

The Evolution and Generations of Innovation Management: A Framework for Understanding the Progressive Expansion of Management Objects and Organizational Capabilities

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Abstract

This paper examines the evolution of innovation-related theories, methods, and processes since the 1990s and reconceptualizes them not as isolated methodological advances, but as a generational evolution of innovation management and the organizational capabilities required to operate it. Although advanced practices such as Stage-Gate, open innovation, and agile development have been widely adopted, many firms have struggled to achieve sustained results. This paper argues that a fundamental cause lies in a mismatch between the organizational capabilities firms actually possess and the scope and objects of innovation management required by these practices.

Through a review of prior research on innovation process models and the evolution of Stage-Gate systems, this study shows that existing generational frameworks have focused primarily on increasing process sophistication. However, as innovation activities have expanded beyond organizational boundaries into platforms, ecosystems, and digitally connected business environments, defining subsequent generations has become increasingly difficult because the objects of management have become more complex and dispersed. To address this limitation, this paper positions innovation management as a higher-level concept that encompasses not only process, but also organizational capability, governance, ecosystem design, and digitally mediated coordination, and proposes a four-generation framework spanning from the first to the fourth generation. For each generation, the framework specifies the environmental conditions, core objects of management, required management systems, and the organizational capabilities necessary for effective operation.

The contribution of this study lies not in rejecting existing theories or practices, but in repositioning them within an evolutionary context. By clarifying which generation of innovation management each approach presupposes, and the organizational conditions under which it can function effectively, the proposed framework provides a theoretical foundation for diagnosing a firm's current position and designing a practical, phased transition toward more advanced generations of innovation management.

Keywords

Innovation management, generational evolution, Stage-Gate, open innovation, ecosystem, organizational capability, platform, digital transformation.

1. Background and Problem Setting

Since the 1990s, theories and practical methods related to innovation have evolved significantly. Firms have actively adopted a wide range of approaches, including new product development processes represented by Stage-Gate, open innovation, design thinking, agile development, and the lean startup¹⁾. Yet in practice, many firms still fail to achieve the outcomes they expect from these advanced methods.

This problem cannot be explained sufficiently by differences in the quality of individual methods or in the skill with which they are implemented. A more important issue is that the organizational capabilities and decision-making mechanisms presupposed by these methods differ greatly across firms. In other words, firms differ in the maturity of their innovation management. For example, organizational ambidexterity, which requires balancing exploration and exploitation, can function only when the firm already possesses a stable management base for operating its existing businesses²⁾. Likewise, open innovation cannot function effectively unless the firm has the capability to evaluate external knowledge appropriately and to absorb and integrate it internally before collaborating with external actors³⁾.

Nevertheless, many discussions focus primarily on which method should be adopted, while paying insufficient attention to the managerial preconditions required to support that method. As a result, many firms imitate advanced methods that do not fit their own organizational conditions, fail to use them effectively, and instead create further confusion. This phenomenon reveals the limitations of viewing innovation as a one-off project or as an isolated process.

Accordingly, this paper reinterprets innovation not as a collection of strategies and methods, but as a management mechanism that supports and enables innovation. To do so, it is necessary to examine how the object of management, organizational structures, decision-making modes, and learning mechanisms have historically expanded and become more sophisticated. By organizing these changes through the concept of generations, firms can identify their current position and design innovation management as a staged evolution rather than as an unrealistic leap.

2. Analysis of Prior Research

2.1 Formation of the Concept of Innovation Management

The concept of innovation management emerged in stages. From the 1950s through the 1970s, the dominant focus was on research and development management, or R&D management. During this period, innovation was understood mainly as an object of efficiency improvement and control within R&D activities. Drucker⁴⁾ argued that the basic functions of management are marketing and innovation, thereby showing that innovation should be treated not as an accidental outcome but as a systematic management issue. Rogers⁵⁾ and Myers and Marquis⁶⁾ also focused on the diffusion of innovation and internal development

processes within firms, positioning innovation as something that could and should be managed. However, although innovation was increasingly recognized as a manageable phenomenon, the term “innovation management” itself was not yet widely used.

From the late 1980s to the early 1990s, the focus broadened from R&D management to technology management. In this context, the concept of innovation management began to take shape. Rothwell⁷⁾ and Brockhoff⁸⁾ used the term “innovation management” in the field of technology management and emphasized the need for comprehensive management linking R&D, markets, and organizational structures. In this view, innovation was no longer understood simply as the management of technological outputs but as a mechanism for value creation across the firm as a whole. Brockhoff⁸⁾, in particular, showed how the object of management expanded from R&D management to technology management and then to innovation management, arguing that from the 1990s onward this area became established as an academically independent field.

