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ABSTRACT

For nearly a century, the key role of innovation in economic growth has been acknowledged and studied. Today, innovations are increasingly understood as being embedded in *ecosystems* of autonomous actors, whether firms, other organizations, or individuals. These actors contribute in complementary ways to create a value proposition that is greater than the sum of the parts, with the integration of their products and processes made possible by modular interfaces between actors. Here we review the emergence of the ecosystem lens within innovation studies in the context of the Special Issue on Innovation Ecosystems and Ecosystem Innovation. After summarizing the history of the special issue, we review the nine articles in the special issue and show how they relate to defining the actors, joint value creation by the actors, coordinating the actors, value capture by the actors, and then the large issue of analyzing ecosystems as the unit of analysis. From this, we offer suggestions for future ecosystem research, including opportunities to combine the ecosystem lens with other lenses used in innovation studies, and new methods for studying ecosystem phenomena.

1. Introduction

The role of innovation as a key driver of firm performance and economic growth, as laid out by Schumpeter (1934, 1942) almost a century ago, is now well established among practitioners, policymakers, and scholars. Innovations may involve new products, processes, services, or technologies. Scholars have made major strides in uncovering different facets of this phenomenon, including upstream generation of focal inventions, downstream commercialization of inventions into innovations, the resulting value creation, and, finally, value capture by inventors, innovators, and others. But even as scholars were deciphering implications of Schumpeterian creative destruction for firms and industries (e.g., Teece, 2006; Fagerberg and Verspagen, 2009; Cohen, 2010; Martin, 2012), the locus of innovation was gradually shifting from single firms within traditional industries to groups of firms and individuals offering complementary goods and services, spanning multiple industries (Moore, 1996; Baldwin and Clark, 2000; Gawer and Cusumano, 2002; Adner, 2006; Kapoor, 2018).

As a result of this shift in innovative activity, scholars, practitioners, and policymakers now increasingly view innovations as embedded in *ecosystems* made up of autonomous actors, including individuals, firms and other organizations such as universities and public agencies. Members of an ecosystem create products and systems whose value is greater than the sum of their separate parts. Each member then captures a part of the resulting "complementary surplus" — the difference between the joint value created by all and the sum of the values they could create separately. (Ecosystems in the social sciences are made up of individual actors and various kinds of organizations. They are distinct from "natural" ecosystems made up of organisms and species.)

In innovation studies, the term "ecosystem" was initially used as a metaphor to highlight the fact that firms might cooperate as well as compete — these are often referred to as "business ecosystems" (Moore, 1996; Iansiti and Levien, 2004). In management and economics, the term is now widely used to denote a network of autonomous economic actors interacting to create value, including a complementary surplus, which is distributed across actors. This is the definition we use in this article.

However, as with any emerging point of view, there is still confusion

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about what exactly the ecosystem perspective on innovation entails, and how it differs from previous approaches. In this article, we explain how the ecosystem perspective has provided a *new lens* within the field of innovation studies and define its key tenets. We then use the ecosystem lens to identify common themes found in the nine articles published in the special issue on "Innovation Ecosystems and Ecosystem Innovation." We end by discussing opportunities for further research.

2. Incorporating an ecosystem lens within innovation studies

2.1. A brief history of innovation studies

Innovation studies originated in the field of industrial organization (IO) beginning in the late 1950s and 1960s. Spurred by an increasing appreciation of the importance of innovation to economic progress and social welfare, IO economists initially focused on the relationship between industry characteristics and firm size and the rate and direction of technological change (Kamien and Schwartz, 1982; Cohen, 2010). Industry characteristics included attributes such as market structure, demand, technological opportunity, and appropriability conditions. Scholars in this tradition explored firms' incentives to invest in R&D and the advantage that might accrue to large firms, a core thesis advanced by Schumpeter (1942) (e.g., Schmookler, 1966; Scherer, 1986).

In the 1970s and 1980s, a new evolutionary economics paradigm was put forward as an alternative to neoclassical economics. Introduced by Nelson and Winter (1982), with important contributions by Freeman (1974), Dosi (1982), Rosenberg (1982), Pavitt (1999), and others, evolutionary economics combined Schumpeter's view of creative destruction with the behavioral theory of the firm (Simon, 1947, 1962, 1969; Cyert and March, 1963). This theory emphasized organizational search and routines, under the assumption that individuals have limited cognitive capacity and thus exhibit "bounded rationality." Scholars adopting the evolutionary paradigm focused on organizational-level processes related to learning and the accumulation of capabilities within innovating firms, as well as industry-level dynamics related to firm entry and exit (Utterback and Abernathy, 1975; Abernathy and Utterback, 1978; Tushman and Anderson, 1986; Anderson and Tushman, 1990, 2001; Henderson and Clark, 1990; Klepper, 1996, 1997; Christensen, 2013). The primary goals were to understand how firms and industries evolve, as well as the implications of evolutionary change for innovation management.

Innovation research in the evolutionary tradition went through a key transition in the late 1980s with Teece's (1986, 2006) account of the critical complementarities that often influence the adoption and commercialization of innovations. Teece's core question was: under what conditions do innovating firms *capture value* from their innovations? The answer, Teece argued, depended on whether other actors controlled access to specialized complementary assets (e.g., distribution, manufacturing, marketing, sales, etc.) that were needed to place the innovation in the hands of users. Any actor controlling an essential and unique complementary asset would be able to claim a share of the surplus value created by an innovation. In contrast, non-essential or non-unique complements could be obtained by the innovator (or by users) at market prices (Baldwin, 2024, Ch. 4).

In the 1990s and early 2000s, three new streams emerged in the innovation literature. First, Moore (1996) and Iansiti and Levien (2004) drew an analogy between natural ecosystems and cooperative and competitive relations between firms, especially in the computer industry. They were followed by Adner (2006) and Adner and Kapoor (2010) who considered innovating firms as dependent on an ecosystem of upstream suppliers and downstream complementors for value creation. In a separate line of work focused on the computer industry, Bresnahan and Greenstein (1999) and Gawer and Cusumano (2002) described how platform owners like Intel and Microsoft could use control over standards to recruit complementors who would innovate and supply compatible hardware and software to users.

Separately, Andy Grove (1996) argued that, in the late 1980s and early 1990s, the computer industry shifted from being dominated by a set of vertically integrated companies to a "horizontal" structure where different companies created components, which were then combined by system integrators and users into complete systems. Baldwin and Clark (1997, 2000) studied the technical underpinnings of computer systems and argued that, in a complex system, "modularity" would permit design and production to be divided among many different firms, coordinated by "design rules." Modularity was a key property of technologies, products and organizations, but firms might "know more than they make" (Brusoni and Prencipe, 2001; Brusoni et al., 2001; Kapoor and Adner, 2012).

The three research streams — ecosystems, platforms, and modularity — proceeded separately for more than a decade until practitioners converged on the concept of platform ecosystems (Kretschmer et al., 2022) and modularity was recognized as a precondition for the creation of both platforms and ecosystems (Jacobides et al., 2018). Implicit within these research streams is the notion that ecosystems can arise through an evolutionary process of disaggregation from integrated to more modular architectures or a process of aggregation in which new or existing components are linked in new ways for joint-value creation (Kapoor, 2018).

