Externalities and Complementarities in Platforms and Ecosystems: From Structural Solutions to Endogenous Failures

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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.

(95 words)

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1 INTRODUCTION

Platforms and ecosystems have emerged as new constructs to describe how economic actors interact as they seek to create and capture value. Motivated by the staggering growth of Big Tech, and the profound impact of firms such as Google, Apple, Microsoft, Amazon, Tencent, and Alibaba (Crémer et al., 2019; Furman et al., 2019; Stigler, 2019), a great deal of attention has been focused on both platforms (Armstrong, 2006; Gawer, 2014; Hagiu, 2006; Parker & Van Alstyne, 2005; 2018; Rochet & Tirole, 2003, 2006; Yoo et al. 2010; Tiwana et al. 2010) and ecosystems (Adner, 2017, 2021; Baldwin, 2018; Iansiti & Levien, 2004; Jacobides et al, 2018, 2019; Kapoor, 2018; Moore, 1993). But why do platforms and ecosystems each emerge in the first place? What problems do they solve? And, as we move beyond the excitement over these new structures, what are the (potentially inherent and distinct) failures that they engender?

While the literature touches on these questions implicitly, it does not do so directly. This paper provides a theoretically grounded discussion of when and why these new interorganizational value architectures emerge, focusing on the nature of the *complementarities* they entail and the *externalities* they each help to address. We argue that platforms and ecosystems, which are partly overlapping yet distinct constructs, offer solutions to specific market failures, and help overcome some of the limitations of traditional supply chains. We then consider the issues that arise due to the inherent attributes of both platform and ecosystem structures, in terms of total value creation and value distribution, and potentially social or psychological externalities. We conclude with implications of our analysis for theory, empirical research, and practice.

The next section briefly summarizes literature on platforms and ecosystems and presents our working definitions. In section 3 we discuss the externalities that each can tackle, and in section 4 the endogenous failures they give rise to. Section 5 considers implications for theory and practice, and section 6 concludes.

2 DRAWING ON AND BRIDGING DISTINCT TRADITIONS

2.1 Platforms: Interorganizational value architectures based on technological architectures and economic market structures

The first use of the concept of *platform* in the management literature was that of the "product platform," which came from engineering design (Jiao et al., 2007; Krishnan & Gupta, 2001; Meyer & Lehnerd, 1997). In that perspective, platforms were defined as specific modular product architectures (Ulrich, 1995) that help firms develop product families (Sanderson & Uzumeri, 1995), thus enabling the systematic re-use of common assets or activities (Krishnan & Gupta, 2001).[2] Firms using platforms could then benefit from the recombination options afforded by modular designs (Baldwin & Clark, 2000; Schilling, 2000; Garud & Kumaraswamy, 1995) and innovate more quickly and cheaply—especially "platform leaders" (Gawer & 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 & 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 & 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).

[2] For Wheelwright & 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 McGrath (1995), Meyer & Lehnerd (1997), and Krishnan & 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 & Clark, 2000; and Robertson & Langlois, 1995, Huang *et al.*, 2005; Jiao *et al.*, 2007).

Some strategy papers have advocated a "unified view" of the economics and engineering-design perspectives (Baldwin & Woodard, 2009; Boudreau, 2010, 2012; Ceccagnoli et al., 2012; Eisenmann et al., 2011; McIntyre et al., 2020; 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, Gawer, and Yoffie (2019) distinguish between *innovation platforms*—those that facilitate innovation on a foundation offered by a central actor[3]—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.

Insert Table 1a here

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

In parallel, 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 & 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 & De Meyer, 2012; Teece, 2007; Zahra & Nambisan, 2012); an

[3] 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.

innovation ecosystem, aggregating all actors who make contributions that are essential to delivering a valuable innovation to the final customer (Adner & Kapoor, 2010, 2016; Alexy et al., 2013; Frankort, 2013; Iyer et al., 2006; Kapoor & Lee, 2013; Leten et al., 2013; West & 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 & Santaló, 2013, 2019; Gawer & Cusumano, 2002; 2008; Parker et al., 2017; Wareham et al., 2014; Jacobides et al., 2019).[4] More recently, a unifying structural view of ecosystems has been put forward (Adner, 2017; Jacobides et al., 2018) and reviews of the concept by Kapoor (2018), Bogers, Sims, and West (2019), and Baldwin (2020) discuss how ecosystem research relates to other streams in strategy and innovation (see Table 1b).

