of providing new features and benefits, while process improvement results in the application of incrementally improved elements to the operations with the purpose of achieving better operational performance [71].

One of Taiichi Ohno's (one of the leading figures of the Toyota Production System) most important teachings is that each member of the organization should learn the ability to observe and identify the waste that weighs down processes and products [72]. Kaizen starts with finding waste in processes, frames them as problems, and fosters an individual and organizational problem-solving effort to solve these problems [73]. To reach this objective, Kaizen starts from the observation of the gemba (i.e., a Japanese word that stands for "the place where value is created") or, in other words, the observation of the existing processes and the existing products. Kaizen improvements are associated with a reduction in process variations, and often leads to tighter coupling between low-level routines, making the organization more internally aligned [47]. Improvements are introduced following a scientific methodology based on the Plan, Do, Check, and Act (PDCA) cycle formalized by Deming [74]. First, problems are analyzed and countermeasures identified (Plan); then, countermeasures are implemented one at a time (Do); the countermeasure that works (Check) is then standardized (Act). PDCA leverages current skills and exploit existing knowledge to incrementally generate new knowledge that is used to improve current products and processes and to search for opportunities to be more productive and efficient.

4.2. Agile and Scrum: Exploring to Introduce Breakthrough Innovations

The concept of agile manufacturing was first introduced in 1991 in the Agility Forum. Agility was defined as "the ability to thrive and prosper in a competitive environment of continuous and unanticipated change and to respond quickly to rapidly changing markets driven by the customer-based valuing of products" [75] (p. 5155).

Numerous frameworks have been developed to implement and deploy the concept of agility. Among all the agile frameworks, Scrum is probably the most well-known and widely adopted. Scrum was first introduced in 1993 by Sutherland and Schwaber as a new way of managing complex projects. Scrum is considered more effective than the more traditional waterfall method, in which projects are developed in sequential stages and which results in slow processes, ill-defined products, delays, and excessive costs [4].

Scrum was originally inspired by the *Harvard Business Review* paper "The new new product development game" by Takeuchi and Nonaka published in1986 [76]. In this paper the authors studied some best-in-class companies which released innovations faster and identified a new approach, i.e., the team-oriented "rugby" approach used by firms such as Fuji-Xerox, Honda, and Canon. Scrum derives its name precisely from the game of rugby and it refers to the way in which a team moves the ball showing "careful alignment, unity of purpose, and clarity of goal" [4] (p. 13).

This new way of developing new products is based on a holistic approach and is built on six characteristics: "built-in instability, self-organizing project teams, overlapping development phases, multilearning, subtle control, and organizational transfer of learning" [76]

(p. 138). This approach "encourages trial and errors and challenges the status quo" [76] (p. 138), moreover, it "stimulates new kind of learning and thinking within the organization at different levels and functions" [76] (p. 138), finally it "can act as a change agent: it is a vehicle for introducing creative, market-driven ideas and processes into an old, rigid organization" [76] (p. 137).

Sutherland [4] translated these principles into the Scrum framework: an overlapping development process characterized by cross-functional teams, which have autonomy and can make decisions with a transcendent purpose. With Scrum, a complex project is divided into smaller pieces called sprints. Each sprint is an iterative cycle in which the whole team work intensively for a short period of time (e.g., one month) to deliver an output that can be evaluated by potential customers (and other stakeholders) at the end of the cycle. The feedback that is collected in the sprint reviews is used as an input for the next sprint to drive the development project towards the customers' needs.

Scrum is, therefore, an agile framework that is best used for complex projects where the degree of uncertainty (unknown unknowns) about market needs, and technological features, is high and the organization needs to explore new knowledge frontiers to introduce breakthrough innovations.

Product innovations introduce new technologies and architectures from the ones in use for existing products, while process innovations create new elements in the organization's operations [71]. Innovation generates new skills and implies the exploration of new knowledge for the discovery of new approaches to technologies, processes, or products. It relies on trial-and-error techniques used to uncover solutions and engenders process variation, making the system more externally adapted [47].

Scrum (and, in general, all agile frameworks) should be used precisely to introduce breakthrough innovations, e.g., innovations that mark a break with previous knowledge within the firm. Both products and processes can be the subject of breakthrough innovations that rely on creative solutions that change the way operations work and how products are designed.

5. Managing the Paradox between Lean and Agile

As we said previously, in complex and global environments, firms need to learn to become ambidextrous [45]. The more complex the environments, the more salient is the tension between exploitation and exploration.

We contend that, when confronted with complex environments, organizations must manage the paradox that derives from the combination of exploitation–exploration through the simultaneous adoption of lean and agile approaches.

