# Distributed Innovation Processes: Key Concepts, Case Studies, Current Developments

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RESEARCH CONTRIBUTIONS TO ORGANIZATIONAL SOCIOLOGY AND INNOVATION STUDIES

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## Abstract

This paper provides a brief overview of the concepts of collective invention, user innovation, and open innovation. All three terms describe variants of distributed innovation processes and can be linked to further ideas of socio-economic decentralization. First, the conceptual differences between collective invention, user innovation, and open innovation are elaborated. Second, exemplary case studies from the past decades are presented before more recent forms of distributed innovation in the development of information technologies are discussed. In this context, it becomes evident that distributed innovation processes and internal research and development activities in public and private sector organizations are not in competition with each other but rather in a complementary relationship.

## Zusammenfassung

Das vorliegende Diskussionspapier bietet einen kompakten Überblick über die Konzepte der Collective Invention, User Innovation und Open Innovation, die unterschiedliche Ausprägungen verteilter Innovationsprozesse beschreiben. Nach einer Aufarbeitung ihrer jeweiligen konzeptuellen Schwerpunkte wird ihr praktisches Zusammenspiel anhand exemplarischer Fallstudien aus den letzten Jahrzehnten illustriert. Daran anknüpfend erfolgt die Diskussion neuerer Entwicklungen auf dem Feld der Informationstechnologien sowie eine kritische Würdigung. Dabei wird ersichtlich, dass verteilte Innovationsprozesse und interne Forschungs- und Entwicklungsaktivitäten in öffentlichen und privatwirtschaftlichen Organisationen in der Regel nicht in einem konkurrierenden, sondern in einem komplementären Verhältnis zueinander stehen.

# Contents

## 1 Introduction: Varieties of distributed innovation

The paradigm of "open innovation," which has gained considerable traction, was first introduced by Henry W. Chesbrough in 2003. It refers to the opening up of innovation processes that were previously internal to a public or private sector organization. Its popularity is based on the promise of decentralizing innovation processes and thus making them more cost-effective and transparent. Moreover, the open innovation paradigm offers a potential solution to how companies can maintain their competitiveness in economic sectors characterized by very short innovation cycles (Chesbrough 2019). However, the fact that organizations share their knowledge outside of formalized cooperative relationships is just as little a new phenomenon as the formative influence of specific user groups in product development. The entrepreneurial exchange of knowledge at the outset of innovation processes was already described by Robert C. Allen (1983) as "collective invention," while the phenomenon of innovating users was given the term "user innovation" by Eric von Hippel (1976) early on.

*Collective invention* refers to the open exchange of organizational knowledge, technical data, and know-how in product development with other market participants via industry publications, professional societies, or informal project groups, with the aim of benefiting from "cumulative advance" (Allen 1983: 21). To date, such episodes of collective invention have primarily occurred in the early periods of radical technological innovation, which are characterized by a high degree of uncertainty, a multitude of potential solutions, and collective trial-and-error processes. These episodes typically end with the emergence of a dominant design and its subsequent commercial exploitation (Osterloh & Rota 2007). The Homebrew Computer Club, for example, founded in 1975, served as an informal forum for exchanging experiences and technical information between computer hobbyists in California. However, the club's open character was rapidly lost following the establishment of spin-off companies, including Apple Computer Inc., and their initial market success.

In contrast, the term *user innovation* encompasses the activities of users in identifying a need to improve already marketed products and developing novel solutions through modification or recombination (von Hippel 2005). Many studies initially focused on intermediate users in professional contexts who adapt standard products supplied by manufacturers to their needs, for example, in the tooling industry (Rosenberg 1976) or the field of library information systems (Morrison et al. 2000). Since the turn of the millennium, the end users of consumer products have also come into focus (Magnusson et al. 2003), particularly in the fields of outdoor and extreme sports (Lüthje 2004; Franke & Lüthje 2020). The snowboard, for instance, was invented in the 1960s by enthusiastic surfers who wished to pursue their hobby in wintertime, too. Due to the lack of suitable solutions, they adapted existing sports products (i.a., the monoski) to their needs (Franke & Shah 2003).

