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Discontinuities, competition, and cooperation: Coopetitive dynamics between incumbents and entrants

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Research Summary: We advance an integrative model in which distinct types of technological discontinuities (core-knowledge vs. complementary-asset) are combined with different appropriability regimes (strong vs. weak) to predict competitive and cooperative dynamics between incumbents and entrants. We posit that incumbents ally with entrants following a core-knowledge discontinuity when the appropriability regime is strong. When the appropriability regime is weak, incumbents are more likely to acquire entrants. We submit that the additional consideration of complementary-asset discontinuities reveals a more integrated theoretical model of competition and cooperation between incumbents and entrants. In particular, incumbents tend to cooperate among themselves following complementary-asset discontinuities, although we highlight theoretical nuances due to different appropriability regimes. We provide falsifiable propositions, and introduce contingencies such as firm-level heterogeneity and time dynamics.

Managerial Summary: Interfirm cooperation is one possible avenue for existing firms to address the challenge of responding to discontinuous technological changes. What is not clear, however, is who should the incumbent ally with: other incumbents or new entrants? We provide an integrative framework to help managers to decide when to cooperate with competitors and when to cooperate with new entrants. When the core knowledge of incumbent firms is made obsolete by technological advances and intellectual property is fairly well protected, managers of existing firms should search out collaboration with new entrants. If intellectual property protection is weak, managers of incumbents firms are better off acquiring new entrants. When the downstream complementary resources such manufacturing, distribution, and sales are replaced by radically new technologies, then incumbents best option is cooperate with other incumbents in order to compete against new entrants.

KEYWORDS

capabilities, complementary assets, coopetition, innovation, platform strategy

1 | INTRODUCTION

Discontinuities are critical moments for incumbent firms because they often challenge firms' ability to adapt and survive (Christensen & Bower, 1996; Henderson & Clark, 1990; Lavie, 2006a; Tushman & Anderson, 1986). Discontinuities, however, also afford an opportunity for established firms to reconsider their competitive and cooperative strategies within an industry. The many strategic alliances between old-line pharma companies and new biotech ventures in the aftermath of the biotech revolution provide well-documented examples of how incumbents use cooperation with new entrants to not only adapt to radical changes, but also to potentially gain a competitive advantage (Arora & Gambardella, 1990; Pisano, 1991). More precisely, if an industry is characterized by a strong appropriability regime that protects the entrants' new knowledge and incumbents hold specialized complementary assets necessary to commercialize the new knowledge, incumbents frequently cooperate with entrants to navigate such core-knowledge discontinuities (Gans & Stern, 2003; Teece, 1986, 1992). A noteworthy feature here is incumbent and entrant cooperation, while each group—incumbents and new entrants—competes among itself. This highlights the dynamics of simultaneous competition and cooperation following a technological discontinuity. Moreover, while a deeper understanding of the tension between competition and cooperation is clearly needed, prior research has highlighted the benefits to interfirm collaboration (e.g., Dyer & Singh, 1998), while frequently neglecting to consider potential downsides (for notable exceptions, see Hamel, 1991; Katila, Rosenberger, & Eisenhardt, 2008). Moreover, prior literature has focused mostly on core-knowledge discontinuities[1] and highlighted strategic alliances formed between incumbents and new entrants (e.g., Baum, Calabrese, & Silverman, 2000; Rothaermel, 2001). We integrate these important accounts by advancing novel predictions for the case of complementary-asset discontinuities—technological changes that introduce radically new complementary assets in manufacturing, distribution, and sales (Cozzolino, 2015). In the aftermath of this distinct type of technological change, we posit that incumbents are more likely to cooperate among themselves rather than with new entrants. Recent examples of these horizontal cooperative arrangements are the intra-industry alliances among universities (e.g., Coursera, edX) and among TV networks (e.g., Hulu) in order to respond to the digital revolution in content distribution.

[1]Building on Teece's (1986) seminal contribution, core knowledge is R&D-based and held upstream in the firm value chain, while complementary assets include things such as manufacturing, regulatory expertise, marketing, and distribution. Such complementary assets are held downstream in the firm's value chain (pp. 288–290). A core-knowledge discontinuity, therefore, devalues an incumbent firm's upstream knowledge, while a complementary-asset discontinuity devalues an incumbent firm's downstream assets.

A natural starting point is the research on strategic alliances (Gulati, 1998).[2] The cooperative strategy literature has examined important aspects of inter-organizational collaboration, especially with respect to the question of why and how alliances are formed and managed (Dyer & Singh, 1998; Dyer, Singh, & Hesterly, 2018; Hoffmann, 2007; Reuer, Zollo, & Singh, 2002; Rothaermel & Boeker, 2008). This fruitful research has also drawn some attention to the specific case of horizontal cooperation among competing incumbents (Ahuja, 2000; Doz, Olk, & Ring, 2000), albeit to a lesser extent than a focus on vertical alliances between incumbents and entrants. Among the few examples of horizontal cooperation documented in literature is the SEMATECH consortium, formed by U.S. semiconductor incumbent firms to fend off Japanese entrants (Browning, Beyer, & Shelter, 1995) as well as the consortia and multi-partner alliances among airlines (e.g., Star Alliance, One World, Sky Team), aircraft manufacturers (e.g., Airbus), and telecommunication companies (e.g., Wi-Fi) (Gomes-Casseres, 2015; Lavie, Lechner, & Singh, 2007).

