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Digital platforms' boundaries: The interplay of firm scope, platform sides, and digital interfaces

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A B S T R A C T

This article explores what factors drive digital platform firms to set or modify their boundaries. Building on economics, strategic management, and information systems research, I suggest that digital platforms make strategic decisions over three distinct types of interrelated 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) the digital interfaces (that specify the 2-way exchange of data between the platform firm and each of its sides). In this article, I explore the interdependence between these seemingly separate decisions and the role of some important moderating variables. These moderators include whether the platform is a transaction or an innovation platform, and the extent to which the platform has developed from its initial formation stage. My work explains why we see so much variation in boundaries across platforms and over time.

Introduction

In recent years, digital platform firms such as Google, Amazon, Facebook, and Alibaba have risen to global prominence, alongside digital platform "unicorns" (i.e., $1B + start-ups) such as Uber and Airbnb. Evans and Schmalensee (2016: 3) praise platforms as "powerful engines of commerce" that are "transforming economies" around the world, "making life easier and better for billions of people." Digital platform firms use digital technologies and connectivity to exploit and control digitized resources that reside beyond the scope of the firm, creating value by facilitating connections across multiple sides, subject to cross-side network effects.

Scholarly enthusiasm for platforms stems from the ability of platforms to generate value by reducing transaction costs or "economic friction" (Parker et al., 2016). The platform phenomenon has stimulated a rapidly growing body of academic research on platform competition (Rochet and Tirole, 2003, 2006; Eisenmann et al., 2011; Cennamo and Santaló, 2013; Bresnahan and Greenstein, 2014; Hagiu and Wright, 2015), platform leadership and innovation (Gawer and Cusumano, 2002, 2014; Gawer, 2009, 2014; Boudreau, 2010), and platform ecosystems (Ceccagnoli et al., 2012; Parker et al., 2017; Jacobides et al., 2018).

This article focuses on digital platform firms' boundaries, an important but underexplored topic in the platform literature. One reason this topic should be investigated is the degree of variance among platform firms about their boundary choices. It is well-known that many digital platform firms, such as Airbnb or Uber, have adopted a so-called "asset-light" model (Goodwin, 2015), where the scope of the platform firm is so narrow that it excludes core assets and most workers. But this is not the case for all platform firms. Some of the most prominent ones, such as Amazon or Google, not only own assets and employ a large number of workers but have also recently made a vast number of acquisitions; the scope of these firms' activities has expanded over time. What factors can account for the different choices that digital platform firms make about their boundaries, not only across platforms but also over time?

Despite the pertinence of this question, the platform economics literature, which has hitherto provided central concepts to the platform strategy literature, has not yet grappled explicitly with the question of platform boundaries. This gap may be due to the

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literature's atomistic view of platforms, which it conceptualizes as a locus of exchange across sides (subject to network effects). Platform economics tends to take for granted the existence and nature of the sides of the platforms, focusing instead on what it considers the platform's main strategic decision: how to price to its various sides to solve the so-called "chicken-or-egg" problem of rallying multiple sides onboard (Caillaud and Jullien, 2003; Rochet and Tirole, 2003, 2006). In the economic view, the multi-sided platform operates as a multi-sided market rather than within it. From this theoretical perspective, the platform as an organization becomes invisible, and its boundaries hard to conceptually define. As such, the current platform economics literature does not offer a solid theoretical explanation for what drives the choice of boundaries of digital platform firms.

This article explores what factors drive digital platform firms to set and modify their boundaries. Drawing from economics, strategic management, and information systems research, I suggest that digital platforms make strategic decisions about three distinct types of interrelated boundaries: (1) the scope of the platform firm (i.e., 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 (i.e., which distinct groups of customers have access to the platform), and (3) the digital interfaces (i.e., how the 2-way exchange of data between the platform firm and each of its sides is specified). In this article, I explore the interdependence between these seemingly separate decisions and the role played by some important moderating variables. In Section 2, these literatures are summarized in order to develop an integrated framework from which a series of propositions are drawn in Section 3.

The propositions identify the factors that drive the setting of digital platform boundaries over time. The criteria for the boundary-setting or boundary-modification choices include whether the platform is a transaction platform or innovation platform, and whether it is in the launch or maturity phase of its lifecycle. In the launch phase, digital platforms prioritize growth through network effects and set their boundaries to enhance transaction opportunities and innovation complementarities across sides. In the maturity phase, they alter their boundaries to prioritize profitability and leverage their dominance, expanding the firm scope, adding sides to the platform while becoming more selective about who can join the sides, and recalibrating or closing their digital interfaces.

Digital platforms and their three types of boundaries: sides, interfaces, and scope of the firm

Digital platform firms "adopt platform business models that use information and communication technologies to facilitate interactions (including commercial transactions) between users, collection and use of data about these interactions, and [are subject to] network effects which make the use of the platforms with most users most valuable to other users" (European Commission, 2018).[1]

Hitherto, there has been no holistic definition of digital platform boundaries in the literature, and the term "digital platform boundary" is generally not used. There are, however, three streams of literature (platform economics, platform strategy, and information systems research) that develop theory on the distinct structural decisions that platform firms make to strategically demarcate their resources and assets, which they govern differentially. These boundary decisions cover the sides of the platform, the digital interfaces between the platform firm and its sides, and the scope of the platform firm, as discussed below.

Boundary decision 1: platform sides

The existing literature identifies platform sides as an essential component of platform business models, focusing on the interplay between pricing and network effects. It does not, however, explicitly consider decisions about sides to be "boundary decisions". In this section, I review this literature and explain that in addition to pricing decisions, platform firms make important decisions on their sides that are strategic and structural. These strategic decisions bear on the configuration (i.e., number of sides) and also on how the sides that are associated to the platform are composed. Since these decisions demarcate between the economic agents that are allowed to access the platform from those who are not, they constitute a platform boundary decision.

The economics literature characterizes platforms by the multi-sidedness of their business model (Rochet and Tirole, 2003, 2006; Armstrong, 2006) and the existence of network effects across sides. Sides are defined as either "users" (as in the European Commission definition, above) or "customers" of the platform (as in Evans and Schmalensee, 2016: 15); both users and customers can be individuals or business organizations (OECD, 2019: 20). Platforms generate value by reducing transaction costs (Parker et al., 2016) and by acting as "matchmakers" among economic agents, helping members of their various sides to "productively interact" (Evans and Schmalensee, 2017).

As Evans and Schmalensee (2016: 15) explain, "the differences between single-sided businesses and multi-sided platforms are stark. Ordinary businesses buy inputs of various sorts from suppliers, sometimes transform them into finished products, and sell goods or services to customers. Their main focus is on attracting customers and selling to them on profitable terms. Multi-sided platforms, in contrast, need to attract two or more types of customers by enabling them to interact with each other on attractive terms. Their most important inputs are generally their customers."

Bringing multiple sides on board will often require pricing models that subsidize at least one side of the platform (Rochet and Tirole, 2003; Caillaud and Jullien, 2003). Evans and Schmalensee (2016: 34) refer to the group of users that pays more than marginal cost as the "money side" while the group of users that pays less than marginal cost is the "subsidy side". The choice of the number of sides and of the nature of the sides is inextricably linked to the pricing structure established by the platform. Hence, this decision will

[1] This is the definition of "online platforms" proposed by the European Commission in its Digital Single Market: Online Platforms (May 2018) communication. https://ec.europa.eu/digital-single-market/en/online-platforms-digital-single-market. I use "digital platform" and "online platform" as synonyms. I use the term "digital platforms" throughout this article.

affect the platform's success and profitability.