Responding to the new emphasis on distributed organizations and complementarities, advice to corporate managers on how to manage innovation shifted 180° in the early 2000s. Where once companies were advised to protect their intellectual property via close control, patents, and secrecy, managers were now encouraged to draw on external sources of knowledge including suppliers, complementors, users, start-ups, universities, and public research institutions. At the same time, they could benefit by opening their own organizational boundaries and sharing their knowledge. As such, "open innovation" emerged as a new paradigm for innovation management (Chesbrough, 2003; Chesbrough et al., 2006; Laursen and Salter, 2006; West et al., 2014; Chesbrough and Bogers, 2014; Dahlander et al., 2021).

2.2. The ecosystem lens in innovation studies

As this historical overview of innovation studies suggests, until recently, the Schumpeterian phenomenon of creative destruction has been studied through an industry-level lens, a firm-level lens, and an innovation-level lens. Applying an ecosystem lens changes the focus of inquiry from the origins and diffusion of a specific innovation to the "value proposition" seen by users. In particular, it recognizes that concerted action by a group of actors may be needed for an innovation to create value in the eyes of the users. For this reason, in contrast to scholars applying other lenses, ecosystem researchers are much more explicit about the demand-side of innovation.

The assets and knowledge needed to realize a given value proposition often reside in different sectors, both public and private, and multiple industries. For example, complementors often play an important role in ecosystems by creating compatible products and services that can be bundled with the focal innovation at the point of use (Adner and Kapoor, 2010, 2016; Jacobides et al., 2018; Teece, 2018).

Because innovation activities are distributed across many different actors, modularity is an important underlying enabler for the functioning of ecosystems. Accordingly, the ecosystem lens focuses not only on complementarities in systems of use, but also on the structure of interdependencies that exist between technical components of the system (Parnas, 1972, 1972b, 2001; Baldwin, 2024, Ch. 3). These interdependencies are caused by the technical architecture in which a given product or service is embedded (i.e., the linkages between different modules and subsystems), as well as the production architecture of input-output flows (Ganco et al., 2020). For example, innovation ecosystems, such as the one surrounding the iPhone, create value via the technical and production architectures that unite the platform owner (Apple) to upstream suppliers (component makers), downstream complementors (application software developers), and iPhone users.

Modular architectures enable actors with very few organizational ties to take complementary actions, but they can also be subject to performance bottlenecks at different locations (Ethiraj, 2007; Adner and Kapoor, 2010; Baldwin, 2018; Hannah and Eisenhardt, 2018; Kapoor, 2018). For this reason, the interdependencies in a modular system must be explicitly recognized and managed through different forms of governance, e.g., via standards, restrictions on access, or negotiation as well as transactions and contracts (Staudenmayer et al., 2005; Kapoor and Lee, 2013). In an ecosystem, governance choices are less likely to be bilateral involving two actors and more likely to be multilateral, involving a group of actors and facilitated by a focal orchestrator (Adner, 2017; Uzunca et al., 2022).

2.3. A framework for ecosystem research

The ecosystem lens often provides a way of understanding existing phenomena (cf. Wurth et al., 2022). At the same time, it has revealed new phenomena, including new sources of innovation, new patterns of interaction among innovators and users, and new approaches to value creation. The complexity of these findings calls for a framework that can be used to structure research and identify related streams of work. A robust framework should permit researchers to identify organizational forms that *are* ecosystems as well as those that *are not*. Furthermore, within the set of organizations that qualify as ecosystems, the framework should facilitate sensible divisions into different research streams. New research projects can then be placed in relation to prior work, enabling cumulative progress in the field.

We propose using the following criteria to identify *ecosystems* in the economy:

1. **Autonomy:** The actors in the ecosystem are autonomous organizations and individuals. As such, they are subject to distributed governance and value capture.
2. **Complementarity:** The actors contribute in complementary ways to a focal value proposition. The joint value created by the whole system is greater than the sum of the values of the separate parts.
3. **Modularity:** The products and processes in the ecosystem are modules within a larger technical architecture.

The dimensions of our framework have been chosen carefully, so that an organization can be separately classified *on each dimension*. First, autonomous actors, by definition, have separate decision rights. Also, in a free market economy, every autonomous actor must remain solvent or be reorganized. This in turn implies that each actor (individual or organization) must *capture enough value to pay for the costs they incur*. However, in general, autonomous actors do not have to contribute complementary inputs to a focal value proposition and they do not necessarily operate within a modular technical architecture.

Complementarity means that the joint value of all the members' contributions is greater than the value single members (or subsets) can attain separately (Milgrom and Roberts, 1995). Modularity means that the actions creating these complementary contributions are not so tightly connected that withdrawal of one will destroy the value of the whole (Baldwin and Clark, 2000).

Complementarity without modularity arises when two or more agents are linked by strong relational ties, thus forming a "thick crossing point" in the underlying task network (Baldwin, 2008). Examples of "complementary but not modular" relationships can be found in Japanese supplier networks, such as the Toyota Production System (Womack et al., 1990; Sako and Helper, 1998; Sako, 2004; Helper and Sako, 2010) as well as in systems where attempts to modularize are incomplete or premature (Staudenmayer et al., 2005; Colfer and Baldwin, 2016).

Modularity without complementarity arises in conglomerate corporations, holding companies, and financial portfolios: each business unit or investment constitutes a separate module, but their joint value is simply the sum of their separate values.

If a group of actors satisfies all three conditions, they qualify as an ecosystem within this framework. Among all ecosystems, it is also useful to distinguish between ***platform ecosystems*** and ***non-platform ecosystems***. Platform ecosystems are coordinated by one or more central hubs (platforms). Non-platform ecosystems use other means of coordination, including bilateral transactions and contracts, multilateral agreements arranged by "orchestrators," and temporary linkages organized by "system integrators" (Kretschmer et al., 2022; Jacobides et al., 2024; Baldwin, 2024, Ch. 3).

In an ***innovation ecosystem***, joint value is created through innovations whose components are (by definition) both complementary and modular. The innovative products and/or processes do not have to be sold in a market for a price, but users must be willing to expend resources (money or labor) to obtain them (von Hippel, 1988, 2005, 2019; Baldwin and Clark, 2006; Baldwin and Von Hippel, 2011). Like all ecosystems, innovation ecosystems can be coordinated via platforms, transactions, contracts, multilateral agreements, systems integration, or some combinations of these mechanisms.

Closely related but not identical to innovation ecosystems are ***entrepreneurial (or regional) ecosystems*** and ***knowledge ecosystems***, which also focus on creating something new (Table 1). These ecosystems create value in the aggregate, while innovation ecosystems create value for users that is delivered through a series of new products or processes. Entrepreneurial ecosystems create value through productive entrepreneurship (Nicotra et al., 2018), while knowledge ecosystems create and disseminate new ideas that do not necessarily have commercial value or value-in-use (Cobben et al., 2022).

