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Externalities and complementarities in platforms and ecosystems: From structural solutions to endogenous failures

Michael G. Jacobides[a,*], Carmelo Cennamo[b], Annabelle Gawer[c]

[a] London Business School, Sussex Place, Regents Park, London NW1 4SA, UK
[b] Copenhagen Business School, Solbjerg Plads 3, DK-2000 Frederiksberg, Denmark
[c] University of Surrey, Stag Hill, University Campus, Guildford GU2 7XH, UK

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ABSTRACT

Platforms and ecosystems provide structures for constellations of economic actors to engage and interact as they seek to create and capture value. We consider how the constructs of platforms and ecosystems relate and explore why they have become more ubiquitous by focusing on the nature of their value-add. We propose that they emerge as a response to distinct market failures, which we identify, and we explain which specific externalities they help overcome. We also identify post-hoc endogenous functional and distributional failures that platforms and ecosystems, in turn, generate. We discuss implications for theory and practice.

1. Introduction

The last decade has seen a surge of research interest in platforms and ecosystems—two constructs that are used interchangeably (and, at times, confusingly) to describe groups of economic actors that combine to create and capture value. Motivated by the staggering growth of Big Tech, scholars have explored the dynamics of both platforms (Armstrong, 2006; Gawer, 2014; Hagiu, 2006; Parker and Van Alstyne, 2005, 2018; Rochet and Tirole, 2003, 2006; Yoo et al., 2010; Tiwana et al., 2010) and ecosystems (Adner, 2012, 2017, 2021; Baldwin, 2022; Iansiti and Levien, 2004; Jacobides et al., 2018, 2019; Kapoor, 2018; Moore, 1993). Until recently, the focus had been on corporate success, but work has now expanded into issues of competition and regulation (Report; Furman et al., 2019; Stigler, 2019; Jacobides and Lianos, 2021a). Yet, some fundamental questions remain: How do platforms and ecosystems differ as constructs? How do they emerge, and what problems do they solve? And what *inherent faults* might they entail?

We address these questions through conceptual development rooted in an up-to-date literature analysis. We make two main contributions. First, we explain why and when platforms and ecosystems emerge, and show that the two constructs can be distinguished by identifying the *complementarities* they entail. We also reveal the specific *externalities* they help address—which are, in turn, related to specific systemic economic failures. We argue that both platforms and ecosystems offer inter-actor organizing arrangements that remedy "value network failures"—the failure of market or state mechanisms to offer templates that enable disparate actors to cooperate and/or co-specialize without the need for integration. Platforms, specifically, provide solutions to "matching failures"—that is, the inability of a non-platform-mediated mechanism to manage the volume and quality heterogeneity that matches different participants—or "systemic innovation failures," which arise from difficulties in cultivating and developing components or complements to support an innovation system. Ecosystems resolve "cooperation failures" that emerge when uncoordinated activities involving multiple distinct actors fail to produce joint value. Such systemic economic failures, in turn, are caused by participants' failure to exchange knowledge, spontaneously converge on technological standards, or align activities, especially when systemic coordination is required, even though there is sufficient modularity to make platforms and ecosystems possible.

Second, we argue that while platforms and ecosystems offer solutions to existing economic failures, they can end up generating other "value

* Corresponding author.
E-mail addresses: mjacobides@london.edu (M.G. Jacobides), cce.si@cbs.dk (C. Cennamo), a.gawer@surrey.ac.uk (A. Gawer).

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architecture" economic failures of their own. We qualify these value architecture failures as *endogenous and inherent faults* because they stem from the very circumstances that engender successful platforms and ecosystems in the first place. These failures lead ecosystem members acting in their economic self-interest to undermine the health and welfare of the entire platform- or ecosystem-based value architecture. We distinguish between *functional* failures, which refer to the platform or ecosystem members' failure to create and deliver joint value to the final customer, and *distributional* failures, which are associated with participants' inability to capture value proportional to their joint contribution. Distributional failures occur either when platform or ecosystem design allows some members to abuse the system to capture disproportionate value, or when orchestrators abuse their dominance. Moreover, distributional failures can engender functional failures by thwarting complementors' participation or quality provision in the platform or ecosystem, and also raise issues of equity that underpin the burgeoning discussion of fairness principles on platform regulation, which we also review. We conclude with implications of our analysis for theory, empirical research, and practice.

2. Drawing on and bridging distinct traditions

2.1. Platforms: production and/or value architectures based on technological structures facilitating inter- and intra-organizational interactions

The first use of the concept of *platform* in the management literature was the "product platform," which came from engineering design (Jiao et al., 2007; Krishnan and Gupta, 2001; Meyer and Lehnerd, 1997). In that perspective, platforms were defined as specific modular product architectures (Ulrich, 1995) that help firms develop product families (Sanderson and Uzumeri, 1995), thus enabling the systematic re-use of common assets or activities (Krishnan and Gupta, 2001).[1] Firms using platforms could then benefit from the recombination options afforded by modular designs (Baldwin and Clark, 2000; Schilling, 2000; Garud and Kumaraswamy, 1995) and innovate more quickly and cheaply—especially "platform leaders" (Gawer and Cusumano, 2002) that could engage outsiders in their innovation process. In parallel, another distinct understanding developed in the economics literature (with some, such as Parker and Van Alstyne, 2005, in the IS Management field). Platforms were seen as facilitating exchange, allowing direct transactions between different types of consumers (members of the platform's so-called "sides"), and referred to as "two-sided markets," "multi-sided markets," or "multi-sided platforms" (MSPs); essentially, specific market architectures (Armstrong, 2006; Caillaud and Jullien, 2003; Evans et al., 2008; Evans, 2003; Rochet and Tirole, 2003, 2006; Rysman, 2009). These platforms are noteworthy for their indirect network effects, as exemplified by digital marketplaces such as eBay (matching buyers and sellers), Tinder (matching daters), and Uber (matching drivers and passengers). Such indirect network effects can, under certain conditions, drive competition between platforms to a "winner takes all" outcome (Eisenmann et al., 2006; Lee et al., 2006).

Some strategy papers have advocated a "unified view" of the economics and engineering-design perspectives (Baldwin and Woodard, 2009; Boudreau, 2010, 2012; Ceccagnoli et al., 2012; Eisenmann et al., 2011; McIntyre et al., 2021; Parker et al., 2017; Thomas et al., 2014). Gawer (2014) suggests that all platforms create value through economies of scope, and distinguishes between *internal platforms*, *supply-chain platforms*, and *industry platforms,* while Thomas et al. (2014: 200) also focus on the distinct drivers of potential "architectural leverage." Cusumano et al. (2019) distinguish between *innovation platforms*—those that facilitate innovation on a foundation offered by a central actor[2]—and *transaction platforms*—those that link buyers and sellers. They suggest that today's most successful platform firms operate *hybrid platforms*, encompassing both the innovation and transaction aspects. These include companies such as Apple, Google, and Facebook, with their interconnected sets of technologies and services. Consider how Apple iOS (an innovation platform) is necessary for the App Store (a transaction platform) to operate. Table 1a provides a selective comparison of these platform definitions.

2.2. Ecosystems: interorganizational value architectures based on co-specialized collaborative relationships

The concept of *ecosystem* has developed separately in the management literature, with scholars focusing on communities or aggregations of economic actors whose activities need to be coordinated in order to achieve a collective outcome that creates value for the final consumer (e.g., Iansiti and Levien, 2004; Moore, 1993). The term "ecosystem" has been used to describe a *business ecosystem*—that is, a community affecting a firm's ability to adapt to its environment (e.g., Moore, 1993; Pierce, 2009; Williamson and De Meyer, 2012; Teece, 2007; Zahra and Nambisan, 2012); an *innovation ecosystem*, aggregating all actors whose contributions are essential to delivering a valuable innovation to the final customer (Adner, 2012, 2021; Adner and Kapoor, 2010, 2016; Alexy et al., 2013; Frankort, 2013; Iyer et al., 2006; Kapoor and Lee, 2013; Leten et al., 2013; West and Wood, 2013); or a *platform ecosystem*, aggregating developers of complementary products required to extend the value of a core platform technology (Ceccagnoli et al., 2012; Cennamo and Santaló, 2013, 2019; Gawer and Cusumano, 2002, 2008; Parker et al., 2017; Wareham et al., 2014; Jacobides et al., 2019).[3]

Finally, another distinction has recently appeared in the managerial literature, reflecting the use of the term "ecosystem" in practice. As Jacobides (2022) argues, several firms build *multi-product* or *experience* ecosystems that consist of multiple connected goods and services (such as Apple's TV services, cloud storage, smartphones, and computers) that create *consumption complementarities* for a final user. Such multi-product ecosystems are driven by a single firm and underpin a consumer-facing bundle. This contrasts with the dominant use of the term "ecosystem" in the management literature to refer to multi-actor structures within a narrow "vertical." Such ecosystems strengthen the hand of the multi-product orchestrator vis-à-vis both its various complementors and the end user. They usually draw on one (technological) platform or several connected platforms (as in the case of Google and its connected AdTech and consumer platforms, reviewed in Jacobides et al., 2020) and tend to involve one or multiple (multi-actor) ecosystems, such as the Apple

[1] For Wheelwright and Clark (1992, p.73), the earliest management scholars to refer explicitly to platforms, they are products that meet the needs of a core group of customers but can be modified through the addition, substitution, or removal of features. For Meyer and Lehnerd (1997), and Krishnan and Gupta (2001), platforms are collections of common elements, defined as sets of subsystems and interfaces, forming a common structure from which a stream of products can be developed. This literature is heavily inspired by the modularity literature (Baldwin and Clark, 2000; Langlois and Robertson, 1992; Huang et al., 2005; Jiao et al., 2007).

[2] For evidence on the value of instituting an innovation platform, consider Benzell et al. (2019), who find that firms that opened themselves to external innovation outperformed standard "closed" firms by 36 % over 16 years.