In the 1990s, innovation management became established as an academic field. Journals such as *Technovation* and *Research Policy* increasingly published articles that explicitly used the term “innovation management.” In Europe in particular, *Technology and Innovation Management* became institutionalized in university education and research centers. Romanowski⁹⁾ argued that the purpose of innovation management extends beyond generating new products and includes organizational sustainability and adaptation to institutional environments. At this point, innovation management came to be recognized as an independent domain linked to corporate strategy rather than merely an extension of R&D or technology management.

Since the 2000s, innovation management has evolved in more diverse directions. Ortt and van der Duin¹⁰⁾ argued that conventional technology-driven and market-oriented approaches were insufficient for increasingly complex environments and proposed “contextual innovation,” in which multiple methods are flexibly combined depending on the situation. Meissner and Kotsemir¹¹⁾ likewise showed that innovation models evolved from linear and coupling models to network and system models and further toward an “active innovation paradigm” that includes social and institutional elements. These developments indicate that innovation management came to be understood as a broader framework encompassing not only internal firm activities but also social challenges and policy environments.

More recently, Sossa et al.¹²⁾ reviewed a broad range of prior studies and systematically classified innovation management models. They showed that innovation management has developed in multiple directions rather than along a single line. In addition, ISO 56002¹³⁾, issued in 2019, explicitly positioned innovation management as an international standard and presented basic principles and processes for systematically and continuously promoting innovation. With the issuance of this standard, innovation management became not only an academic concept but also a practical framework used as a common language in business.

2.2 Innovation Process Models

Several frameworks have been proposed to define generations of innovation process models (table 1). Among them, Rothwell’s framework⁷⁾ is the most widely cited. Rothwell⁷⁾ presented a generational model of innovation up to the fifth generation, and this became the starting point for subsequent research. In the fifth-generation model, which emerged in the mid-1990s, ideas that later became associated with open innovation were already implied. Later studies³⁾²¹⁾ explicitly proposed open innovation as a sixth-generation model emerging in the 2000s.

Table 1. Generational Characteristics and Overview of Innovation Process Models

Source: Author

Gen-eration	Model	Period	Overview and Characteristics
1	Technology-push model	1950s to mid-1960s	A simple linear and sequential process emphasizing science and R&D. Strong in radical innovation, but weak in market connection and network interaction.
2	Market-pull model	Mid-1960s to mid-1970s	A simple linear process emphasizing market demand as the source of innovation. Strong in incremental innovation, but weak in technological exploration and radical product development.
3	Coupling model	Mid-1970s to mid-1980s	Integrates technology push and market pull, recognizing feedback loops between R&D and marketing. Improves coordination but remains limited in network interaction.
4	Chain-link model	Early 1980s to mid-1990s	Emphasizes internal integration and iterative feedback among design, testing, learning, and market interaction. Process complexity increases, and operation depends heavily on organizational skill.
5	System integration and network model	Mid-1990s onward	Emphasizes knowledge accumulation, external linkage, system integration, and broad networking. Strong in leveraging advanced technologies, but difficult to coordinate across many actors.
6	Network innovation model	2000s onward	Corresponds to open innovation. Combines internal and external ideas and market paths. Strong in using multiple knowledge sources, but difficult to institutionalize and operate consistently.

No clear generational model of innovation processes has been proposed for the seventh generation and beyond. The reason is that models up to the sixth generation were based on a firm-led network centered on a single firm and its collaborators. By contrast, platform businesses and innovation ecosystems that expanded from the 2010s onward, and industry ecosystem platforms that emerged later, require management not only within the firm but across the ecosystem as a whole (20).

At this stage, firms must design and operate in parallel both a framework for managing exploration, investment, and decision-making at the level of individual firms and a framework

for coordinating the structure and role allocation of the ecosystem as a whole. As a result, the objects of management have become multilayered and distributed. This makes it difficult to represent the current stage through a single generational model of innovation processes (20).

2.3 Generational Shifts in Stage-Gate

Stage-Gate is a management process for implementing innovation processes, and its initial form emerged in the early 1980s¹⁾. Since then, it has evolved by incorporating new innovation theories into its design. Although Cooper, R. G. did not explicitly define Stage-Gate generations, he used the expression “next-generation Stage-Gate” and reported several new model types²⁷⁾. Based on this development, it is possible to infer five generations of Stage-Gate (Table 2).

The first generation⁷⁾ in the 1980s corresponded to the period when industrial innovation studies by Myers and Marquis⁶⁾ and the A–U model were discussed. An orderly process for moving technology into products was emphasized, and the basic model of managing development through stages and gates became widespread.

The second generation in the 1990s corresponded to the period when architectural innovation¹⁴⁾ and the chasm theory¹⁵⁾ attracted attention. The need to pursue both deepening in existing markets and expansion into new markets became stronger. As a result, Stage-Gate evolved toward emphasizing market fit while incorporating parallel processing and cross-functional coordination¹⁾.