When greater involvement by agents of one side of the platform increases its value for agents of the other side(s), indirect network effects arise (Evans and Schmalensee, 2017). Network effects lead to increasing returns to scale, which in turn lead to "winner-take-all" dynamics, and many platform markets end up with a concentrated or monopolistic structure (Eisenmann et al., 2006). Strong network effects can lead to market tipping, again leading to a winner-take-all market outcome. 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) weakening the network effects, or when network effects are highly localized[2] or not very strong, or when there is differentiation across platforms or the opportunity arises for niche competition (Eisenmann et al., 2006).

Platform economics consider multi-sided platforms to operate as multi-sided markets that are characterized by a price structure and price levels. The extent of the characterization of sides in platform economics is limited to whether they constitute the "money" side or the "subsidy" side. The characterization of sides in this literature is generally static: most models do not offer theory on the sides' configuration and composition, nor do they look at the evolution of the sides of the platform over time.

Platform strategy scholars, building on platform economics, identify that the decision as to the number of sides is an essential step in building a platform business. For example, Hagiu (2014) focuses on the question of the number of sides and identifies critical trade-offs involved in the choice of more or fewer sides. More sides lead to potentially greater cross-side network effects, as well as larger scale and diversified sources of revenue. But having too many sides runs the risk of creating too much complexity and can generate conflicts of interest between the multiple sides. The need to create value for multiple sides may also cause what Hagiu (2014) calls a "lowest common denominator" issue, suggesting that the need to please multiple heterogeneous platform constituents constrains the platform's ability to innovate.

Cusumano et al. (2019) identify "choose your platform sides" as the first of their 4-step process for building a platform business. Decisions about sides are not limited to choosing the number of sides, but also require determining *who* will be allowed to participate on the platform, a practice that Cusumano et al. (2019) term "curating members". For example, the digital freelance work platform Freelancer.com connects over 24 million employers and freelancers globally and does not restrict the number of types of freelancers. By contrast, its rival Upwork performs algorithmic curation and uses multiple means to verify that freelancers are who they say they are, including authenticating online addresses. It deliberately restricts the platform's freelancers to those whom it can authenticate and who agree to pass online skills tests.

In summary, platforms make strategic decisions that bear on the configuration (i.e., number of sides) and the composition (i.e., who can join) of the sides that they aim to associate to their platform. Since these decisions demarcate those economic agents who are allowed to access the platform and those who are not, they constitute a platform boundary decision.

Boundary decision 2: digital interfaces

Another boundary decision that platform firms make is that of the design of their technological interfaces. Interfaces are boundaries that separate while connecting various entities within a system. Scholars in strategy, innovation, and information systems research have all noted that strategic decisions on technological interfaces play a significant role in the ability of platforms to stimulate complementary innovation.

The notion of interface, originally developed in the (pre-digital) engineering design literature, describes a technological boundary situated between elements or modules within the architecture of a product or system. In the technology realm, "the specification of the interfaces among interacting physical components" (Ulrich, 1995: 420) is what defines a system's architecture. In the organizational realm, the modularity literature explicitly links system interfaces to organizational boundaries, as interfaces "indicate how the various modules interact between each other and within the larger system" (Baldwin and Clark, 2000), and are associated with demarcations between teams or even across firms (Baldwin, 2008). The technological interface, therefore, acts as both a border and a bridge. It divides or demarcates economic activities, but it also specifies the characteristics of the connection or communication that it helps achieves.

Interfaces can be designed to be more or less open. The concept of "open" versus "closed" interfaces is not black or white but rather comprised of "many shades of grey" (West, 2007). However, an open interface is commonly understood to make information from one module or the platform accessible to external agents. Open technological interfaces are particularly well-suited to inducing external complementary innovation (Gawer, 2014; West, 2003). In a platform ecosystem, developers of complementary innovation use the information (or data) that they can access through the open interface to build compatible and complementary innovation. In the context of platforms, opening a system to complementary development affects innovation by drawing on a wider set of accessible external capabilities and distributed heterogeneous knowledge (Chesbrough, 2003, 2006), as well as independent experimentation (Langlois and Robertson, 1992). Boudreau's studies (Boudreau, (2010, 2012)) find that "opening up" a platform interface does trigger innovation by complementors. Overall, if a platform firm aims to stimulate external innovation on complements, it will open up its interfaces.

A *digital interface* structures the modalities of interconnection between various agents in a digitalized connected context. It therefore acts as a demarcation between agents and as a connector or conduit of data. A platform's capacity to stimulate and take

[2] An example of a localized network effect is ride-sharing, which is organized in a series of local markets (e.g., NYC versus Los Angeles). The availability of a large number of drivers in one city does not increase the value of a ride-sharing service for users in another city. I thank an anonymous reviewer for this clarification.

advantage of distributed innovation is enormously multiplied in a digitalized economy with high connectivity. Such distributed innovation is facilitated by increasingly digitized and modularized design and production practices, coupled with the availability of very low-cost internet-based communication. Baldwin and von Hippel (2011) identify digitalization as a "paradigm shift" in innovation, with users becoming increasingly willing and able to engage in distributed and collaborative innovation.

While economics, strategy, and innovation scholars have developed theory on platforms in general, information systems researchers have explicitly focused on digital platforms. In this literature, the emergence of digital platforms is seen as a major outcome of digitalization, with platforms having become "the central focus of digital innovation" (Yoo et al., 2012: 1400). Digital platforms, considered in information systems research as an instantiation of "modular layered architectures" (Tiwana et al., 2010), are seen as essentially "generative" (Zittrain, 2005), i.e., they enable distributed and unpredictable innovation.

In information systems research, the digital interface situated between the platform and its complementary products or services is construed as a "boundary resource". Ghazawneh and Henfridsson's (2012) study identifies the Apple iPhone as an example of this (as do Eaton et al., 2015). The interface must be designed to manage the delicate balance of generativity and control in the platform. When an organization exercises too much control over the platform, it runs the risk of driving out third-party developers, thus choking the generativity of its platform. However, when organizations fail to exercise any control, the platform becomes too varied and fragmented and is hence less useful for both developers and customers; this makes it difficult for the firm to capture value from its innovations (West and Gallagher, 2006). The design of the digital interface is crucial to solving the recurring tension between stimulating third-party developers' complementary applications while at the same time maintaining platform control (Ghazawneh and Henfridsson, 2012; Yoo et al., 2012; Boudreau, 2017).

In this context, Application Programming Interfaces (APIs) are uniquely important digital platform interfaces. Generally invisible to end-users, APIs are essential tools for external software developers aiming to develop applications that can interact with the platform and use its software resources, whether in the form of data or code modules. They are usually made accessible to developers through Software Development Kits (SDKs). SDKs are important boundary resources that facilitate and streamline the app development process by providing developers with a set of software tools, developer libraries, APIs, documentation, code samples, and guides. When digital platform firms open up or "expose" their APIs, they effectively share with complementors codified technical instructions for how to connect complementary innovations with the platform; this therefore increases complementors' capability to develop platform-compatible innovations, hence extending the functionalities of the platform. Opening up or exposing an API does not necessarily mean the platform will relinquish control. The same API can also be used to maintain control over the platform via, for example, the capture and control of user data. This is because digital interfaces facilitate a 2-way exchange of data between the platform and the external developers. They also facilitate a 2-way exchange of data between the platform and the application's users. In a continuous feedback loop, users of digital services not only consume but also generate data; this is fed back to the producers of the digital services who process it and use it to, inter alia, improve the existing services.

In summary, digital interfaces constitute a type of boundary for digital platform firms, one that specifies the 2-way exchange of data between the platform firm and each of its sides. The decisions that platform firms make about their digital interfaces concern the extent to which these are to be more or less open (i.e., which data will be shared or withheld, and to and from whom). In other words, they concern the balancing of directionality of data exchange. These choices have implications for the degree of complementary innovation, as well as for the degree of control that the platform maintains over its sides. The balancing act is, therefore, between generating third-party complementary innovation and maintaining control over the evolution of the platform.