[3] Another literature looks at *regional ecosystems*, where the term "ecosystem" is conceptually close to the "clusters" of yesteryear (see Porter, 1990; Saxenian, 1996), and where the term often used is *entrepreneurial ecosystems*, meaning the loosely related firms that all participate in entrepreneurial activities in one place, and as such complement each other. This "looser" use of the term has led us to exclude regional ecosystems from our own analysis in related previous research. However, as recent papers suggest, there is a kinship in terms of the structures that operate in such entrepreneurial ecosystems and those in other varieties. See Thomas and Autio (2020) for a discussion.

Table 1a
Platform definitions: a selective comparison.

Representative article	Rochet and Tirole (2003)	Parker and Van Alstyne (2005)	Tiwana et al. (2010)	Gawer (2014)	Cusumano et al. (2019)
Platform definition	Platforms are two-sided markets facilitating value exchange between two sides of the market, usually buyers and sellers.	Platforms are products with a two-sided network of users linked by interdependent demand for the product.	A platform is conceived as the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate.	Platforms are organizations or meta-organizations that federate and coordinate multiple agents to facilitate innovation on top of the platform's technology, whose architecture is modular and composed of a core and a periphery.	Platform types create value in distinct ways: • Transaction platforms intermediate and facilitate direct exchange or transactions across sides, subject to network effects. • Innovation platforms offer a technological foundation upon which other firms develop complementary innovations. • Hybrid platform firms combine transaction and innovation platforms.
Analytical elements of focus	• Two-sidedness of market structure • Network externalities • "Price structure": price allocation between the two sides of the market (loss-leader, i.e., subsidized market segment vs. profit-making, i.e., subsidizing market segment) • Platform competition	• Strategic pricing behavior (why are information products priced at "free"?) • Product design decisions • Product(s) demand interdependence	• Platform design • Platform governance • Platform system evolution	• Economies of scope in innovation • Technological interfaces and organizational arrangements coordinating innovation of external agents on top of the platform • Organizational form and governance	• Platform business model • Organizational form • Platform-based ecosystem governance
Representative example(s)	Credit cards, newspapers, internet portals… but also operating systems, videogame consoles	Newspapers, development toolkits, portable document readers, internet browsers	Operating systems (Apple iOS); browsers (Firefox); gaming consoles (Xbox)	Intel microprocessors, Google's Android, Apple iOS	• Transaction platforms: Amazon Marketplace, eBay, but also Twitter, Facebook social network • Innovation platforms: Apple iOS, Google Android, Microsoft Windows, Amazon AWS • Hybrid platform firms: Google (Play Store + Android); Facebook (FB social network + FB for developers); Apple (App Store + iOS)

iPhone app (multi-actor) ecosystem that forms part of Apple's multi-product ecosystem.

Turning to multi-actor ecosystems, a unifying structural view has been put forward (Adner, 2017; Jacobides et al., 2018) that aims to single out the key features that distinguish ecosystems from platforms (upon which ecosystems may rest).[4] Adner (2017) focuses on "alignment structures," i.e., interorganizational structures allowing firms to align their interests to collaborate and build a joint value proposition. Jacobides et al. (2018) focus on the reasons why such alignment structures emerge, highlighting the role of *modularity* and, perhaps more importantly, the nature and strength of *complementarities* as defining features.[5] This view is shared by Baldwin, 2022, who claims that "for an ecosystem to be sustained, the complementarities among products and/or actions must be strong enough to require coordination but not so strong as to need unified governance" (2022: 7).[6] Thus, there is still significant variance in ecosystem research, leading some (e.g., Thomas and Autio, 2020) to argue that "ecosystem" should be considered as a concept rather than a construct, as it is not yet sufficiently operationalized to allow for robust measurement and testing.

Despite these differences in emphasis, scholars seem to concur that ecosystems define interorganizational value architectures based on co-specialized collaborative relationships. Therefore, we view innovation ecosystems and platform ecosystems as particular types of business ecosystems. Innovation ecosystems entail certain non-generic complementarities of actors who coordinate to generate interrelated innovations. Platform ecosystems, meanwhile, focus on the non-generic complementarities and interdependences created by the technological platform that serves as a medium of coordination. Both are characterized by a modular interorganizational architecture that enables a non-hierarchical alignment of actors' interests, often guided by the "hidden hand" of an orchestrator, and where (non-generic) complementarities

[4] Reviews of the concept by Kapoor (2018), Bogers et al. (2019), and Baldwin, 2022 discuss how ecosystem research relates to other streams in strategy and innovation (see Table 1b).

[5] For Jacobides et al. (2018: 2264), ecosystems consist of "a set of actors with varying degrees of multi-lateral, non-generic complementarities that are not fully hierarchically controlled." A distinguishing feature of Jacobides et al. (2018) is to clarify that not all complementarities necessarily give rise to ecosystems, and that ecosystems comprise sets of interdependent firms that are not unilaterally hierarchically driven.

[6] Bogers et al. (2019) integrate different streams of related research (such as open innovation, entrepreneurial and regional ecosystems, or value networks), emphasizing interdependence, network, and self-interested actors as core operational elements.

enable a joint value proposition. Table 1b presents a comparative summary of these conceptualizations.

2.3. Beyond literature silos: phenomenological and theoretical distinctions

Platforms and ecosystems are partly overlapping and closely interrelated, despite the largely independent trajectories the respective literatures have taken. Any effort to relate the two constructs will inevitably depend on the exact definitions used in each case: the tighter the definitions, the sharper the distinction. However, a platform usually entails an ecosystem, and an ecosystem often rests on a platform. To clarify the relationship between the two, we turn to their respective foci.

Platforms, we submit, tend to be associated with the "infrastructure" that offers a technological foundation (Cennamo, 2021) that can be used within or between organizations to connect and either transact (as in a marketplace and MSP) or engage and support innovation (as with Google's Tensorflow in AI, which provides a basis for developers—see Jacobides et al., 2021). Platform scholars are concerned with the *specific medium offered* that allows participants to engage, whether for production or consumption.[7] In contrast, we view ecosystems as associated with the sets of interorganizational arrangements that allow different organizational participants (and/or individual actors) to collaborate and jointly produce, or allow the consumer to jointly consume, compatible products or services that have value.

Thus, while many ecosystems rest on platforms, ecosystems may not require platforms in order to emerge and operate. Also, platform owners (such as, e.g., Amazon with its multi-sided marketplace) may provide standardized rules for engagement without any co-specialization between the members, thus eschewing the need to set specific collaborative arrangements with platform members. That said, platforms are likely to have associated ecosystems, which is why much of the discussion in the literature—this paper included—relates to platform-based ecosystems.[8] However, the two address different types of issues, by dint of the externalities each can address and the complementarities they relate to.

3. Platforms and ecosystems: structural solutions to distinct externalities

3.1. Externalities, market failures, and value creation

Broadly speaking, "externalities" are features associated with an economic activity that are not accounted for, or reflected in, the transaction terms and parameters governing the market.[9] Externalities can be negative (as in pollution) but also positive (as in network effects, where the value of a network to the user increases as others join it). They can be unidirectional, with one agent (or a set of agents) imposing an externality on another or others, or reciprocal, with each party imposing an externality on all others (Dasgupta, 1982). When positive externalities are not harnessed, market failures can ensue, reducing consumer and social welfare.[10] Often, the problem is that there is insufficient incentive for economic agents to make the right level of investment (or consumption decision) because they cannot fully appropriate the potential benefits. To understand the value-add of platforms and ecosystems, then, we should consider the specific externalities and exogenous market failures that make them attractive. These are summarized in Table 2 and discussed in detail below.[11]

3.2. Externalities, complementarities, and value creation in platforms

In the context of *multisided transaction platforms*, which the economics and strategy literatures tend to call "multi-sided platforms" (MSPs), externalities take the form of indirect network effects: one user's decision to adopt the platform affects the benefits it generates for another. However, individual users do not take account of these cross-user benefits when making their decisions. This can lead to market failure in terms of, for instance, the suboptimal adoption or pricing of the platform (e.g., Katz and Shapiro, 1992; Rochet and Tirole, 2003, 2006). Boudreau and Hagiu (2009), for instance, discuss the governance role of MSPs, which goes well beyond price-setting to encompass devising rules and imposing constraints on market participants to shape behaviors and manage externalities.

Value to platform users is seen as arising from the access that one "side" of a market has to the other. Thus, much of the literature has focused on how to bring multiple sides on board, given that none would have an incentive to join without the other(s) (Caillaud and Jullien, 2003; Evans, 2003; Rochet and Tirole, 2006). Studies in this stream draw from examples in the information, communication, and technology (ICT), media advertising, videogames, mobile app, or payment industries (see, for example, Evans et al., 2008; Seamans and Zhu, 2014; Wilbur, 2008; Zhu and Iansiti, 2012). Platforms, bringing together different sides that benefit from each other's presence, allows for these externalities to be internalized. They represent solutions to "matching failures."

Multisided transaction platforms represent specific interorganizational value architectures based on multi-sided market structures facilitating matching and value exchange between consumers and product/service providers (Cennamo and Santaló, 2019; Tajedin et al., 2019). An extreme case of such matching benefits is where the sheer size of connected parties drives benefits, which drives network externalities. A few uncharacteristic examples of network effects generating non-linearly increasing value, such as networks of fax machines, have led to much of the (sometimes unjustified) excitement over platforms, including stratospheric valuations of heavily loss-making companies from Uber to

[7] Companies that have *platform strategies* are those that use platforms to underpin their competitive positioning. The focus is usually on companies that own or sponsor platforms. Yet, the literature also considers the plight of smaller complementors who need to decide either which platform to join, or how to compete within it—even if this is a less prominent theme. See, e.g., Boudreau and Jeppesen (2015); Cennamo et al. (2018); Rietveld and Eggers (2018); Tavalaei and Cennamo (2020).

[8] See, for instance, Boudreau and Hagiu (2009) on transaction platform owners also orchestrating ecosystems and Eisenmann et al. (2009); Gawer and Cusumano (2002); Gawer (2021b, 2022); Gawer and Henderson (2007); Kapoor (2018); Parker et al. (2017); Parker and Van Alstyne (2018); Rietveld et al. (2019), and Thomas et al. (2014) on platform owners also building ecosystems that they orchestrate atop their platforms.