In many cases, an innovation, entrepreneurial, or knowledge ecosystem may also have an explicit regional or place-based focus, and they may, in practice, be overlapping as well. For example, well-known regional ecosystems such as Silicon Valley in the US or Brainport Eindhoven in the Netherlands demonstrate attributes of all three ecosystem types. Similarly, an innovation ecosystem may overlap with a knowledge ecosystem (Miric and Jeppesen, 2023).

Just as natural ecosystems evolve, so do socio-economic ecosystems. Over time, in a healthy ecosystem, actors, activities, and architectures will change, as preferences shift and innovations make new value propositions possible (Kapoor, 2018). Using a metaphor from physics, at the most basic level, evolution within business ecosystems is shaped by centripetal forces that push economic activities toward integration and centrifugal forces that pull economic activities into separate organizations or out onto the market (Holgersson et al., 2022; Baldwin, 2024, Ch. 3). For example, strong technological complementarities caused by process flow synchronization, non-contractible effort, and/or co-specialized assets imply centripetal forces that call for unified governance, the use of direct authority, and managerial hierarchies. In contrast, product modularization, distributed knowledge, and network effects create centrifugal forces that reward autonomous organizations with diverse policies and structures, capable of independent search and experimentation.

In summary, in the social sciences, we define an ***ecosystem*** as a set of interacting autonomous organizations and individuals united around a focal value proposition. Members of the ecosystem each capture enough of the value created by the group to keep them involved. The value created by the combination minus the value created by the separate parts is the ***complementary surplus*** of the ecosystem. In an innovation ecosystem, value is created by innovations — new products and services linked by an architecture that users (including user-innovators) are willing to expend resources to acquire.

Our framework and definition are broadly consistent with earlier definitions found in the management and innovation literatures. These include "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize" (Adner, 2017: 40); "a set of actors that contribute to the focal offer's user value proposition" (Kapoor, 2018); "an interdependent network of self-

Table 1
Comparing ecosystem attributes.

	Innovation ecosystem	Platform ecosystem	Entrepreneurial ecosystem	Knowledge ecosystem
Source of value creation	Focal innovation	Focal platform	Productive entrepreneurship	Novel knowledge
Typical actors	Innovators, Suppliers, Complementors	Platform owner(s), Complementors	Entrepreneurs, Funders, Research Organizations, Accelerators	Universities, research institutes, firms, government agencies
Primary Interaction	Technological and input-output flows	Technological and multi-sided markets	Knowledge and resource flows	Knowledge flows
Link with Innovation studies	Innovation and technological change	Innovation by platform owners, complementors	Innovation clusters and regional ecosystems	University-industry knowledge flows

interested actors jointly creating value" (Bogers et al., 2019: 2); and "the evolving set of actors, activities, and artifacts, and the institutions and relations […] that are important for the innovative performance of an actor" (Granstrand and Holgersson, 2020: 1). However, our framework provides an explicit way to determine whether a group of autonomous actors is or is not an ecosystem, and if so, what type it is. We believe this structure can reduce the ambiguity and confusion that currently exists in the field.

An *ecosystem lens* explicitly looks at economic complementarities and technological interdependencies among different actors operating within a larger system. The system-level approach recognizes a more complex set of relationships between technical components and economic agents than the traditional product-firm-industry-market view found in classic industrial organization and innovation studies. As Adner (2012) has argued, in complex evolving technical systems, "widening the lens" to focus on ecosystems offers a better view of the underlying phenomena and thus can serve as a foundation for future cumulative research.

Other research streams in the field of innovation studies have also advanced a "systems" view, by considering the broader set of institutions and actors contributing to innovation within a given region (cf. Nelson, 1993; Freeman, 1995; Edquist, 1997), sector or nation (Pavitt, 1984; Mowery and Nelson, 1999; Malerba, 2002). However, the focus in these works has been on the processes of knowledge generation and learning that underpin innovation in a given regional or industrial context and the resulting implications for policy. In contrast, our focus and that of the special issue is on value creation and capture related to the delivery of specific innovations *to users* — new products, processes, services, or technologies — and the implications of the success or failure of different delivery mechanisms for innovation management and strategy.

3. About the special issue

Since 2010, there has been an exponential rise in the number of academic publications explicitly examining business-related ecosystems (see Fig. 1). Such research has included innovation ecosystems (Adner, 2006, 2012; Adner and Kapoor, 2010), platform ecosystems (Parker et al., 2017; Kretschmer et al., 2022), entrepreneurial (or regional) ecosystems (Acs et al., 2017; Stam and Spigel, 2018), and knowledge ecosystems (Järvi et al., 2018; Olk and West, 2023).

Released in early 2020, our call for papers for a conference and this special issue was limited to innovation and innovative platform ecosystems. We received a strong response, in two separate waves of submissions. A total of 75 papers were submitted to the June 2020 special issue conference, of which 33 were accepted for presentation; the conference was structured to provide detailed feedback for each paper. Four months later, 60 papers were submitted for consideration in the special issue. Of these, nine papers completed a minimum of four rounds of reviews and have been published.

Table 2 provides an overview of the contents of the special issue, including the authors and title of each paper, the empirical context (if any), and the types of ecosystem considered in each article. Under the publisher's current rules, the articles in this and other *Research Policy* special issues are organized as a "virtual issue" but no longer appear simultaneously in paper or on the website. Our article, rather than being first as in a physical special issue, was finalized and submitted last, after all the other articles were in final form.

As guest editors, we are excited about the published articles' potential to have a significant impact on the field of innovation studies. However, we were struck by the number of submitted papers, which, despite studying novel and interesting phenomena, could not convincingly articulate the contributions of their research to ecosystem research and the broader field of innovation studies. This supported our original conjecture that, because ecosystems are a comparatively new

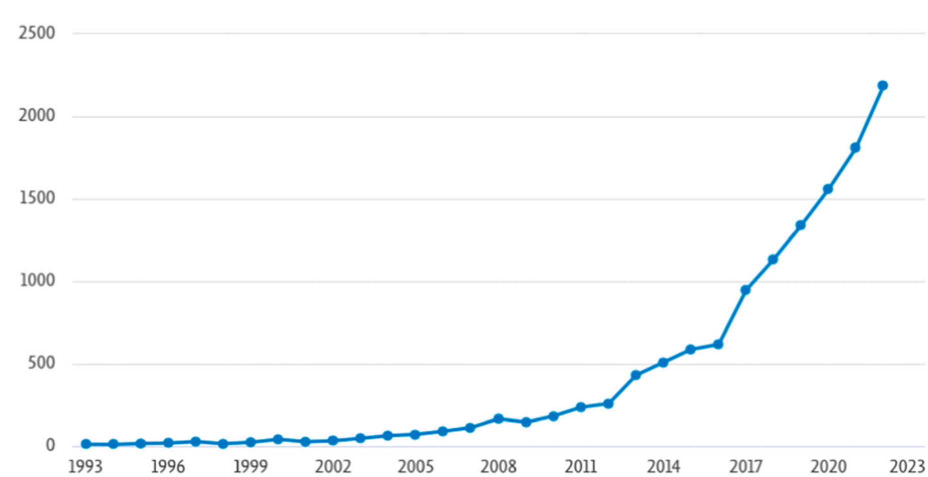

Fig. 1. Ecosystem articles in Scopus-indexed journals, 1993–2022.
Source: A total of 12,794 Scopus-indexed articles from 1993 to 2022 that have a Subject Area containing "busi" and Title, Abstract or Keywords that contain "ecosystem" or "ecosystems".