Although the prevailing research on core-knowledge discontinuities has clearly advanced our understanding, we posit that the additional inclusion of complementary-asset discontinuities in such considerations actually reveals a more integrated theoretical model of competition and cooperation between incumbents and entrants. To develop a more complete conceptual model, therefore, we combine different types of technological discontinuities (core-knowledge vs. complementary-asset) with an industry's appropriability regime (strong vs. weak) to explain and predict competitive and cooperative dynamics between and among incumbents and entrants. To establish a robust theoretical contribution, we follow Bacharach (1989) by asking the fundamental *how, when,* and *why* questions applied to our specific context:[3]

1. *How* does the type of a technological discontinuity affect the competitive and cooperative dynamics in an industry?
2. *When* does a technological discontinuity induce cooperation between incumbents and entrants, and when does it induce cooperation among otherwise competing incumbent firms?
3. *Why* do firms compete and/or cooperate following a technological discontinuity?

Moreover, we introduce a number of contingencies into our integrative conceptual model to explain firm-level variance as well as time dynamics. In particular, we consider the role of organizational status as a moderating factor influencing the complex coopetitive dynamics (Brandenburger & Nalebuff, 1995; Padula & Dagnino, 2007) between incumbents and entrants. We conclude with considerations of how and why cooperative arrangements suitable in the immediate aftermath of a discontinuity may change over time as initial uncertainty is reduced. Taken together, we attempt to provide a more holistic model of the coopetitive dynamics between incumbents and entrants following different types of technological changes to not only gain fresh theoretical insights, but also to guide future empirical research by advancing a set of falsifiable propositions (Popper, 1959).

[2]Following Gulati (1998), we use the terms *interfirm cooperation* and *strategic alliances* interchangeably, and define *strategic alliances* broadly as "voluntary arrangements between firms to exchange and share knowledge as well as resources with the intent of developing processes, products, or services" (p. 293).

[3]See Bacharach's criteria for evaluating a theoretical contribution: "The primary goal of theory is to answer the questions of how, when, and why" (1989, p. 498). For a related argument regarding fundamental questions underlying a theoretical contribution, see also Whetten (1989).

1.1 | Technological discontinuities, core knowledge, and complementary assets

The competitive strategy literature documents in rich detail that incumbents frequently lose their advantage after discontinuous technological changes (e.g., Abernathy & Utterback, 1978; Christensen & Bower, 1996; Henderson & Clark, 1990; Tripsas & Gavetti, 2000; Tushman & Anderson, 1986). A discontinuity "offers sharp price-performance improvements over existing technologies" because it is a "technical advance so significant that no increase in scale, efficiency, or design can make older technologies competitive with the new technology" (Tushman & Anderson, 1986, p. 441). Examples of discontinuities are digital photography replacing film-based photography (Benner & Tripsas, 2012), the advent of electric furnaces in steel production (Anderson & Tushman, 1990), and the substitution of mechanical calculators by electronic computers (Taylor & Helfat, 2009). In all these and other similar cases, entrants pioneering the new technology often gain the advantage over incumbents (Abernathy & Utterback, 1978). The eventual substitution of old-line incumbents by new entrants is what Schumpeter (1942) theorized as the process of creative destruction.

Technological discontinuities provide a fruitful avenue for theory development because they punctuate existing industry structures and dynamics (Hill & Rothaermel, 2003; Romanelli & Tushman, 1994). Although we study competition and cooperation following discontinuities in a comprehensive fashion by considering both incumbents and entrants, we begin the theoretical analysis from the perspective of a vertically integrated incumbent firm facing an exogenous technological discontinuity. This allows us to ground our contribution solidly in prior work (e.g., Abernathy & Utterback, 1978; Christensen & Bower, 1996; Henderson & Clark, 1990; Tripsas & Gavetti, 2000; Tushman & Anderson, 1986) before going beyond it by considering both competition and cooperation between and among incumbents and new entrants.

It is important to note that the vast majority of discontinuous changes examined in prior literature are devaluing the upstream core knowledge held by incumbents. In all of the previously mentioned studies (photography, steel, and calculators) as well as in many other industry settings such as semiconductors (Dosi, 1984), pharmaceuticals (Arora & Gambardella, 1990), watches (Glasmeier, 1991), and medical diagnostics (Mitchell, 1991), the technological change was in each instance an exogenous shock to the upstream core knowledge of incumbents. For example, the scientific discovery of biotechnology rendered obsolete the core knowledge in organic chemistry of incumbent pharmaceutical companies.[4] This line of prior work is consistent with Tushman and Anderson's (1986) foundational observation that competence-destroying discontinuities render the upstream core knowledge of incumbents obsolete.[5] In a similar vein, Henderson and Clark's (1990) notion of architectural innovation also indicated that the incumbents' core knowledge is adversely affected by changes in the underlying knowledge linkages of a product. The predominant focus in the literature on core-knowledge discontinuities is also reflected in some of the identified factors explaining incumbent failure, such as core-knowledge obsolescence, core rigidities, inertia and path dependency in competence and knowledge development as well as capability reconfigurations (Danneels, 2011; Lavie, 2006a; Leonard-Barton, 1992; Sosa, 2011; Teece, Pisano, & Shuen, 1997; Tripsas & Gavetti, 2000).