The third generation in the 2000s was influenced by disruptive innovation¹⁶⁾ and open innovation³⁾. External collaboration and portfolio thinking spread, and Stage-Gate evolved toward emphasizing risk evaluation and resource allocation¹⁾. During this period, firms such as P&G and IBM moved away from closed internal R&D systems and developed mechanisms for exploration and commercialization through external collaboration³⁾³¹⁾.

The fourth generation in the 2010s was shaped by the spread of the lean startup¹⁷⁾ and reverse innovation¹⁸⁾. To cope with uncertainty, Stage-Gate evolved into a hybrid form that incorporated agile development and design thinking¹⁾. Firms such as Dropbox and GE experimented with these ideas. At the same time, ambidexterity²⁾, as discussed by O’Reilly and Tushman, gained practical importance in firms such as Microsoft and Fujifilm.

In the 2020s, innovation management moved beyond optimization within a single organization. Managerial capability itself, especially the ability to respond to uncertain environmental change, became an object of management. Discussions of ambidexterity²⁾, dynamic capabilities, digital transformation¹⁹⁾, and ecosystem platforms²⁰⁾ converged into a framework characteristic of fifth-generation innovation management. In this context, Stage-Gate has been reconfigured from a fixed evaluation mechanism into a dynamic decision-support system using AI and data. Sustainability criteria and ecosystem-wide collaboration

have also been incorporated, making Stage-Gate part of a broader management infrastructure addressing economic value, social value, and digital transformation simultaneously.

Table 2. Generations of Stage-Gate Source: Author

Generation / Period	Purpose	Core Content
First Generation (1980s)	Standardize disorderly development and terminate unfit projects early	Makes progress and investment decisions visible through stages and gates.
Second Generation (1990s)	Balance development speed and market fit	Introduces parallel development, cross-functional coordination, and stronger governance.
Third Generation (2000s)	Optimize risk management and resource allocation	Integrates portfolio management, risk-based criteria, and IT support into the gate system.
Fourth Generation (2010s)	Respond to uncertainty with agility	Incorporates agile, lean, and design thinking into Stage-Gate as hybrid mechanisms.
Fifth Generation (2020s onward)	Simultaneously pursue digitalization, ecosystem collaboration, and sustainability	Uses AI and data to make gate decisions more dynamic and integrates external collaboration and ESG criteria.

3. Analysis Toward the Definition of Innovation Management Generations

3.1 Diffusion of Innovation Theories and Changes in the Objects of Management

Innovation theories have diffused from academia into corporate practice since the 1960s, usually after a certain time lag. What matters in this process is not only the content of the theories themselves, but also how they changed what firms regarded as the object of management in innovation activities.

In the 1960s and 1970s, diffusion theory by Rogers⁵⁾ and innovation studies by Myers and Marquis⁶⁾ focused mainly on how technologies and products were developed and introduced into markets. At this stage, innovation was understood as the problem of efficiently developing and introducing individual technologies or products. Accordingly, the object of management was limited to individual projects and R&D activities.

In the 1980s, Rothwell’s A-U model⁷⁾ drew attention to the relationship between product innovation and process innovation. It became increasingly recognized that competitiveness depended not only on product success but also on improvements in manufacturing processes and broader business activities. As a result, the object of innovation management expanded from products to business operations.

In the 1990s, architectural innovation¹⁴⁾ and chasm theory¹⁵⁾ showed that innovation outcomes depend not only on technological novelty but also on how components are combined and how markets evolve. Innovation thus came to be understood as involving product architecture and market transition, not simply technology development.

In the 2000s, disruptive innovation¹⁶⁾ and open innovation³⁾ gained wide influence. Innovation was no longer assumed to be completed within a single firm. Instead, knowledge inflows and outflows across organizational boundaries became part of the object of management.

Since the 2010s, platform business, business model innovation, and innovation ecosystem concepts have diffused simultaneously. Combined with digital technologies, the unit of innovation has expanded further. In this period, the object of management extends beyond products and businesses to include business models, customer interaction, and networks of complementors¹⁰⁾¹¹⁾. At the same time, the lean startup and reverse innovation became widely accepted as methods for conducting exploration under uncertainty.

In recent years, concepts such as organizational ambidexterity, dynamic capabilities, digital transformation (DX), and ecosystem platforms have become widely adopted. As shown in Table 3, at this stage, innovation is no longer confined to specific projects or individual departments. Instead, it has come to be treated as an object of design and management at the level of the entire firm, and even across groups of firms and industries.

As the diffusion of these theories is observed through Table 3, it becomes evident that the underlying assumptions and objects of management in innovation have evolved in a stepwise manner as these theories have been translated into practice. This shift in the object of management constitutes the starting point for the analysis presented in the following sections.