Table 2
Summary of special issue articles.

Authors	Title	Empirical context	Type of ecosystem
Borner et al. (2023)	Another pathway to complementarity: How users and intermediaries identify and create new combinations in innovation ecosystems	Smart home products	Innovation ecosystem, w/ both platforms and intermediaries, coordinated by toolkits
Cozzolino and Geiger (2024)	Ecosystem disruption and regulatory positioning: Entry strategies of digital health startup orchestrators and complementors	Healthcare IT startups	Innovation ecosystem, not platform-based
Jacobides et al. (2024)	Externalities and complementarities in platforms and ecosystems: From structural solutions to eendogenous failures	Theory	Innovation platforms, transaction platforms, all business ecosystems (not only innovation ecosystems)
Kuan and West (2023)	Interfaces, modularity and ecosystem emergence: How DARPA modularized the semiconductor ecosystem	Fabless semiconductors	Multilateral innovation ecosystem orchestrated by DARPA
Miric and Jeppesen (2023)	How does competition influence innovative effort within a platform-based ecosystem? Contrasting paid and unpaid contributors	Free vs. paid iPhone apps	Platform-based innovation ecosystem
Pujadas et al. (2024)	The value and structuring role of web APIs in digital innovation ecosystems: The case of the online travel ecosystem	Online travel purchase sites	Complex ecosystem with multiple platforms
Reiter et al. (2024)	Managing multi-tiered innovation ecosystems	European banking industry	Comparison of five platform-based innovation ecosystems
Song et al. (2024)	From early curiosity to space wide web: The emergence of the small satellite innovation ecosystem	Small satellites	Multilateral innovation ecosystem, orchestrated by “core actors” making specialized investments
van Dyck et al. (2024)	From product to platform: How incumbents’ assumptions and choices shape their platform strategy	Agricultural equipment manufacturers	Comparison of two nascent platform-based innovation ecosystems

phenomenon in management research, many authors lack a strong conceptual foundation on which to ground their research. Thus, while the upsurge in interest in ecosystems is a noteworthy development, scholars studying ecosystems do not yet share a conceptual framework that would allow them to position their findings relative to prior work and to explicate their own work’s novelty and importance.

4. Themes in the special issue

In this section, we demonstrate the value of the ecosystem lens to the field of innovation studies by identifying the key themes that multiple articles brought to the fore. The themes appearing in multiple articles were: (1) Who are the actors in the ecosystem and why do they join? (2) How do the actors jointly create value through innovation and other means? (3) How are members coordinated and interdependencies managed? (4) Who captures value and how? and (5) What are the consequences of taking ecosystems as the unit of analysis? We discuss the themes in subsections below.

4.1. Who are the actors in an ecosystem?

All of the articles touched on the central issue of identifying the different types of actors in an ecosystem, as well as the processes and mechanisms that enabled them to contribute to the focal value proposition. For both Kuan and West (2023) and Song et al. (2024), academic research played an important role in reducing entry barriers and getting a new ecosystem off the ground. In the former case, the defense agency DARPA adopted an explicit strategy of fostering the creation of a fabless semiconductor industry. In the second case, involving small satellites, new entrants pursued commercial opportunities suggested by the experiments of an academic pioneer.

Both Reiter et al. (2024) and van Dyck et al. (2024) show how incumbents created platforms precisely to attract new firms and users that would complement their core value propositions. Cozzolino and Geiger (2024) show how new entrants whose products complemented the offerings of large incumbents were able to partner with those incumbents and industry groups. Pujadas et al. (2024) document how both incumbents and new firms exploited low entry barriers (but also low switching costs) as hotel booking transactions shifted from one-to-one reservations to web-enabled aggregators.

There is some disagreement in the literature about who should be considered “members” or “participants” in an ecosystem. The issue is often framed as a distinction between “generic” vs. “specific” complementarity. Components with *generic* complementarity can be used outside the focal ecosystem: they are sometimes called “commercial off-the-shelf” or “COTS” components. Components with *specific* (or *specialized*) complementarity work only within the focal ecosystem.

Some authors have suggested that, because suppliers of “generic” complements do not require explicit coordination and may be unaware that the ecosystem even exists, they need not be considered part of the ecosystem. Adner (2017), for example, recommends “start with a value proposition and … identify *the set of actors that need to interact* in order for the proposition to come about.” (Adner, 2017, p. 41, emphasis added; see also Jacobides et al., 2018). However, as Song et al. show, *providers of generic complements can sometimes play essential role in ecosystem emergence* — even if they may play no role in ecosystem governance. Specifically, new ecosystems can be built piecemeal, starting with mostly generic components and adding more specialized components bit by bit.

At the same time, Song et al. show that there is *risk to the ecosystem* when key actors do not make specialized investments. In the small satellite ecosystem, the initial generic components fit poorly into the ecosystem’s central value proposition. The key to growth and success was attracting more committed members *who invested in specialized components* and eventually supplanted the generic contributors.

A related question is: should a would-be disruptor be viewed as part of an ecosystem? In their study of six digital startups in the much larger healthcare ecosystem, Cozzolino and Geiger (2024) show that ecosystems have ways of resisting disruption by new entrants. However, the resistance can be overcome (1) if the entrant is supported by regulatory authorities or (2) existing regulations do not apply to the new entrant. The same conclusion can be drawn from Kuan & West: without DARPA’s consistent support and funding, the diffusion of Electronic Design Automation (EDA) and the separation of chip design and fabrication would have occurred much later, if at all.

Finally, many definitions of ecosystems in the social sciences assume that the main actors are firms (Moore, 1993, 1996; Adner, 2006, 2012) or other organizations (Autio and Thomas, 2021). Kuan & West and Cozzolino & Geiger both show that government agencies — DARPA and healthcare regulators respectively — can play a crucial role both in forcing incumbents to change strategies and enabling entry opportunities for innovative startups.

Only a handful of ecosystem definitions explicitly allow for individual actors (Qiu et al., 2017; Bogers et al., 2019; Altman et al., 2023; Baldwin, 2024, Ch. 3). However, the importance of individuals is demonstrated in two articles in the special issue. First, in the smart home ecosystem studied by Borner et al. (2023), the initial platform sponsors were manufacturers of domestic appliances (BHS) or lighting systems (Philips Signify). However, as users began to combine products from different platforms, a new layer of intermediaries emerged supplying toolkits that made such combinations easy (Franke and von Hippel, 2003). Users could then create custom adaptations and systems of use. The intermediaries then tabulated the specific combinations users created, disseminated this information to other users (and the platforms), and counted how often each combination appeared. From the data, it became apparent that "users are better able to identify which combinations create value for them (and for others)" (Borner et al., p. 10). Today enthusiasts and hobbyists are among the most active innovators in this ecosystem.