[9] Examples include the effect of the pollution from one own's car on others, or the benefits that owners of orchards derive from bees that pollinate them. Externalities prevent consumers (individuals, households, and businesses) from making fully informed consumption choices (or investments) because they cannot internalize externalities in their decision choices (Pigou, 1920).

[10] This is the sense in which they are a "failure," as opposed to "market imperfection," which is itself a euphemism to denote oligopolistic power and lack of competition, which hurts consumers. In macroeconomic terms, "market failure" is a justification for public intervention, while for organizational economists such a failure might displace markets in favor of forms of organization better suited for such externalities—including vertical integration. See Williamson (1985).

[11] In Table 2, we focus on the characterization of platforms as either multi-sided transaction or innovation platforms, as those two types capture the key distinguishing features that map onto different types of externalities. Thus seen, other types of platforms (such as illustrated in the examples provided in Tables 1a and 1b) map to one of these two categories.

Table 1b
Ecosystem definitions (and relation to platforms): a selective comparison.

Representative article	Adner (2017)	Jacobides et al. (2018)	Kapoor (2018)	Bogers et al. (2019)	Baldwin, 2022
Ecosystem definition	"The alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize" (p. 40)	"A set of actors with varying degrees of multilateral, nongeneric complementarities that are not fully hierarchically controlled" (p. 2264)	"An ecosystem encompasses a set of actors that contribute to the focal offer's user value proposition" (p. 2)	"An interdependent network of self-interested actors jointly creating value" (p. 2)	"A network of autonomous firms and individuals whose products or actions are complementary" (p. 7)
Analytical elements of focus	• (Joint) value proposition • Members' alignment (compatible incentives and motives)	• Type of complementarities (supermodular vs. unique) and fungibility (generic vs. specific complementarities) • (Need for) multilateral coordination at the group level	• User value proposition • Complementarities between actors' offers (in terms of the potential for user value creation)	• Members' goals • Members' network of relations and interdependence with goals	• Modularity (of components and complements) • "Design rules" (interfaces enabling connections and innovation)
Representative example(s)	Michelin's run-flat tire technology (and connected actors)	Android system and connected apps; competing 5G-compatible IoT product systems; Sony PlayStation and compatible videogames	Electric car (as "product ecosystem"); Apple's iPhone (as "platform-based ecosystem")	N/A	Apple iOS and app developers; PC computer system and external developers
How ecosystems and platforms relate	Platforms are outside the scope of ecosystems: "Whereas platforms are concerned with the governance of interfaces, ecosystems are concerned with the structure of interdependence." (p. 54)	Platforms offer specific ways to coordinate non-generic complementarities in ecosystems; not all platforms entail ecosystems.	Some ecosystems ("platform-based ecosystems") build on top of platforms that offer specific technological architectures connecting actors and offers.	Platforms (through their interfaces) can help structure the relationships and interdependence of members' network.	"Open platforms of all types rely on ecosystems of firms and individuals to supply many parts and perform many of the tasks needed to arrive at a complete product" (p. 7).

WeWork.[12] The "winner-takes-all" view has remained disconcertingly popular, despite more nuanced views introduced in more recent work (Boudreau and Jeppesen, 2015; Cennamo and Santaló, 2013; Cennamo, 2018; Zhu and Iansiti, 2019).[13]

Innovation platforms, in turn, are interorganizational value architectures based on modular technologies facilitating production, integration, and extension of (core and complementary) innovation. The literature discusses different kinds of externalities: technological and knowledge spillovers between the interdependent modular components of a technological system and their providers (Boudreau, 2010; Gawer and Cusumano, 2002, 2014; Gawer, 2014); adoption of components across the system (Ozcan and Santos, 2015); and integration of system components (Boudreau, 2017).

Such externalities can have consequences at the level of the market or the firm. For example, Ozcan and Santos' (2015) study of the early mobile payment market (pre-Apple Pay) ascribes its failure to materialize to the turf war between incumbents from various sectors, each a leader in its respective domain. The emergence of this new market required coordination among actors providing potentially complementary components, but they failed to build a common platform because they could not agree how jointly created value should be shared.

In other cases, the survival of the focal firm can be at stake when it provides a component within a larger system architecture and the value of its product to end users depends on third parties providing complementary technologies, products, or services. If that focal firm must innovate to stay ahead of the competition, its survival can be jeopardized by the intermittent or unpredictable generation of complements. Faced with this externality problem in the late 1980s/early 1990s, Intel created an innovation platform by shaping and sharing standard interfaces such as PCI, USB, and FireWire to stimulate innovation by software developers and hardware peripheral makers (Gawer and Cusumano, 2002). Parker et al. (2017) underscore this point by demonstrating the superiority of such platform-centric models to firm-centric ones for internalizing externalities due to innovation spillovers arising from third-party complements. They refer to the model as the "inverted firm."

Similar externalities exist in other systemic industries, such as videogames, where dynamic competition pushes incumbent console makers to introduce a new generation every few years. To ensure that third parties develop games for the latest models, console makers provide them with reliable labor-saving capabilities and tools (Özalp et al., 2018). In such a context, platforms address a potential lack of coordination among industry participants and uncertainty over the future distribution of value capture that could lead to "innovation failures." Digital interfaces between the platform and complementary modules play a crucial role. By opening up such interfaces, digital platform owners can successfully attract innovators of complementary products (Parker et al., 2017)—especially if it is cheap or free to connect (Gawer

[12] The fact that (at least until recently) the stock market valued growth over margins, and will even fund patently unprofitable platform businesses, suggests that investors may be expecting them, sooner or later, to become the "winner" in a "winner-takes-all" dynamic, buoyed by network externalities. Common exceptions to this winner-takes-all outcome occur when users multi-home (i.e., use more than one platform for the same purpose at the same time), when network effects are highly localized, when there is differentiation across platforms, or when the opportunity for niche competition arises (Eisenmann et al., 2006).

[13] Some studies have looked not just at one platform in isolation, but at the factors—such as multi-homing, first-party complements, and within-platform market competition—that may limit "winner-takes-all" dynamics and lead to the coexistence of multiple platforms (Cennamo and Santaló, 2013; Cennamo, 2018; Corts and Lederman, 2009). This may affect the incentives and strategies of various players, particularly complementors, for co-creating value (Landsman and Stremersch, 2011; Mantena et al., 2010).

Table 2
Innovation platforms, transaction platforms, and ecosystems comparison: externalities, exogenous failures addressed, and structural solutions provided.

	Innovation platforms	Multisided transaction platforms	Business ecosystems
Conceptualization	Interorganizational value architectures based on modular technological architectures: • Structures of interoperable technological components and complements facilitating production, integration, and extension of innovation	Interorganizational value architectures based on multi-sided market structures: • Structures of economic relations facilitating matching and value exchange between consumers and product/service providers	Interorganizational value architectures based on co-specialized collaborative relationships: • Structures of interorganizational collaborative relationships facilitating collective value production for actors and joint value proposition for end customers
Nature of externalities	Innovation spillovers • Individual actors' innovation design choices benefit (constrain) other actors' innovation capacity or value, for which they receive no direct economic benefits (costs)	Consumption externalities • Individual actors' consumption choices generate benefits (costs) for others, for which they are not compensated (held liable)	Cooperation externalities • Increases (or reductions) in the total value produced for all actors from an individual actor's cooperative effort/investments, for which the actor captures (bears) only partial value (cost)
Type of exogenous failure addressed	Innovation system failure • Individual actors' limited incentives to invest in needed components and complements for an innovation system to work effectively due to failures to exchange knowledge and converge on a technological standard	Market failure • Individual actors' limited or lacking incentives to engage in a transaction due to failures to coordinate with other actors for exchange (or capture value from it)	Value network failure • Bottlenecks within value network due to: - Individual actors failing to recognize the multilateral interdependencies with other actors and to cooperate for joint value production - Individual actors' lack of incentives to invest in critical components or complements for an integrated solution to emerge
Structural solution provided	Coordination of technological innovation problems including: • Lack of interoperable complements and components • Components' integration and extension into technological system • Convergence over technological standard • Knowledge exchange for development of compatible complements	Coordination of consumption problems including: • Information asymmetry problems • Transaction costs • Searching and matching of product/service providers with consumers • Preserving incentives for high-quality contributions from product/service providers	Coordination of interfirm cooperation problems including: • Interfirm co-specialization • Moral hazard and free-riding problems • Innovation bottlenecks in critical components and complements • Lack of integrated solution to customers • Structure of interdependence (of collaborating firms' products/technologies)

and Cusumano, 2002; Gawer, 2021a).[14]

Thus, value creation in innovation platforms flows from the possibility to attract and align complementors to develop complementary innovations. The design of the interfaces around the platform, and whether they are "open" or "closed" (West, 2007), directly affect the facilitation of complementary innovation at the industry level (Langlois and Robertson, 1992). In this regard, platform scholars have explored how value emerges from *design*—in particular, "product design" and "platform design" (Baldwin and Clark, 2000; Garud et al., 2008; Yoo et al., 2010). Platforms create value by providing access to critical complementary assets for production and the use of system components in innovation. This underpins "generativity"—that is, the capacity for the continual creation of variant system components offering new affordances to the technology user (Yoo et al., 2010; Wareham et al., 2014: 1195).

Appropriate platform design enables (modular) components to extend the core product or service. Platforms are deliberately designed with an inherent "incompleteness," which is a "trigger for the creation of many diverse ideas on how a design can be extended and further developed" (Garud et al., 2008: 358). This opens up new avenues for ongoing engagement with different sets of innovators. This benefit tends to be contrasted with "traditional" product design, which is usually conceived as having predefined functionalities and "closed" architectures, intended to offer standalone value in the market (Attour and Peruta, 2016; Gawer and Henderson, 2007). Thus, the main value-creation mechanism in innovation platforms is the enabling of complementarities in systemic innovation through the compatibility of interdependent system modules (Ceccagnoli et al., 2012: 266), lowering the barriers to entry for innovators of complementary modules, products, and services (Boudreau, 2010, 2012).