Table 3 Periods of Diffusion of Major Innovation Theories Source: Author

Concept	Period of Diffusion	Representative Corporate Examples
M. Rogers, <i>Diffusion of Innovations</i> (1962)	Late 1960s–1970s	Studies on the diffusion of agricultural technologies; later applied to the analysis of high-tech product adoption
S. Myers & D. G. Marquis, <i>Innovation Study</i> (1969)	1970s	Empirical studies of technological development in manufacturing industries (U.S. manufacturing sector)
A–U Model (transition from product to process innovation) (1978)	1980s	Manufacturing industries in general (applied in automobile and electronics industries)
Architectural Innovation (Henderson & Clark, 1990)	1990s	Computer and semiconductor industries (e.g., reuse of components combined with new architectures)
G. Moore, <i>Crossing the Chasm</i> (1991)	1990s	High-tech market expansion strategies (e.g., Intel, Microsoft; later Apple’s iPod cited as an example)
C. Christensen, <i>Disruptive Innovation</i> (1997)	Early 2000s	Disk drive industry; later examples include Netflix (DVD to streaming) and the smartphone market
H. Chesbrough, <i>Open Innovation</i> (2003)	Late 2000s	P&G (Connect and Develop strategy), IBM (externally linked R&D), Intel

Platform Business	Late 2000s– Early 2010s	Apple App Store (2008), Google Android, Airbnb (2008), Uber (2009)
Business Model Innovation (BMI)	Early 2010s	Netflix (streaming model), Amazon (AWS), IBM (transition to services)
Innovation Ecosystem	Early 2010s	Apple (iOS ecosystem), Google (Android ecosystem), Tesla (EVs and charging infrastructure)
Digital Disruption	Early 2010s	Uber (taxi industry disruption), Airbnb (hotel industry disruption), Netflix (video distribution)
E. Ries, <i>Lean Startup</i> (2011)	Early 2010s	Dropbox, Zappos, and others; later adopted by Amazon, GE, and Toyota (Toyota Development System)
Reverse Innovation (Govindarajan & Trimble, 2012)	Early 2010s	GE (portable ultrasound devices), Unilever (products for emerging markets), M-Pesa (mobile payment system)
Organizational Ambidexterity	Late 2010s	Microsoft (balancing cloud growth and existing businesses), Fujifilm (exploration and exploitation)
Dynamic Capabilities	Late 2010s– Early 2020s	IBM (cloud transformation), GE (Industrial Internet of Things), Cisco (acquisition-driven restructuring), multinational firms adapting to environmental change
Digital Transformation (DX)	Late 2010s onward	Amazon (company-wide digital transformation), Siemens (Industry 4.0 initiatives)
Ecosystem Platform	Late 2010s onward	Expansion from corporate groups and industry consortia: Volkswagen, BMW, Siemens, Bosch, Haier; industry data-sharing initiatives such as Catena-X, GAIA-X, and Manufacturing-X

3.2 Analysis of Trends in Innovation Management

In prior academic discussions, no explicit generational framework has been proposed that systematically corresponds to the evolution of innovation management. However, if the structural elements of innovation management in each generation and the effects produced by these mechanisms can be understood, such a framework can serve as a practical target for firms seeking to introduce innovation management in a staged manner. In this sense, defining generations is highly useful from a managerial perspective.

Accordingly, this study integrates and analyzes, by period, the generations of innovation process models, the evolution of the Stage-Gate system, and the diffusion of major innovation theories. Based on this integrated analysis, it attempts to derive the generational stages of innovation management (Figure 1).

Year	Innovation Process Model	Innovation Management	Stage-Gate	Diffusion of Major Innovation Theories
1960	◆ 1st Generation Technology-Push Model (1950–mid 1960s)			
1970	◆ 2nd Generation Market-Pull Model (mid 1960s–mid 1970s)			◆ Diffusion of Innovations ◆ Innovation Study
1980	◆ 3rd Generation Coupling Model (mid 1970s–mid 1980s)		First Generation	
1990	◆ 4th Generation Chain-Linked Model (early 1980s–mid 1990s)	(First Generation)	Second Generation	◆ A-U Model (Product to Process Transition) ◆ Architectural Innovation ◆ Crossing the Chasm
2000	◆ 5th Generation Systems Integration and Networking Model (mid 1990s–)			
	◆ 6th Generation Network Innovation Model (2000–)	(Second Generation)	Third Generation	◆ Disruptive Innovation ◆ Open Innovation ◆ Platform Business
2010		(Third Generation)	Fourth Generation	◆ Business Model Innovation ◆ Innovation Ecosystem ◆ Digital Disruption ◆ Lean Startup ◆ Reverse Innovation ◆ Organizational Ambidexterity
2020		(Fourth Generation)	Fifth Generation	◆ Dynamic Capabilities ◆ Digital Transformation ◆ Ecosystem Platform ◆ AI-driven Innovation

Figure 1. Trends in Innovation Management Source: Author

3.2.1 Key Points of Generational Innovation Process Models

Innovation studies have long attempted to understand the evolution of innovation through changes in process models. Rothwell ⁷⁾ showed that innovation process thinking evolved from linear technology-driven models to models incorporating market interaction and then to models assuming collaboration inside and outside the firm. The importance of this framework lies in its reinterpretation of innovation not as a series of isolated success stories but as shifts in dominant managerial assumptions.