Boundary decision 3: Firm's scope

I now turn to the scope of the platform firm as the third type of organizational boundary for digital platforms. All firms (whether they be traditional or digital, platform or non-platform) have a scope that they make decisions upon deciding what assets, activities, and resources they will own and what kind of labor they will employ. This section summarizes key results on the determinants of digital platform firms' decisions about their scope. We shall see that firms are subject to economic forces that pull in opposing directions. One the one hand, digitalization enables the control of assets without ownership and the remote control of workers without employment; this tends to make the narrowing of the platform firm's scope cost-effective. On the other hand, digitalization increases the ease of exploiting synergies across digitally connected markets; this eases entry into adjacent markets, hence facilitating platform scope expansion.

Determinants of firm's scope for non-platform firms in traditional contexts

Management research has examined the scope of the (traditional) firm (in pre-digital contexts) through the lens of transaction cost economics (TCE) (Coase, 1937; Williamson, 1975, 1985;). In the classic Coasian account (1937), firms and markets are described as alternative modes of governance where profit-seeking leads to making choices that minimize transaction costs. In TCE, the boundaries of the firm are therefore conceptualized as a demarcation between two alternative types of economic activities: production and exchange. All production activities are performed in-house, while activities relating to exchange are performed across the firm and beyond it to agents situated in the market.

The firm's span of control is contained within its scope through the ownership of productive assets and the employment of its workforce through labor contracts and managerial fiat. Engagement between a firm and its external environment is defined and safeguarded through formal contractual arrangements that enable transactions, allowing the firm to mobilize external resources. The successful implementation of these arrangements is subject to the effectiveness of written contracts, which are enforceable through legal means. The structuring decision of "make or buy" in TCE hinges crucially on whether and when such legal contracts would be

difficult to draft or enforce. The key factors of uncertainty, asset-specificity, and transaction frequency are identified as being likely to lead to future moral hazards that would be difficult to resolve *ex-post*. In such situations, TCE suggests that resorting to ownership (that is, "making" in-house rather than "buying" from external autonomous contractors acting as suppliers) would be the best way of resolving such *ex-ante* issues of problematic control before they develop.

Drivers that narrow firm scope in digital contexts

The process of digitalization changes firm boundaries for all digital firms, including digital platform firms, as it supports an economy-wide redesign of value creation, delivery, and capture processes (Autio et al., 2018). First, connectivity enabled by digital infrastructures, such as the internet and mobile networks, allows data to be shared, linking objects, individuals, and organizations who consume as well as generate data (Siggelkow and Terwiesch, 2019). Digital technologies rely on re-programmable functionality and re-purposable digital devices (Tilson et al., 2010; Yoo et al., 2010), leading to a reduction of asset-specificity. The fungibility of digital assets, such as software, data analytics capability, and installed user-base data can create opportunities in multiple markets. Complementarities between the processes of data generation, connectivity, and aggregation help reduce transaction costs over time, which impacts firm boundaries and the architecture of the value chain (Adner et al., 2019).

Second, the transition to always-on connectedness has fundamentally changed the way agents or resources can be identified, monitored, and controlled (Adner et al., 2019). In internet-connected and digitalized contexts, resources can be controlled without formal ownership or employment. In fact, digitalization allows assets and individuals to be monitored and controlled to a degree that was not previously possible. For example, individual drivers can be connected to the web via mobile devices such as a smartphone or a sensor embedded within a car or an engine; drivers' movements can thus be tracked and their behaviors monitored.

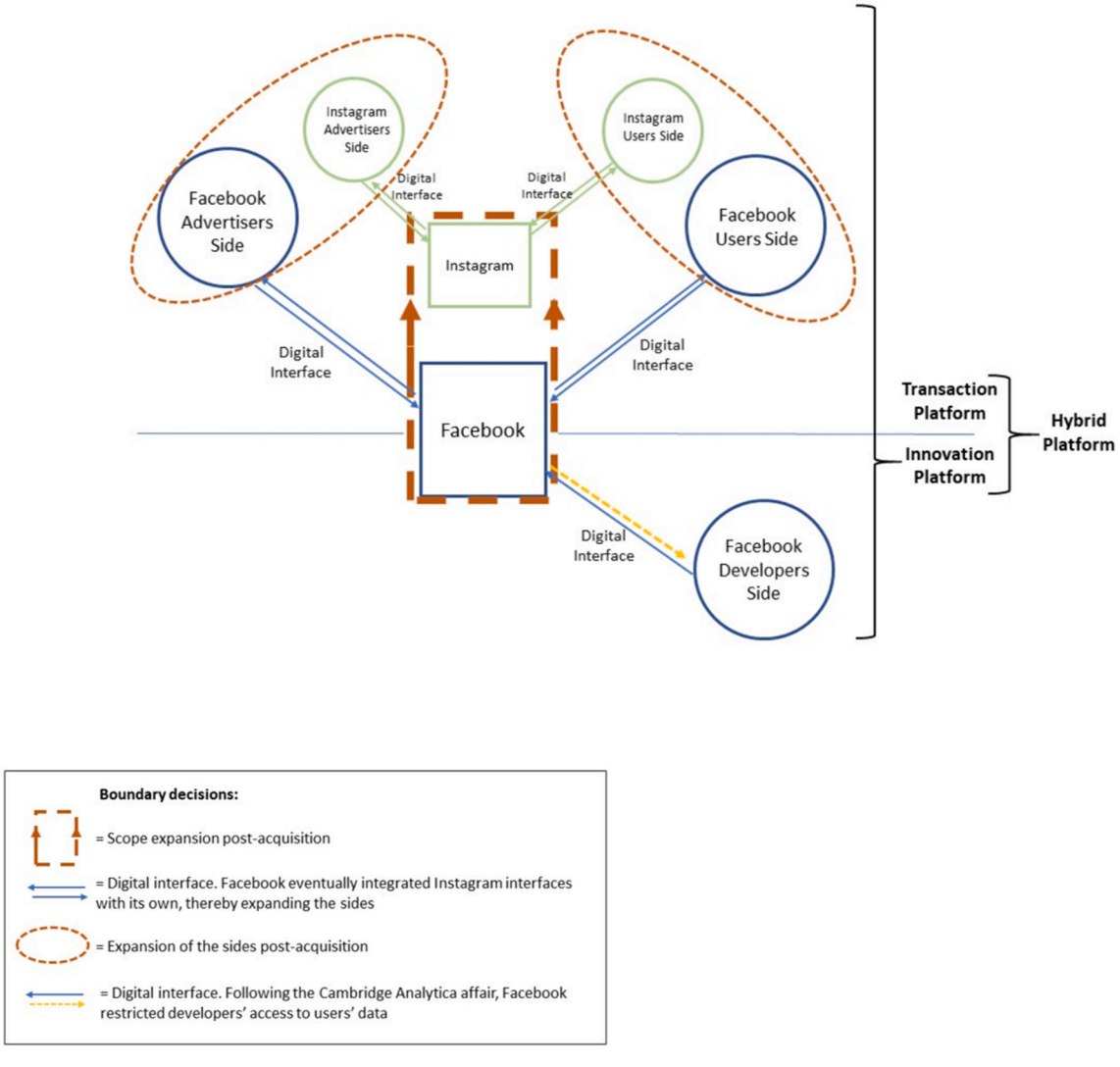

Fig. 1. Facebook boundaries: A simplified illustration.

As Hal Varian, chief economist of Alphabet-Google, explains: "Because transactions are now computer-mediated, we can observe behavior that was previously unobservable and write contracts on it" (Varian, 2014). This reduction in uncertainty helps reduce the need for ownership of resources, suggesting firms can narrow their scope boundaries if they can digitally connect to remote agents and resources to capture data from them, which they can analyze and exploit. We can, therefore, expect the emergence of new asset-light firms that focus on data capture, aggregation, and analysis, requiring little necessity to invest in physical resources.