Literature offers several studies on the dichotomy between lean and agile. We can divide this body of studies into two streams. The first stream contrasts lean and agile, highlighting the differences between the two systems. One of the most famous papers on this contrast was written by Marshall Fisher [5]. Professor Fisher proposed that supply networks serving different markets should be managed in different ways. In particular, supply networks that produce and deliver innovative products should be agile (responsive, flexible, fast) while supply networks that produce and deliver functional products should be lean (efficient, minimum inventory, low-cost). Another article that contrasts lean and agile is the one by Narasimhan, Swink and Kim [8]. The authors found that, when looking at the differences in plant performance, lean plants emphasize efficiency, quality control, and reliability, while agile plants have superior capabilities in terms of quality, delivery, and flexibility. The authors also found that agile performers dominate lean performers in most of manufacturing best practices. This might suggest that lean manufacturing is a possible antecedent to agile manufacturing.

A second stream of research emphasizes the complementarity between lean and agile systems. These studies suggest the application of a combination of the two approaches, a new system that is named leagile. Krishnamurthy and Yauch [7] proposed that corporations should simultaneously pursue both lean and agile manufacturing strategies by adopting a

leagile infrastructure. This organizational structure consists of three main levels: a corporate headquarters, a sales and service group, and multiple lean production units. Similarly, Bruce, Daly and Towers [77] illustrated that companies in the textiles and apparel sector utilize aspects of both agile and lean perspectives. A combination of the two perspectives leading to a leagile approach was seen to be evident. Table 3 synthetizes some of the most relevant studies on the contrast/combination of lean and agile approaches.

Table 3. Selected Contributions on Combining or Contrasting Lean and Agile.

Authors (Year)	Type of Contribution	Key Findings
Fisher (1997) [5]	Empirical (qualitative)	Supply networks that produce and deliver innovative products should be agile (responsive, flexible, fast) while supply networks that produce and deliver functional products should be lean (efficient, minimum inventory, low-cost)
Bruce et al. (2004) [77]	Empirical (Qualitative)	Companies in the textiles and apparel sector utilize aspects of both agile and lean perspectives
Narasimhan et al. (2006) [8]	Empirical (quantitative)	Lean plants emphasize efficiency, quality control, and reliability while agile plants have superior capabilities in terms of quality, delivery, and flexibility.
Krishnamurthy and Yauch (2007) [7]	Empirical (Qualitative)	The authors propose that corporations should simultaneously pursue both lean and agile manufacturing strategies by adopting a leagile infrastructure.
Hallgren and Olhager (2009) [6]	Empirical (Quantitative)	The results indicate that lean and agile manufacturing differ in terms of drivers and outcomes. The major differences in performance outcomes are related to cost (lean) and flexibility (agile).
Oliveria-Dias et al. (2022) [78]	Conceptual	The study distinguishes between Lean supply chains and Agile supply chains. The authors analyze the relationships between Information Technologies (IT) and two supply chain strategies and study the effect.
Sadeghi et al. (2022) [79]	Empirical (Quantiative)	Even if lean and agile are different strategy, the authors find that Agile-Lean strategy based on sustainable supply chain leadership strategy is placed as the first priority to improve performance indicators of the analyzed case.

Our framework differs from both streams of research. We contend that lean and agile approaches, while serving opposing goals, should be implemented simultaneously by adopting a paradoxical approach that keep the two forces separated and integrated at the same time.

As we said previously, lean and agile approaches serve different (and partially opposing) goals. These forces are inconsistent with one another yet are necessary for the long-term success of the firm [54].

Lean and kaizen starts from what we know and leverages current knowledge to incrementally and frequently add improvements. Lean creates new knowledge from existing knowledge. This incremental innovation process is therefore strongly "path dependent".

Agile introduces breakthrough innovations that embed new knowledge, and, for this very reason, cannot arise from what is known. Instead, a new path must be taken, the path of exploring new frontiers, which will lead to the creation of new knowledge that is not linked to the existing stock of knowledge.

The paradox between lean and agile approaches requires managing a dynamic balance between these two forces. Over time, a situation comparable to a tug of war arises. When the strength of the two teams is equal, the rope tends to remain in a central position but never stops moving continuously from one side of the field to the other.

Similarly, the paradox requires the dynamic management between lean and agile with choices that frequently change sign. Decisions may be inconsistent with each other but over time they achieve consistency as they obtain the benefits of both alternatives.