The concept of *open innovation* is the most recent to be discussed here. It emerged with the first success of community-based forms of production on the Internet. In contrast to traditional innovation concepts, which view the exclusivity of the innovation as the innovator's primary benefit (Schumpeter 1942), this approach assumes that contemporary research and development (R&D) activities can no longer be conducted in isolation within a single company, as it has become increasingly challenging to maintain a comprehensive understanding of all relevant knowledge assets in-house. Consequently, organizations frequently require the integration of external knowledge into their innovation activities and the selective disclosure of internal knowledge to external parties (Chesbrough & Appleyard 2007). The fundamental assumption of the open innovation model is that corporate boundaries become increasingly permeable in all phases of an innovation process—encompassing the stages of invention, product development, and commercialization (Chesbrough et al. 2024).

All three manifestations represent variations of *distributed innovation* (Bogers & West 2012) and can be related to other ideas of socio-economic decentralization, such as the notion of "prosumer capitalism" (Ritzer 2015, 2019), in which users are perceived to challenge the traditional boundaries between the spheres of production and consumption, thereby undermining the pivotal role of formal organizations in innovation processes. The subsequent section will elaborate on the conceptual differences between collective invention, user innovation, and open innovation. This will be followed by the presentation of exemplary case studies. Finally, recent forms of distributed innovation in the development of information technologies will be discussed and critically assessed.

## 2 Collective invention, user innovation, open innovation: Core assumptions and conceptual differences

### 2.1 Collective invention

The insight that, in phases of radical technological change, organizations seek cooperation with external partners and that the success of a company depends not solely on its internal R&D activities but also on its ability to exploit external sources of knowledge was established in applied research as early as the 1970s (e.g., Tilton 1971; Nelson 1982). This process of "collective invention" has been explicitly described as an underestimated "fourth inventive institution," alongside governmental research institutions, companies, and individual inventors, by Allen (1983: 1) and related authors based on numerous historical examples (Table 1).

*Table 1: Historical examples of collective invention*

| Episode | Exchange processes | Results |
|---|---|---|
| **The Cornish pumping engine**<br>ca. 1810–1850, Cornwall, England (Nuvolari 2004) | Exchange of technical data; comparison of individual progress | Development of a fuel-saving high-pressure steam engine for the mining industry |
| **Paper production**<br>ca. 1827–1857, New England, USA (McGaw 1987) | Community of mill owners; regular informal exchange of experiences | Increase in productivity due to increasing mechanization of production |
| **Blast furnace technology**<br>ca. 1850–1880, Cleveland District, England (Allen 1983) | Knowledge sharing via professional societies and journals; collective trial-and-error processes. | Reduction of the energy supply by increasing the construction heights and temperature adjustments |
| **Flat screens (LCD, plasma)**<br>ca. 1969–1989, Japan/Europe/USA (Spencer 2003) | Scientific publication of results from in-house research | Incremental improvement and development in the pre-commercial phase |

*Source: Own compilation*

A general definition of collective invention that takes into account interactions between universities and industry, such as those that existed in the early days of computers (Schrape 2019), is offered by Walter W. Powell and Eric Giannella (2010: 578): "Collective invention is technological advance driven by knowledge sharing among a community of inventors who are often employed by organizations with competing intellectual property interests." The following key factors have been identified as reasons for the willingness to openly share knowledge despite the risk that other companies may benefit from the results of collective research without contributing resources themselves (Rotolo 2022; Osterloh et al. 2007; Nuvolari 2004):

- *Considerable learning potential*: In the context of radical new technological trends, such as mechanization and digitization, the active exchange of knowledge between divergent market players often represents the most viable option for adequately exploring the potential use cases and applications of these technologies.
- *Low opportunity costs*: As long as novel technologies are refined in development niches that are decoupled from the general market, the losses associated with

knowledge exchange are perceived as low. Conversely, comprehensive industry standards must first be defined in order to enable the development of application-friendly products.

- *Selective incentives*: At the outset of innovation processes, an organization can gain a considerable reputation by engaging in open collaboration projects, influencing the direction of industry-fundamental structures while gaining an experience advantage over competitors.

Typically, the positive effects of participation in collective development activities diminish as soon as stable commercialization patterns emerge. However, Powell and Giannella (2010) observed that the probability of more frequent processes of collective invention increases in the modern era as the range of available knowledge expands, as does the diversity of knowledge sources to be considered.