Drivers of firm's scope expansion in the case of digital platforms

Digitalization also creates economic forces that facilitate firms' expansion of scope. Digitalization makes market entry easier, as firms that can capture and aggregate data from various sectors can unearth and exploit new kinds of synergies (Yoo et al., 2012; Seamans and Zhu, 2014, 2017). Such data-driven market entry results in the expansion of the scope of digital platform firms.

A case in point is the often-observed "platform envelopment" (Eisenmann et al., 2011). This refers to a specific mode of entry known as bundling, whereby one platform firm enters another platform's market by bundling its own functionality with the target's. The mechanisms of platform envelopment rely on a combination of factors. Demand-side and supply-side economies are harnessed by leveraging common components or shared user relationships, while rivals are weakened by cutting off a target's access to customers (Eisenmann et al., 2011: 1275). In addition, incumbent digital platforms follow the example set by traditional non-platform firms by acquiring innovative targets solely to curtail the target's innovation projects and pre-empt future competition in a phenomenon known as "killer acquisitions" (Cunningham et al., 2019).

Summarizing the argument presented so far, I have shown that the economics, strategy, and information systems literatures provide insights on various structural decisions that digital platform firms make regarding their platform sides, digital interfaces, and firm scope. Each of these decisions is a type of boundary decision.

Interactions between platform scope, sides, and interfaces: an illustration

The literature examines these decisions separately and tends not to focus on the possible interrelations between the different types of boundary. In reality, however, decisions on scope and sides and digital interfaces often interact. In order to understand how they do this, it is useful to consider, as an example, a simplified view of Facebook's boundary decisions (see Fig. 1).

i. *Interaction between sides and interfaces*: Facebook started in 2004 as a social network between users, adding almost immediately the side of advertisers. It could not have connected to advertisers without having designed the digital interfaces that conveyed data between the advertisers and the Facebook platform. It then added another side in 2007, that of the developers of Facebook apps. However, it could not have added this side without opening up a new digital interface that included Facebook for developers. Facebook continued to evolve and develop its APIs over several years (Helmond et al., 2019).
ii. *Interaction between scope and sides*: As it evolved, Facebook engaged in a number of acquisitions (Ramzeen, 2019). Acquisitions have an effect on both scope and sides, as illustrated by the interrelated effects of Facebook's acquisition of Instagram in 2012. Instagram was an emerging and potentially rival platform. The acquisition obviously expanded the scope of the firm. And it also, at the same time, expanded the sides to Facebook by adding the Instagram user and advertiser sides to the collection of Facebook sides.
iii. *Interaction between scope, sides, and interfaces*: Further, this acquisition had a longer-term effect on digital interfaces. When Facebook acquired the growing Instagram platform and then the WhatsApp platform (2014), its stated intention was to limit the exchange of data with Facebook services, thereby insulating the respective sides of these platforms from Facebook's sides. But in 2019, Facebook revised its position, recalibrating the interface between WhatsApp, Instagram, and Facebook Messenger. This interface decision allowed the combined 2.6 billion users to communicate across the platforms for the first time, in effect merging the Instagram and WhatsApp user sides with the Facebook user side. It also merged Instagram advertisers with Facebook advertisers. Facebook again recalibrated its interface with developers in the wake of the Cambridge Analytica affair (discussed below).

The Facebook example illustrates how different types of boundaries are interrelated.

Conceptually, building on the literature review, we can see indications that decisions about scope and sides can interact. For example, the literature notes that, on the one hand, transaction costs are directly affected by choices about scope (just as they are for a traditional firm); on the other hand, in digitalized contexts, control of resources and over workers can be achieved without direct ownership or employment (Varian, 2014; Zuboff, 2019). Whether it is the Uber driver (Rosenblatt, 2019), the Deliveroo bike-rider, or the Handy cleaner, digital platforms use sides as an alternative to formal employment relationships. This results in the "asset-light" model, reducing costs of ownership, maintenance, and labor. Decisions about sides can therefore be related to decisions about scope.

Decisions about sides and digital interfaces also interact because, in addition to striving to reduce transaction costs, digital platform firms also aim to generate transaction opportunities across side members as well as innovation complementarities between the platform and the side of complementary innovators (should this side exist). Facilitating transaction opportunities across side members includes the reducing the costs of joining the platform sides, e.g., the measures that eBay, Amazon, and others have taken to simplify the process of joining the platform sides with easy-to-use digital interfaces (accessed via the apps). Generating innovation complementarities involves facilitating the generation of innovations that are complementary to the platform. An example is Google, who has made it easy for developers to join its sides by designing its digital interface to generate innovation complementarities. It has developed over 100 Google APIs that allow external developers to create apps that communicate and integrate with Google services, such as

Search, Gmail, Translate, and Google Maps. Google's APIs provide functionalities such as analytics, machine learning as a service, and access to user data.

The digital platform firm's combined decisions over its boundaries can therefore have an effect on not only its transaction costs (from the combined decisions on scope and sides) but also on how it identifies, generates, and exploits transaction opportunities and innovation complementarities (from the combined decisions on sides and digital interfaces). The question of what outcomes might be yielded by the combined choices of multiple boundary types is not, however, clarified in the literature. This gap motivates the conceptual development presented in the next section.

Digital platform boundaries: conceptual development and propositions

Section 3 develops an integrated conceptual framework for digital platform boundaries and presents propositions that identify the factors that drive digital platform firms' decisions over their boundaries. I start by offering a holistic definition of digital platform boundaries. I then discuss the different types of platforms (innovation and transaction platforms), and the implications of the launch vs maturity phases on the platform lifecycle. This leads to the development of four propositions on boundary choices for transaction and innovation platforms in the launch and maturity phases.

A holistic definition of digital platform boundaries

Organizations and meta-organizations can have multiple types of boundaries, and strategy scholars have suggested that there are benefits to developing a holistic view that can reveal the complementarities and interactions between them (Santos and Eisenhardt, 2009; Gulati et al., 2012; Jacobides et al., 2006).

Having observed that there is an interaction between the different types of boundaries, I define digital platform boundaries as the combination of:

(1) Platform firm scope (what assets are owned, what labor is employed, and what activities are performed in-house)
(2) Platform sides' configuration and composition (which distinct groups of customers have access to the platform)
(3) Digital interfaces (these specify the degree of openness and the balance of directionality of the 2-way exchange of data between the platform and each of its sides)

These three boundaries constitute structural choices that the platform firm makes regarding the allocation of assets, resources, and activities to various governance modes, in support of the strategic aim of optimally organizing and managing resources.

Two types of platforms: transaction platforms and innovation platforms

Cusumano et al. (2019) distinguish between transaction platforms and innovation platforms in their assertion that not all platforms are the same (see Fig. 2).[3] They identify transaction platforms as those whose main function is to facilitate exchange or transaction across sides (that is, whose side members use the platform principally to exchange *existing* goods or services). In contrast, innovation platforms create value by facilitating innovation on the platform (that is, whose side members innovate on goods and services that are *new and complementary* to the platform). The properties of the platform (whether transaction or innovation) are driven by the strategic decisions that platform owners make when they design their business, design their value proposition for each side, and choose their platform sides.

Transaction platforms are intermediaries or online marketplaces or social networks that create value by facilitating the buying and selling of existing goods and services or by facilitating other interactions, such as enabling users to create and share information and content. Examples include Twitter, Uber, Airbnb, and Amazon Marketplace. Transaction platform sides are typically populated by buyers and sellers, loaners and renters, providers of services and users of services, digital content generators and viewers, and, of course, digital advertisers. The more participants, functions, and digital content that is available in transaction platforms, the more useful they become. They primarily capture value by collecting transaction fees, charging for advertising, or both. A firm wishing to build a transaction platform will, therefore, aim to populate its sides with members that will exchange or transact goods, services, and data amongst themselves via the platform.