3.3. Externalities, complementarities, and value creation in ecosystems

Business ecosystems are interorganizational value architectures based on co-specialized collaborative relationships facilitating collective value production for actors and joint value propositions for end customers. In this context, externalities take the form of joint value creation problems in cooperative relationships for cospecialized investments, whereby the decision of one actor to invest in one specialized asset or component (of the system) will affect the benefits that other actors enjoy from investing in the asset or contributing their own components, or consuming them in conjunction (e.g., Jacobides et al., 2018).

While the dynamics of ecosystems can resemble those of platforms, they mainly concern *interorganizational dynamics* and involve *non-generic complementarities.* The latter is what makes the ecosystem economically distinct from e.g., supply chains, as its members have made investments that are specific to their complementors, without the unilateral positions

[14] Platforms thus also address "standards failure" by preventing the proliferation of potentially incompatible standards: through their design decisions on compatibility or incompatibility, platforms can favor the convergence of complements towards a unified standard (Gawer and Henderson, 2007), thereby encouraging industry growth.

of authority that often characterize lead firms in supply chains (or platform owners).

When specialized actors focus solely on their own individual components, they tend to underestimate—and hence fail to internalize—the impact of their component-level decisions at the system level, because they neglect multilateral interdependencies. This can lead to suboptimal investments. Consider, for instance, how complementors in the video-game industry underinvested in quality because they could not capture the value of the fruits of their innovative labor (Cennamo and Santaló, 2019) or enterprise software providers investing in the production of standalone applications that fail to integrate fully and coherently with other modular system components produced by other innovators (Wareham et al., 2014). Uncoordinated action will lead to innovation bottlenecks in critical components or complements (Ethiraj, 2007), as in the case of the innovation challenges of must-have complements for semiconductor lithography tools described in Adner and Kapoor (2010), or misaligned incentives between key contributors due to lack of proper interorganizational governance structure, as in the failure of Symbian's ecosystem (West and Wood, 2013).

Furthermore, in the absence of a clear ecosystem architecture, firms may lack information about the potential benefits from co-specialization, potentially leading to underinvestment (Masucci et al., 2020). Thus, individual actors' failure to recognize multilateral interdependencies with other actors and cooperate for joint value production would reduce other actors' ability to produce value, and eventually to the failure of the ecosystem to create value for end customers.

Ecosystems thus offer architectural blueprints to structure relationships among complementors and define the roles and rules of participation (Adner, 2017). They serve as governance arrangements to internalize the externalities of these cooperation interdependencies (Jacobides et al., 2018). They provide a relational architecture of inter-firm collaboration that allows the clear division of roles and complementors' tasks across sectors, integrating their specialized modular contributions into a unified value network. This facilitates customer-facing integrated solutions, driven by autonomous complementor contributions, set within the boundaries of ecosystem governance (Cennamo, 2021; Gawer, 2021a; Ozcan and Eisenhardt, 2009; Shipilov and Gawer, 2020; Wareham et al., 2014).

Ecosystem research has considered how to address innovation bottlenecks in the critical components and complements of a focal innovation (Adner and Kapoor, 2010); how to overcome poor governance of inter-firm cooperation (Gulati et al., 2012; West and Wood, 2013); the challenges of aligning actors' incentives to participate and develop high-quality contributions (Ceccagnoli et al., 2012; Cennamo and Santaló, 2013; Panico and Cennamo, 2022); and (lack of) convergence over core and complementary components and market architecture of the overall system (Ozcan and Eisenhardt, 2009; Ozcan and Santos, 2015; Hannah and Eisenhardt, 2019).

Value is created in different ways. In the realm of production, benefit arises from the existence of sets of cospecialized firms that can interchangeably produce and consume, so that the ecosystem allows for more opportunities to source an input or place an output, and to reduce both frictional transaction costs and the need for ad hoc arrangements that might be uneconomical. For a firm that buys services through an ecosystem, variety in potential supply-chain partners is beneficial; for those selling through ecosystems, this flexible option may be more attractive than traditional captive arrangements (Adner and Kapoor, 2010; Kapoor and Lee, 2013; Ganco et al., 2020). As for ecosystems focused on new innovations, they provide an effective, organizationally distributed way of seeking new advancements: ecosystems create value *through* the coordination they offer—a topic to which we return later (also see Jacobides et al., 2019).

Ecosystems consider *cooperation externalities* resulting from multilateral interdependencies that cannot be fully solved through traditional hierarchical vertical integration or bilateral contracting—let alone arm's-length market relationships (Adner, 2017; Jacobides et al., 2018).[15] Ecosystems provide a means to ensure that not only production but also innovation is aligned. Orchestrators help to resolve such alignment requirements (Jacobides et al., 2018)—a theme recently developed by (Foss et al., 2023). Ecosystems therefore minimize the costs of coordination and cooperation and allow the comparative advantages in innovation to be leveraged by firms that specialize in each module (Langlois, 2003) while also guaranteeing system-level integration of those modules into a coherent set of value options for the customer.

In all, ecosystems afford superior access to capabilities and control over governance costs (Foss et al., 2021; Jacobides et al., 2018; Parker et al., 2017). Some specific types of failures that ecosystems can address include *technological system failures* (Baldwin and Clark, 2000; Garud et al., 2008; Wareham et al., 2014); *innovation bottlenecks* (Adner and Kapoor, 2010; Adner, 2017; Kapoor, 2018; Masucci et al., 2020), and *lack of cross-sector coordination*, especially in nascent markets for integrated solutions (Logue and Grimes, 2020; Khanagha et al., 2022; Hannah and Eisenhardt, 2019; Ozcan and Eisenhardt, 2009).

Finally, we should mention another set of externalities that lie beyond the scope of this article: *social and psychological externalities*. On one hand, as Jacobides et al. (2019: Chapter 3) note, ecosystems can be, and have been, used to tackle complex societal problems. Most of the issues we face nowadays, from climate change to traffic congestion, are systemic and require the creative integration of private and public actors.[16] On the other hand, there is mounting evidence that the very attributes that make platforms and ecosystems such a success—their ability to offer convenient, all-encompassing, and compelling value propositions—also have a darker side, e.g., for social cohesion (Allcott et al., 2020)[17] or new forms of addiction (Athey and Luca, 2019; Rosenquist et al., 2021).[18] There is a need for psychology and sociology research to understand the micro-dynamics and systemic effects of such externalities.

3.4. Platforms' governance and coordination mechanisms

The topic of externalities and complementarities leads naturally to

[15] As noted earlier, Jacobides (2022) argues that another value-adding angle, specifically for *multi-product ecosystems*, is that ecosystem members can use or usefully combine each other's services so that the customer can benefit from a coherent and well-integrated whole (e.g., different digital health services, from devices to receptors to health-service provision). This yields *consumption complementarities* that accrue at the level of the proposition, which benefit the consumer but can also pay a dividend to the multi-product ecosystem firm by significantly easing competitive pressures.

[16] In this context, the ability of platforms to engender behavior and facilitate collective action has the potential to *improve* both psychological and social well-being (through a sustainable sense of offering and belonging). Interestingly, Big Tech firms, especially in China, have grasped some of these principles. AntGroup's AntForest, for instance, has employed a gamified platform to induce 200 million users to moderate their carbon consumption; another result has been the planting of 500 million trees. On a drastically smaller scale, start-up Velocia works with local authorities such as Miami-Dade in the U.S., transport providers like Uber, and automobile OEMs such as Toyota to recognize drivers' eco-friendly commuting and reward them with credits for public transport.

[17] The study finds, for instance, that users who give up Facebook see their views become less polarized and may even become happier. At the same time, in less developed economies, platforms such as Facebook represent the only way to access certain information, for better or worse.

[18] Both studies point to the addiction risk posed by digital platforms and their related services for users, also suggesting that platforms deliberately attempt to make their offerings more addictive—for instance, through techniques such as gamification, focusing excessively on "user experience" while failing to account for the negative societal externalities that this attraction to their services can generate.

that of governance. The literature on platform governance provides some valuable views on how multiple, dispersed, and ex-ante uncoordinated actors can converge, and what specific coordination mechanisms are in play.

The literature on *innovation platforms* (e.g., Anderson Jr et al., 2014; Gawer and Henderson, 2007; Tiwana, 2015; West and Wood, 2013) tends to focus on establishing technological interfaces and standards to attract and coordinate producers of modular components around a technology system (Bresnahan and Greenstein, 1999)—such as, for instance, the case of enterprise software systems (e.g., Ceccagnoli et al., 2012). Developers must have incentives to create complementary innovations, which implies preventing coordination failures that could constrain the innovation capacity of the system (West and Wood, 2013).

Governance at the level of the platform technological system is enforced through technological interfaces and standards, exploiting modularity. This is what (Baldwin and Clark, 2000; Baldwin, 2022) and (Baldwin, 2008) refer to as "design rules," engendering a "plug and play" type of coordination (see also Anderson Jr et al., 2014; Gawer and Henderson, 2007; Gawer, 2014, 2021a; Tiwana, 2015). This literature emphasizes the role of the platform designer as an architect who ensures the "production and adoption of different components of the system by external actors" (West and Kuk, 2016: 170), aiming to "preserve the design's dynamic qualities, i.e., one which allows elements of a system to inform but not determine one another" (Garud et al., 2008: 365).

In this context, the digital interface between the platform and its complementary products or services plays a central role. In information systems research, the interface is construed as a "boundary resource"—as in Ghazawneh and Henfridsson's (2013) and Eaton et al.'s (2015) studies of Apple and the tuning of its iPhone interface with developers. The interface must be designed to balance generativity and control (Wareham et al., 2014). When an orchestrator or platform owner exercises too much control, it risks driving out third-party developers, constraining generativity. On the other hand, absent sufficient control, the platform may become fragmented and unstable, diminishing its usefulness to both developers and customers (West and Gallagher, 2006). Digital interface design is crucial to maintaining this delicate balance (Ghazawneh and Henfridsson, 2013; Yoo et al., 2012; Boudreau, 2017).