Hobbyists are also integral to the iPhone's "jailbreak" platform marketplace, the focus of Miric and Jeppesen's (2023) article. The jailbreak market exists for the purpose of disseminating applications not allowed in Apple's larger App Store. Its members are individual software developers (not companies) who can elect to be paid or not paid for their products. In this sample, unpaid developers outnumbered paid developers by around twenty-five to one (10,132 to 440). Unpaid developers may (1) benefit from the intrinsic satisfaction of developing and sharing their creations with like-minded people; (2) receive reputational benefits in the form of increased status within the community; or (3) obtain indirect, long-term financial benefits in the form of enhanced career opportunities. As in Borner et al., an important contribution of this article is to demonstrate that motives unrelated to direct financial gain can be sources of value for individuals and thus drivers in the evolution and growth of an ecosystem.

4.2. How is joint value created?

Several articles in the special issue advance our understanding of how joint value is created in ecosystems. First, as discussed above, Song et al. highlight the tension between *generic* and *specific* components in the ecosystem. Components with generic complementarities may be the only viable option when the ecosystem is very new: specific components create more value for customers, but suppliers defer making specialized investments when there is limited demand. The authors document an iterative process in which the initial ecosystem members standardized a technical architecture and created enough value with generic components to attract more actors and more specialized investments.

Pujadas et al. highlight the joint value created by providing, accessing and recombining data via Web APIs in the online travel agency (OTA) ecosystem. The network of OTAs and related service providers is both large and decentralized, with low barriers to entry and few dominant hubs. The revenue from a single booking may be shared with multiple players whose Web APIs are deployed at some point in the end-to-end process. The study finds that, in this data-driven ecosystem, the competitive advantage gained from controlling specific Web APIs is not very long-lasting.

Borner et al. find that successful smart home innovations were predominantly recombinations of existing products, coming from downstream homeowners rather than upstream producers. Miric & Jeppesen highlight the importance of innovations by unpaid complementors in ecosystems and show how paid and unpaid actors responded differently to competition in terms of nature and speed of their innovations.

Using contrasting case studies of five European banks, Reiter et al. show how the approach by incumbent banks in Europe to orchestrated innovation ecosystems differed depending on the degree of uncertainty about the value proposition. Similarly, van Dyck et al. contrast the ways in which two established incumbents in the global agricultural equipment industry pursued different strategies for managing complementary innovations. Their divergent strategies resulted in very different results for both the quantity and nature of the applications provided by third-party complementors.

In addition to showing how joint value is created, several articles in the special issue discuss the antecedents to value creation in ecosystems. Cozzolino and Geiger (2024) point to the difficulty that startup firms face in realigning an ecosystem to a new model of value creation, and how regulation can enable, impede or have no effect on such realignment. Kuan & West show how the DARPA-funded creation of a modular architecture with open interfaces fueled entry and innovation by EDA firms and "fabless" semiconductor firms.

4.3. How are ecosystem members coordinated?

Another commonly asked question is: how are ecosystem members coordinated (or otherwise aligned) to achieve joint value creation? Platform ecosystems have historically been governed by a single firm (Bresnahan and Greenstein, 1999; Jacobides et al., 2018; Baldwin, 2024, Ch. 9) or a coalition of firms (O'Mahony and Karp, 2022). In these cases, the sponsor defines the value creation goals, the rules of interaction, and (often) who is allowed to participate. In some cases, however, multiple platform sponsors may vie for market share. The articles by Reiter et al. and van Dyck et al. in this special issue describe such cases in the European banking and global agricultural equipment industries respectively.

Jacobides et al. in the special issue distinguish between platform ecosystems and "business" ecosystems without platforms. In the former, the platform sponsor(s) govern via standards ("design rules") and/or prices charged to different "sides." The sponsor also determines the rules of access. In ecosystems without platforms, mutually agreed-upon collaborative arrangements bring members of the ecosystem together. Members may also agree to create shared assets and develop common processes that allow them to achieve their joint goals (Jacobides et al., 2024 Exhibit 3).

In related work, Baldwin (2024, Ch. 3) argues that, in the absence of platforms, ecosystems can be coordinated via market prices, bilateral contracts, multilateral negotiations (often orchestrated), and systems integration. She further argues that the primary advantage of platforms relative to other means of coordination is that, by standardizing design rules, platforms can scale efficiently. Thus, as the numbers of participants and activities in an ecosystem grow, platforms are likely to emerge in order to cost-effectively handle the increased rates of innovation and/or volume of trade (Baldwin, 2024, Ch. 7).

For firms and industries where ecosystem-based value creation was not previously viewed as *modus operandi*, coordinating and aligning interests requires new competencies and even cultural norms. Reiter et al. show that, in the ecosystems sponsored by five different banks, the sponsors used formal governance mechanisms to solve well-defined problems, and informal mechanisms for more uncertain or ambiguous ones. Similarly, in their study of rival ecosystem strategies of two agricultural equipment manufacturers, van Dyck et al. show how these strategies were constrained by existing partners, particularly dealers.

Incentives and governance are more complicated in cases of overlapping ecosystems. Horizontal overlaps arise when two or more platforms compete for complementors and users, a practice known as multihoming (Eisenmann et al., 2011; Zhu and Iansiti, 2012; Cennamo and Santalo, 2013). In the special issue, Pujadas et al. show that, given very low specialization and switching costs, analyzing "overlapping" ecosystems is meaningless: instead, ecosystem members are all part of a single indivisible, interwoven network.

Horizontal overlaps are also possible in non-competing ecosystems. For example, a fabless semiconductor firm located in Santa Clara is part of the global semiconductor innovation ecosystem *and* a member of the

Silicon Valley entrepreneurial ecosystem. It might contribute to different knowledge ecosystems, for example, university-sponsored research consortia focused on state-of-the-art technologies. It will be the customer of a semiconductor foundry like TSMC (a platform) and a supplier of downstream computer and device makers. Finally, its chips may be a platform in their own right (e.g., Nvidia's graphic processing chips are a platform for AI applications). How firms and individuals balance their contributions and potential goal conflicts in such situations has yet to be studied.

Hierarchical (or nested) overlaps arise in industry consortia, when firms or individuals join a specific consortium within a larger industry ecosystem (Olk and West, 2023) or when a consortium creates a hierarchy of projects and allocates governance rights to managers of both projects and subprojects (O'Mahony and Karp, 2022; Baldwin, 2024, Ch. 16). In the special issue, Cozzolino & Geiger, Reiter et al., and van Dyck et al. all show how firms created new ecosystems by attracting members from a larger ecosystem to specific projects or platforms. Reiter et al. also show how layered hierarchies (tiers of governance) within each ecosystem allowed the platform sponsors to selectively engage their complementors in the development of their respective shared value propositions.

Recently, researchers have examined weaker forms of control often termed orchestration (Reypens et al., 2021; Altman et al., 2022; Olk and West, 2023). Cozzolino & Geiger suggest that in a regulated industry, new entrants will face difficulty in orchestrating a new set of relationships unless the proposed change is supported by existing regulatory authorities or laws.