Kline and Rosenberg’s chain-link model ²²⁾ further developed this perspective by showing that innovation proceeds not in a single direction but through iterative interactions among knowledge search, design, experimentation, and learning. This model positioned learning as a central element of the innovation process.

Practical models such as Stage-Gate translated these insights into management tools that firms could actually use. However, process models mainly focused on process design and operation. They did not sufficiently explain broader changes in organizational structures, decision-making patterns, or the object of management itself. This limitation is a key premise for the present analysis.

3.2.2 Transition from Firm-Centered Innovation to Learning and Relational Frameworks

Early studies viewed innovation mainly as an internal R&D activity. Accordingly, management focused on efficiency and control. As technological complexity and market uncertainty increased, however, this perspective became insufficient.

Kline and Rosenberg's chain-link model ²²⁾ showed that innovation proceeds through repeated experimentation and organizational learning. This shifted the view of innovation from simple process control to organizational learning.

From the 1990s onward, technological specialization made it increasingly difficult for a single firm to possess all the required knowledge internally. As a result, collaboration with external organizations became unavoidable. Chesbrough's concept ³⁾ of open innovation framed innovation as a process involving knowledge inflows and outflows across firm boundaries. This implied that learning and value creation increasingly occur through inter-organizational relationships.

The key insight here is that innovation shifted from being an object of internal control to a manifestation of organizational capability evolving through learning and relationships. The central challenge of innovation management thus became the design of mechanisms that enable continuous organizational learning.

3.2.3 Transition to Firm-Centered Complementor Platforms

Another major transformation since the 2000s has been the emergence of platform-based innovation. In this model, firms expand value creation by designing technological foundations and rules that allow external complementors to participate.

In the 2010s, as exemplified by Apple's iOS, Google's Android, and Intel's x86 architecture, this type of platform was characterized by a core firm defining the foundational elements of the platform, including APIs, development environments, technical specifications, and participation rules. Within this framework, external developers and partners provided a wide range of complementary goods and services. In this context, the source of competitive advantage did not lie in the performance of individual products as such. Rather, it lay in the extent to which the firm could expand the value of the platform as a whole through the participation of complementors.

Gawer and Cusumano ²³⁾ argued that the source of advantage in such ecosystems lies in architecture design, governance, and complementor relationship management rather than technology alone. The object of innovation management thus expanded beyond individual R&D projects to include the structure and evolution of the platform itself.

At the same time, decision-making remained concentrated in the core firm. Although complementors had some autonomy, the participation rules and governance structures were

set by the platform owner. In this sense, firm-led platforms extended beyond firm boundaries while retaining an asymmetric structure centered on the platform leader.

3.2.4 Transition to Industry-Level Ecosystem Platforms

More recently, platform ecosystems have expanded beyond firm-led models to industry-wide ecosystem platforms. The defining feature of these systems is that they are not controlled by a single dominant firm. Instead, multiple firms and organizations jointly design and operate shared infrastructures.

Examples include Catena-X, GAIA-X, and Manufacturing-X. These are not merely IT systems. They include data-sharing rules, standards, certification mechanisms, security frameworks, and broader governance structures.

Adner²⁰⁾ argued that the success of ecosystem innovation depends not mainly on the capabilities of individual firms but on the alignment of the entire ecosystem structure. In such environments, innovation outcomes depend on whether the ecosystem as a whole functions effectively.

As a result, the object of innovation management expands further to include institutional design, rule formation, trust-building, and industry-level coordination. AI and data analytics intensify this trend by making exploration and decision-making increasingly algorithmic and distributed. Innovation thus becomes a dynamic activity involving the interaction of technologies, organizations, relationships, and data.

4. Definition of the Four Generations of Innovation Management

4.1 Method for Defining Generations

The four generations proposed in this paper are not simply lists of methods or organizational forms. They represent differences in the dominant managerial assumptions underlying innovation activities.

The framework integrates four elements:

- (1) the object of management,
- (2) the unit and structure of decision-making,
- (3) organizational structures and role distribution, and
- (4) mechanisms for learning and capability formation.

These elements go beyond the scope of process models and Stage-Gate frameworks. They also connect with theories such as ambidexterity, dynamic capabilities, open innovation, and ecosystems, each of which has focused on part of the broader problem.