## 2.2 User innovation

From the 1970s onwards, the discourse on the role of users in innovation processes intensified (Bogers et al. 2010; Franke & Lüthje 2020). Although there had already been some empirical analyses of the contributions of users to incremental product improvement (e.g., Freeman et al. 1968; Hollander 1965), it was not until von Hippel's (1976, 1977) wide-ranging empirical studies on the development of scientific devices that product users came to the fore as key innovators. His studies of 111 exemplary cases demonstrated that 80 percent of the product innovations investigated had been invented, prototyped, and tested in their fields of application by users before they were standardized industrially. A distinction can be made between user innovators in professional fields and innovating consumers (Table 2).

The triggers highlighted for user engagement in innovation processes include intrinsic motivations (e.g., altruism) and extrinsic justifications (e.g., peer recognition, industry advancement). In particular, the probability of user innovation dynamics increases (1) if the respective knowledge stocks are locally anchored or milieu-specific ("sticky information") and the transaction costs toward industrial stakeholders are perceived as exceptionally high (von Hippel 1994); (2) if the market has not yet offered a feasible solution to a problem from the user's perspective and the user (company) can directly benefit from its own innovation activity (von Hippel 2005, 2017); (3) if the commitment is likely to increase the user's reputation within a company or industry (Bogers et al. 2010).

As early as 1986, von Hippel identified so-called *lead users* among the early adopters of new technologies, whose "present strong needs will become general in a marketplace […] in the future" (von Hippel 1986: 791). These trend-setting lead users are now actively involved by some companies in their R&D activities, i.a., through idea competitions or publishing toolkits that provide customers with a defined scope for product modifications (Goduscheit et al. 2013).

*Table 2: Historical examples of user innovations*

| | **Sample/observation field** | **Share of innovating users** |
|---|---|---|
| *Professional area* | | |
| **CAD software for electronic circuit boards** (Urban and von Hippel 1988) | 136 participants of applying companies at a conference | 24% (of the applying companies) |
| **Pipe suspensions** (Herstatt and von Hippel 1992) | Employees in 74 companies operating accordingly | 36% (modifications by companies or employees) |
| **Surgical instruments** (Lüthje 2003) | 261 surgeons in German university hospitals | 22% (of the applying physicians) |
| *Consumer area* | | |
| **Skateboards, snowboards** (Shah 2000) | Innovation trajectories of 57 sports equipment innovations | 58 % (including companies founded by users) |
| **Kitesurfing equipment** (Tietz et al. 2004) | 157 using athletes | 45 % (including ideas)<br>27 % (actual implementation) |
| **Mountain bike (MTB) equipment** (Lüthje et al. 2005) | 106 MTB club members; 185 MTB Internet forum members | 39 % (including ideas)<br>19 % (implementation) |

*Source: Own compilation; von Hippel 2005*

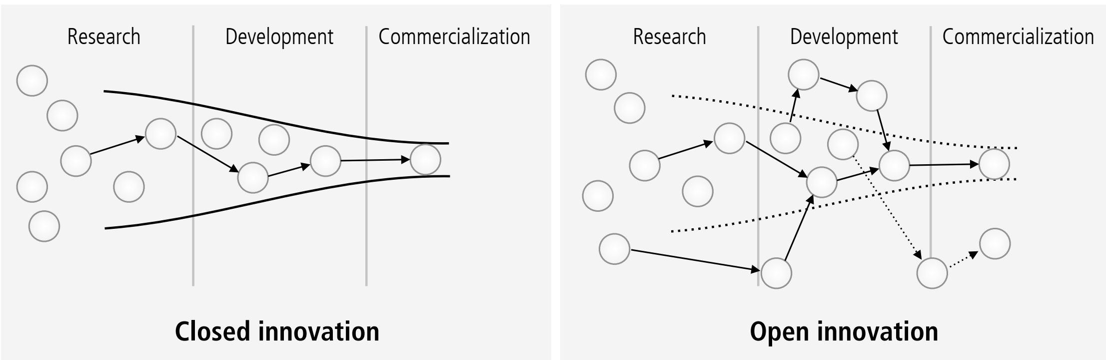
One prime example is the software development kits (SDKs) that Apple and Alphabet (Google) have made available for iOS and Android devices since 2008. SDKs provide amateur developers and third-party companies with the opportunity to create applications for the corresponding operating systems and to distribute them in a controlled market environment (Altman & Tushman 2017). These "micropreneurs" of the app economy (Thackston & Umphress 2012: 50) can be classified as *user entrepreneurs* who bring their inventions to market independently and often start their own companies to do so. Burton Snowboards, for example, a company that today operates on a global scale, was established by a group of lead users in 1977 (Shah 2000).