The economics and strategy tradition focusing on *multisided transaction platforms* is more concerned with the coordination of diverse agents across different platform "sides" and how this affects the platform's capacity to compete (Armstrong and Wright, 2007; Boudreau, 2012; Cennamo and Santaló, 2013; Hagiu, 2006; Rochet and Tirole, 2006). Governance is mainly concerned with rules on platform membership (i.e., the affiliation of users and providers to the platform marketplace) and usage (i.e., the rules governing transactions and value exchange—see, for example, Hagiu, 2006; Parker and Van Alstyne, 2005; Rochet and Tirole, 2006). This literature focuses on platform adoption, and how the decisions of users on one side affect those of users on the other. Early work focused on platform pricing as a coordination mechanism for adoption (e.g., Caillaud and Jullien, 2003; Hagiu, 2006; Rochet and Tirole, 2003; Parker and Van Alstyne, 2005).[19]

Other research on platform governance has considered users' decision to single- or multi-home (Armstrong and Wright, 2007; Lee, 2013), the orchestrator's option to produce first-party complements (Hagiu and Spulber, 2013), and which side(s) to open up to third-party contributors, and when (Parker et al., 2017).

Drawing a distinction between access and governance, Van Alstyne et al. (2016: 60) argue that maximizing value creation requires platform owners to make "smart choices about access (whom to let onto the platform) and governance (or 'control'—what consumers, producers, providers, and even competitors are allowed to do there)."[20] Another aspect of governance relates to "search rules" that guide or direct users' search (Claussen et al., 2013; Hagiu and Jullien, 2011) to drive coordination, value creation, and value capture.[21] A syncretic approach on platform governance is offered mostly in applied literature, such as the work of Parker et al. (2016), which considers some key prescriptive aspects of participation and ownership rights (including voting rights for participants, legal ownership of the platform, data and IP ownership and access, and rules on competition within and between platforms), revenue management (including price-setting rules, revenue and profit sharing, etc.), and conflict resolution. Competition research has also turned to platform governance (Cennamo and Santaló, 2019; Jacobides and Lianos, 2021a; O'Mahony and Karp, 2022; Wareham et al., 2014; Zhu and Liu, 2018), and the rules of platforms have also attracted interest from regulators (Report).[22] Yet, as Rietveld and Schilling (2021) note in their review of the field, platform governance is still under-researched as a topic.

Offering a broader synthesis that applies to both transaction and innovation platforms, Gawer (2021a, 2022) suggests that digital platforms govern their resources differentially by setting and managing three types of boundaries: (1) the scope of the platform firm (what assets are owned, what labor is employed, and what the firm does); (2) the configuration and composition of the platform's sides (which groups of customers have access); and (3) digital interfaces (which specify the two-way exchange of data). Similarly, Cennamo (2021) discusses how platforms' multiple scope decisions in relation to functionality and target markets are closely intertwined, since they will affect the type of users and complementors the platform will attract, user experience, and expected (desired) behavior from complementors.

Governance requires a firm hand, since platform owners must centrally govern members' interactions by setting specifications and enforcing rules in order to internalize cross-side externalities (Gawer, 2021a; Panico and Cennamo, 2022; Parker et al., 2017; Parker et al., 2016). For digital platforms, this includes decisions about how open to make interfaces, what data will be shared, and how. Since digital platform owners decide what behaviors to encourage or discourage, most therefore act as *private regulators* (Boudreau and Hagiu, 2009; Report; Gawer and Srnicek, 2021; Gawer, 2021b, 2022).

In summary, the main question in platform governance is not only how to coordinate across actors, but "who is allowed to do what"

[19] In this regard, the primary governance tool is "price structure" (Rochet and Tirole, 2003, 2006)—that is, how to structure prices for access between the two sides so as to minimize search and transaction costs and facilitate interactions and market exchanges.

[20] The important interaction between governance and competition has been explored in research focusing on the market-coordination strategies used by the orchestrator, as well as their effects on market competitiveness, complementors' incentives to join the platform or provide higher-quality complements, user utility, and platform competition and market structure (e.g., Armstrong and Wright, 2007; Cennamo and Santaló, 2013, 2019; Corts and Lederman, 2009; Hagiu, 2006; Hagiu and Spulber, 2013; Rochet and Tirole, 2003, 2006).

[21] Platform governance also considers "membership rules," including exclusivity to one platform versus multi-homing (Cennamo and Santaló, 2013; Corts and Lederman, 2009; Lee, 2013). Such rules also relate to orchestrator roles, illustrated by work on the strategic and welfare analysis of the provision of first-party complements by the orchestrator (e.g., Cennamo, 2018; Hagiu and Spulber, 2013; Zhu and Liu, 2018), the regulation of platform competition intensity (Armstrong, 2006; Casadesus-Masanell and Halaburda, 2014; Cennamo and Santaló, 2013, 2019; Panico and Cennamo, 2022), or the provision of additional information signals that can augment price signals (Tajedin et al., 2020). These topics have also been picked up by recent regulatory studies, which are particularly interested in the possibility that a platform that benefits from network externalities and undue power can leverage its position to favor its own products (see Report; Furman et al., 2019).

[22] Thus, research is starting to examine how platform governance and, in particular, rules such as search algorithms, self-preferencing on platforms, and pricing help both to resolve the coordination issue and also allow for joint value creation—with important distribution effects (Hagiu and Wright, 2020; O'Mahony and Karp, 2022; Panico and Cennamo, 2022; Zhu and Liu, 2018).

(Cusumano et al., 2019). This includes decisions about access, technology, and pricing.

3.5. Ecosystems' governance and coordination mechanisms

Ecosystem governance focuses on the interorganizational arrangements through which orchestrators set rules to facilitate operation and attract and motivate partners and complementors. For platform-based ecosystems, governance is centralized by necessity, while for non-platform-based ecosystems, coordination can be achieved via multilateral arrangements. Achieving alignment poses problems similar to those faced by platforms, with the additional subtlety that ecosystem members are independent, yet interdependent by virtue of their non-generic co-investments. The emphasis is on collaborative arrangements to set incentives for actors to collaborate and invest in co-specialized assets/activities for joint value creation (Adner, 2017; Jacobides et al., 2018; Wareham et al., 2014; West and Wood, 2013)—what Adner (2017) terms “alignment structure.”

Often, these interorganizational issues are rooted in platforms, showing the close connection between the two constructs; the difference is in terms of focus. For instance, in a pioneering study on ecosystem governance failure, West and Wood (2013) document how rules of engagement around Nokia's Symbian OS that were biased towards the value-capture interests of a subset of actors unbalanced the collaborative structure, eventually leading to multiple failures and the demise of Symbian in the mobile domain.

Some ecosystems (such as the PAX system, per Adner, 2012 and 2017, or Nespresso, per Jacobides, 2021) are built around a product or technology rather than a platform in a narrow sense. Ecosystems leverage modularity to enable firms to adjust to the actions of other members (e.g., Pierce, 2009; Zacharakis et al., 2003), to the “smart power” of the ecosystem orchestrator (Williamson and De Meyer, 2012, 2020; Iansiti and Levien, 2004), or—and perhaps fundamentally—to final users' choices between ecosystems. Drawing on multiple examples, Pidun et al. (2021) enumerate the choices orchestrators must make as they set up their ecosystems—and why their choices are not always wise. Recent research has looked at how decentralized ecosystems (such as those based on blockchain) draw on mechanisms such as algorithmic coordination, whereby rules ensure alignment, and social and goal coordination, where actors converge on the basis of aligned interests (Hsieh and Vergne, 2023).

For ecosystems built around platforms, coordination mechanisms include the orchestrator offering product development resources (such as APIs and SDKs); standardized rules for accessing and using platform resources; self-selection incentives to participate based on pricing structure (Panico and Cennamo, 2022) or other screening rules (Wareham et al., 2014); within-platform ecosystem competition (Tiwana, 2015; Cennamo and Santaló, 2013, 2015); platform–complementor coopetition (Gawer and Henderson, 2007; Ceccagnoli et al., 2012); and feedback from ecosystem generativity (Cennamo and Santaló, 2019; Yoo et al., 2010; Tiwana, 2015).

The relatively scarce empirical work on ecosystem governance (such as Jansen, 2020, on software ecosystems) lists the attributes that define the nature of the interorganizational arrangements, over and above platform governance rules,[23] and research is only just beginning to look at decentralized ecosystems (Hsieh and Vergne, 2023; Jacobides et al., 2024). Table 3 summarizes the different governance mechanisms in place in platforms and ecosystems.

[23] Jansen (2020), in his detailed analysis of software ecosystems, draws on and substantially expands on the analysis from Parker et al. (2016) on platform governance and develops a model of (software) ecosystem governance and management. He identifies rules for ecosystems, the structural features of an ecosystem, and the practices that are necessary for the ecosystem to succeed.

4. When the solution becomes the problem: the dark side of platforms and ecosystems

So far, we have explored the factors that make platforms and ecosystems more efficient and identified how they can redress market failures and sometimes outperform structures of vertical integration or bilateral contracting.[24] Yet, they also come with problems of their own. The positive attributes that allow platforms and ecosystems to create benefits and deal with externalities may also impose barriers, constraints, or costs that discourage actors from engaging, ultimately leading to (platform or ecosystem) *value architecture failures.* While we have distinguished between platforms and ecosystems in the way they offer distinct solutions to distinct problems, when it comes to failures, we find that there is significant overlap across the factors that drive platforms and ecosystems to fail. Below, we describe the drivers of failure for both, indicating when they are similar and when they differ.

We conceptualize these value architecture failures as situations in which platform/ecosystem members' individual actions negatively affect the value network to the point where the functioning of the entire value architecture is undermined. With *functional* value architecture failure, less joint value is created (or consumed) than would be otherwise, given the capabilities and resources available among the actors. This can lead to an inferior joint value proposition for the end customer, and an inferior joint (system-level) innovation/solution. With *distributional* failure, certain individual actors are capturing less value in relation to their contribution. Here, actors (often orchestrators, but not always) exploit their inherent position of power within the value architecture, leading to an inequitable distribution of surplus. To better understand the nature of these failures, we first identify and characterize the governance trade-offs for ecosystems and the platforms they tend to depend on.