Innovation platforms, in contrast, provide value to their sides' members by acting as a technological foundation upon which the members of one side (who may be organizations or individuals) can develop new complementary innovations. One side of innovation platforms will, therefore, always consist of developers of complementary innovations; they are the platform's complementors or complementary partners. Examples include Microsoft Windows, Google Android, Apple iOS, and Amazon Web Services. All of these are commonly-used operating systems and cloud computing services that serve as innovation platforms for the computer and smartphone ecosystems. These platforms usually consist of technological building blocks that the platform owner and complementors can share to create new complementary products and services. Complementary innovations developed by third parties add functionality or grant access to assets that make the platform increasingly useful. Network effects arise from the increasing number or

[3] A previous version of Fig. 2 was developed by A. Gawer in collaboration with M. Jacobides and C. Cennamo. The first appearance of the terms "innovation platforms" and "transaction platforms" is in Evans and Gawer (2016).

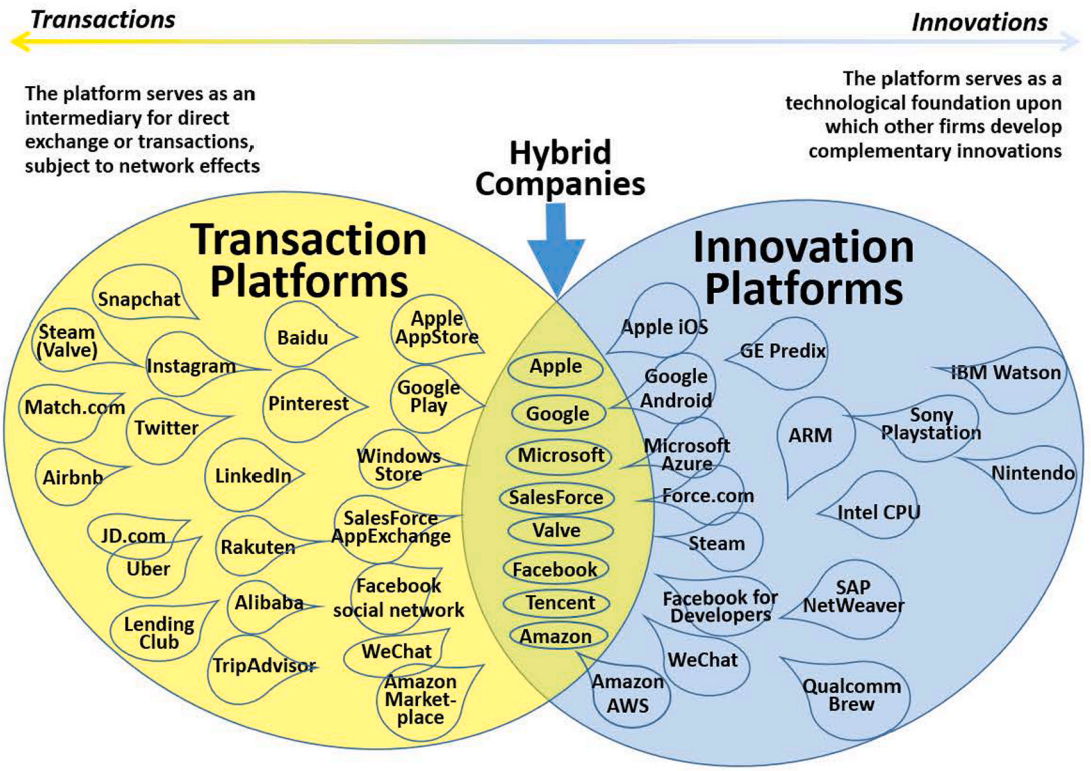

Fig. 2. Basic platform types
Source: Cusumano, M. A., A. Gawer, D. B. Yoffie (2019). *The Business of Platforms* (p. 18). HarperCollins. Reproduced with permission.

utility of the complements.

Two phases of the platform lifecycle: launch and maturity

I now identify two phases of the digital platform lifecycle: launch and maturity. In the launch phase, before the market tips, nascent platforms are especially vulnerable to competition. If a platform does not win the race for network effects before the market tipping point, it will most likely fail. Winner-takes-all dynamics create a situation where digital platforms aim for dominance as a survival strategy. Hence, the digital platform's strategic imperative in its formative years is to achieve scale through network effects.

Many digital platforms, hoping to achieve dominance, choose to forego fledgling profits in order to bring one or more sides on board. The potential for incumbency rents compensates for early losses (Crémer et al., 2019). During the maturity phase, however, once markets have tipped, platforms are then likely to prioritize profit-seeking while building or maintaining barriers to entry against rivals or newcomers.

This sequence of strategic decisions can be observed, for example, in the case of Amazon. As Khan, (2017) (749) explains, the premise of Amazon's business model was to establish scale. As Amazon founder and CEO Jeff Bezos wrote in his first letter to shareholders in 1998, "market leadership" signaled that "Amazon intended to dominate."[4] To achieve scale, the company prioritized growth, leading it to "make decisions and weigh trade-offs differently than some companies"; "we choose to prioritize growth because we believe that scale is central to achieving the potential of our business model" (Bezos, 1998). Khan indicates that although Amazon experienced staggering user and revenue growth, its profits were meagre because it chose to price below cost in order to expand its reach.

In its formative years, Facebook also adopted a policy of prioritizing the growth of its user-base rather than its profits, as Mark Zuckerberg remarked in 2008 (FAZ, 2008): "What every great internet company has done is to figure out a way to make money that has to match to what they are doing on the site. […] In three years from now, we have to figure out what the optimum model is. But that is

[4] In his first letter to shareholders, Jeff Bezos wrote: "We believe that a fundamental measure of our success will be the shareholder value we create over the *long term*. This value will be a direct result of our ability to extend and solidify our current market leadership position … We first measure ourselves in terms of the metrics most indicative of our market leadership: customer and revenue growth, the degree to which our customers continue to purchase from us on a repeat basis, and the strength of our brand. We have invested and will continue to invest aggressively to expand and leverage our customer base, brand, and infrastructure as we move to establish an enduring franchise." (Bezos, 1998).

not our primary focus today. Growth is primary, revenue is secondary." Facebook returned its first profit in 2009.

We can therefore expect that digital platform firms' choice of boundaries will differ depending on their stage of evolution; during the launch phase, they will prioritize the growth of the sides rather than profits by fostering their network effects. In contrast, during the maturity phase, boundaries will help digital platform firms achieve profit even if this somewhat diminishes the existing network effects.

Propositions

The factors that drive digital platform firms' decisions over all their boundaries (scope, sides, and interfaces) will depend on the type of platform (transaction or innovation), as well as the phase of its lifecycle (launch or maturity). The 2-by-2 matrix in Fig. 3 summarizes the propositions that now follow.

In the creation of transaction platforms, the interaction between scope, sides, and interfaces plays out in the following way. During the launch phase, digital transaction platform firms tend to use the sides as alternatives to employing workers and owning assets; thus, they deliberately narrow the scope of the firm. The digital interfaces then set out the modalities of the data exchange that takes place, allowing digital platform firms to monitor their side members' behaviors.