## 2.3 Open innovation

The open innovation paradigm (Figure 1) integrates insights into collective invention and user innovation (Alexy et al. 2020). It encompasses all phases of organization-centered innovation: “We define open innovation as a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization’s business model.” (Chesbrough & Bogers 2014: 17)

Chesbrough (2003a, 2006a, 2007, 2019) identifies a need for a shift in knowledge management from a closed innovation model, wherein all R&D processes and their subsequent commercialization occur within the company, to distributed innovation activities that involve other market participants. This need is particularly pertinent to sectors such as pharmaceuticals or software, which are characterized by very short innovation cycles. In these sectors, the product development costs are rising, and the company’s own market is no longer sufficient to cover the associated expenses (Figure 2).

*Figure 1: Closed and open innovation processes (ideal-typical comparison)*




*Source: Own representation, based on Chesbrough 2003a, 2006a*

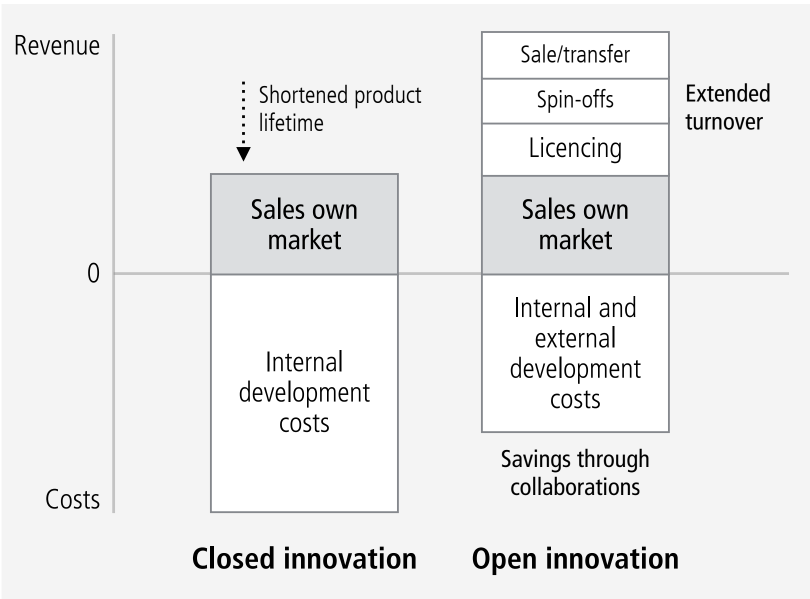
Based on the orientation of knowledge exchange between an organization and its environment, three modes of open innovation can be distinguished (Chesbrough et al. 2024; Temel & Vanhaverbeke 2020):

- *Outside-In*: A company’s knowledge base is expanded by tapping external sources of knowledge, including customers, suppliers, competitors, public and private research institutions, and crowdsourcing activities. This allows the nucleus for innovations to remain within the company. One elementary example is the inclusion of lead users in company-specific R&D activities.
- *Inside-out*: Internal knowledge is transferred outside the company in order to facilitate the commercialization of technologies at a faster pace than would be possible through in-house development. This is achieved through a variety of mecha-

nisms, including licensing, the sale of intellectual property rights (IPR), spin-offs, and the transfer of technologies to other markets. One illustrative example is the synthetic fluoropolymer PTFE, which was developed by DuPont for use in space travel in 1938 and is now utilized under the brand name Teflon to coat frying pans.

- *Coupled*: The combination of both transfer directions is regarded as the most frequently used mode. This mode serves the exchange between market participants on an equal footing and, in this respect, is similar to the concept of collective invention but also relates to the commercialization phase. Examples include strategic alliances in the information technology sector (e.g., the Open Handset Alliance), which aim to establish standards or standardized product platforms (e.g., the Android mobile operating system).