The focus in Adner (2017) is on structures allowing firms that collaborate in ecosystems, often to build a joint value proposition, to align their interests. 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 (2020), 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" (2020: 7).[6] Thus, there is still significant variance in ecosystem research, leading some (e.g., Thomas & Autio, 2020) to argue that "ecosystem" should be considered as a

[4] 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 *latu sensu.* 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.

[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.

concept rather than a construct, as it is not yet sufficiently operationalized to allow for robust measurement and testing. Despite differences in emphasis, though, there seems to be a shared view among scholars that ecosystems define interorganizational value architectures based on co-specialized collaborative relationships. Table 1b presents a comparative summary of these broadly consistent but distinct conceptualizations, showcasing subtle differences in emphasis.

Insert Table 1b here

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 the final user and its various complementors. They usually draw on one (technological) platform or a number of connected platforms, and they tend to involve one or multiple (multi-actor) ecosystems, such as the Apple iPhone App (multi-actor) ecosystem.

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 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

[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 & Hagiu (2009) on transaction platform owners also orchestrating ecosystems; and Eisenmann et al (2009), Gawer & Cusumano (2002), Gawer (2021), Gawer & Henderson (2007), Kapoor et al (2018), Parker et al (2017), Parker & van Alstyne (2018), Rietveld et al (2019) and Thomas et al (2014) on platform owners also building ecosystems they orchestrate atop their platforms.

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. 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). Externalities can be negative (as in pollution) but also positive (as in network effects, where the value to the user of a network 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.[9] In particular, absent some intervention (by the firm or, in our case, the platform or ecosystem), these externalities, valuable as they are, might not motivate the right behavior and investment for the benefit they promise. 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.

Insert Table 2 about here

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[9] 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).

3.2 Externalities, complementarities, and value creation in platforms

In the context of *transaction platforms*, which the economics and strategy literature 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 & Shapiro, 1992; Rochet & 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 as a way to shape behaviors and manage externalities.

Value to platform users is seen to arise from the access of one "side" of a market 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 & Jullien, 2003; Evans, 2003; Rochet & Tirole, 2006). Studies in this stream draw from examples in ICT, media advertising, videogames, mobile apps, or the payment industry (see, for example, Evans et al., 2008; Seamans & Zhu, 2014; Wilbur, 2008; Zhu & Iansiti, 2012). Even with generic complementarities between parties, the very fact that platforms (and their owners) can bring together different sides that benefit from each other's presence adds value, as it allows for these externalities to be internalized.

This positive network-effects externality has led to much of the excitement over platforms, including stratospheric valuations of heavily loss-making companies, from Uber to WeWork. The fact that the stock market values growth over margins, and will even fund patently unprofitable platform businesses, suggests that investors may be expecting them, at some stage, to become the "winner" in a "winner-takes-all" dynamic (Eisenmann et al., 2006). Exceptions to this winner-takes-all outcome occur when users multi-home (i.e., when they use another 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 arises for niche competition (Eisenmann et al., 2006). The "winner-takes-all" view has remained popular, despite more nuanced views introduced in more recent work (Boudreau & Jeppesen, 2015; Cennamo & Santaló, 2013; Cennamo, 2018).[10]

All studies in this stream recognize that the coordination of the market participants by the platform provider is a critical condition for enhancing interactions and transactions between end users and complement providers, and thus increasing value-creation opportunities by limiting the problem of free-riding (e.g., Cennamo & Santaló, 2019; Tajedin et al., 2019). Transaction platforms can thus be seen as specific interorganizational value architectures based on multi-sided market structures facilitating matching and value exchange between consumers and product/service providers.

Innovation platforms can be seen as interorganizational value architectures based on modular technological architectures 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 (Gawer, 2002; Boudreau, 2010; Gawer & Cusumano, 2014; Gawer, 2014); adoption of components across the system (Ozcan & Santos, 2015); and integration of system components (Boudreau, 2017). The key issues in this regard are, e.g., compatibility and interoperability of components of a technological system.

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

[10] 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 & Santaló, 2013; Cennamo, 2018; Corts & Lederman, 2009). This may affect the incentives and strategies of various players, particularly complementors, for co-creating value (Landsman & Stremersch, 2011; Mantena et al., 2010).

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 complementors such as software developers and hardware peripheral makers (Gawer & Cusumano, 2002). Parker et al. (2017) underscore this point by demonstrating the relative superiority of such platform-centric models—compared to firm-centric ones—for internalizing externalities due to innovation spillovers arising from third-party complements. They refer to it as the "inverted firm."