Generational distinctions are based on the scope of uncertainty that organizations attempt to manage. In the early stage, uncertainty is handled within individual projects. In later stages, it is addressed at the level of organizational capability, inter-organizational

coordination, and eventually industry ecosystems. On this basis, this paper defines four generations of innovation management.

4.2 Definition of the First to Fourth Generations

First Generation (1990–2000): R&D-driven, closed innovation management

In the first generation, innovation was understood mainly as an R&D-driven project. The object of management was the individual research theme, and success was defined largely in terms of technological achievement and adherence to planned schedules⁶⁾⁸⁾.

The organizational structure was functionally separated. R&D departments and business units were clearly divided. Business units typically became involved only after the research stage, which created structural discontinuities between technological development and business implementation⁶⁾. This led to the well-known valley of death. The problem did not stem only from poor project execution but from the structural separation between R&D and business functions⁶⁾⁷⁾.

Stage-Gate and early process models were introduced to improve visibility and control, but gate decisions remained largely internal to R&D (1). External collaboration was limited because knowledge and technology were viewed as assets that should be kept inside the firm. This strong closed-innovation logic supported technological accumulation but made market validation and use of complementary assets difficult, thereby deepening the valley-of-death problem³⁾²⁴⁾²⁵⁾.

Second Generation (2000–2010): Enterprise-wide innovation management based on organizational capabilities

In the second generation, innovation was no longer viewed as the responsibility of a single department. It became recognized as a corporate activity requiring the mobilization of enterprise-wide capabilities⁴⁾⁹⁾.

R&D, corporate development functions, and business units were integrated into a unified innovation management process. Stage-Gate frameworks became enterprise-wide management infrastructures in which technical feasibility, market fit, business viability, and resource constraints were assessed together¹⁾²⁷⁾. This enabled business units to become involved from earlier stages and supported lifecycle-wide management.

External collaboration also became institutionalized. Firms began systematically comparing internal development with external sourcing and integrating outside knowledge where appropriate³⁾²⁵⁾²⁸⁾. Portfolio management became³⁾²⁵⁾²⁸⁾ another important feature, allowing firms to balance growth investment, exploitation of existing businesses, and exploration of new opportunities²⁾¹⁹⁾²⁶⁾.

The essence of the second generation was the use of enterprise-wide processes and portfolio management to connect organizational capability with corporate growth. Innovation became an object of management itself rather than an isolated departmental activity.

Third Generation (2010–2018): Innovation management centered on the firm and its ecosystem

In the third generation, innovation was no longer confined within the boundaries of the firm. It was increasingly designed and operated as an ecosystem involving complementors, customers, developers, and partners around a core platform firm.

Digital technologies made knowledge and functions more modular and easier to recombine across organizational boundaries. As noted by Yoo et al. ³⁶⁾, digital innovation proceeds through continuous development and experimentation rather than through a fixed product development process. This expanded the unit of innovation from the individual project to the platform and its surrounding ecosystem.

Platform firms such as Amazon, Google, Apple, and Microsoft built infrastructures composed of data, APIs, and development environments that allowed external developers to create complementary value. Competitive advantage depended on architecture design, governance, and rules of participation rather than on the performance of a single product ³⁷⁾³⁸⁾.

Innovation management thus developed a two-layer structure: management of internal capabilities and management of ecosystem governance. Exploration and experimentation became increasingly distributed, while the core firm guided the ecosystem indirectly through standards, interfaces, rules, and data policies. In this sense, the platform provider acted not only as a producer but also as an orchestrator and designer of the ecosystem ³⁵⁾.

Fourth Generation (2019–2025): Industry ecosystem integration

The fourth generation extends beyond firm-centered ecosystems to industry-level innovation systems. Here, multiple leading firms jointly build and operate shared digital infrastructures across the industry.

The object of innovation management expands to include shared structures, rules, and data foundations. Industry Operating System-type platforms provide common data models, API standards, and integration protocols that connect developers, manufacturers, service providers, and customers on shared infrastructures. Examples include Siemens Xcelerator, Microsoft Industry Cloud, and AWS for Manufacturing ⁴⁴⁾⁴⁵⁾.

A central mechanism in this generation is the digital twin. Digital twins integrate design, manufacturing, operation, and maintenance across products, factories, supply chains, and even urban infrastructure. As shown by NVIDIA Omniverse and Siemens Digital Twin, they are evolving from visualization tools into decision infrastructures combining simulation, optimization, and AI-supported control ⁴⁶⁾⁴⁷⁾.

Supply-chain integration platforms and trust infrastructures also become indispensable. To respond to demands such as decarbonization, traceability, product passports, and quality and safety regulation, firms increasingly share regulatory and environmental data across organizational boundaries ⁴⁸⁾.

The core requirement of fourth-generation innovation management is therefore the ability to build and operate shared digital infrastructures across industry ecosystems. Competitive advantage shifts from the superiority of individual technologies to the ability to design, integrate, and lead shared industry architectures.