For example, the freelance platform Upwork monitors how long freelance workers are on task through a time tracker that they encourage workers to install on their computer. The data gathered by the tracker is associated with Upwork's "payment protection" service "as proof of activity should a freelancer or their client need it to ensure proper payment" (Upwork, 2019). With pervasive connectivity, big data analysis, and wearable computing, workers are remotely monitored and controlled to a previously unimaginable extent. Studies of platforms such as Uber observe that drivers can receive behavioral "nudges" or instructions "over the air" via their mobile phones. These nudges are adjusted in real-time according to data the drivers have themselves generated, which is then combined with data the platform captures from other sources, including other workers. This practice is referred to as "algorithmic control," "algorithmic surveillance," "limitless surveillance," or "algorithmic labor" (Rosenblat and Stark, 2016; Rosenblat, 2018; Ajunwa et al., 2017; Wood et al., 2019; Zuboff, 2019).

Proposition 1. *During the launch phase, digital transaction platforms will: (1) narrow the scope of the firm, to minimize costs; (2) expand the configuration and composition of the sides as an alternative to owning or employing assets; (3) open the digital interfaces to facilitate monitoring of assets and help sides' members identify transaction opportunities across sides. Taken together, these three choices help digital transaction platforms grow network effects across the sides.*

At launch, innovation platforms face specific challenges and have specific aims that inform their boundary choices. As innovation platforms require developers of complementary innovation, a firm aiming to build an innovation platform will always have to populate one side by complementors or complementary partners. Further, innovation platforms often capture and deliver value (monetize the platform) by directly selling or renting a product. In a few cases where the platform is free (e.g., Google Android), they usually monetize the platform by selling advertising or other services. The literature review has described the central role of open digital interfaces to generate third-party complements, and innovation platforms, which depend on high levels of third-party innovation, will therefore tend to make their interfaces open to achieve this objective.

As regards the firm scope and platform sides of innovation platforms, these firms tend to produce in-house the technological foundation upon which third parties will develop complementary innovations. Building this foundation usually requires significant investment, ownership of assets, and employment of workers, implying a larger scope of activities internally performed than is seen in the transaction platforms. In addition, we often observe that innovation platforms will produce and release at launch a set of compelling complements (called 1st party complements) in order to create a users side. Examples include Nintendo releasing its Mario Brothers game with the launch of its Nintendo Entertainment System platform in 1995 (Evans et al., 2008), or Apple who launched the first iPhone in 2007 pre-loaded with Apple-developed apps such as the Safari browser and an iPod video and player app. Once it becomes clear that the functionalities and early complements of the platform are attractive to users, the platform becomes increasingly attractive to the developers of complementary applications, who then come to the complementors' side.

Proposition 2. *During the launch phase, digital innovation platform firms will: (1) Broaden the scope of the firm through the ownership of assets necessary to build the foundational technology and to develop 1st-party complements; (2) Have one of their sides composed of developers of complementary innovation; (3) Open the digital interfaces to allow complementors greater access to the platform's technological resources and captured data, to stimulate complementary digital innovation. Taken together, these three choices help digital innovation platforms grow network effects across sides.*

Once digital markets tip, the digital platform firms that have survived the launch phase will enter the maturity phase. Their main strategic objective will then be to achieve profitability. Once firms reach this maturity stage, they face less direct competition, which means their complementors have fewer alternatives and less bargaining power; they are therefore less likely to leave the platform. While not all platforms reach monopolistic or quasi-monopolistic status (as discussed in the literature, this generally depends on the strength of network effects and the likelihood of multi-homing) but they all face less competition in the maturity phase. Hence, they can then alter their behavior vis-à-vis their side members.

For example, in the maturity phase, as they start to more aggressively pursue profitability, some digital platforms with significant market share will begin to expand their scope to compete with some of their side members, in effect encroaching onto their sides. This plays out differently for transaction platforms and innovation platforms.

Examples of transaction platforms competing with select side members include Amazon's patterns of entry into its own third-party

Platform Type / Lifecycle Phase	Transaction platform	Innovation platform
Launch	*Proposition 1* **Scope** Narrow **Sides** One side for asset owners and/or workers **Interfaces** Open for increasing transactions and for monitoring	*Proposition 2* **Scope** Broaden **Sides** One side for complementary innovators **Interfaces** Open for third-party innovation
Maturity	*Proposition 3* **Scope** Broaden through exploiting asymmetric data flows and/or acquisitions **Sides** Add new sides to become hybrid + more selective about who can join the sides **Interfaces** Recalibrate or close to prevent rivals from accessing data	*Proposition 4* **Scope** Broaden by absorbing complements' functionalities and/or acquisitions **Sides** Add new sides to become hybrid + more selective about who can join the sides **Interfaces** Recalibrate or close to prevent rivals from accessing data

Fig. 3. Digital platforms' boundary decisions.

sellers' product spaces (Zhu and Liu, 2018). Here again, we can observe an interaction between the firm scope, the platform sides, and its digital interfaces. As transaction platforms can easily capture detailed data from their sellers' sales via the digital interfaces, they can strategically use that data to guide their selective entry into specific high-selling product markets. For example, Amazon has been found to exploit data from their Amazon Marketplace sellers to identify particularly lucrative categories of products, which they have gone on to sell under their private label (Mattioli, 2020).

Expansion of scope into sides can also result in the digital platform's recalibration or closure of the digital interfaces. For example, Twitter used to make its "firehose" data available to third parties. Firehose data refers to the full, unfiltered stream of tweets available. These side members, including Gnip and DataSift, used Twitter firehose data as the input for developing and selling meta-analyses of tweets. When Twitter acquired its complementor Gnip in 2014, it removed all third parties' access to its firehose data (Reselman, 2018). Twitter's objective in redrawing the boundary was to increase its revenue from data licensing, which from then on became only available direct from the platform.

Transaction platforms may choose to expand scope through acquisition, and when digital platforms acquire other platforms, they also naturally acquire the target platform's connections to its own sides. Amazon has spent $20B on its top 10 acquisitions since 2011 in the various sectors of groceries, media and content, e-commerce, computing hardware, robotics, smart homes, and healthcare (CB Insights, 2019; Crunchbase, 2019). The drivers of acquisitions vary, but in some cases, such as Amazon's acquisition of Zappos, the transaction platform acquired a key rival platform. Transaction platforms also acquire emerging rival platforms (thereby expanding the scope of the firm) to protect themselves from new competition, as occurred in the case of Facebook's acquisitions of WhatsApp and Instagram (Scott Morton and Dinielli, 2020).

There is another dimension to platform expansions. As digital platforms evolve, they tend to add a side that changes the nature of the platform into a hybrid, combining transaction and innovation functions. Cusumano et al. (2019) observe that over time, many platforms have evolved into hybrids. Examples include Amazon, Alphabet Google, Facebook, Tencent, and Alibaba (see Fig. 2). The main reason transaction platforms add an innovation side is that more apps or features will make the transaction platform a more compelling experience for users. And it will also create additional opportunities for monetization, such as the creation of different types of transaction fees. Platforms, when adding a side for developers of complementary innovation, usually open one or more APIs and release corresponding SDKs and reference documentation. For example, Expedia, the travel services platform, became a hybrid when it added a set of APIs. Thus, it allowed complementors to build and customize hotel booking applications end-to-end, from shopping to booking to payment. It enabled external developers to build applications using Expedia transaction capabilities (Expedia, 2020). Another example is Uber. In 2014, Uber, which started as a transaction platform, became a hybrid by offering a free API to app developers. This could be used by app developers to allow users to request an Uber ride from within their app, or to allow online shops and local retailers to build on-demand delivery solutions, and could also be used to add geolocation tracking (Uber, 2020a). The data generated by the transaction platform on user behavior can also become a useful asset that third parties and the platform firm can use

to generate cross-side network effects.