Similar externalities exist in other systemic industries, such as videogames, where dynamic competition pushes incumbent games-console makers to introduce a new console generation every few years. To ensure that external actors develop games that are compatible with the latest models, console makers provide labor-saving technological capabilities and development tools that third-party game developers can rely on (Özalp et al., 2018). In such a context, platforms are well equipped to 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 they make little or no charge for connecting to the interface (Gawer & Cusumano, 2002; Gawer, 2020). Platforms also address "standards failure" by preventing 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 & Henderson, 2007), thereby encouraging industry growth.

Thus, value creation in innovation platforms flows from the possibility to attract and align complementors that can use the connectors provided by the platform owner to develop complementary innovation. The design of the interfaces around the platform, and the extent to which they are "open" or "closed" (West, 2007), have a direct effect on the facilitation of complementary innovation at the industry level (Langlois & Robertson, 1992). In this regard, platform scholars have thoroughly explored how value emerges from *design*—in particular, "product design" and "platform design" (Baldwin & 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 is what underpins the idea of "generativity"—that is, the capacity for 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 & Peruta, 2016; Gawer & 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 (that go beyond standard buyer-supplier or alliance relationships) facilitating collective value production for actors and joint value propositions for end customers. In the context of business ecosystems, 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).

The ecosystem dynamics, which can have close parallels with those of platforms, 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 engaged in investments that are specific to their complementors, without the unilateral positions of authority that often characterize lead firms in supply chains (or platform owners in the context of platforms).

When specialized players 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 players in the videogame industry underinvested in quality because they could not capture the value of the fruits of their innovative labor (Cennamo & 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 case of the failure of Symbian's ecosystem (West & Wood, 2013).

Furthermore, in the absence of a clear ecosystem architecture, firms may lack information about the potential benefits from co-specialization (e.g., through the best use of their resources and assets in combination with those of third parties), potentially leading to underinvestment (Masucci et al., 2020). Thus, failure by individual actors to recognize the 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 as a whole 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, 2020; Ozcan & Eisenhardt, 2009; Wareham et al., 2014).

Ecosystem research has considered how to address innovation bottlenecks in the critical components and complements of a focal innovation (Adner & 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 & Santaló, 2013; Panico & Cennamo 2022); and (lack of) convergence over core and complementary components and market architecture of the overall system (Ozcan & Eisenhardt, 2009; Ozcan & Santos, 2015; Hannah & 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, the existence of 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 & Kapoor, 2010; Kapoor & Lee, 2013; Ganco et al., 2020). As for ecosystems focused on new innovations, their emphasis is on ensuring that there can be 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, then, consider cooperation externalities resulting from multilateral interdependencies that cannot be fully solved through traditional hierarchical vertical integration or bilateral contracting such as in supply-chains—let alone through arm's-length market relationships (Adner, 2017; Jacobides et al., 2018).[11] Ecosystems provide a means to ensure that not only production but also innovation is aligned. Orchestrators of ecosystems help resolve such alignment requirements (Jacobides et al., 2018)—a point recently reiterated and developed by Foss, Schmidt, and Teece (2021). 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 & Clark 2000; Garud et al., 2008; Wareham et al. 2014); *innovation bottlenecks* (Adner & Kapoor 2010; Adner 2017; Kapoor 2018; Masucci et al., 2020), and *lack of cross-sector coordination*, especially in nascent markets for

[11] As noted earlier, Jacobides (2022) argues that another angle of value add, specifically for *multi-product ecosystems* is the use each other's services or usefully combine 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, that benefit the consumer but can also pay a dividend to the multi-product ecosystem firm as this can significantly reduce competitive pressures.

integrated solutions (Logue & Grimes 2020; Khanagha et al., 2020; Hannah & Eisenhardt, 2019; Ozcan & Eisenhardt, 2009).

3.4 Platforms' governance and coordination mechanisms

The discussion on externalities and complementarities in both platforms and ecosystems leads naturally to a discussion about governance. Starting with platforms, 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 stream focusing on *innovation platforms* (e.g., Anderson et al., 2014; Gawer & Henderson, 2007; Tiwana, 2015; West & Wood, 2013) tends to focus on the importance of establishing technological interfaces and standards to attract and coordinate a set of producers of modular components around a key technology system that benefits its users (Bresnahan & Greenstein, 1999)—such as, for instance, the case of enterprise software systems (e.g., Ceccagnoli et al., 2012). An important part of innovation platform governance consists in maintaining incentives for populations of developers to create complementary innovations. This implies avoiding coordination failures, which constrain the innovation capacity of the system and its overall value for the innovation user (West & Wood, 2013).