To advance our theoretical understanding, we consider the opposite scenario where the technological impact of a discontinuity occurs at the complementary-asset level of existing firms

[4]For a detailed historic perspective, see Galambos and Sturchi (1998).

[5]More precisely, Tushman and Anderson (1986) distinguished between competence-destroying and competence-enhancing discontinuities. They went on to document, however, that only competence-destroying discontinuities challenge incumbents, and are thus the relevant concept for our further considerations.

(i.e., downstream at manufacturing, distribution sales), rather than at their upstream core-knowledge level (Cozzolino, 2015). Given the newness of the phenomenon, it is an under-researched discontinuous change that is particularly pertinent today with the ongoing digitalization of many industries such as music, TV, movies, newspapers, education, book publishing, and a variety of information-intensive services such as legal, tax, financial, and higher education among many others. Clearly, the internet is a discontinuous technological change for old-line physical manufacturing, distribution and sales assets held by incumbents in many industries. At the same time, the downstream digitization of content and distribution did not make obsolete the upstream core knowledge held by incumbents to create information-intensive products and services. The internet is primarily a distributive technology that offers new channels to distribute and/or commercialize information-intensive products.[6]

As a first step in clearly delineating the more novel construct of a complementary-asset discontinuity, we build on Teece's (1986) seminal treatise on how incumbents can profit from innovation.[7] Therein, he introduced the notion of complementary assets and indicated that they are almost always needed to commercialize an invention successfully:

[A]n innovation consists of certain…[core] knowledge…. In order for such know-how to generate profits, it must be sold or utilized in some fashion in the market…. Services such as marketing, competitive manufacturing, and after-sales support are almost always needed. These services are often obtained from complementary assets which are specialized (p. 288).

Teece (1986) further distinguished between *generic* and *specialized* complementary assets.[8] Generic complementary assets are commodity-type assets that are not adjusted to the innovation and are widely available on the open market. Given that generic complementary assets are neither valuable, rare, nor hard to imitate (Barney, 1991), they do not afford their owners an advantage. General purpose manufacturing equipment falls into this category. In contrast, specialized complementary assets are frequently built over long periods of time, and thus, are path-dependent and often idiosyncratic (Teece et al., 1997). Accordingly, specialized complementary assets are critical and unique for the commercialization of an innovation. These specialized types of assets obey the conditions laid out in the resource-based view (Barney, 1991; Peteraf, 1993), and thus, can be a source of competitive advantage. Often serving as bottlenecks to market entry and penetration (Kapoor & Furr, 2015), specialized complementary assets allow incumbents to capture value from an innovation because they are not, unlike generic assets, widely available on the open market.

It is useful to reiterate that, in Teece's (1986) model, innovation is a value-creating activity that occurs at the upstream core-knowledge level, while the commercialization of the innovation refers to value-capture activities, and occurs through downstream specialized complementary assets. In this vein, a long tradition has investigated how incumbent firms facing core-knowledge discontinuities have used strategic alliances with new entrants to access their new core knowledge in exchange for

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[6]It is helpful to understand that digitalization has incrementally affected the underlying core-knowledge production to some extent, but the relevant distinction here is that old-line complementary assets have been radically challenged because the new digital distributive technologies can *substitute* older technologies, while the same advances in computing and IT have *complemented* the core knowledge held by incumbents (Brynjolfsson & McAfee, 2014).

[7]In his framework, Teece (1986) referred to *innovation* and how to appropriate its value, while we extend the framework to the broader case of *knowledge production* (of which innovation is a specific case).

[8]Technically speaking, Teece (1986) identified three different types of complementary assets: generic, specialized, and cospecialized (p. 286). Specialized and cospecialized complementary assets are differentiated by the degree of dependence between the innovation and the assets to commercialize it; specialized assets are defined by unilateral dependence, while cospecialized assets are defined by bilateral dependence. Because this fine-grained distinction is not critical to our analysis, we follow prior literature (Gans & Stern, 2003; Rothaermel & Hill, 2005) and use the term *specialized complementary assets* to include both specialized and cospecialized complementary assets.

access to the incumbents' specialized complementary assets (Arora & Gambardella, 1990; Pisano, 1990; Rothaermel, 2001; Tripsas, 1997).

By integrating the technological discontinuity framework with the complementary-asset concept, we are able to explore the more novel case of a complementary-asset discontinuity. We define a *complementary-asset discontinuity* as an advance in which new technologies in manufacturing, distribution, and sales offer superior alternatives in terms of price/performance ratios and efficiency to incumbents' specialized complementary assets that no improvements in the older assets can match the performance of the new ones.

1.2 | Competition and cooperation following distinct types of discontinuities

Our investigation of the tension inherent in competition and cooperation following distinct types of discontinuities is guided by two overarching questions:

1. Is the incumbents' core knowledge needed to produce within the new technology?
2. Are the incumbents' complementary assets needed to commercialize within the new technology?