Meanwhile, at both a global and local level, well-defined interfaces provide thin crossing points to structure a value-creating collaboration between two or more firms (Baldwin, 2008; Baldwin, 2024, Ch. 2). Research on interfaces has typically focused on those provided by a platform sponsor within an overall platform architecture (West and Dedrick, 2000; Baldwin and Woodard, 2009; Gawer, 2021). However, in the special issue, van Dyck et al. show how two agricultural equipment companies used different types of interfaces to manage their respective digital innovation platform ecosystems. One company saw its platform as a venture separate from its existing product line: they created a modular connectivity device that could link the platform to any piece of machinery, regardless of brand. They actively recruited users to their digital platform who did not use their machinery. Finally, they monetized the platform by charging third-party app suppliers a 30 % surcharge.

The second company saw its digital platform as a way to enhance its existing product line. They retrofitted their entire product line to be compatible with the digital platform and created an open API. They did not charge complementors for access to the platform, but allowed them to choose prices and keep all the revenue from their apps. Not surprisingly, they attracted many more complementors than the first company, and, as a result, did not have to staff a large internal group of software engineers. Despite these differences, as of the time of publication, both platform strategies appear viable.

A key benefit of stable interfaces is support for decentralized innovation. Normally, it is assumed that such interfaces will be established as design rules by a central platform sponsor. (Baldwin and Clark, 2000; Gawer and Cusumano, 2002; Baldwin and Woodard, 2009). Two articles in the special issue describe exceptions to this rule. First, Borner et al. demonstrate that end users can recombine off-the-shelf products using interfaces provided by intermediaries in the form of toolkits. Second, Pujadas et al. present a radically decentralized model of interface creation — the antithesis of centralized platform sponsorship. In the OTA ecosystem, very low switching and programming costs allowed both creators and users to generate and recombine a broad range of ever-evolving interfaces. The resulting network contains a large number of *interconnected* platforms, but no dominant hub (Pujadas et al., Fig. 9). It is more like a classic transportation or electrical network with many transfer points than the classic single or overlapping platform ecosystems seen in the computer industry.

Finally, when considering issues such as governance, value creation, or incentives, prior research has tended to distinguish between different types of actors based on their structural position within the ecosystem — typically defined as focal firm, supplier or complementor (e.g., Adner and Kapoor, 2010; Dattée et al., 2018). However, two articles in the special issue (Reiter et al., Song et al.) illustrate how differences in actions and strategy in an ecosystem may not always be driven by structural position of the actors. For example, the incentives and contributions to value may be similar between suppliers and complementors in one customer segment, while dissimilar across a different customer segment. Future research might thus examine interdependence between actors using more fundamental definitions of complementarity, such as by applying Milgrom and Roberts' (1995) observation that the ultimate measure of complementarity is when absence of the complementor reduces the value of the offering.

4.4. *Who captures value in an ecosystem and how?*

Two articles in the special issue examine factors that can limit firms' and individuals' ability to capture value. In their study of data-based travel ecosystems, Pujadas et al. show that the constant threat of new entry, imitation and disintermediation meant that value capture opportunities typically dissipated rather quickly, forcing firms to constantly update their strategies and reconfigure their ties. Meanwhile, by contrasting the platform ecosystem strategies of two agricultural equipment makers, van Dyck et al. show that the platform sponsor that shared value more generously with complementors attracted 7× as many complements as its rival. This example demonstrates how "taxing" an ecosystem can reduce value creation.

Van Dyck et al. notwithstanding, ecosystem research has rarely documented or measured this inherent tension between value creation and value capture, which has long been observed in other streams of innovation research (see, for example, Simcoe, 2006; Laursen and Salter, 2014). Future research might examine possible moderators of this tradeoff, such as growth, complexity, and degree of control, the presence of competing ecosystems, and the external appropriability regime (Teece, 1986). Future research could also validate the prediction set forth in Jacobides et al. (Table 2, Column 1) that centralized governance by a platform sponsor can avoid or reduce the risk that misallocated (or uncertain) values will discourage participation in the ecosystem, thus reducing value created and possibly causing innovation failure.

4.5. *Ecosystems as the unit of analysis*

Researchers increasingly consider ecosystems to be a unit of analysis distinct from firms, industries, and markets. In this regard, it is useful to distinguish between articles that look at the impact *of* ecosystems on different actors and those that look at the impact *on* ecosystems of actions taken by members and other agents. While causality in any ecosystem runs both ways, it is still useful to view each direction separately.

Much prior research has examined the benefits of a successfully functioning ecosystem for its members, including sponsors, orchestrators, complementors and users (Moore, 1993, 1996; Adner, 2006, 2012; Ceccagnoli et al., 2012; West and Wood, 2013; Cennamo and Santaló, 2019; Olk and West, 2020). But how does an ecosystem's success impact the rest of the economy? Song et al. show how the maturation of the small satellite ecosystem — with the concomitant improvements in price and performance — enabled the creation of entirely new communication businesses that were not economically viable given earlier, more integrated, and more expensive satellite designs. Pujadas et al. also show how new businesses, supplying both platforms and complementary goods and services were built on top of new Web APIs.

The articles in the special issue pay relatively more attention to the impact of actors *on* ecosystems. In particular, several articles address two key questions: (1) where do ecosystems come from? and (2) why do they change? A common finding in several articles was that ecosystems may be created to jump-start the value creation strategy of a for-profit firm or a regulator. Thus, Kuan & West describe the history of a key interface that enabled vertical specialization within the semiconductor industry. The interface was prototyped by government-funded academic researchers who predicted that the modularization of chip designs would allow chip performance to continue to improve at the rate predicted by Moore's Law. With DARPA's backing, a tripartite ecosystem made up of EDA toolmakers, fabless chip designers, and semiconductor foundries arose and became competitive with established integrated device manufacturers like Intel (Baldwin, 2024, Ch. 8).

Similarly, three of Cozzolino and Geiger's six health care startups received assistance from a regulator or were founded in response to a new regulatory initiative or law. And Song et al. describe how the University of Surrey built and launched the first small satellite as a proof that the concept was viable.

Four other articles in the special issue reflect the more common reason for an innovation ecosystem to emerge: one or more platform sponsors sees the benefit of tapping external sources of innovation and creates a platform with open (and stable) interfaces for that purpose. In two cases, Reiter et al. and van Dyck et al., the platform sponsors were incumbents in traditional industries—banking and agricultural equipment respectively.

In the two other cases, new platforms emerged that responded to the demands of individual users. First, as described above, in the smart home ecosystem studied by Borner et al., when users began to combine products from different platforms, a new layer of intermediaries emerged supplying toolkits that made such combinations easy. Second, in the iPhone jailbreak ecosystem, described by Miric & Jeppesen, when Apple opened the App Store, most iPhone developers migrated from the initial jailbreak platform to the Store. However, there were some applications that Apple did not want to encourage, and would not allow on its site. The initial jailbreak platform continues to serve this niche market.