Governance at the level of the platform technological system (and thus at the level of the platform-centered ecosystem) is enforced through technological interfaces and standards, exploiting modularity. This is what Baldwin (2000) refers to as "design rules," engendering a "plug and play" type of coordination of innovation extensions and integration (see also Anderson et al., 2014; Gawer & Henderson, 2007; Gawer, 2014, 2020; 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 & 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 manage the delicate balance of generativity and control in the platform (Wareham et al. 2014). When an orchestrator or platform owner exercises too much control over a platform, it runs the risk of 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 and making it harder for the orchestrator to capture value from its innovations (West and Gallagher, 2006). Digital interface design is crucial to solving the recurring tension between stimulating third parties' complements while at the same time maintaining platform control (Ghazawneh & Henfridsson, 2013; Yoo et al., 2012; Boudreau, 2017).

The economics and strategy tradition focusing on *transaction platforms*, meanwhile, is more concerned with the coordination of diverse agents across different platform "sides" and how this affects the capacity of the platform to compete and win against rival platforms (Armstrong & Wright, 2007; Boudreau, 2012; Cennamo & Santaló, 2013; Hagiu, 2006; Rochet & Tirole, 2006). Governance is mainly concerned with platform membership rules (i.e., the affiliation of users and providers to the platform marketplace) and platform usage rules, (i.e., the rules governing transactions and value exchange within the platform marketplace—see, for example, Hagiu, 2006; Parker and van Alstyne, 2005; Rochet and Tirole, 2006). The focus in this literature is on platform adoption, and how the decisions of users on one side affect those of users on the other side. Early work has been primarily concerned with platform pricing as a coordination mechanism for adoption (e.g., Caillaud & Jullien, 2003; Hagiu, 2006; Rochet & Tirole, 2003; Parker & Van Alstyne, 2005). In this regard, pricing is the primary governance tool, specifically "price structure" (Rochet & Tirole, 2003, 2006)—that is, the structure of access price between the two sides of the platform

(instead of price levels, as in traditional markets), to lower searching and transaction costs between the interacting actors and facilitate interactions and market exchanges.

While coordination mechanisms are essential for platform governance, there is more to platform governance than coordination mechanisms. This is principally because platforms do not operate in a vacuum, and must survive and compete with other platforms or traditional firms. Research has considered other factors, including users' decision to single- or multi-home (Armstrong & Wright, 2007; Lee, 2013); the orchestrator's option to produce first-party complements (Hagiu & Spulber, 2013), and which side(s) to open up for third parties to contribute to, and when (Parker et al., 2017).

Making a separation between providing access to the platform and platform 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)" in addition to providing the technology for developing the platform—something the literature takes as a given. 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 & Wright, 2007; Cennamo & Santaló, 2013, 2019; Corts & Lederman, 2009; Hagiu, 2006; Hagiu & Spulber, 2013; Rochet & Tirole, 2003, 2006). Another aspect of governance relates to "search rules"—enacted through algorithms, user interfaces, or policies for user-complementor engagement—intended to direct user attention toward what to search for (Claussen et al., 2013; Hagiu & Jullien, 2011). This drives coordination, value creation, and value capture.[12]

[12] Platform governance also considers "membership rules," including exclusivity to one platform versus multi-homing (Cennamo & Santaló, 2013; Corts & 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 & Spulber, 2013; Zhu & Liu, 2018), the regulation of platform competition intensity

A syncretic approach on how best to govern platforms 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, competition rules within and between platforms), revenue management (including price-setting rules, revenue and profit sharing, and other incentives—and their control), and conflict resolution.[13]

Offering a broader synthesis on platform governance that applies to both transaction and innovation platforms, Gawer (2021) suggests that the way digital platforms govern both their internal and external resources differentially is by setting and managing three specific and interacting types of platform boundaries: (1) the scope of the platform firm (what assets are owned, what labor is employed, and what activities are performed by the firm); (2) the configuration and composition of the platform's sides (which distinct groups of customers have access to the platform); and (3) digital interfaces (which specify the two-way exchange of data between the platform firm and each of its sides). In this context, platform boundary setting is understood as an integral part of platform governance. Similarly, Cennamo (2021) discusses how the multiple scope decisions that platforms must make in relation to the markets they want to operate in and the technology architecture are highly intertwined since they will both affect the type of users and complementors the platform will attract as well as user experience and expected (desired) behaviour from complementors. In this context, platform boundary setting is understood as an integral part of platform governance.