4.1. Functional failures

Many ecosystems that rely on a central orchestrator (such as a platform owner) create value through interfaces that complementary innovators can build upon, or through which the members of market sides can interact and exchange. Functional failures can therefore stem from the orchestrator's operational failure to deliver such stable and shared interfaces.

When orchestrators fail to rally complementors to their standards, or to coordinate with complementors, their platforms may suffer from forking, splintering, or fragmentation. “Forking” refers to the creation of a new version of a standard or application that is not backwards compatible.[25] Splintering occurs when decentralized technology adoption leads to excessive product variety. Finally, fragmentation occurs when all parties would like to adopt a common standard but cannot agree what it should be. In practice, fragmentation often occurs when standards or platforms are upgraded, and the different parties all bring their own technologies to the table and push for their adoption. All of

[24] The relative merits of ecosystems as an organizational structure relates to their ability to tackle the need for coordination (itself a driver of integration or, at best, supply chain governance) in the presence of modularity (which enables ecosystems to function through interdependent, co-specialized but separate entities). In the absence of modularity, ecosystems are not tenable; if there is no need to coordinate, they are not necessary. See Baldwin (2022) and Jacobides et al. (2018) for a more detailed discussion of such comparative institutional analysis.

[25] The term “forking” is widely used in software development, where the practice is common. The Unix operating system has been forked many times. In the 1990s Microsoft tried to fork Java, and more recently Google has been accused of forking Java to create Android. Amazon forked Android to create the Kindle Fire (Simcoe and Watson, 2019). The terms “forking” and “splintering” are used in sometimes overlapping ways, and we retain the two terms as they are both used in the computing and management literature.

Table 3
Innovation platforms, transaction platforms, and ecosystems comparison: governance trade-offs and endogenous failures.

	Innovation platforms	Multisided transaction platforms	Business ecosystems
Governance aims	• To stimulate third-party innovation • To successfully compete against other platforms or traditional firms	• To augment the volume and profitability of transactions or exchange among platform sides' participants • To successfully compete against other platforms or traditional firms or marketplaces	• To ensure alignment among ecosystem members • To successfully compete against other business ecosystems
Governance structure	• Centralized governance	• Centralized governance	• Can be centralized (in the case of platform-based ecosystems) or distributed (if ecosystem is not platform-based)
Levers of action for governance	• "Design rules": Designing the system's architecture and specifying the digital interfaces guiding the production and integration of modular technological extensions in a "plug and play" fashion • Technology system's degree of decomposition and modularity • Open vs. closed interfaces and standards, specifying who can access the core technology • Digital interfaces specify the two-way exchange of data between the platform firm and each of its sides	• "Price structure": Price allocation between the distinct sides of the platform; which side(s) to subsidize, and to what extent • Membership rules: the configuration and composition of the platform's sides (which distinct groups of customers have access to the platform) • Transaction rules: what the distinct groups of customers can exchange, and under what conditions	• "Alignment structure": Collaborative arrangements that balance the value creation–capture tensions of ecosystem members to induce the right level of investment in co-specialized assets • Shared assets: architectural blueprint for using shared assets to build complementary products/ services for joint value • Common goal: setting shared vision for collective enterprise objective and end customers' benefits

Governance trade-offs	• Control versus generativity
	• How to govern the platform when multiple sides have divergent incentives?
	  • Special case of business-model asymmetries (e.g., one side pays but the other doesn't)
	• When to compete with complementors? (Temptation to squeeze complementors' profit by imitating their innovation and bundling it within the platform)
	• How open should access to sides be (via the design of digital interfaces) while respecting privacy
	• How to maintain the platform's incentives for continuing to innovate, if and once market has tipped
	• How can the platform persuasively commit to neutrality vis-à-vis the platform sides, while continuing to be the most competitive vis-à-vis other platforms?
		• How to govern the platform when multiple sides have divergent incentives?
		  • Special case of business model asymmetries (e.g., users' privacy vs. profit for social networks whose business models make advertisers pay but not end users)
		• When to compete with side members? (e.g., question of self-preferencing for Amazon marketplace)
		• Too much curation will weaken network effects, but too little will degrade users' experience (e.g., checking quality of products or services offered by side members or moderating violent or illegal user-generated content on social networks)
		• Trade-off of upholding end users' freedom of expression while maintaining a safe space
			• Tensions across joint value creation and individual value capture: needed investments in cospecialized assets by ecosystem members to enhance joint value creation may create hold-up and value capture problems for individual members
			• Bottlenecks: removing bottlenecks in the ecosystem is needed to unleash joint value, but risks commoditize complementors' assets and reduce their incentives to invest. Complementors battling to gain a strategic bottleneck position in the ecosystem
			• Need to guarantee investments in complement quality and specific, specialized complements, while also guaranteeing discretion and autonomy to complementor

Endogenous governance failures	• Failure to sustain complementors' incentives to innovate on the platform • Failure to curate complementors' input, leading to degradation of users' experience • Failure to exclude "bad actors" • Abuse of bargaining power with complementors and with end-users • Failure to maintain trust on the platform	• Failure to sustain side members' incentives to join and exchange on the platform • Failure to curate side members' input, leading to degradation of users' experience • Failure to exclude "bad actors" • Abuse of bargaining power with sides' members • Failure to maintain trust on the platform	• Failure to provide right collaborative structure for complementors to invest in cospecialized assets • Free-riding behavior of complementors joining the ecosystem at mature stages, leading to under-provision of complements' quality while imposing further competition on early-contributor complementors • Knowledge/value misappropriation from shared asset

these can lead to functional failures by jeopardizing the integrity of the system, as limiting the interoperability of existing components constrains the value of the system to users, even if it might increase competition.[26] As Loh and Kretschmer (2023) suggest, if a community of potential users is splintered across multiple disconnected networks, overall adoption and welfare is diminished unless users and networks are highly heterogeneous (Farrell and Saloner, 1986; Kretschmer, 2008; Simcoe and Watson, 2019).

Simcoe and Watson's (2019) study of forking, fragmentation, and splintering in markets with network effects offers useful insights into such failures and the various instances of mis-coordination that cause them. The authors suggest that while forking can be efficient (when the benefits of variety outweigh the costs of forgone compatibility), where there are strong disagreements over compatibility, contested forking may generate "cat and mouse" games in which one actor (or group of actors) seeks to differentiate its offerings while another works to restore compatibility. This can result in partial or intermittent interoperability.[27] The cases suggest that forking, fragmentation, and splintering emerge when the costs and benefits of coordination are asymmetrically distributed.

In terms of *ecosystems,* functional failures relate to the inability to enlist complementors who can make the joint output attractive to end users and the overall value proposition viable. For ecosystems that do

[26] Another pathway to limiting innovation is through increasing technological uncertainty and costs of innovation for complementors and reducing generativity of components. That said, it can open up competition through contestability of the main platform, which can have long-term benefits. We revisit these trade-offs in the context of inherent platform failures.

[27] Simcoe and Watson (2019) also note that large firms may even find themselves on both sides of the debate between those who favor and oppose intervention in support of interoperability. For example, Google was criticized (and sued) for forking Java to create the Android operating system, but at the same time, drew heavy fines from regulators for including anti-forking provisions in its Android licensing agreements.

not rely on an orchestrator, this can be the result of poor design (as in Michelin PAX—Adner, 2012). It can also be the result of competitive challenges to the functional integrity of an ecosystem, as in Karhu et al.'s (2018) study of the Android/Google-dominated platform-based ecosystem, when forkers sought to undermine a platform by controlling boundary resources and exploiting shared resources, core, and complements to create a competing platform business. Such forking could affect not only the benefits within the ecosystem, but also the viability of the ecosystem as a whole.

While there is significantly less work on ecosystems without a central orchestrator, some work has shed light on decentralized ecosystems that rely on webs with low centrality such as a "cave" rather than a "hub-and-spoke" model of operation—exemplified by Web3 (see Hsieh and Vergne, 2023; Jacobides et al., 2024). Here, one possible source of endogenous failure is that technological change requires coordinated responses, yet decentralized structures often lack the decision-making simplicity that allows for such adaptation; decentralized ecosystems are thus more prone to creating bureaucratic structures to manage the inescapable interdependencies (O'Mahony and Ferraro, 2007), which can make them inefficient or even technologically unviable. Thus, decentralized ecosystem governance, for all its intellectual appeal, has been associated with functional ecosystem failures (Pidun et al., 2021; Hsieh and Vergne, 2023).

The irony is that in the world of platforms and ecosystems, rule-setters are often driven by the desire to create more equal worlds that do not entail distributional inequity. Yet, these very features end up undermining functional stability or the ability to engage platform sides or ecosystem orchestrators. In some cases, a benevolent despot (such as Linus Torvald with Linux) must use their final say to ensure the ecosystem is functional and viable. This brings us to the concern with *distribution.*

4.2. Distributional failures

Both platforms and ecosystems can suffer downsides related to distribution. The first type of distributional failure relates to rules (or loopholes) that enable some actors to "piggyback" on the efforts of others. Here, the problem is not aligning all the actors involved, but preventing specific actors from undermining the system for their own short-term benefit. Zhang et al., 2022 show the need for ecosystem governance to balance cooperative and competitive tensions between interdependent members to preserve their willingness to cooperate. They use a quasi-experiment in the mobile app developers' community to show that once the "jailbreak" that overcame Apple's protection of its iOS source code was discovered, the developer community exploded, because Apple's ability to maintain gatekeeping had been compromised.[28] As a result of this expansion, software developers on the iOS platform became significantly less likely to share knowledge with each other, due to eroded cohesion and trust in the ecosystem. The underlying reason might be a shift in the co-opetitive relational balance among complementors towards a more competitive relationship.