5.1. Differentiating and Integrating Practices

To manage the dynamic equilibrium between lean and agile, we suggest the application of the dynamic decision-making model advanced by Smith [54]. Studying six strategic units with annual plans to exploit existing products while exploring innovation, the author found that, to sustain exploration and exploitation, leaders adopt differentiating and integrating practices. Differentiating practices introduce a distinction between exploitation and exploration and stress their unique characteristics. Organizations adopt three types of practices to differentiate exploration from exploitation: "domain-strategic roles, comparing domains to raise novel distinctions and seeking information about domains independently" [54] (p. 1614). Integrating practices stress synergies, connections, and interdependencies between exploration and exploitation. There are three types of integrating practices adopted by the organization: "integrative roles, stressing overarching goals, and solving problems jointly" [54] (p. 1614).

Differentiating supports leaders to focus on exploration and exploitation independently and convey substantial investment in each strategic domain. Integrating allows the emergence of overarching goals and elevates leaders' attention to the organizational level. The implementation of integrating and differentiating practices helps to bring conflict to the surface and motivates relations and interdependencies between strategic domains.

When organizations adopt only one type of practice, they fall prey to defensive routines [80], which can result in favoring either exploration or exploitation. On the one hand, differentiating without integrating leads organizations to choose only innovation. Differentiating practices helps to avoid inertia and detach the past from the future. However, without integration, leaders tend to overlook the synergies between different time horizons and pay attention only to the future. On the other hand, integrating without differentiating leads organizations to choose only exploitation. In the effort to integrate exploitation and exploration without the necessary distinction between the two, leaders tend to be stuck in the present and fail to see unique innovation needs.

An organizational context shaped both by differentiating and integrating practices help the leaders to focus on the different needs of individual products (or processes), yet at the same time support the management of the connections between them creating an organization that is flexible and adaptable. Managers in such organizations become consistently inconsistent [45]. Managers fluctuate between different strategic domains and levels of analysis and make temporary decisions by alternating support between exploitation and exploration. Leaders adopt an adaptive approach and make decisions in response to specific tensions, while at the same time allowing these decisions to be inconsistent with previous decisions. These decisions are seen as flexible and temporary, and ambidexterity is achieved over time.

5.2. Differentiating Lean and Agile

Differentiation involves the distinction of efforts between the different tensions of the paradoxes. In other words, continuous improvement and a lean approach should be kept separated from breakthrough innovation and an agile approach. Only by maintaining these

two domains separately can a firm nurture the tension between exploration and exploitation. If correctly managed, this tension will lead to a truly ambidextrous organization that continuously improves its current performance while developing its ability to adapt to future challenges.

This distinction can be achieved in several ways: by the creation of roles and organizational units each dedicated to one of the domains, the creation of reports and dedicated performance indicators, and continuous comparisons between the two tensions to highlight the distinctions between them. When the creation of dedicated organizational units is not possible (for example due to the small size of a company), differentiation can be achieved through management control mechanisms. For example, it is important to clarify the differences between lean and agile in objectives (and key performance indicators) and develop separate reporting systems for the two domains.

If the distinction between the tensions of exploration (agile) and exploitation (lean) is not introduced, the risk is that one will prevail over the other and that, in the end, the whole organization will slide towards only one of the two poles.

Dab Pumps is a good example of how firms that adopt both lean and agile approaches should keep the two separated [81]. Dab Pumps is a worldwide leader in technologies for the treatment and movement of water. The firm has adopted both lean and agile approaches for several years but keeps the adoption of the two approaches rigorously distinct. Projects deemed more routine and/or complicated (where technologies are known, and the results partially expected) are managed with the lean framework. Small kanban teams are formed that are in charge of short-term projects with the aim of introducing incremental improvements to existing platforms/processes/products. For more complex and uncertain projects, the scrum framework is used. In particular, scrum is used to create new platforms and products, or for initiatives that have a great impact on the organization. For these projects, the needs of the customers are not completely known early on. An intense exploration phase is needed to discover and define the problems to be faced and generate the knowledge that is necessary to introduce breakthrough innovations.

5.3. Integrating Lean and Agile

The integration of lean and agile approaches is aimed at exploiting the synergies and connections between opposing tensions. Following the logic of the paradox theory, the integration between exploitation and exploration efforts is necessary to "elevate leaders' attention to the organizational level. Juxtaposing both domains brings conflict to the surface, and motivates connections and compromises between strategic domains" [54] (p. 1614).

As previously explained, lean and agile approaches have different objectives. However, there are strong synergies between these two domains. Given the challenge to develop ambidextrous organizations, both must be considered as important levers for the realization of a corporate strategy. Leaders must consider and manage the tension between lean and agile and recognize the connection between the two approaches. Lean without agile supports the firm to slowly adapt and improve but it is ill-equipped to deal with quick and abrupt disruptions. Agile without lean will make the firm extremely flexible but less equipped to design and implement processes that produce tangible results over time.