Combining these two key questions leads to four states of competitive and cooperative dynamics, as shown in Figure 1. Table 1 provides a more detailed extension of Figure 1.

We first consider the northwest-southeast diagonal in Figure 1 (Quadrants I and II). This is a predominantly competitive diagonal in which incumbents compete either primarily among themselves due to the absence of discontinuities (Quadrant I) or compete against new entrants whose new radical technologies devalue both the core knowledge and complementary assets of incumbents (Quadrant II).

The theoretically more interesting cases in regard to the interplay of competition and cooperation, however, lie on the northeast-southwest diagonal (Quadrants III and IV). This diagonal exhibits

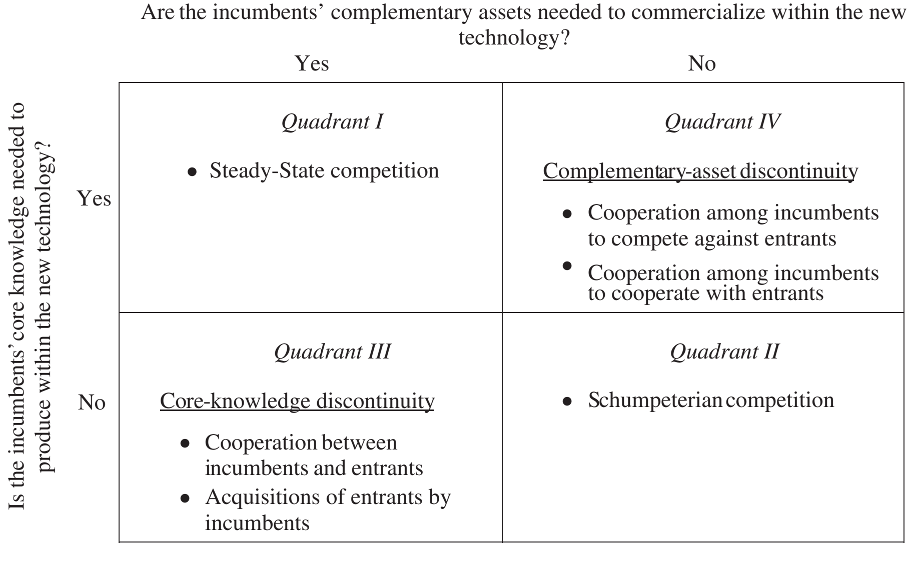

FIGURE 1 Industry-level dynamics of competition and cooperation following core-knowledge and complementary-asset discontinuities

TABLE 1 Industry-level dynamics of competition and cooperation following core-knowledge and complementary-asset discontinuities

	Incumbent specialized assets needed within the new technology	Incumbent specialized assets not needed within the new technology
Incumbent core knowledge needed within the new technology	**STEADY-STATE COMPETITION** **QI** ***Incumbents*** • Strategic positions are based on market power; competition tends to be either on price and/or differentiation. • Underlying technology assumed to be constant, despite possible incremental advances. ***Entrants*** • Any new entry is based on existing technology. ***Competitive Dynamics*** Specific type of competition depends on underlying market structure (i.e., perfect competition, monopolistic competition, oligopoly, and monopoly).	**COOPERATION AMONG INCUMBENTS** **QIV** ***Incumbents*** • Incumbents' value capture is undermined by the new assets and by the disinter-mediation of downstream entrants. • Incumbents' products are threatened by entrants' platform orchestration of increasingly abundant products and by potential product commoditization. ***Entrants*** • Opportunities for downstream entrants to redesign the industry value chain by developing new standards for distribution and controlling them. • Downstream entrants acting as platforms can exploit abundant upstream products, disintermediating incumbents' vertical value chain, and putting incumbents in competition. ***Dynamics and Incumbents' Response*** • Horizontal cooperation among incumbents to: (a) develop jointly proprietary downstream assets/platforms, and (b) protect upstream products. • Synergies among incumbents stem from reaching multiple common objectives: gain critical mass, exploit network externalities, control proprietary distribution and customer data, reposition products as premium quality by reintroducing scarcity.
Incumbent core knowledge not needed within the new technology	**COOPERATION BETWEEN INCUMBENTS AND ENTRANTS** **QIII** ***Incumbents*** • Incentives for incumbents to cooperate with upstream entrants to access and exploit entrants' new knowledge. ***Entrants*** • Upstream entrants hold the new knowledge, but need to cooperate with incumbents to commercialize it through incumbents' specialized downstream assets. ***Dynamics and Incumbents' Response*** • Vertical cooperation between incumbents and upstream entrants to exploit complementarities along the value chain (i.e., upstream entrant and downstream incumbent activities). • Synergies stem from division of labor, comparative advantages in, and access to, specific value chain portions.	**SCHUMPETERIAN COMPETITION** **QII** ***Incumbents*** • Few opportunities to cooperate for incumbents as their upstream knowledge and downstream assets are destroyed and cannot be exploited to attract partners. • Few reasons to cooperate as incumbents do not have valuable assets/competences to protect. ***Entrants*** • Upstream entrants can establish new competitive positions imposing new dominant designs for products. • Downstream entrants have the opportunity to set new standard for distribution. ***Dynamics and Incumbents' Response*** • Incumbents and entrants compete fiercely against and among each other. • More innovative entrants eventually replace incumbents in a Schumpeterian process of creative destruction.