Platform-mediated marketplaces (i.e., transaction platforms) may also malfunction due to divergent incentives between the platform owner and its sides' participants. Accordingly, platforms may manipulate and even downgrade the information that they share with users to nudge them towards revenue-maximizing choices rather than potential best-value options (De Cornière and Taylor, 2019). For instance, hotel booking platforms can manipulate search rankings in favor of offers that increase their fee revenue, while search engine platforms may refine their algorithms and rankings to promote ads/advertisers that yield higher margins (e.g., De los Santos and Koulayev, 2017). This leads to a distributional failure by reassigning benefits within the platform/ecosystem. However, this also entails a further, functional failure, as we see below.

4.3. From distributional issues to functional problems

Problems with distribution often lead to collective functional problems. An unbalanced value split between the hub firm and third parties, or among third parties in a given period T (or phase of the ecosystem evolution), if perceived as unfair by complementors, is likely to lead to complementors' disengagement or underinvestment in future periods T + I (with I = 1, ….N). This can lead to sub-par solutions that do not (functionally) deliver value to the final customer—a "tragedy of the commons" problem (Ostrom, 1990). Cennamo and Santaló (2019) and Panico and Cennamo (2022) point to possible unique "commons" problems that platform-based ecosystems might be exposed to, due to incentive conflicts occurring at two levels: between the orchestrator and complementors, and between early- and late-joining complementors (who thus hold different vested incentives in the shared assets of the ecosystem). Cennamo and Santaló (2019) empirically examine potential free-riding issues among complementors in platform ecosystems in the context of investments in developing videogames for gaming consoles. Complementors contributing high-quality software co-create value by establishing an aggregate quality reputation for the whole ecosystem: a collective, shared asset that late-joining complementors can exploit without contributing to. This creates value-capture tensions among complementors and can reduce incentives to invest in quality complements, leading to a misalignment between the objectives of the overall ecosystem and individual complementors. In other words, ecosystems are endogenously hampered in their ability to deliver as a result of their structure.

Moving from the platform issues noted above to ecosystems, recent research has looked at how an ecosystem's structure can influence the quality and type of contributions to it (e.g., Cennamo and Santaló, 2019; Khanagha et al., 2022; Zhang et al., 2022) and the power distribution among its members (e.g., Miller and Toh, 2022; Panico and Cennamo, 2022). This research highlights different kinds of unique, post-hoc problems in ecosystems that can emerge once a particular architecture is established under the control of an orchestrator. They include moral hazard issues from later participants exploiting investments in shared resources made by early members (Cennamo and Santaló, 2019); value-creation/capture tensions and "cooperation failures"—value-capture problems undermining incentives to invest in quality and cooperate (e.g., Miller and Toh, 2022; Panico and Cennamo, 2022; Zhang et al., 2022); local bottlenecks—parceling of the ecosystem into sub-systems for strategic control over parts of the value-creation process (e.g., Khanagha et al., 2022); and exploitation of data aggregation and control to dictate excessive terms of participation (Kramer et al., 2019; Petropoulos, 2020). Issues like these do more than influence who wins and loses; they potentially undermine complementor participation and ecosystems' fundamental effectiveness and functional merit.

4.4. Distributional platform and ecosystem failures and the power of orchestrators

Beyond the role of orchestrators as inefficient architects of platforms/ecosystems, there is the further issue of these powerful actors' self-interest, which raises issues of equity and potentially the need for regulation (Cennamo and Sokol, 2021; Jacobides and Lianos, 2021a,

[28] With the iOS gatekeeper undermined, entrants could free-ride on incumbent complementors' knowledge to develop copy-cat complements and undercut them on price. Incumbent complementors will thus face a cooperative incentive problem and reduce knowledge-sharing accordingly.

2021b; Sokol and Zhu, 2021). The endogenous, inherent source of failure we observe here stems from the behavior of central, orchestrating actors abusing their hub position and associated power, leading to distributional failure. Rietveld et al. (2020) for instance show that as platforms grow more dominant, their orchestrators increasingly (1) capture more value for themselves at the cost of complementors and (2) increasingly redistribute the value created by complementors to become more skewed (e.g., through biased algorithmic recommendations).

A platform or ecosystem orchestrator (and, almost always, owner) is, by design, a central agent at the nexus of a distributed network of value creators. They can capture much of the value created in that network and can monitor, control, and use resources without necessarily owning them (Gawer, 2021a, 2021b, 2022). For example, Greve and Song (2017) note that Amazon's self-publishing platform has dramatically shifted power away from major publishers towards smaller ones and independent authors, consolidating Amazon's central position in the publishing ecosystem and granting it greater value-capture opportunities. Miller and Toh, 2022 document how ecosystem orchestrators can strategically make some of their patents available to lock ecosystem partners into choices that increase the patent-holders' profits from their non-disclosed complementary patents. In the context of videogame consoles, Rietveld et al. (2019) examine the incentives of orchestrators to selectively support and promote certain game developers in order to manipulate their fortunes and reduce their bargaining power. This finding is in line with other research showing how the design of recommendation systems can alter the distribution of value among complementors, with negative or positive effects on the overall collective value creation in the ecosystem (e.g., Brynjolfsson et al., 2010; Cennamo et al., 2021). Such distortions are particularly visible in the case of "self-preferencing"—i.e., when platforms promote their own services at the expense of those of complementors (Report; Furman et al., 2019), exemplified in a 2019 investigation of Amazon by the EU.[29]

Data can make the members of a platform or ecosystem more dependent on its orchestrator. Since orchestrators control the user relationship, they can augment the benefits of ecosystem participation through economies of scope in data aggregation. This can improve quality for the final customer, while also strengthening the architectural power of the orchestrator (Kramer et al., 2019; Petropoulos, 2020). The orchestrator can then impose excessive terms for access to data and participation in the ecosystem (Petropoulos, 2020) or steer activities and interactions towards particular business areas and services to its own benefit, even if it does not control or offer them directly (Kramer et al., 2019). This makes ecosystem members more economically dependent on the ecosystem, putting them at the mercy of the orchestrator (see also Cutolo and Kenney, 2021 on platform-dependent entrepreneurship).[30]

In this regard, we should consider how orchestrators such as digital platform firms manage users' personal data and protect their privacy. The ever-increasing collection and analysis of quantified data by such platforms creates privacy risks with implications for both individual users and society as a whole (Stigler, 2019; Gawer and Srnicek, 2021). Consider, for example, concerns over the "datafication" of health—a topic discussed by analysts of the Google-Fitbit acquisition (Bourreau et al., 2020; Caffarra and Valletti, 2020).[31]

Sokol and Zhu (2021) examine the effect of rule changes on data usage unilaterally imposed on ecosystem participants. They show how changes that ostensibly benefit users can actually make them more dependent on the orchestrator's core services, driving up switching costs and resulting in lock-in. Specifically, they examine the recent "privacy policy" change introduced by Apple, which prohibits apps from engaging in broad categories of data use unless users opt in—while leaving its own services exempt. While Apple promotes this policy on the basis of consumer gains, Sokol and Zhu (2021) argue that it can in fact create market failures within the ecosystem (and even across competing ecosystems). Since there are fewer free, ad-based apps and services available, users switch to paid ones, many of which are provided through Apple's own aggregation/distribution services. This shift can force app developers and third-party service providers, particularly small ones, to change their business model from ad-based to fees-for-service and use Apple's aggregation services to market their services. As a result, not only can Apple increase its control and power over its own ecosystem, but cross-ecosystem competition can be undermined too; in contrast to ad-based apps and services that run across multiple mobile OS providers and ecosystems, Apple's paid services lock users into Apple's ecosystem, increasing users' switching costs between mobile operating systems and imposing not only a distributional cost but potentially also a functional one. The trade-offs between these costs will be a key topic for policymakers in the years to come.

All said, our analysis points to a potential area for future research. Despite the excitement with decentralized governance evident in the literature (Lumineau et al., 2021; Hsieh and Vergne, 2018, 2023), examples of centralized governance by strong, potentially abusive orchestrators are far more pervasive. This might be because while decentralized ecosystems and more equitable governance are valuable, they cannot always tackle the inherent functional issues that such complicated ecosystems raise.[32] It remains to be seen whether the development of decentralized technologies such as Web3 in the metaverse will prove this issue to be short-lived (Jacobides et al., 2024).

4.5. Addressing platform and ecosystem failures through regulation

The dynamics that make platforms and ecosystems so attractive inevitably lead to the risk of their orchestrators abusing their strength, vis-à-vis both final consumers and partners or complementors. As is becoming clear (Khan, 2017; Jacobides and Lianos, 2021a, 2021b; Jenny, 2021), the tools of existing antitrust laws, which focus on one market (not ecosystem) at a time, are ill equipped to curb such abuses. Reports published in 2019 in the UK (Furman et al., 2019), the EU (Report), and the U.S. (Stigler Report, 2019) all identified the problem

[29] Self-preferencing occurs also in nascent platform markets orchestrated by traditional, industrial companies, such as in the case of the automotive industry: car manufacturers can leverage their exclusive access to all data collected by connected cars to give preferential access to their own network of accredited dealers and aftermarket service providers, and as a result distort competition with independent service providers (Martens, 2020).

[30] Some authors seem to want to dismiss such power issues as part and parcel of competition, or as a transient state that will (in their view) sort itself out naturally as long as government does not intervene in the competitive process (Petit and Teece, 2021; Foss et al., 2023). This thesis, congenial to the interests of Big Tech firms that have been shown to abuse their position, has been countered by others stressing the need to address the issue of abuse head-on (Jacobides and Lianos, 2021a, 2021b; Caffarra and Valletti, 2020), drawing on the literature of antitrust and regulation.

[31] A report by the Ada Lovelace Institute (2020: 4) warns that: "Datafication raises significant concerns: it makes individuals' health legible to a broad array of actors outside recognized medical and clinical settings, giving those with the appropriate digital tools an increased ability to know about, and engage with, people's health through their data. Datafication also creates increasingly comprehensive and quantified renderings of health, creating the conditions for disempowerment and providing unprecedented opportunities to monitor and influence people."