(Armstrong, 2006; Casadesus-Masanell & Halaburda, 2014; Cennamo & Santaló, 2013, 2019; Panico & Cennamo, 2020), 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 Crémer et al., 2019; Furman et al., 2019).

[13] Research has recently started exploring aspects of platform governance (Cennamo & Santaló, 2019; O'Mahony & Karp, 2020; Wareham et al., 2014; Zhu & Liu, 2018), and the rules of platforms have also attracted interest from regulators (Crémer et al., 2019). 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 & Wright, 2020; O'Mahony & Karp, 2020; Panico & Cennamo, 2020; Zhu & Liu, 2018).

Platform governance appears to require a firm hand, since it is platform owners who must centrally govern interactions across their members to internalize the cross-side externalities (Gawer, 2020; Panico & Cennamo, 2020; Parker et al., 2017; Parker, Van Alstyne, & Choudary, 2016) by setting specifications and enforcing rules. This includes decisions about how open to make digital interfaces, and in the context of digital platforms, what and how data will be shared. As digital platform owners decide what behaviors to encourage or discourage on their platforms, most digital platform owners therefore act as *private regulators* (Boudreau & Hagiu, 2009; Cremer et al., 2019; Gawer & Srnicek, 2021; Gawer, 2021).

In summary, the main question in platform governance is not only how to coordinate across actors, but more generally, "who is allowed to do what" (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 ecosystems set rules to facilitate operation and attract and motivate partners and complementors. For platform-based ecosystems, governance is by necessity centralized, 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 the proper incentive structure for the different 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 & Wood, 2013)—what Adner (2017) refers to as e.g., "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 excessively geared towards the value-capture interests of a subset of actors (those in control of the shared asset) created misalignment in the collaborative structure among the various actors involved in Symbian mobile ecosystem. This eventually led to multiple failures (including the inability to mobilize a fully functional ecosystem of app developers or create a proper marketplace for apps working across multiple devices and telco operators) and the demise of Nokia Symbian in the mobile domain.

Some ecosystems (such as the PAX system, per Adner, 2012, or Nespresso, per Jacobides, 2019) are built around a product or technology, not 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 & De Meyer, 2012, 2020; Iansiti & Levien, 2004) or—and perhaps fundamentally—to the choices that final users make between ecosystems.

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

The relatively scarce empirical work on ecosystem governance (such as Jensen, 2020 on software ecosystems) lists the attributes that define the nature of the interorganizational arrangements, over

and above platform governance rules.[14] Table 3 summarizes the different governance mechanisms in place in platforms and ecosystems.

Insert Table 3 about here

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4. FROM SOLVING SPECIFIC PROBLEMS TO GENERATING NEW FAILURES: 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 under some conditions, outperform structures of vertical integration or bilateral contracting.[15] Yet, they also come with pathologies of their own. The positive structures that allow a platform to create benefits and deal with externalities may also confer great power on orchestrators, often protecting them thanks to reinforcing network effects—and leading, in turn, to *platform* and *ecosystem failures.*

To understand where these failures come from, we identify and characterize the governance trade-offs that platforms and ecosystems face. Platform governance is complicated because of the multiplicity of platform sides, all of which—at least ideally—the platform should create value for. However, objectives (and incentives) may also diverge between the platform and its sides' members, and these divergences may worsen over time. In this context, platform governance decisions are an inherently complex balancing act, likely to involve multiple complex trade-offs involving multiple constituencies in highly dynamic settings. Therefore, failures are very likely.

[14] 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.

[15] 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 (that 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.

While these are all governance failures, broadly speaking, we propose a finer distinction. First, *functional failures* concern the inherent ability of platforms and ecosystems to deliver value to the final customer. Secondly, *distributional failures* relate to an orchestrator's abuse of power and its ability to extract excessive value from its partners and complementors.

4.1. Functional platform and ecosystem failures

Many platforms create value through interfaces that complementary innovators can build upon, or through which the members of market sides can interact and exchange. Functional failures of platforms can therefore stem from the platform orchestrator's operational failure to deliver such stable and shared interfaces. Some scholars go so far as suggesting that markets' "failure to tip" is evidence of market inefficiency (Farrell, 2007).

Successfully managing a platform in the context of dynamic technological development and competition requires the ability to navigate complex trade-offs, retaining complementors while continuously innovating on the platform (Gawer & Henderson, 2007; Parker & Van Alstyne, 2017; Özalp et al., 2018). 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.[16] 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 different parties all bring their own technologies to the table and push for their adoption. All of these can lead to functional platform failures by

[16] 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 & Watson, 2019).