*Figure 2: Key assumptions of the open innovation paradigm*




*Source: Own representation, Chesbrough 2006b*

As a concept, open innovation was explicitly derived from open-source software development by Chesbrough (2003a). It accordingly focuses on peer production processes in online-centered communities, in addition to collaboration with competitors and public research agencies (Lakhani et al. 2008). This coincidence suggests that the enabling infrastructures of the Internet significantly promote an opening-up of organization-centered innovation processes. Depending on the industry, the proportion of companies that report using open innovation methods is as high as 80 percent (Chesbrough 2019; West et al. 2014). However, this figure is also influenced by the fact that the umbrella term “open innovation” encompasses a wide range of very different collaboration dynamics.

# 3 Exemplary case studies: From the blast furnace industry to open-source software

Allen (1983) demonstrated in his historical reconstruction of the progress of blast furnace technology in the British Cleveland district (ca. 1850 to 1880) that the essential innovations—an increase in the overall height of the furnaces as well as the furnace temperature from 215 to 760 degrees Celsius with a lower energy input—had not been initiated by state institutions or in formal corporate relationships. Instead, they were the consequence of an incremental collective trial-and-error process that was only possible because the firms in the industry openly shared their experiences with experimental design changes with other market participants in face-to-face meetings and via trade publications. Jennifer W. Spencer (2003) observed a similar form of *collective invention* in developing liquid crystal displays (LCDs) from 1969 until their commercialization, starting in 1989. In these and other cases (e.g., Lamoreaux & Sokoloff 2000), the firms involved temporarily waived their intellectual property rights (IPR) and could access their competitors' knowledge simultaneously. In contrast to the classical economic literature (e.g., Arrow 1962), Allen (1983: 21) concluded that "the willful dissemination of technical knowledge under a variety of circumstances […] increases the rate of invention by allowing cumulative advance […]".

Case studies on *user innovation* can first be found in the further development of products in professional contexts. James Fleck (1988) questioned linear innovation models in light of the high proportion of innovations initiated by user companies in his study of the development of industrial robotics. Glen L. Urban and von Hippel (1988) observed comparable dynamics in the field of CAD planning software for electronic circuit boards. Numerous examples of innovating professional users have also been found in the field of enterprise software (Ebner et al. 2009; Nambisan et al. 1999).

Furthermore, several case studies on the development of consumer products exist, demonstrating customer involvement in various fields. These include sailing (Raasch et al. 2008), early automobiles (Franz 2005), HiFi audio systems (Langlois & Robertson 1992), crowdsourcing in IT (Allen & Potts 2023; Bigliardi et al. 2021; Schenk & Guittard 2011), and the platform-based Internet (Peuckert & Kern 2023; Rayna & Striukova 2021). In this context, a study on manufacturer-user ecosystems analyzed the innovation model of the toy producer LEGO and observed that the controlled assembly of an online-centered user community and its participation in the design process of products could reduce entrepreneurial risk (Hienerth et al. 2014). Additionally, dedicated user entrepreneurs have increasingly become the focus of social science innovation research over the past 20 years (Escobar et al. 2023). One classic example is Bette Nesmith Graham, a secretary and amateur painter who invented a correction fluid to cover up typing errors in the 1950s. After no established company showed interest in the idea, she started her own company in 1956, which was subsequently sold to Gillette Corporation in 1979.

An illustrative case study from which Chesbrough (2003b) derived the paradigm of *open innovation* is the eventful corporate history of the International Business Machines Corporation (IBM). While IBM successfully relied on in-house R&D activities for a long time, the corporation was confronted with shrinking markets in the mid-1990s and concurrently observed that the core technologies of the emerging Internet did not originate from internal corporate research. Against this background, IBM decided to open up its innovation activities in a controlled manner. This entailed initiating collaboration projects with customers and other market participants in order to be able to integrate external knowledge, and licensing its own technologies that could not be implemented internally in a product within a reasonable period. IBM's investment in Linux development communities at the turn of the millennium is also evidence of a change in thinking (Capek et al. 2005). The change in strategy "has expanded IBM's prediction horizon, giving it greater visibility into the future and the ability to plan research initiatives to exploit that vision" (Chesbrough 2003b: 112). Nevertheless, this did not result in a loss of relevance of intellectual property rights. In 2021, IBM repeatedly topped the United States patent list with over 8,500 patents. From 1993 to 2020, IBM received over 125,000 U.S. patents (IFI 2022). For an overview of studies on open innovation in other economic fields and its potential and limitations in different industries, see Chesbrough et al. (2024), Bertello et al. (2024), Audretsch and Belitski (2023), Dabić et al. (2023), and West et al. (2014).