[32] Tellingly, Hsieh and Vergne (2023) find that, in addition to "algorithmic coordination" (which essentially suggests built-in rules ensure convergence), the other two mechanisms used are "social coordination", which suggests some additional features of control must exist for the arrangement to be stable, and even "goal coordination"- like the blockchain-fans' distaste of banks, government or authority. This is meant to ensure there is common purpose, which is expected, at best, to iron out issues that inherently emerge as the ecosystem seeks to function.

and called for new analytical tools.[33]

Platform and ecosystem failures can be addressed in a number of ways, starting with self-regulation (Cusumano et al., 2021). Here, the fear of a "tragedy of the commons" outcome (i.e., the risk of a *functional* failure) or even reputational concerns might motivate powerful firms to create a fairer or more efficient ecosystem, self-policing around abusive or ineffective practices. Yet, the extent to which powerful players will entertain potentially intrusive self-regulation is a function of their views on what may happen if they don't—such as being subject to even more intrusive, and blunt, top-down regulation.

Such regulation can take two distinct forms: *ex ante,* that is, rule-setting that determines how platform orchestrators should collaborate with their ecosystem partners, and *ex post,* which is what antitrust authorities would do in investigating the conduct of particular firms. While current competition law does not directly accommodate platforms and ecosystems adequately, significant strides are being made, and we expect this situation to change quickly (Jacobides and Lianos, 2021b; Cennamo et al., 2023), with an increasing interest in developing theories of ecosystem harm, drawing not only on IO but other areas such as network economics (Caffarra et al., 2023; Caffarra and Scott-, 2021).

Finally, one area on which competition law has increasingly focused is the expansion of firms with broad ecosystems—such that there is now academic talk of breaking up Big Tech platform firms (see Kwoka and Valletti, 2021). The broadening of Big Tech's offer through merger and acquisition raises serious concerns (Parker et al., 2021). We believe that as the discussion on excessive power of platforms and ecosystems rages on, with authors seeking analytical foundations on what drives these issues (e.g., Biggar and Heimler, 2021), we hope our conceptualization can be of help.

5. Discussion and conclusion

We have offered a conceptual analysis of why and when platforms and ecosystems emerge by identifying the specific *complementarities* they entail and the specific *externalities* they help address, associated with a specific type of systemic *failure*. We also consider their governance and coordination mechanisms and identify the nature of the *value architecture failures* they inherently engender, suggesting both *functional* and *distributional failures,* showing how they relate, and highlighting concerns about orchestrators' abuse of power. This approach, besides qualifying existing research, offers some important implications for theory and practice.

First, our analysis reveals how platforms and ecosystems provide an interorganizational architecture that offers a solution to specific externality problems, and thus emphasizes the role of the orchestrating firm as an "architect" (Gulati et al., 2012). Thus, we argue that as we increase our understanding of (technological) "design rules" (Anderson Jr et al., 2014; Baldwin, 2023) and market design through "governance rules" (Boudreau and Hagiu, 2009; Wareham et al., 2014), we should also focus on (inter-)organizational design, including ecosystem governance, and how such design can overcome externalities and prevent failures. Concretely, we can use our framework to explain when and why ecosystems emerge (or potentially struggle) in more industrial, business-to-business settings (e.g., Ansari et al., 2016; Hannah and Eisenhardt, 2019; Masucci et al., 2020; Ozcan and Santos, 2015). The focus in this research is on why firms converge on specific technologies and collaborate to remove "bottlenecks," often pointing to co-opetition problems as inhibitors to the emergence of the ecosystem. We argue that such ecosystem failure may be more endemic to the underlying economics of the situation, and posit that we should look at what problems and externalities platforms or ecosystems solve, and how susceptible they are to inherent faults.

Second, our approach suggests that orchestrators face a difficult task, but also that their privileged position means that they may still be able to prevail, especially if competition is limited, even when they do not fulfil the potential of the ecosystem. Thus, the mere existence of an ecosystem may be a sign that the current structure is merely hard to dislodge, rather than particularly efficient. This suggests that we should understand not only the achievements of platforms and ecosystems, but also their failures—whether they be functional, distributional, or due to the abuse of power. To do so, we argue that we need to study *platform and ecosystem structures* and focus on their *value architectures* while considering their features and their failures. We can do so by relating them to network externalities (when they occur), the nature of complementarities, and the dependencies they engender as they drive value creation and value capture. We also suggest it is valuable to consider the underlying Industry Architecture (Jacobides et al., 2006). Some sectors may provide no reason for ecosystems to emerge, while in others, ecosystem structures may be idiosyncratic for a reason—as Jacobides et al. (2021) show for respective AI ecosystems of the U.S., EU, and China.

Third, our approach can help shed light on the crucial topic of cross-platform and cross-ecosystem competition dynamics. It might explain, for instance, why platform ecosystems differ in terms of the type and intensity of network effects (e.g., Panico and Cennamo, 2022) and different sources of complementarities. Consider the contrasting design approaches of Amazon Marketplace and eBay. Amazon aimed at enabling online transactions primarily by solving logistics problems, thus curating the full customer journey from search to shipping. In contrast, eBay focused more on solving the information problems related to transactions—mainly, the information asymmetry about the quality and trustworthiness of sellers—by providing a range of tools including direct seller-buyer communication and dispute resolution mechanisms. Accordingly, the two firms' respective online marketplaces ended up providing different solutions to similar market failure problems. These structural differences might affect systematically and differentially a) the benefits for buyers and sellers of participating in each platform and b) the type and intensity of network effects. Differences in these structural elements may thus prove "sticky" points of platform differentiation and be consequential for the competitive advantage of the focal platform.

Fourth, our approach has implications for how we see and analyze network effects and complementarities. Current research focuses on the network size, volume of interactions, and number of complements as influenced by the size and scope of the ecosystem. Yet, the structure and composition of the network, and the configuration of the ecosystem (e.g., modularity, openness, standardization, etc.) can affect these dynamics just as much (Kretschmer et al., 2022; Parker et al., 2017; West and Wood, 2013). Recent research has shown, for instance, how network effects may grow stronger or weaker as network size increases, depending on the composition of the user base (Panico and Cennamo, 2022), and how the ecosystem's greater openness to the contributions of more heterogenous complementors with different incentives may create problems of "free-riding" on shared assets, alter complementarities, and lead to failures (e.g., Cennamo and Santaló, 2019; Zhang et al., 2022). More research is needed to understand which architecture designs are more exposed to ecosystem failures, how they unfold, and under what conditions—like the story we witnessed in real time through the evolution of the metaverse ecosystem (Jacobides et al., 2024).

Fifth, in terms of orchestrators' strategies, extent research has focused on their ability to capture disproportionate value. However, our focus on failures suggests that some of these strategies may prove short-sighted and undermine the long-term ability of the ecosystem to generate value. We need more analysis on such ecosystem failures to understand when, and up to which point, a powerful orchestrator can leverage its dominant position to exploit ecosystem participants'

[33] In the regulatory context, the focus is on platforms and the multi-party ecosystems they create. There is an awareness building now that multi-product ecosystems further cement the power of multi-party ecosystems, which strengthen the hand of big orchestrators (Jacobides, 2021).

investments for its own private benefit without impairing the functioning of the overall ecosystem. It also might help us identify the "gray zone" where orchestrators can abuse their dominance without jeopardizing their future—raising questions of regulatory involvement. Similarly, understanding these constraints may help us drive better *complementor strategies,* which are arguably more broadly applicable, and socially needed to redress imbalances.

Sixth, our approach also suggests that there is no silver bullet in resolving distributional inequity, as decentralized ecosystems may sound more promising than their record to date suggests. Barring radical design innovations, decentralized ecosystem governance, for all its merits in warding off the abuse of orchestrator power, may be open to functional failures. This tradeoff will require dedicated study, unclouded by the romantic aspirations of researchers and informants involved. Relatedly, our analysis of the *nature* of failures that platforms and ecosystems create offers a theoretical background to inform not only research but also the current regulatory debate (Jacobides and Lianos, 2021a) by offering some underlying theory to help structure the conversation.

Our analysis reveals how platform features (which determine the user experience), ecosystem architecture (the rules of the game) and business motives (which determine monetization) must all be assessed directly and separately. This can combine with the pragmatic approach of regulators looking at rising economic power in platforms and ecosystems (Jenny, 2021).[34] For instance, regulators in the EU's recent Digital Markets Act (Cennamo et al., 2023; Larouche and de Streel, 2021) identify features such as the existence of "gatekeepers" with reference to specific orchestrators' size as opposed to their structural attributes.[35]

Finally, as authors begin to question whether the market is becoming obsolete as a unit of analysis and should be replaced by interconnected ecosystems (Carballa-Smichowski et al., 2021; Caffarra et al., 2023), our paper offers a structured way to understand the key elements of this new topography. The emergence of platforms and ecosystems poses some fresh and exciting challenges to the theory of the firm, representing a profound shift in the patterns of organization of economic activity that requires us to update our terminology and analytical arsenal to grapple with shifting and sometimes murky phenomena. The competitive structure and architecture of a number of industries is being transformed by the advent of the new constellations, and we hope that our approach will help to clarify ongoing debates on the nature, power, and implications of platforms and ecosystems.

CRediT authorship contribution statement

Michael G. Jacobides: Conceptualization, Writing, Original Draft, Writing, Review & Editing; **Carmelo Cennamo:** Conceptualization, Writing, Original Draft, Writing, Review & Editing; **Annabelle Gawer**; Conceptualization, Writing, Original Draft, Writing, Review & Editing.

Declaration of competing interest

There is no conflict of interest from any of the authors and firms referenced in this paper.

[34] The discussion around the proposed $71 billion merger between Microsoft and Activision, which was blocked by the UK's Competition Markets Authority, is an example of a recent effort to pre-empt the threat of such dominance.

[35] Such attributes, we posit, should consider the lock-in that complementors in multi-actor ecosystems are subject to as, among others, the result of an orchestrators' multi-product ecosystem scope, such as the ever-sprawling webs of products and services promulgated by Big Tech firms. These create not only the possibility of abuse of orchestrator power, but also specific instances of abuse (Jacobides, 2021).

Data availability

No data was used for the research described in the article.

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