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.[17]

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 a state of partial or intermittent interoperability.[18] The cases suggest that forking, fragmentation, and splintering emerge when the costs and benefits of coordination are asymmetrically distributed.

Karhu et al. (2018) identify another kind of platform failure, this time from the perspective of the platform firm: falling prey to platform forking. This is where a hostile firm—i.e., a forker—bypasses the platform's controlling boundary resources and exploits its shared resources, core, and complements to create a competing platform business. These results are drawn from an empirical study of Google's Android platform, a successful open digital platform, by analyzing the fate of five Android forks and related exploitative activities. While forking affects who benefits in the ecosystem, and/or which platform or platform variant succeeds, it can potentially undermine the very health and quality of a platform, which is the focus of these "functional" issues.

[17] 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.

[18] 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.

Platform-mediated marketplaces (i.e., transaction platforms) may also go wrong 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 & Taylor, 2019). For instance, hotel booking platforms can manipulate search rankings in favor of offers that increase their fee revenue; search engine platforms may refine their algorithms and rankings to promote ads/advertisers that yield higher margins (e.g., de los Santos & Koulayev, 2017). Beyond imposing self-evident distributional problems, this undermines product quality.

As for ecosystems, recent research has increasingly focused on how value-capture dynamics in the ecosystem (i.e., the distribution of value among ecosystem participants) can undermine its value creation capacity. Research has looked at how ecosystem structure can influence the quality and type of contributions to that ecosystem (e.g., studies on platform-based ecosystems by Cennamo & Santaló, 2019; Khanagha et al., 2020; Zhang et al., 2020) and the power distribution among its members (e.g., Miller & Toh, 2020; Panico & 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 (most often a platform firm). They include moral hazard issues from later participants exploiting investments in shared resources made by early members (Cennamo & Santaló, 2019); value-creation/capture tensions and "cooperation failures"—value-capture problems undermining incentives to invest in quality and cooperate (e.g., Miller & Toh, 2020; Panico & Cennamo, 2022; Zhang et al., 2020); local bottlenecks—parceling of the ecosystem into sub-systems for strategic control over parts of the value-creation process (e.g., Khanagha et al., 2020); and exploitation of data aggregation and control to dictate excessive terms of participation (Kramer et al., 2019; Petropoulos, 2020). Thus, *distributional* problems can lead to ecosystem failures by undermining the potential engagement of partners or reduce their investment, such that an unbalanced (unfair?) split of value between the hub firm and third-parties, or among third-parties in a given period T (or phase of the ecosystem evolution) would lead to

complementors' disengagement or underinvestment in future periods T+I (with I=1, ….N). All of which 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 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.

Similarly, Zhang et al. (2020) show the need for ecosystem governance to balance cooperative and competitive tensions between interdependent members to preserve their willingness to cooperate. Zhang et al. (2020) use a quasi-experiment in the mobile app developers' community to show that after the discovery of the "jailbreak" that overcame the protection of Apple's iOS source code, the developer community exploded, because Apple's ability to maintain gatekeeping had been compromised. 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. 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.

4.2. Distributional platform and ecosystem failures

Platform and ecosystem governance also influences how power is allocated across complementors and, thus, value capture. This is particularly true in platform-based ecosystems, where the orchestrator can leverage its control over the platform to set unilateral rules of access (and behavior).

A platform orchestrator (or, almost always, owner) is, by design, a central agent at the nexus of a distributed network of value creators. It can capture much of the value created in that network, and can monitor, control, and use resources without necessarily owning them (Gawer, 2020; 2021). For example, Greve and Song (2017) note that Amazon's self-publishing platform has dramatically shifted power away from major publishers to smaller ones and independent authors, consolidating Amazon's central position in the publishing ecosystem and granting it greater value-capture opportunities. Miller and Toh (2020) 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 recommender 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 (Crémer et al., 2019; Furman et al., 2019), exemplified in a 2019 investigation of Amazon by the EU.[19]

Data can make the members of an 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 of access to data and participation in the ecosystem (Petropoulos, 2020), or steer activities and interactions towards business areas and services to its 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.

Ecosystem governance also encompasses how 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 & 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 & Valletti, 2020).[20]

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

[19] 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).

[20] 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 recognised 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."

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, users switch to paid services, 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 as well. The trade-offs of these costs will be a key topic for policymakers in the years to come.