The history of the software industry represents a salient field of application for all three forms of distributed innovation (Schrape 2019, 2024; Piller & West 2014; Holtgrewe & Werle 2001). As early as the 1950s, when software was not yet considered a separate product, hardware manufacturers, applying companies, and universities collaborated according to academic principles to make the first digital computers usable in their respective application contexts (*collective invention*). In the 1960s and 1970s, software was increasingly commoditized, and, in parallel, a computer-centric hobbyist scene emerged that developed many industry-fundamental innovations (*user innovation*). This milieu gave rise to The Free Software Movement in the 1980s, which established legally sound licensing models for free software, thus creating an essential basis for the selective exchange of knowledge in open-source software communities between market participants otherwise in direct competition. This has led to the current central position of open-source projects as cooperation interfaces for the collective development of product platforms and industry standards (*open innovation*). However, a closer look at market-relevant open-source projects such as Android, OpenStack, Apache, or the Linux kernel reveals that this does not result in a loss of relevance of in-house R&D activities or a loss of importance of economic resource distributions. In contrast, these projects serve as essential incubators for fundamental infrastructures and standards in the international information technology industry, which has been expanding steadily for several decades and is expected to continue to do so (Deloitte 2024; Dolata & Schrape 2023, 2018).

## 4 Recent developments and critical discussion

The information technology sector has witnessed the emergence of further, more specialized manifestations of distributed innovation. In addition to the *beta programs* established by numerous software and hardware providers, which involve customers in the testing of their products (Marres & Stark 2020), the platform-based internet has spawned more extensive processes of *customer co-creation* that enable companies to continuously benefit from user-generated ideas in product or content development (Goyal et al. 2020; Ramaswamy & Ozcan 2018; Piller & Ihl 2013).

Moreover, there has been a notable expansion in the scope of action of *outlaw users* who, as hackers, crackers, or jailbreakers, modify software environments or penetrate protected computer networks. Their activities not only reveal security vulnerabilities but also provide an impetus for further product development. For example, Alphabet (Google) and Apple regularly integrate new features into their mobile operating systems that were first applied in subversive niches. Moreover, outlaw users can contribute to the emergence of novel usage patterns, which may significantly alter business models (Söderberg 2017; Flowers 2008). A prominent illustration of their influence is digital music and video streaming: Prior to the advent of Spotify and Netflix, media streaming emerged in the context of illegal file sharing at the turn of the millennium, driven by the fact that copyright-protected content was not stored permanently on the computer in this way, which was considered a legal gray area at the time.

Furthermore, since 2008, *app stores* for mobile software applications have become prevalent, offering innovating users and startup companies the potential for their products to attract the attention of many users relatively quickly and, eventually, companies willing to acquire them. As part of broader socio-technical ecosystems, app stores "invite others to build on top of the original offering, allowing the economies of standardization in the platform to coexist with customization in the applications built on top of it." (Chesbrough 2017: 37) In a broader sense, Annabelle Gawer (2021: 7; see also Cusumano et al. 2021; Jacobides et al. 2024) describes *innovation platforms* such as Amazon Web Services or Microsoft Azure, which provide application programming interfaces (APIs) or software development kits (SDKs), as "a technological foundation upon which the members of one side (who may be organizations or individuals) can develop new complementary innovations" that "add functionality or grant access to assets that make the platform increasingly useful."

Against this background, processes of user innovation and open innovation are often associated with the idea of democratizing innovation processes and a loss of relevance of traditional organizations, as in the fields of 3D printing, the "sharing economy," and blockchain technology (e.g., Rifkin 2014; Harhoff & Lakhani 2016; Vergne 2020; critical overview: Schrape 2024; Dickel & Schrape 2017). For instance, a recent review article on open innovation dynamics commences as follows, encapsulating the widespread narrative: "The innovation paradigm has significantly shifted from centralized to decentralized, from manufacturer-centric to democratized, from closed to open, and from internal discovery to external engagement." (Wang et al. 2021)

However, in its radicality, this view remains distorted for two reasons. First, the open innovation paradigm has been explicitly conceptualized to take account of the increased market complexity and the number of knowledge sources to be integrated *from a corporate perspective*. In this regard, the nucleus for innovations, as well as their primary exploitation, remains within the company in the majority of cases, and distributed innovation efforts serve, as in the case of many open-source projects, to create industry standards and basic infrastructures for proprietary development (Schrape 2019; Dahlander et al. 2021; Dahlander & Gann 2010). As Ulrich Dolata (2018: 100) notes, this applies to the Internet economy in general: "The core of the innovation model of the five Internet companies is therefore a strong internal orientation of their R&D and the practice of those activities under quarantine-like conditions of extreme secrecy. […] At the same time, however, there are also controlled openings at the edges of this closed system."