two different variations of cooperation as dominant strategic response by incumbents to different types of discontinuities. Quadrant III refers to the response of incumbents to a core-knowledge discontinuity. It indicates cooperation between incumbents and upstream entrants, which pioneer the new knowledge. These types of vertical alliances have been studied extensively by scholars examining the response of incumbent pharmaceutical companies to the biotech revolution, a well-established core-knowledge discontinuity (Arora & Gambardella, 1990; Pisano, 1990; Rothaermel, 2001). We briefly discuss Quadrant III as a baseline proposition before extending it through exploration of the variance introduced by different appropriability regimes and time horizons.

Quadrant IV depicts the response of incumbents to a complementary-asset discontinuity. It presents a theoretically more interesting case that is under-researched: horizontal cooperation among otherwise competing incumbents. This allows us to explain the recent formations of consortia and intra-industry alliances in industries such as newspapers, academia, TV, movie, and music to adapt to the digital revolution (e.g., edX in academia; the Local Newspaper Consortium in the publishing sector). While horizontal cooperation among existing organizations has been explored in prior research to some extent (Doz, 1996; Dyer & Singh, 1998), we highlight inter-incumbent cooperation as a strategic response to complementary-asset discontinuities. Next, we explore variations in incumbent and entrant responses due to different appropriability regimes, time horizons, and other firm-specific contingencies such as organizational status.

1.3 | Steady-state competition (Quadrant I)

Quadrant I represents a situation where both the incumbents' core knowledge and specialized complementary assets remain necessary to produce and commercialize. This is the baseline scenario of steady-state competition. In the world of Quadrant I, any new entry is based on incremental improvements in old-line existing technologies (both at the core and complementary-asset levels). Incumbents continue to compete with one another and are not challenged by any discontinuities. This quadrant, therefore, serves as a comparison category.

1.4 | Schumpeterian competition (Quadrant II)

The situation is quite different in Quadrant II, depicted in the southeast corner of Figure 1. This quadrant depicts a technological discontinuity that not only devalues the incumbents' core knowledge, but also makes their specialized complementary assets irrelevant. This combination implies that incumbents' core knowledge is no longer needed to produce within the new technology, nor are their complementary assets required to commercialize within the new technology. This scenario generally leads to the well-documented situation of Schumpeterian creative destruction, where new entrants tend to overtake incumbents (Gans & Stern, 2003; Schumpeter, 1942). Historic examples in the transportation industry include the replacement of horse-drawn carriages by automobiles, or the substitution of sailboats by engine-powered commercial vessels (Foster, 1986; Foster & Kaplan, 2001). More recently, streaming video-on-demand via the internet has replaced retail-based video tape rental chains (again, the change encompasses both the upstream core technology *and* the downstream complementary distribution system).

1.5 | Core-knowledge discontinuity (Quadrant III)

Quadrant III depicts an environment in which a discontinuity devalues incumbents' upstream core knowledge while the incumbents' downstream complementary assets continue to be required in order to commercialize the new technology. This quadrant represents a competence-destroying discontinuity for incumbents' core knowledge in which the new knowledge is introduced by upstream entrants (Gans & Stern, 2003).

Backward integration into the new knowledge production is generally not a viable strategic option for incumbents in the immediate aftermath of a core-knowledge discontinuity.[9] This is because building new upstream core knowledge internally is time-consuming, resource-intensive, path dependent and characterized by time decompression (Dierickx & Cool, 1989), a process made more difficult by the devaluation of the incumbent's existing expertise within the new technology (Rothaermel, 2001). Backward integration into the new knowledge production is also risky because of uncertainty about future technological developments (Abernathy & Utterback, 1978).

In the aftermath of a core-knowledge discontinuity, the industry value chain is one in which incumbents still possess valuable specialized complementary assets but lack expertise in the new core-knowledge base. At the same time, upstream entrants lack the required specialized complementary assets to commercialize the innovation. Building specialized complementary assets for upstream entrants is also time-consuming, resource-intensive, and characterized by path dependency and time decompression as well as shrouded in uncertainty. Alas, incumbents—on their own—are unable to create value based on the new technology, at least initially, and upstream entrants are unable to capture value from the innovation on their own (Gans & Stern, 2003).

To solve this conundrum, Williamson (1991a) theorized that interfirm cooperation is a preferred strategic response during periods of transition and uncertainty, while Teece (1992) proposed that cooperation with innovative entrants might permit incumbents to renew their businesses. Therefore, the environment in the immediate aftermath of a core-knowledge discontinuity (Quadrant III) evinces favorable conditions for interfirm cooperation between old-line incumbents and upstream entrants, which would be competing otherwise. Incumbents have an incentive to access upstream entrants' new core knowledge, while entrants, in turn, have an incentive to access incumbents' downstream complementary assets, thus exploiting collaborative synergies based on a division of labor (Dyer & Singh, 1998; Lavie, 2006b).