4.3.Addressing platform and ecosystem failures through regulation

The dynamics that make platforms and ecosystems so attractive inevitably lead to the risk of them abusing their strength, both vis-à-vis final consumers and partners or complementors. As it is becoming clear (Khan, 2017, Jacobides & Lianos, 2021, Jenny, 2021), the tools of existing antitrust laws, which focus on one market (not ecosystem) at a time, are ill equipped to deal with them. Reports published in 2019 in the UK (Furman et al., 2019), the EU (Crémer et al., 2019), and the US (Stigler Report, 2019) all identified the problem and called for new analytical tools.

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 competition law does not directly accommodate platforms and ecosystems adequately at the moment, significant strides are being made, and we expect this situation to change quickly (Jacobides & Lianos, 2021b).

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 & 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 & Heimler, 2021), we hope our conceptualization can be of help.

4.4. Platforms and ecosystems: social and psychological externalities

For completeness' sake, we should also point out that there is one final way in which platforms and ecosystems can be inherently problematic, relating to their *social and psychological externalities*. There is mounting evidence that the very attributes that make platforms and ecosystems such a success—their ability to offer convenient, all-encompassing value propositions that cater to our every need (*ipso facto* a good thing)—also have a darker side.

At the social level, such externalities might be, first, the (unplanned) side-effects of the success of particular platforms and ecosystems on the way our society functions. The fact that (for instance) two-thirds of all the digital ad spend in the EU is captured by two Big Tech platforms is a concern, as it might undermine not only the commercial sector of journalism, inherently pluralistic, but with

it also a pillar of democratic society, given the informational role of the press (see CMA, 2020). Furthermore, ecosystems may impact social cohesion directly. According to a recent *AER* study (Allcott et al., 2020), users who give up Facebook see their views become less polarized, let alone happier. At the same time, in less developed economies, platforms such as Facebook represent the exclusive way to access to information, with the positive and negative consequences this might have.

In addition to social costs, there are also psychological externalities. As Rosenquist et al. (2021: 1–2) argue, "the stimuli digital platforms produce are not physical substances consumed by the body like recreational and prescription drugs, but their effects on the brain follow the same common pathway of reward through the nucleus accumbens, which in turn regulates pathways of addiction. Furthermore, these platforms have been shown to be harmful when consumed in excess, particularly by vulnerable populations." Constant A/B testing (Athey & Luca, 2019) suggests that Big Tech firms are deliberately attempting to make their offerings more addictive, focusing excessively on "user experience" while failing to account for the negative societal externalities this attraction to their services can generate. Also, the shift towards gamification that has taken hold in China and is fast moving to the West shows how potent is the power of some platforms and ecosystems not only to satisfy real consumers' needs but also to exploit their short-term desires in ways that mimic stimulants such as gambling and other sources of addiction (Rosenquist et al., 2021).

That said, externalities are not only negative. 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.[21]

[21] In this context, the ability of platforms to engender behavior and facilitate collective action has the potential to *improve* both psychological and social wellbeing (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

5. DISCUSSION

The fast-growing literatures on platforms and ecosystems address a fascinating range of topics (Shipilov & Gawer, 2020). As often happens in such febrile periods, the downside of researchers' understandable keenness to engage with the new realities is an initial fuzziness, also understandable, around terms and concepts. In the case of platforms and ecosystems, we believe we have reached a point where we need to take stock as a basis for moving ahead. To better understand the new constructs, we suggest that it is essential to consider the specific externalities that need to be addressed and the complementarities that underpin them. We also consider the governance and coordination mechanisms that relate to platforms and ecosystems and identify the nature of the failures that platforms and ecosystems inherently engender. This approach helps inform and qualify existing research in several ways.

First, it outlines the difference of focus and emphasis between platforms and ecosystems. These, we argue, are related yet separate constructs. Not only do they differ in terms of their intellectual heritage and the way they have been defined in the literature; they also could (and, we posit, should) be used to tackle related yet distinct sets of issues. Our paper proposes how we can usefully distinguish between the two, while acknowledging their interrelated nature, in the hope that this will help inform theoretical and empirical research on these important topics.

Second, it moves beyond the identification of the contextual factors that have led to platforms' and ecosystems' rapid growth to consider the nature of the failures that they are intended to address. Yet, at the same time, it articulates their own endogenous weaknesses, lest their growth distracts us from a balanced view. This offers an opportunity to engage in research to empirically consider both the conditions that give rise to platforms and ecosystems and the nature of the issues that these

been the planting of 500 million trees. On a drastically smaller scale, upstart Velocia works with local authorities such as Miami-Dade in the US, transport providers like Uber, and automobile OEMs such as Toyota to recognize drivers' eco-friendly commuting and reward them with public transport.

structures create.