Second, Paul Trott and Dap Hartmann (2009: 728) pointed out early on that "the dichotomy between closed innovation and open innovation may be true in theory, but does not really exist in industry". Even in earlier decades, companies that relied solely on closed R&D activities were only able to operate successfully in exceptional cases or a few economic sectors, and have largely disappeared from the landscape today: "While it is not known how many companies could have been labeled 'closed innovators' (or simply 'closed') in the past, it is obvious that such companies do not appear to exist today, except in very specialized fields with niche markets." Conversely, according to their literature review, "R&D managers have recognized for over 100 years that not all knowledge and expertise resides within their firm", and concurrently "have been exploring how best to exploit knowledge beyond the firm." (ibid.: 719)

This is also one of the reasons why established companies join many initially open innovation activities over time and, if successful, thereby benefit as *second movers* from the preliminary work of smaller companies or innovation communities (Holler 2018: 54–119; Hoppe 2000; Shankar et al. 1998). IBM, for instance, belatedly entered the personal computer market in 1981 but subsequently dominated it a few years later. MakerBot Industries, which tapped into personal 3D printing in 2009, was acquired by Stratasys in 2013. This firm had already been active in the industry for a considerable period and was merged in 2022 with Ultimaker, a Dutch 3D printer manufacturing company. Another example of a highly successful second mover is Apple Inc.: While the company did not pioneer music streaming, video streaming, or personal cloud services, it has established a relevant market presence in these areas within a few years.

## 5 Conclusion

In recent decades, the concepts of collective invention, user innovation, and open innovation have drawn social science attention to distributed innovation processes. However, the selective sharing of knowledge and collaborative R&D is not a hallmark of the digital age; instead, it has always played a prominent role in technological research and development, especially at the beginning of innovation processes, without diminishing the relevance of subsequent exploitation by individual firms. Rather than focusing on individual case studies, it thus seems more productive to place these episodes of distributed innovation in long-term socio-economic contexts and to examine the interplay between open or distributed innovation dynamics and proprietary in-house R&D processes over time.

The complementarity between distributed and "closed" innovation is particularly evident in the changing relationships between control and openness, or centralized innovation management and decentralized R&D activities, in the recent platform economy (Dolata 2024: 26–32; Dolata & Schrape 2023): It has become common practice for all major technology companies to expand their portfolios of innovation activities to include a wide range of more or less open R&D platforms, with many of them also engaging in a variety of open-source projects that provide a legally sound framework for project-based collaboration with other market participants. However, this does not imply a decline in the significance of proprietary in-house development. Rather, contemporary proprietary research and development is regularly based on collaboratively generated industry infrastructures, fundamental standards, and basic components, as well as the impulses of users, customers, and partners. Once again, Apple, Meta, and Alphabet serve as prime examples of this phenomenon: In many instances, the operating systems, platforms, and ecosystems of these companies are based on software modules developed in open-source projects or on user impulses and customer co-creation. Yet, they still serve genuine corporate exploitation interests.

In a broader context, multi-level perspectives on socio-technical transition processes suggest that innovation dynamics in their niche phases are indeed often driven by "small networks of dedicated actors, often outsiders or fringe actors" and characterized by a relatively free and open exchange of knowledge. Nevertheless, once these inventions and innovations gain traction in the broader market, they typically undergo rapid professionalization, commodification, and appropriation by established economic actors (Geels & Schot 2007: 400; Geels & Turnheim 2022). The Internet and digital transformation have undoubtedly increased the frequency and reach of episodes of collective invention, user innovation, and open innovation. This, however, does not indicate a general decentralization or democratization of innovation processes, nor does it diminish the economic significance of proprietary research and development.

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