To understand the competitive and cooperative implications in this quadrant more deeply, however, it is important to distinguish further between strong and weak appropriability regimes. This is because collaboration between incumbents and new entrants does not only provide upside, but also downside, especially for the entrants that expose their new upstream core knowledge to misappropriation by opportunistic incumbents (Katila et al., 2008).

1.5.1 | Core-knowledge discontinuity under a strong appropriability regime (Quadrant III.a)

A second important building block to determine who benefits from innovation is the appropriability regime, which Teece (1986) defined as "the environmental factors…that govern an innovator's ability to capture the profits generated by an innovation" (p. 287). Some of the most effective ones are legal protection mechanisms (e.g., patents and copyrights) as well as the nature of the underlying knowledge (e.g., tacit vs. codified).

Confirmed by detailed survey data (Cohen, Nelson, & Walsh, 2000), the pharmaceutical industry is characterized by a strong appropriability regime because the effectiveness of patent protection of newly discovered and developed drugs received the highest score in more than 60 industries surveyed. The pharma industry also presents a quintessential case of a core-knowledge discontinuity in which incumbents' specialized complementary assets maintained their value after the introduction of biotechnology (Galambos & Sturchi, 1998). The discontinuity represented a radical shock to incumbents' core knowledge because their scientific knowledge in chemical screening was rendered

[9]We introduce time dynamics into our framework later in this article.

	Appropriability regime: Strong	Appropriability regime: Weak
Core-knowledge discontinuity	*Quadrant III.a* ▶ Cooperation between incumbents and entrants • Pharma industry after biotech	*Quadrant III.b* ▶ Unstable cooperative equilibrium ▶ Acquisitions of entrants by incumbents • Typesetting industry • Medical diagnostic industry
Complementary-asset discontinuity	*Quadrant IV.a* ▶ Cooperation among incumbents to cooperate with entrants • Music industry • Movie industry	*Quadrant IV.b* ▶ Cooperation among incumbents to compete against entrants • News media industry • Higher education industry

FIGURE 2 Core-knowledge and complementary-asset discontinuities under strong and weak appropriability regimes

obsolete by new genetic engineering pioneered by startups. Scholars studying this phenomenon have shown that incumbents can survive the discontinuity if they cooperate with the same entrants that challenge their core knowledge. Arora and Gambardella (1990) demonstrated that incumbent pharmaceutical companies enter strategic alliances with new research-intensive entrants to access the new upstream core knowledge. Complementing this finding, Rothaermel (2001) documented that incumbent pharmaceutical companies that cooperate with new biotech entrants outperformed those incumbents exploring the new knowledge territory through internal R&D. The alliances between old-line pharma and new biotech companies generally take the form of licensing agreements, where the new ventures grant incumbent pharma companies the right to commercialize and market their biotechnology inventions (Arora & Ceccagnoli, 2006). This type of division of collaborative labor in vertical alliances works well because the underlying intellectual property (IP) is protected by patents—and thus, the exchange of knowledge takes place within a strong appropriability regime (Gans & Stern, 2003).

Benefits to these vertical alliance arrangements flow to not only incumbents, but also new entrants. For instance, Stuart, Hoang, and Hybels (1999) showed that new biotechnology ventures that are able to ally with a reputable pharma firm are more successful. In particular, they document that those new ventures that form an alliance with a high-status incumbent go faster to an initial public offering, and do so at higher valuations. Indeed, under a strong appropriability regime, the benefits to incumbent-new entrant alliances outweigh their costs (Katila et al., 2008), thus making a collaborative equilibrium between incumbents and upstream entrants in the face of a core-knowledge discontinuity the theoretically likely outcome (Quadrant III.a in Figure 2).

The collaborative equilibrium, notably, also brings with it a number of competitive benefits for each party involved. In particular, incumbents can achieve a competitive advantage over other incumbents by allying with the most promising new entrants (Gans & Stern, 2003; Rothaermel & Boeker, 2008). In turn, new entrants can outperform other upstream entrants by allying with the most reputable incumbents (Katila et al., 2008; Stuart et al., 1999). Taken together, although incumbents cooperate with upstream entrants, each group competes among one another. Not unlike constellations in the airline industry (Gomes-Casseres, 2015), alliances made up of incumbents and entrants are likely to compete against other alliances.

Following a core-knowledge discontinuity in an industry characterized by a strong appropriability regime (Quadrant III.a)…

Proposition 1a (P1a) *Incumbents are more likely to form strategic alliances with upstream entrants introducing the new core knowledge (rather than with other incumbents).*

1.5.2 | Core-knowledge discontinuity under a weak appropriability regime (Quadrant III.b)

We next examine the less explored subcase of a core-knowledge discontinuity under a weak appropriability regime (Quadrant III.b in Figure 2). When the IP regime is weak, rather than allying with new entrants, we expect incumbents to focus on internal R&D in order to enhance their absorptive capacity (Cohen & Levinthal, 1990) and to acquire new upstream entrants (Capron & Mitchell, 2012; Hoffmann & Schaper-Rinkel, 2001; Rothaermel & Hess, 2007). We expect this outcome because a weak IP protection retards the emergence of a market for technologies in which inventions can be sold to companies that are better positioned for commercialization (Arora, Fosfuri, & Gambardella, 2001). The absence of an effective market for technology reduces entrants' incentive to cooperate with incumbents. Second, a weak appropriability regime leaves the new entrants exposed to imitation by incumbents (Katila et al., 2008). A well-known example is the introduction of the CT scanner by EMI, which was quickly imitated by GE (see Teece, 1986). Taken together, the fact that the entrants' IP is less protected makes them unwilling to license their new upstream core knowledge. Under a weak appropriability regime, incumbents are likely to compete among one another to acquire the most promising startups following a core-knowledge discontinuity.