Third, our analysis of the *nature* of failures that platforms and ecosystems create offers a theoretical background to inform not only research but also policy—in terms of firms and their efforts to leverage these structures, but also of a society that is mindful of fairness and efficiency. It helps complement the current regulatory debate (Jacobides & Lianos, 2021a) by offering some underlying theory to help structure the conversation. This may be important, as the pragmatic approach of regulators concerned with the rise of economic power in platforms is phenomenologically driven (Jenny, 2021). For instance, regulators identify issues such as "gatekeepers" with reference to firms' size as opposed to their structural features. This is not only bad for policy and regulation; it also clouds our understanding of the changes in how we organize things, and their ramifications (Jacobides, 2021).

Fourth, 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., 2022), our paper offers a structured way to understand the key elements of this new topography: platforms and ecosystems. Thus, our paper could help in the empirical and theoretical agenda focused on understanding the current reconfiguration of the industrial landscape, such as e.g., "Industry 4.0." We hope it paves the way to a more structured consideration of the implications of such changes for the theory of the firm.

Finally, with our focus on endogenous failures, we help inform the debate on the upsides and downsides of these new structures. Our analysis reveals how platform features (which determine the user experience) and ecosystem architecture (the rules of the game, which then set behavior and complementor outcomes) as well as business motives (which determine monetization, and as such the direction of orchestrators' and complementor actions) need to be assessed directly and separately. This might help, for instance, in the context of two key initiatives currently under way: the finalization of the EU's Digital Services Act (Caffarra & Scott Morton, 2021) and the repeal in

the US of Regulation 230, which affords platforms immunity from prosecution for material posted on their websites (Smith & Van Alstyne, 2021). Given the importance of the externalities that platforms and ecosystems exact on both the psychological wellbeing and the fabric of society, we expect that this will be crucial talking point for years to come, given the ever-growing scope of these new organizational forms.

6. CONCLUSION

The emergence of platforms and ecosystems poses some fresh and exciting challenges to the theory of the firm. Let us not forget that Coase (1937) based his theory on the empirical observation of American industry after his voyage from England. Armed with similar curiosity—or heeding Herbert Simon (1991), who exhorted us to see through the eyes of "the visitor from Mars"—we have to report a profound shift in the patterns of organization of economic activity, with Big Tech, platforms, and ecosystems all moving center-stage. This change requires us to update our terminology and analytical arsenal, and to get our hands dirty by grappling with shifting and sometimes murky phenomena. Doing so will not only enrich our empirical understanding of the world; it will also further our exploration of the essence of organization.

As regulatory interest in Europe and the US gathers pace, with regulation of "gatekeeper" firms becoming ever more central, we aim to contribute by helping to anchor an increasingly polarized policy debate. 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 power of firm deployment of platforms and ecosystems. We need to ascertain where customer convenience ends and anticompetitive lock-in begins, and where competition on merit risks being confused with ecosystem hegemony and platform dominance. Drawing a distinction between *functional* and *distributional* failures can help structure a debate that we expect to grow in importance.

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Table 1a. Platform Definitions: A Selective Comparison

Representative article	**Rochet & Tirole (2003)**	**Parker & Van Alstyne (2005)**	**Tiwana, Konsynski, & Bush (2010)**	**Gawer (2014)**	**Cusumano, Gawer, & Yoffie (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 two-sided network of users linked by interdependent demand for the product.	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)

Table 1b. Ecosystem Definitions (and Relation to Platforms): A Selective Comparison

Representative article	**Adner (2017)**	**Jacobides, Cennamo, & Gawer (2018)**	**Kapoor (2018)**	**Bogers, Sims, & West (2019)**	**Baldwin (2020)**
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 videogame console and compatible videogames	Electric car (as "product ecosystem"); Apple's iPhone (as "platform-based ecosystem")	N/A	Apple iOS and apps 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 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)

Table 2. Innovation Platforms, Transaction Platforms, and Ecosystems Comparison: Externalities, Exogenous Failures Addressed, and Structural Solutions Provided

	Innovation Platforms	Transaction Platforms	Business Ecosystems
Conceptua-lization	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 • Limited individual actors' 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 • Lack of or limited individual actors' 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 - lack of individual actors' 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 of high-quality contributions of product/service providers	Coordination of interfirm cooperation problems including: • Inter-firm 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)

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 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 not enough curation will degrade users' experience (curation e.g., checking quality of products or services offered by side members; or checking violent or illegal content on 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 complements quality and specific, specialized complements, while also guaranteeing discretion and autonomy to complementor

Governance Endogenous 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