Transaction platforms in the maturity phase also begin to become more selective about who can join their existing sides, aiming to exclude so-called "bad actors" either before or after they join. Preventing the entry of fraudulent sellers and terminating the accounts of dishonest sellers is a way for platforms to curate interactions on the platform in order to maintain buyers' trust. For example, Uber gradually made the screening process through which they allow individuals to become drivers more stringent after well-publicized occurrences of physical attacks by Uber drivers on riders (CNN, 2018; Uber, 2020b). Amazon has enhanced its processes to verify the identity of sellers on Amazon Marketplace in an effort to crack down on the sellers of counterfeit products.

Proposition 3. *In the maturity phase, digital transaction platforms firms will: (1a) Broaden the scope of the firm, exploiting the asymmetric flows of data they capture from side members to enter new markets, potentially competing with its existing sides; (1b) Broaden the scope of the firm through acquisitions, which may include snuffing out nascent rivals; (2) Add new sides to become hybrids and become more selective about who can join the sides; (3) Recalibrate or close their interfaces to prevent rivals from accessing their data or user networks, while capturing more data from their side members. Together, these choices help digital transaction platforms fend off competition while generating profit.*

Innovation platforms may also start to compete with some of their side members in the maturity phase, but this is for a different reason. They tend to do this when they believe that absorbing certain functionalities developed by complementors and integrating them within the shared technological foundation will generate more value for the ecosystem as a whole, or if they see it as essential to the evolution of the platform technology. The literature recognizes an important interaction between scope and sides, in that there is a trade-off between platform scope expansion and a platform's ability to stimulate complementors' innovation. When an innovation platform firm enters the side of their complementors and starts competing with them, innovation on complements by third parties tends to get depressed. There is support for this from empirical studies that focus on platform owners in their maturity phase. For example, Gawer and Henderson (2007) show that Intel in the late 1990s was acutely aware of the negative effects that its entry into the microprocessor platform's complementary markets was likely to have on its complementors' incentives to innovate. It attempted to mitigate these issues by selectively entering a small set of such markets, the so-called "connector markets", which would help create new markets for complements. Wen and Zhu (2019)'s study of Android mobile app developers' response to the threat of Google's entry into their markets finds that after Google's entry threat increased, affected developers reduced innovation and raised the prices for their apps.[5] Critically, the effect on further ecosystem innovation will depend on the platform's decision about the degree of openness of its digital interface: Parker and Van Alstyne (2018) claim that an innovation platform's decision to absorb complements can result in increasing innovation if it chooses to provide access to the absorbed functionality as a technological foundation upon which its developers can build.

Innovation platforms can also add become hybrid by adding a marketplace. In doing so, they add sides that consist of the buyers and sellers of the platform's complements. The main reason innovation platforms add transaction platform capabilities is to facilitate and control the distribution channel of complements (Cusumano et al., 2019). Transaction features create value for complementors by offering them a distribution infrastructure, and the platform firm can usually capture a significant portion of the value created, thereby generating considerable revenue. For example, Apple's App Store revenue in 2019 reached $50 billion (CNBC, 2019), paying $35 billion to its developers.

Similar to transaction platforms, innovation (and hybrid) platforms can also expand their scope through acquisitions. For example, Alphabet-Google has made more than 200 acquisitions since its IPO in 2004 (Elias, 2019). As at 2020, it operated in over 20 sectors, including internet search, mobile operating systems, and digital advertising. Some of these acquisitions are currently attracting interest from regulators, being suspected, in retrospect, to have been driven by an intent to snuff out potential competition. Thus, the US Federal Trade Commission, the European Commission, and the UK Competition and Market Authority have all launched enquiries to examine the effect that these acquisitions have had on innovation and the consolidation of market dominance, and to establish whether they constituted killer acquisitions (Cunningham et al., 2019; Crémer et al., 2019; FTC, 2020; Argentesi et al., 2019).

An innovation (or hybrid) platform can also decide to close or recalibrate its digital interfaces in order to control the behavior of complementors. Examples include Facebook's decisions to restrict developers' access to user data in the wake of the Cambridge Analytica debacle when developers abused users' data privacy (Facebook, 2018). Another example also concerns Facebook behavior's after its rival Twitter acquired the video-sharing platform Vine in 2013. Before Twitter's acquisition, Vine users were able to find friends they already knew on Facebook.com through Facebook's 'Find Contacts' API. However, following its acquisition by Twitter, Facebook disallowed Vine's access to this API. In doing so, Facebook was able to degrade consumers' experience of Vine and reduce the platform's competitive threat. Vine was discontinued by Twitter in 2016 (CMA, 2019: 89).

Proposition 4. *In the maturity phase, digital innovation platforms firms will: (1a) Broaden the scope of the firm by absorbing technological functionalities developed by a complementor; (1b) Broaden the scope of the firm through acquisitions, which may include snuffing out nascent rivals; (2) Add new sides to become hybrids and become more selective about who can join the sides; (3) Recalibrate or close their interfaces to prevent complementors (whether they be rivals or reputationally damaging partners) from accessing their data. Together, these choices help digital innovation platforms fend off competition while generating profit.*

[5] However, Wen and Zhu (2019) find that Google's entry does not appear to have entirely suppressed its complementors' innovation incentives; rather, complementors appeared to shift innovation to unaffected and new apps.

Discussion and conclusion

This article has explored what factors drive digital platform firms to set or modify their boundaries. In summary, it suggests that digital platform firms' decisions about their multiple types of platform boundaries (the scope of the firm, the sides of the platform, and its digital interfaces) interact. It clarifies these interactions, and proposes that the combinations of boundary choices depend on the type of platform (whether it be innovation or transaction) as well as on the phase of the lifecycle that the platform firm is in (launch or maturity).

These propositions matter because platform boundaries decisions constitute an essential aspect of the strategy of digital platforms, who are playing an increasingly central role in the digital economy. In 2019, seven out of the eight largest companies in the world by market capitalization were digital platform firms. Between 2009 and 2019, their combined market capitalization had increased by over $4 trillion (PwC, 2020). The increasing importance of platforms has generated a surge of scholarly research in various literatures on platform business models and pricing, platform strategy, and platform design. Hitherto, however, the literature has not offered an integrated theoretical framework on the strategic drivers of digital platform firms' boundary decisions, nor has it answered the overarching question of why, when, and how digital platform firms set or modify their boundaries.

To answer this question, I have built on economics, strategy, and information systems research that separately examine distinct types of boundaries. I integrate these literatures and suggest that digital platform boundaries consist of three types of interrelated boundaries: (1) the scope of the platform firm, (2) the configuration and composition of the platform sides, and (3) the digital interfaces that specify the 2-way exchange of data between the platform firm and each of its sides. I argue that while the platform firm's scope, sides, and digital interfaces have thus far been seen as distinct phenomena and therefore discussed separately, they are, in fact, better understood in the context of digital platforms as different facets of the same phenomenon. They all express attempts by digital platform firms to achieve the same objective: that of organizing and governing internal and external resources. I suggest that they are interrelated and can complement each other in how they help digital platform firms achieve these strategic objectives.

I elucidate in the propositions the factors that drive the setting and modification of digital platform boundaries over time. These criteria include whether the platform is in the launch or maturity phase of its lifecycle and whether it is a transaction or an innovation platform. In the launch phase, digital platform firms make boundary decisions that support their aim of prioritizing growth through network effects. Hence, they set their combined boundaries to enhance transaction opportunities and innovation complementarities across sides. In the maturity phase, they alter their boundaries to prioritize profitability and leverage their dominance, expanding the firm scope, adding sides to the platform while being more selective about who can join the sides, and recalibrating or closing their digital interfaces.

This article makes several novel contributions. To the best of my knowledge, it is the first to combine as a unified set the multiple boundary decisions of scope, sides, and interfaces. The interest of this approach lies in how it allows the interactions between these variables to be explored and clarified. The propositions suggest that boundary decisions can interact in multiple ways, and they identify various patterns of interaction of boundary decisions that depend on the type of platform and the phase of their development.