Therefore, an integration between lean and agile approaches is necessary. Through this integration, leaders recognize that both approaches are needed and that one complements the other. This integration can occur using various mechanisms.

First, companies can have senior roles that have overall responsibility for both tensions. These leaders are usually top executives, such as the CEO or general manager of the business unit. However, there could also be other roles with a broad span of responsibility. The KPO (Kaizen Promotion Officer), for example, could have the responsibility of managing the portfolio of innovation projects and assigning the execution of these projects to agile or lean teams according to the nature of the projects. Another important integration figure could be the DTO (Digital Transformation Officer), a role that is having an ever-growing importance

in the era of the corporate digital revolution. The presence of high-level committees or executive boards could facilitate the management of project portfolios and resolve any conflicts over the allocation of resources.

Second, the organization should consistently communicate a both/and vision that is based both on the improvement of existing products and processes and on the exploration of new frontiers of the competition.

Finally, leaders must continually fight the "anxiety traps" generated by tensions and the defensive routines and attitudes that anxiety causes. Increasing confidence in one's abilities and cultivating a culture of risk-taking facilitate the acceptance of the paradox and reduce defensive routines that can lead to decision paralysis.

Dab Pumps achieves integration between lean and agile approaches through a preliminary analysis of the projects performed by a corporate-level inter-functional committee chaired by the CEO of the company. Within this committee a negotiation takes place between different members. This negotiation leads to the classification of the projects relative to the level of their complexity. Firms also achieve the integration between lean and agile approaches through the development of a supportive organizational infrastructure [82,83]. The organizational infrastructure sets the purpose of the organization, the processes to deliver the results, and develop the right contexts where people can flourish. Organizations that adopt lean and agile approaches develop a vision that stresses the ambidextrous nature of the firm with the need to explore and exploit simultaneously. At the level of single projects, however, objectives are kept separate, given the different nature of lean and agile approaches. Many practices that are used to design and manage strategic and operational processes are shared between lean and agile projects. For example, several firms manage lean and agile projects with hoshin kanri, a strategy deployment tool that supports identification, implementation and resource allocation between different projects. Finally, ambidextrous organizations invest in continuous training to develop proactive behaviors in solving problems regardless of the involvement of the organizational members in agile or lean projects [84,85].

Coherent with the dynamic decision-making model depicted above, we contend that companies that adopt both lean and agile approaches, but do not sufficiently differentiate between the two, will tend to focus only on incremental improvements and to use agile tools (such as Scrum) to manage improvement projects. Using agile tools to introduce incremental improvements is possible but extremely expensive.

Conversely, we maintain that companies that differentiate between lean and agile approaches, but do not sufficiently integrate the two, will mostly focus on explorative innovation. Over time, they will dedicate fewer and fewer resources to the improvement of existing processes and products, resulting in poor and non-sustainable performance.

The tension between lean and agile that is kept alive through the dualism of differentiation and integration leads to a continuous conflict between the two forces of exploitation and exploration that compete for the same scarce resources in the short term. Over time a balance must be achieved between the two forces. This balance is what makes the company truly ambidextrous.

Figure 2 summarizes the characteristics of managerial practices of differentiation in managing the dynamic balance of tensions of the paradox between lean and agile. The paradox between lean and agile is managed though the adoption of a set of practices that keep the two forces separated (organizational differentiation) while at the same time try to find synergies and integrate them (organizational integration). A dynamic equilibrium between lean and agile (or exploitation and exploration) needs to be achieved over time. Even if in the short term, leaders make choices that appear inconsistent (favoring lean or agile), in the long term a dynamic equilibrium between lean and agile is achieved.
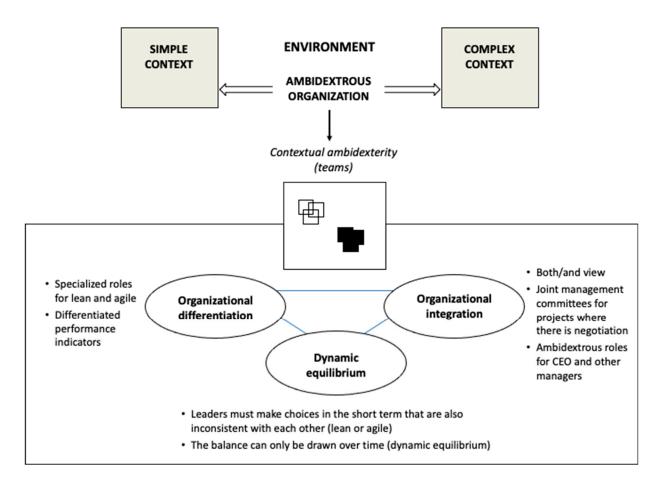
Figure 2. Managing the lean–agile paradox.