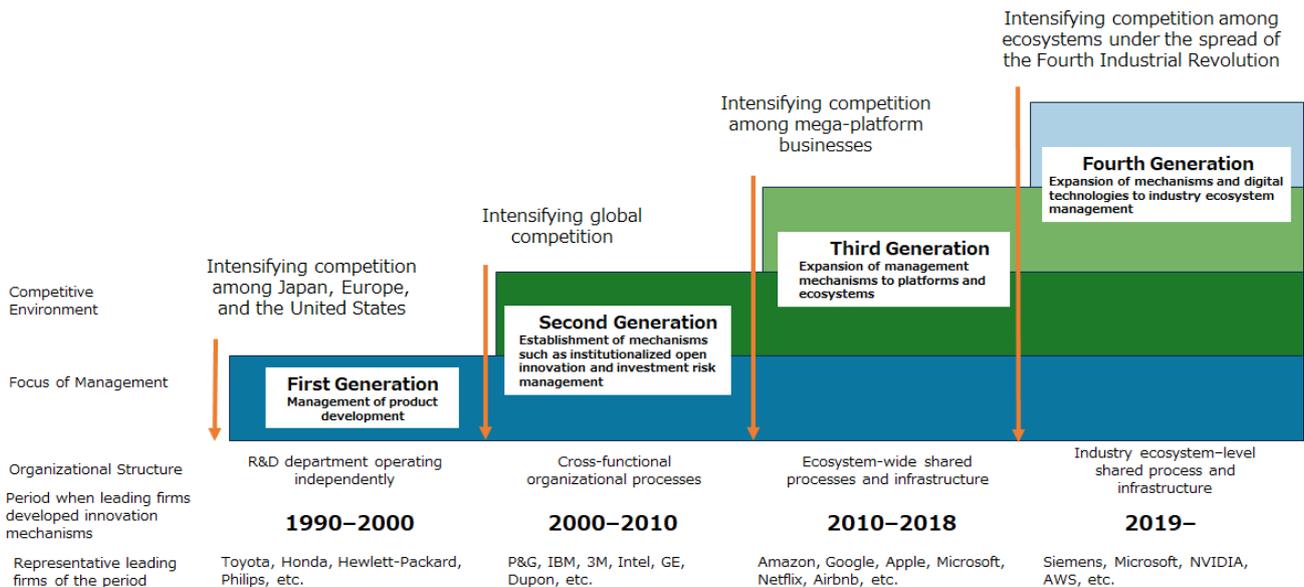


Figure 2 Evolution of Innovation Management Generations Source: Author

4.3 Conditions for Transition to Higher Generations

These four generations represent stages in the maturity of a firm’s organizational capabilities and therefore cannot be skipped in a simple or discontinuous manner. If the managerial frameworks that serve as prerequisites in the lower generations are not established, the mechanisms of the higher generations will not function effectively.

For example, introducing open innovation without enterprise-wide process management and coherent decision-making leads only to fragmented collaboration with external organizations. If a firm lacks the organizational capability to absorb external knowledge and integrate it into business concepts and processes, open innovation becomes symbolic rather than operational.

The necessary condition for moving to a higher generation is the stable operation of the object of management characteristic of the current generation. In the first generation, this means controlling R&D projects. In the second generation, it means operating enterprise-wide innovation processes, organizational coordination, and coherent investment decisions. In the

third generation, it means managing exploration and execution across both the firm and the ecosystem.

The sufficient condition is the deliberate redesign of management itself so that the firm can absorb the expanded uncertainty of the next generation. This includes decentralizing decision authority, redesigning roles, and expanding the unit of management. The transition is therefore not simply the adoption of a new method. It is a redesign of what the organization manages and how far it is prepared to take responsibility.

By distinguishing between necessary and sufficient conditions, firms can reinterpret innovation failure not as the failure of an individual method but as a structural mismatch between generations.

5. Gradual Advancement of Innovation Management in Firms

5.1 Sequence of Introducing Higher-Generation Mechanisms

The four generations defined in this paper should not be treated as a checklist of methods to be introduced. What matters is the sequence in which firms build mechanisms they can actually operate and the capabilities required to sustain them.

In many Japanese firms, advanced concepts such as open innovation, agile development, and digital transformation have been introduced before the corresponding organizational mechanisms and capabilities were in place. As a result, new programs exist formally, but decision-making and behavior remain unchanged. From this perspective, many Japanese firms remain largely within first-generation innovation management.

The transition from the first to the second generation requires mechanisms that allow multiple organizational units to participate in, execute, evaluate, and govern innovation projects together. Stage-Gate must function not as a formal procedure but as a platform for expert participation, responsible decision-making, and organizational learning. Without such a foundation, expanding exploratory activity merely increases uncertainty without generating learning.