Clarifying these patterns of interplay constitutes a contribution to platform strategy research. It enriches the scholarly discussion of platforms by situating the questions relative to digital platforms firms' scope within the broader strategic question of how they create and capture value by setting and manipulating *all* their platform boundaries. Platform economics has contributed central notions to platform research, including the concept of sides and network effects, and the importance of getting the right pricing structure (involving subsidies) to solve the chicken-and-egg adoption problem (Rochet and Tirole, 2003; Armstrong, 2006). But it has not focused explicitly on the question of platform boundaries or examined their evolution. Strategy scholars (Gawer and Cusumano, 2002, 2014; West, 2003; Boudreau, 2017; Cusumano et al., 2019) and information systems scholars (Ghazawneh and Henfridsson, 2012; Eaton et al., 2015) have identified that digital platform firms make boundary decisions concerning both their scope and their digital interfaces (through which they attempt to influence and control their ecosystem members). Incorporating insights from these works has highlighted how the choices made by digital platform firms about their digital interfaces interact with their choices about their scope and sides. Most importantly, this enriches the conceptual framework to situate scope-of-the-firm expansions within a broader strategic game that involves not only competition, but also the stimulation of complementary innovation, and the generation of new combinations of co-created value.

The propositions present combinations of three boundary decisions that are not only interdependent but also mutually compatible. This suggests that coherence across these decisions can, therefore, be a factor in the success of digital platform strategies. For example, we have seen that decisions on scope and interfaces can have opposite effects: opening up digital interfaces can boost complementors' innovation incentives and capabilities, whereas platform scope expansion, when aimed at competing with complementors, is likely to have the opposite effect. If the platform firm makes both these decisions at the same time, complementors might be tolerant when the platform is in the maturity phase because there are by then fewer platforms for complementors to join. However, making such decisions during the launch phase, when platform firms are more dependent on early complementors and more vulnerable to competition, may well lead complementors to reduce their investment in platform-specific innovations or even to leave the platform altogether.

Understanding the patterns of interplay between decisions about scope, sides, and interfaces has clear relevance for managerial practice. The notion of mutually-compatible boundary decisions has implications for platform firm managers because it implies that they must be mindful of the coherence of the set of choices they make. This article suggests that managers need to ensure they combine their various boundary decisions in ways that are mutually reinforcing rather divergent. Digital platform firm managers need to be cautious about how their choices of scope, sides, and interfaces will interact, and recognize that some configurations may be internally inconsistent, leading to unsustainable boundary configurations.

The article also contributes to a larger debate among academics, regulators, and policy-makers (Crémer et al., 2019; Furman et al., 2019; Stigler, 2019; Scott Morton and Dinielli, 2020) on how to ensure that digital platform markets remain competitive. In this debate, there is growing recognition that, on the one hand, network effects can lead to monopolization, and, on the other hand, digital platforms' treatment of users' data can have negative consequences on competition by potentially erecting barriers to entry. In parallel, past mergers leading to platform scope expansion are also being re-examined by regulators in the context of killer acquisitions. It is difficult to determine *ex-ante* whether a digital platform firm's acquisition of another firm has the primary aim of improving efficiency or neutralizing a competitor. The framework developed in this article is helpful in that regard, as it suggests that scrutiny of platform firms' behavior towards the flow and control of data should be considered as part of a broader pattern of actions through which platforms evolve over time. Hence, consideration should be given to the design of such platforms' digital interfaces together with the decisions they made on scope and sides. In short, the contribution to regulators and policy-makers is the advice that the effects of platform decisions on scope, sides, and interfaces should be examined together, if the combined effects of these decisions on competition and innovation are to be properly assessed and measured.

This study is not without limitations that call for further research. First and foremost, the contribution of this article is theoretical and is built on an innovative articulation of existing work, illustrated by stylized facts. It requires empirical testing and validation. Empirical research is needed to test whether the combinations of boundary decisions identified in the propositions are adopted by large samples of innovation and transaction platform firms during the phases identified. Such research should ideally cover platforms from multiple industries, aiming to correct the point, noted by McIntyre et al. (2020), that most empirical research on platforms has been limited to platforms within individual sectors. Further empirical work should also aim to estimate the extent to which digital platform firms' adoption of the configurations of boundaries identified in the propositions impacts their survival and performance.

Second, the boundary decisions I have discussed constitute only a subset of all of platform firms' strategic decisions, which clearly also include decisions on pricing (Caillaud and Jullien, 2003; Armstrong, 2006) and governance (Wareham et al., 2014). A promising line of research is to build on Rietveld et al.'s (2020) work which suggests that as platforms become more dominant, their governance strategies shift over time and end up making complementors worse off. These findings seem consistent with this article's propositions, and more research is needed to validate the findings across other sectors.

Third, the main theoretical perspective used to determine firm scope was TCE. Other theoretical perspectives, however, such as the resource-based/competence view of the firm (Penrose, 1959; Wernerfelt, 1984; Barney, 1991; Macher, 2006) and the power view (Pfeffer and Salancik, 1978) are potentially relevant. Future work might explore the additional benefits of using these perspectives for the setting of digital platform firm boundaries.

Fourth, this article has treated sides as a black box, and not addressed the question of heterogeneity within platform sides. Some platforms, however, have tried to attract the "right" kind of complementors and have attempted to ensure the availability of exclusive complements to maximize the benefits of indirect network effects (McIntyre et al., 2020). Further research could examine the implications of digital platforms boundary decisions that identify and incentivize specific complementors within sides, building on Corts and Lederman (2009), Rietveld and Eggers (2018), and Tavalaei and Cennamo (2020).

Further empirical research would also be useful to clarify the boundary conditions of the propositions. In particular, more research is needed to characterize more precisely and find observable indicators of the threshold between the launch and maturity phases. Such future work would usefully contribute to the burgeoning research on platform lifecycles (Teece, 2017) which has so far focused mainly on their interaction with dynamic capabilities (Helfat and Raubitschek, 2018). In general, research on the evolution of platforms over time is still immature. While this article has focused on only two phases of platform evolution, launch and maturity, a fuller examination of platform evolution (which is outside the scope of this paper) would also consider what happens after platform firms achieve maturity. Teece (2017) envisions four phases: birth, extension, leadership, and self-renewal, recognizing that this is an aspirational view as, during this evolution, many platforms fail. One could also envision another phase, in which declining or obsolete platforms still try to maintain a niche presence.[6]

Future research that would characterize more precisely and find observable indicators of the threshold between the launch and maturity phases would also be illuminating for regulators and policy-makers who are trying to establish how to determine the criteria of the threshold from which platforms should be subject to increased specific *ex-ante* regulation. See, for example, the European Commission (2020) initiative that is striving to establish the criteria that will correctly identify so-called "platform gatekeepers" (Chee, 2020; CPI, 2020), and Furman et al. (2019)'s report for the UK Treasury on "unlocking digital competition", which proposes to reserve such regulation for "platforms with strategic market status". Studies that empirically observe when platforms have a wholesale shift in their three types of boundaries could potentially provide firms with a test that indicates that they have switched from one phase to the next; this would be a helpful input into this policy area.

The research agenda on platforms is at an inflection point. Given the increasingly central role that digital platforms play in the digital economy, scholars' focus is shifting away from the clarification of platform business models and the identification of their success factors toward more complete and dynamic models of platform firms' behavior. Scholars may find that an approach that bridges different literatures, as presented in this paper, can be helpful in providing further insights on platforms' impact on competition and innovation that will be relevant for both practitioners and policy-makers.

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CRediT authorship contribution statement

Annabelle Gawer: Conceptualization, Methodology, Writing - original draft, Writing - review & editing.

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