6. Discussion and Conclusions

Firms operate in competitive environments that globalization, sustainability and digital transition make highly complex in relation to the three dimensions of complexity [86]: (1) the number of elements in the competitive environment affecting the firm (variety); (2) the number of relationships between these elements (connectedness); and (3) the emergence of unpredictable events in the competitive environment (uncertainty). As firms that live in complex competitive environments must mirroringly develop internal complexity, managing complexity has become a pressing strategic imperative with relevant organizational implications. Incumbent firms that have acquired a sound competitive position in their industries must maintain their current business while at the same time exploring a new scenario, one that is entirely different and decidedly more complex than the one in which they have succeeded to date. Looking at the dilemma these firms face, our paper investigated the lean–agile dichotomy as a possible viable solution by their strategic leaders and managers.

Our paper offers several contributions that lie at the intersections between the complexity theories applied to management, ambidexterity, paradox theory, lean and agile.

First, our results provide a contribution to the complexity theories. Specifically, we have found a solid theoretical background for our framework in two conceptual perspectives that have so far remained separate: the Cynefin framework [1] and research on ambidextrous organizations [39,40]. Both perspectives propose a view of the competitive environments as consisting of distinct contexts in relation to the complexity to be faced.

Research on organizational ambidexterity leads to the identification of a typology of possible solutions to the exploration–exploitation dilemma. At one extreme, there is structural ambidexterity with organizational units devoted to exploitation and others to exploration, while at the other extreme there is contextual ambidexterity, as defined

by Gibson and Birkinshaw [47], in which every individual in the organization develops ambidextrous capabilities. In between the two, one finds contextual ambidexterity with teams aimed at exploration and teams aimed at exploitation [52]. This hybrid form of organizational ambidexterity is the one that seems to best fit the lean–agile dichotomy.

Second, our study contributes the stream of management literature that deals with the concept of paradox. In the first and foundational attempt to build a theory of paradoxes applied to management, Smith and Lewis [45] pointed to an obvious convergence between their idea that organizations must search for a dynamic equilibrium between contradictory but interdependent activities and the theory of ambidexterity, which posits that the processes of exploration and exploitation must coexist in ambidextrous organizations. However, this convergence has been neglected in management studies [87].

Our contribution exploits this gap by analyzing the lean–agile dichotomy through the paradox lens. Previous studies either contrast lean and agile or suggest combining the two approaches. The first line of studies highlights the different performance dimensions that lean and agile approaches achieve. The lean approach is typically associated with efficiency while the agile approach is associated with flexibility. The second line of study proposes a system that merges the two approaches. Lean and agile are seen as complementary approaches and firms should derive a synthesis between these two approaches.

Our study differs from both lines of study. We contend that lean and agile are contradictory forces that serve oppositive goals (exploitation and exploration). Firms should become ambidextrous by managing the tension that come from these opposite forces.

Our study also has relevant managerial implications. We advance a practitioners' guide that is aimed at managing the paradox between lean and agile. This guide is threefold. First, managers need to differentiate between lean and agile, finding ways of keeping the two approaches separate. This way, the creative tension between exploitation and exploration is nurtured. Second, lean and agile approaches should be integrated. By finding ways of integrating lean and agile, one is able to rip the synergies between incremental and breakthrough innovations. Finally, managers should achieve a dynamic equilibrium over time in their decisions to exploit through a lean approach and explore through an agile approach.

Our framework is relevant to firms across industries regardless of their size or other contingencies. Nowadays, most industries are complex environments and firms that intend to excel in their respective industries must become ambidextrous.

However, the level of maturity of the firms can represent a boundary condition of our framework. In the previous paragraph, we explained that lean and agile integration is built on a common organizational infrastructure [82,83]. A supportive organizational infrastructure sets a clear and engaging purpose, implements best practices in managing processes, creates effective communication systems, and develop spersonal values that are aligned with the firm's purpose. We maintain that the paradox of lean and agile can be successfully managed only by firms that have achieved a minimum level of maturity in their organizational infrastructure.

The main limitation of our study is its explorative nature. We provided a first attempt to propose a framework that combines lean and agile using the paradox theory. Empirical research is needed both to substantiate our framework and to propose other ways to keep alive the tension between lean and agile without losing the peculiarities of the two approaches. We welcome future research on this topic based on qualitative case studies, ethnographic studies, and experiments. We believe that these methodologies are the ones best equipped to shed further light on this area of research.

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