Using acquisitions of new entrants as a response by incumbents to core-knowledge discontinuities has been documented in a careful study of the typesetter industry (Tripsas, 1997). Here, the leading incumbent firm—Mergenthaler—was able to weather several waves of discontinuities because it owned a specialized complementary asset: a large library of proprietary fonts. This font library (protected under copyright law) allowed Mergenthaler to acquire novel upstream core knowledge externally in each of several technological transitions. The discontinuous changes occurred at the upstream core knowledge (e.g., from hot metal mechanical typesetting presses to digital CRT typesetters). The appropriability regime for the core technical knowledge in this industry was weak, however, as mechanical inventions can be patented around quite simply by altering a few screws and components within much more complex products (Cohen et al., 2000).[10] Therefore, the limited IP protection for the innovation reduced entrants' incentive to license the new core knowledge to incumbents. At the same time, it also left the new entrants exposed to imitation by incumbents (Katila et al., 2008). Under these conditions, Mergenthaler acquired some of the new entrants and developed some of the new knowledge internally (Tripsas, 1997).

The medical diagnostic industry provides additional evidence for our prediction (Quadrant III. b.). As documented by Mitchell (1989), incumbents in the medical diagnostic sector operate under a weak IP regime and faced discontinuous threats to their core knowledge while maintaining control of valuable specialized assets. He found that medical diagnostic incumbents facing core-knowledge

[10]Certainly the IP protection of fonts (e.g., Times New Roman) is stronger because they are protected by copyrights and their imitation is also prevented by the fact that any page typed using the font in question is highly visible. Fonts are specialized complementary assets. They are not the core knowledge, which is where the innovation occurred (i.e., in the method of typesetting). New entrants came into the industry upstream, attempting to commercialize new typesetting technologies. The appropriability regime is defined precisely with respect to the upstream core knowledge underlying an innovation (Teece, 1986).

threats acquired new entrants to enter new technical subfields by exploiting their specialized complementary assets.

The build-borrow-buy framework by Capron and Mitchell (2012) can provide a further theoretical foundation for our prediction. The model argues that when an incumbent firm faces a resources gap, it has three options: "build" the new resource internally, "borrow" it through alliances, or "buy" it externally. The "build" option is possible, but less likely in the aftermath of a core-knowledge discontinuity for the reasons identified above (e.g., competence destruction, high risk, time compression diseconomies, and path dependence). The "borrow" option becomes less likely under weak appropriability regime because resources are not easily tradable through licensing agreements or equity alliances. Moreover, under a weak appropriability regime, new entrants are less likely to enter alliances with incumbents due to the fear of their novel core knowledge being misappropriated (Katila et al., 2008). The "buy" option, therefore, remains the most likely strategic response of incumbents in the specific environment of Quadrant III.b.

Following a core-knowledge discontinuity in an industry characterized by a weak appropriability regime (Quadrant III.b)…

> **Proposition 1b (P1b)** *Incumbents are more likely to acquire upstream entrants introducing the new core knowledge (rather than to cooperate with them).*

1.6 | Complementary-asset discontinuity (Quadrant IV)

Quadrant IV (in Figure 1) depicts an environment where the incumbents' complementary assets are no longer needed to commercialize within the new technology. At the same time, the incumbents' upstream core knowledge remains relevant to produce within the new technology. This quadrant, therefore, represents a complementary-asset discontinuity. Given the relative novelty of this construct, some illustrative examples may be helpful. In the news and higher education industries, for instance, the production of online reporting and teaching does not draw on a new knowledge base, but continues to rely on the existing core knowledge and expertise held upstream by traditional publishers and universities. Distributing content digitally is, however, radically novel and does not require previous physical assets of incumbents. In particular, the digital technologies are far superior in reach, scale, interactivity, and in time, to publication and distribution. In academia, for instance, massive open online courses (MOOCs) now provide an efficient and effective way to publish lectures and reach a large global audience in real time.[11] At the same time, the knowledge of the subjects and the owners of such know-how are essentially unaltered by the new complementary technologies. Other industries facing similar complementary-asset discontinuities are music, TV, radio, movie, and advertising after the new internet distribution—to mention a few cases.