Our original call for articles suggested another way to study ecosystems as the unit of analysis: it asked for research on *ecosystem innovation*, defined as "new models of ecosystem creation and management." While each of the innovation ecosystems studied in this special issue had unique story of emergence, in most cases, the eventual ecosystem conformed to our framework based on autonomy, complementarity and modularity. However, the online travel ecosystem described by Pujadas et al. is arguably a new form of ecosystem: a radically decentralized, highly interconnected network of firms and users. This form of organization can be found in other settings, e.g. international communication networks, electricity grids and airlines route networks. Meanwhile, the "massive modular" ecosystem that that designs and manufactures mobile communication devices reflects an admixture of the decentralized model interspersed with a small number of firm-sponsored platform ecosystems (Thun et al., 2022).

5. The future of ecosystem research

We end this article by discussing two broad areas for future research. The first concerns convergent perspectives — questions at the intersection of innovation ecosystem research and other established lines of inquiry. The second suggests other methods that might fruitfully be used to extend ecosystem research in new directions.

5.1. Convergent perspectives in innovation studies

In this section we suggest how the ecosystem lens might be combined with other lenses commonly used by innovation researchers to produce a sharper picture of the underlying phenomena. We emphasize insights provided by the empirical articles.

5.1.1. Business models

New technologies often enable both new business models (Baden-Fuller and Haefliger, 2013) and new ecosystems (West and Wood, 2013). Like ecosystem research, business model research focuses on demand-side value creation (Massa et al., 2017), but it is much more explicit about choices with respect to value capture (Teece, 2018; Adner, 2017; Kapoor, 2018; Snihur et al., 2021). In the special issue, Cozzolino & Geiger, Kuan & West, and Song et al. all show that new entrants to an ecosystem can capture enough value to severely disrupt incumbents' business models, adding to the emerging theme of how new entrants disrupt incumbents' business models within an ecosystem (see also Ansari et al., 2016). However, more research is needed to illuminate the relationships between the two phenomena, focusing on the dynamics of value creation and capture among multiple actors in an ecosystem.

An iconic example of these complex relationships is the emergence of the personal computer industry. In the 1970s, the birth of the microprocessor enabled a new ecosystem of microcomputers, peripherals and accessories. This allowed Apple Computer and then IBM to create new platform business models that depended on the ecosystem for complementary hardware and software (Freiberger and Swaine, 1984; Chposky and Leonsis, 1988; Cringely, 1992; Baldwin, 2024, Ch. 9). Subsequently, when Compaq and Phoenix Technologies reverse engineered IBM PC firmware, another business model emerged based on the control of critical standards that ensured interoperability between the basic computer, hardware devices, and software applications (Froot, 1992; Morris and Ferguson, 1993; Intel Oral History Panel, 2008).

In the 1990s, the worldwide dominance of the Wintel standards-based platform led to the formation of a "modular production network" — a globally distributed ecosystem comprised of contract manufacturers, original design manufacturers (ODMs), and lead firms (such as Compaq, NEC, Toshiba, and Dell) which controlled access to final customers (Sturgeon, 2002; Sturgeon and Kawakami, 2011; Thun et al., 2022; Baldwin, 2024, Ch. 11). Each of these specialized roles was associated with a corresponding business model. The rise of the Internet enabled new online transaction platforms that bypassed traditional retailers. Such a pattern of technological innovation, business model innovation and ecosystem adaptation is common, and deserves further analysis.

5.1.2. Open innovation

The ecosystem lens helped extend open innovation from a dyadic to multilateral value creation strategy (West, 2014). For its part, the open innovation paradigm has been used to explain the basis of value creation in a range of ecosystems (Rohrbeck et al., 2009; Bogers et al., 2017; Randhawa et al., 2021), although recent evidence shows a complex relationship between open innovation and financial performance (Schäper et al., 2023). In the future, open innovation research would benefit by using the lens of collaborative value creation from ecosystem research, while ecosystem research could learn from open innovation's careful examination of the motives of the collaborating partners and the implications for value capture. Finally, there is an opportunity to study the nexus of open innovation, business models, and ecosystems, given the common focus on value creation and capture across organizational boundaries (Zott et al., 2011; Chesbrough and Bogers, 2014).

5.1.3. Research consortia, standards-setting organizations, and open source projects

Research consortia, standards-setting organizations (SSOs), and open source projects provide parallel examples of how a coalition of firms (or other organizations) can sponsor an innovation ecosystem (O'Mahony and Karp, 2022; Olk and West, 2023). In most cases, this sponsorship is provided by an incorporated (often nonprofit) organization, which has formal rules for membership and governance. This organization can hold title to common property and gain the advantages of asset separation, limited liability, and indefinite life. At the same time, this sponsoring organization is lodged within larger ecosystems whose structure and membership are more fluid.

Prior research has tended to focus on governance at one but not both of these levels of organization. Future research could recognize the hierarchical relation between the larger ecosystem and these special-purpose organizations, and examine their interaction. For example, when do the norms of the larger ecosystem constrain the policies of the central governing body? And when does the center affect the direction of innovation of the larger ecosystem? These issues have been studied in the context of open source software projects and communities, but not in innovation ecosystems more generally.

5.1.4. Intellectual property (IP)

The allocation of IP rights has been crucial for the effective operation of many ecosystems, whether open source platforms (West and Gallagher, 2006; O'Mahony and Karp, 2022) or those organized by R&D consortia to guide academic-industry collaboration (Sydow et al., 2012; Leten et al., 2013; Olk and West, 2020) or those coordinated by standard setting organizations (Toh and Miller, 2017). Indeed, the attributes of the network of collaborating partners have been identified as one of the elements that determine the balance between IP sharing and protection (Bogers, 2011). To better understand interdependencies and complementarities, patent citations have been used to measure the structure of knowledge flows in innovation ecosystems (Lee et al., 2016; Jones et al., 2021). Future research could study the impact of different types of IP regimes or strategies within an innovation ecosystem, whether endogenous (demanded or chosen by the members) or exogenous (imposed by legal or regulatory authorities). Future research could also explore how firms in an ecosystem leverage their IP and navigate the tension between value creation and value capture.

5.1.5. Organizational capabilities

Previous research has emphasized the influence of capabilities upon ecosystem leadership, including how they can help universities lead an entrepreneurial ecosystem (Heaton et al., 2019), enable intermediaries to shape service ecosystems (Randhawa et al., 2022), or allow platform sponsors to encourage ecosystem members to be more innovative (Gawer and Phillips, 2013; Haki et al., 2022). However, most work on both *ordinary* and *dynamic* capabilities assumes that these skills are cultivated and remain within companies or business units (Nelson and Winter, 1982; Chandler, 1977; Teece et al., 1997; Dosi et al., 2000; Helfat, 2000; Teece, 2009; Helfat and Peteraf, 2015).

Future research might consider the development of capabilities for firms in an ecosystem (Helfat and Raubitschek, 2018), the diffusion of complementary capabilities across firms in an ecosystem, and perhaps the transmission of capabilities from one ecosystem to another. For example, in contrast to U.S. automakers, Toyota is known to actively build capabilities within its suppliers (Sako and Helper, 1998; Sako, 2004). TSMC's Open Innovation Platform provides a toolkit for modeling combinations of designs and services provided by TSMC and third-party companies in its ecosystem, and testing the combinations to see they will function properly. The toolkit avoids expensive rework of chip designs, lowering the customers' time to market (Chesbrough, 2020).