The transition from the second to the third generation requires the organizational ability to operate enterprise-wide mechanisms flexibly according to context. As ambidexterity theory suggests, if exploration and exploitation are treated within the same evaluation and control framework, one of them will be suppressed. At this stage, evaluation systems, human-resource allocation, and decision-right design all become part of innovation capability itself. Managers in core firms also need the ability to maintain motivation and evaluate performance across the ecosystem, not just within their own firms.

The transition to the fourth generation requires an even higher level of managerial capability. Industry ecosystem innovation cannot be introduced merely as a concept. Firms must assess how much uncertainty they can realistically bear and whether they can build

governance structures that are jointly operable with other firms. The order of adoption should therefore be determined not by the attractiveness of new concepts but by the maturity of the mechanisms and capabilities that make those concepts workable.

5.2 A Hidden Pitfall in Japanese Firms: Generational Misalignment

One major structural problem in Japanese firms is generational misalignment. This refers to a situation in which a firm still operates with first- or second-generation management structures while attempting to adopt third- or fourth-generation methods.

The core problem is not the choice of method itself but the lack of alignment between innovation mechanisms and the organizational capabilities required to operate them. This helps explain why some platform businesses fail to generate thriving ecosystems or satisfactory performance even after sustained effort.

Another reason why open innovation becomes hollow is that many firms lack the internal capability to integrate external collaboration outcomes into decision-making and business implementation. This is not simply an issue of individual skills. It arises because roles, processes, and evaluation criteria required for collaboration have not been designed as part of the organizational system.

A second pitfall concerns the imitation of best practices. When Japanese firms imitate the mechanisms of Western firms or policy models without considering the organizational capabilities and market conditions that support them, they often end up with formal systems that do not change actual behavior. As dynamic capability theory emphasizes, competitive advantage depends on the fit between organizational mechanisms and the context in which they operate.

5.3 A Staged Roadmap: From Diagnosis to Transition Management

Given these issues, what Japanese firms need is not a leapfrog reform but a staged roadmap for building mechanisms and developing the organizational capabilities required to operate them.

The first step is diagnosis. Firms need to identify which generation of innovation management they currently operate and to what extent. The focus should not be on which methods have already been introduced, but on which mechanisms and capabilities are missing and why innovation efforts fail.

The second step is to design the mechanisms required for the next generation and to develop the capabilities necessary to operate them. In the second generation, the key challenge is enterprise-wide mechanisms and the capabilities to operate them. In the third generation, the key challenge is the ability to integrate and manage external collaboration. This is consistent with recent discussions that treat innovation not as a technical issue but as a core management issue.

The third step is transition management. This involves introducing new mechanisms while maintaining the stability of existing businesses and simultaneously building the capability to operate those new mechanisms. Digital technologies can support this transition, but digital transformation itself should not become an end in its own right. It should be positioned as one of the means that support generational transition.

6. Conclusion and Future Research

This paper has examined the theories, processes, and practices of innovation that have developed since the 1990s and has redefined them not as isolated methodological developments but as stages in the evolution of innovation management mechanisms and the organizational capabilities required to operate them.

The analysis shows that innovation evolution cannot be explained solely by the advancement of processes. What changes across time is also the object of management itself and the capability requirements of the organization expected to manage it. Stage-Gate and related process-management approaches have played an important role in improving decision quality and speed. However, process is only one component of innovation management. Without organizational capability development, inter-firm coordination, and ecosystem governance, process mechanisms cannot function effectively.

On this basis, the paper defined four generations of innovation management. The first generation centered on project control. The second generation centered on enterprise-wide mechanisms and organizational capability. The third generation centered on integration across firm-led ecosystems. The fourth generation centered on integration at the level of industry ecosystems. This framework is useful because it allows existing theories such as open innovation, ambidexterity, and dynamic capabilities to be repositioned according to the generation of mechanisms and capabilities they presuppose.

The paper also introduced the concept of generational misalignment as a hidden cause of innovation failure in Japanese firms. Rather than explaining failure only in terms of weak execution or organizational culture, this perspective locates the problem in the structural mismatch between innovation mechanisms and organizational capabilities. This view is consistent with recent discussions that position digital transformation and open innovation as means of broader management transformation.

At the same time, several limitations remain. First, the four-generation model is based on dominant managerial assumptions, and real firms may contain elements of multiple generations simultaneously. Intermediate or mixed states are likely to be common, and future research needs to examine how such mixed states can be diagnosed and sequenced for transition.

Second, although this paper analyzed innovation management mainly along a temporal dimension, it did not examine industry-specific conditions in detail. Market structure,

technological characteristics, regulatory environments, and supply-chain configurations may strongly affect which generation of mechanisms and capabilities is feasible in practice. Further research should therefore develop more concrete design frameworks tailored to industries and organizational contexts.

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