5.1.6. Entrepreneurial and regional ecosystems

While research on innovation ecosystems focuses on the value proposition to users and the interplay of technological interdependencies and economic complementarities among members of the ecosystem, research on entrepreneurial ecosystems generally emphasizes the conditions within a given geographic region that support the emergence and growth of new ventures and entrepreneurial activities (Locke, 1996; Saxenian, 1996; Chang, 2009; Sturgeon and Kawakami, 2011; Blyde, 2014; Stam, 2015; Acs et al., 2017; Wurth et al., 2022). The overlapping memberships by organizations in innovation and entrepreneurial ecosystems suggest numerous opportunities to research how actors, activities or coordination within one type of ecosystem can enable, constrain or accelerate the development of the other.

5.1.7. Knowledge ecosystems

Research on knowledge ecosystems has focused on how networks of knowledge-intensive ecosystem participants facilitate knowledge creation and sharing, often within strategic alliances and research consortia (van der Borgh et al., 2012; Cobben et al., 2022; Clarysse et al., 2014). A key research opportunity at the nexus of knowledge and innovation ecosystems lies in examining how the mechanisms used to foster trust and cooperation in knowledge ecosystems influence the processes of innovation and commercialization in innovation ecosystems. As with entrepreneurial ecosystems, there are possibilities to study the impacts of overlapping memberships with innovation ecosystems, but also nesting, joint control and other stronger ties that sometimes link knowledge and innovation ecosystems (Leten et al., 2013; Olk and West, 2023).

5.2. New insights from new methods

Virtually all papers submitted to and accepted for the special issue used qualitative, comparative case studies and/or longitudinal methods to conduct their research. Exceptions in the special issue were Miric & Jeppesen, who use large-sample hypothesis testing and Pujadas et al. who trace the evolution of the OTA ecosystem using network visualizations. The application of qualtitative and historical methods allows for a deep exposition and analysis of the underlying phenomena.

Although by definition innovation ecosystems create value through new innovations, researchers rarely seek to measure the quality or quantity of innovation generated. In contrast, there is a long tradition of measuring both quality and quantity at the level of firms (e.g., Garcia and Calantone, 2002; Hagedoorn and Cloodt, 2003), technologies (Suarez, 2004), and national economies (Smith, 2006; Gault, 2018). Future research could similarly seek to contrast the quality or other aspects of the innovation with the overall value created by an ecosystem. Such measures could be used to explain the sources of value within a given ecosystem, or to compare different ecosystems.

Also, while value capture is central to the ecosystem concept, it is notoriously difficult to measure (Rietveld et al., 2019). Thus, studies of value capture have tended to use qualitative measures, such as bifurcated success vs. failure (West and Wood, 2013) or the trend over time — higher, lower, or the same (Schreieck et al., 2021).

Further, it is important not only to identify governance structures and mechanisms in ecosystems and trace their evolution, but also to show which structures and mechanisms are common and which are rare. This, in turn, requires systematic quantitative measurement across large sets of actors and a broad range of industries. Quantitative approaches can also be employed to study the nature and rate of innovation in ecosystems, and how they contribute to the overall economic progress and the specific performance of the different actors over time (e.g., Adner and Kapoor, 2016; Kapoor and McGrath, 2014).

The most important impediment to such research is the lack of appropriate datasets. Ecosystems are, by definition, groups of actors, linked in various formal and informal ways. Detailed data on interfirm transactions is very limited: government input-output tables are too aggregated to be of much use in identifying transactions in ecosystems, although social network tools might shed light on the nature and impact of interdependencies between individual or organizational actors.

Another promising methodology is to look at software traces, such as web APIs. These are generally susceptible to large-sample hypothesis testing (Kapoor and Agarwal, 2017; Agarwal and Kapoor, 2022) as well as network visualization and deconstruction methods (MacCormack et al., 2006, 2012; Baldwin et al., 2014; Pujadas et al., 2024). Other potential sources of data for large-sample studies are the statistics published by various open consortia and platforms, such as the Linux and Apache Foundations and the GitHub repository.

The dual concepts of complementarity and joint-value creation are central to the application of the ecosystem lens. Today, however, it is difficult to measure the *incremental value* created by combinations of complementary components. Identifying the causes of complementarity within an ecosystem, and describing how the joint value created changes over time are thus important avenues of future research (e.g., Agarwal and Kapoor, 2022).

Such analysis requires new methods, however. A structural analysis of the functional components contributing to value in complex technical systems can be used to deconstruct joint-value creation and connect it to innovation outcomes (Adner, 2021, Ch. 1; Baldwin, 2024, Ch. 4). “Value structure” analysis also provides a way to distinguish between specialized and generic complements and thus predict which contributors to the system are likely to capture a significant percentage of the complementary surplus. To date, however, these methods have been rarely used.

6. Conclusion

Since Schumpeter’s path-breaking work, the field of innovation studies has moved from an initial focus on industries and firms to an increasing focus on ecosystems. However, despite the rising prominence of ecosystems, there remains significant ambiguity about what constitutes an ecosystem and how an “ecosystem lens” can be applied to innovation in ways that facilitate cumulative progress in our knowledge.

To address this ambiguity, this article provides three criteria that can be used to define ecosystems. First, ecosystems are comprised of autonomous actors (organizations and individuals) subject to distributed governance that capture enough value to justify their participation. Second, the actors contribute in complementary ways to a focal value proposition, so that the joint value of the whole system is greater than the sum of the values of its separate parts. Finally, the technical components in an ecosystem are modules within a larger technical architecture. An *ecosystem lens* on innovation focuses on innovations and organizations satisfying these criteria.

The articles in the special issue highlight the benefits of using an ecosystem lens to study innovation. These benefits include: (1) the identification of different types of actors (e.g., users, suppliers, complementors, distributors, public actors, and intermediaries); (2) descriptions of the processes that shape innovation and joint-value creation in both established and emerging industries; and (3) uncovering common features and themes across the different articles. This lens can also help us to understand differences between types of ecosystems. For example, we can distinguish between innovation ecosystems coordinated by platforms and those coordinated by other means, as well as between ecosystems concerned primarily with innovation vs. those focused on entrepreneurship, regional development, or the creation of new knowledge.

Taken as a whole, the articles shed light on how incumbents and entrants can create novel value propositions by orchestrating their respective ecosystems, while acknowledging the challenges associated with governing autonomous actors and maintaining multilateral alignment in an ever-changing environment. Beyond offering new insights to better understand innovation ecosystems, we also hope that our special issue will spur better research, practice and policy on ecosystem innovation.

CRediT authorship contribution statement

Carliss Y. Baldwin: Conceptualization, Writing – review & editing. **Marcel L.A.M. Bogers:** Conceptualization, Writing – review & editing. **Rahul Kapoor:** Conceptualization, Writing – review & editing. **Joel West:** Conceptualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

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