Entrants in Quadrant IV are downstream entrants introducing the new complementary assets (differently from upstream entrants of core-knowledge discontinuities). Leading downstream entrants emerge after an era of ferment and competition to impose a dominant technological design

[11]In this context, NYU's Clay Shirky's assessment of what he calls the "artisanal" (i.e., traditional) model of instruction is quite illuminating: "The minute you try to explain exactly why we do it this way, though, the setup starts to seem a little bizarre. What would it be like to teach at a university where you could only assign books you yourself had written? Where you could only ask your students to read journal articles written by your fellow faculty members? Ridiculous. Unimaginable. Every college provides access to a huge collection of potential readings, and to a tiny collection of potential lectures. We ask students to read the best works we can find, whoever produced them and where, but we only ask them to listen to the best lecture a local employee can produce that morning. Sometimes you're at a place where the best lecture your professor can give is the best in the world. But mostly not. And the only thing that kept this system from seeming strange was that we've never had a good way of publishing lectures" (Gans, 2016, p. 52).

in manufacturing or distribution (Abernathy & Utterback, 1978). The literature suggests that dominant standards emerge due to network externalities (Schilling, 2002; Suarez, 2005). This is even more probable in the case of technological discontinuities in manufacturing, distribution, and sales (Quadrant IV), which can generate externalities. Similar discontinuities represent essentially changes in factors of production, and as such, they can generate external economies of scale and positive externalities (Marshall, 1920). According to the economist Alfred Marshall, advancements in the factors of production (e.g., electricity; internet) generate external economies of scale that afford economic benefits (e.g., cost reductions) to all companies. By reducing firm-specific advantage of internal scale economies (e.g., Ford's assembly line), external scale economies incentivize firms to exploit positive externalities outside of their boundaries to gain advantage. This can explain why leading downstream entrants after the internet discontinuity tend to be platforms orchestrating third-party products and services (Greve & Song, 2017).

In the newspaper example, the use of internet technologies allowed to reduce costs and increase other mutual benefits for all producers, distributors, and customers (hence, increasing positive externalities), and indeed, it favored the emergence of new digital platforms for content and advertising distribution. Another example from a different industry, the home video recording business, may additionally illustrate these points. In the 1980s, the battle between VHS (by JVC) and Betamax (by Sony) was fought to establish a new standard in downstream video distribution (hence, it was a complementary-asset discontinuity). VHS emerged as the dominant platform because JVC engaged with content producers (e.g., Universal) and with customers by creating a video recording technology that satisfied the need of recording up to 2-hour long movies. JVC appeared to comprehend better than Sony the critical role of network externalities induced by the new distributive technology among content producers, customers, and manufacturers. In sum, after complementary-asset discontinuities in manufacturing and distribution, we assume that positive externalities tend to increase[12] (Farrell & Saloner, 1985; Marshall, 1920) and industries are more likely to converge on common standards and compatible solutions in the form of platforms (Greve & Song, 2017; Schilling, 2002 ; Suarez, 2005). These solutions are initially offered by entrants competing downstream, and in this study, we examine the (cooperative) responses of incumbents to offer similar proprietary solutions.

The industry value chain following complementary-asset discontinuities is one in which incumbents lack the new downstream complementary assets, while downstream entrants lack the upstream core knowledge (Quadrant IV). This situation is symmetrical to the industry value chain after core-knowledge discontinuities, when incumbents lack the new upstream core knowledge and upstream entrants lack the specialized downstream assets (Quadrant III). Despite the fact that the two post-discontinuity value chains seem to be symmetrical and mirroring each other, they are profoundly different and generate different competitive and cooperative outcomes. Rather than expecting vertical cooperation between incumbents and entrants (the prediction for Quadrant III), in the case of Quadrant IV, we predict horizontal cooperation among incumbents. To explain our different prediction, we utilize a step-by-step approach. We need to explain: (a) why incumbents do not cooperate with downstream entrants (as their first-best option), (b) why incumbents do not develop the new

[12]This assumption is neither particularly strong nor restrictive. Marshall (1920) theorized that changes in the external factors of production can cause external economies of scale and positive externalities. Hence, the assumption that complementary-asset discontinuities in manufacturing and distribution ("factors of productions") give rise to network externalities is not a strong assumption, and economic theory even predicts this outcome. Moreover, it is not restrictive or unique to changes related to the "digital revolution." For instance, the technological advancements by Tesla in electric charging stations represent a downstream discontinuity for incumbent car manufacturers that rely on a network of gas stations (hence, a "non-digital" example). New network externalities exist among car producers, battery manufacturers, and customers. The emergence of a technological standard will depend on the ability to consider these externalities.

assets by going it alone, and (c) why incumbents ultimately turn to cooperation among themselves (and compete against entrants).

First, incumbents (in Quadrant IV) do not have an incentive to cooperate with downstream entrants because the entrants control the new specialized assets through which they can capture the value created by incumbents. Moreover, incumbents tend to be resources-rich and could, in theory, attempt to build new proprietary assets. Indeed, the literature indicates that incumbents should own specialized complementary assets internally to exclusively appropriate the value they create upstream (Chandler, 1990; Teece, 1986). Furthermore, based on prospect theory (Kahneman & Tversky, 1979), vertically integrated incumbents may perceive downstream entrants as a significant threat of losses because these new ventures capture the value incumbents were originally appropriating. This perception stands in contrast to that held by incumbents in Quadrant III, where upstream entrants might be perceived as a net positive because incumbents are able to capture value created by the new entrant innovation (Gans & Stern, 2003).

Second, incumbents (in Quadrant IV) are unlikely to develop new specialized downstream assets in isolation. As discussed above, downstream discontinuities at the distribution and manufacturing level are likely to evince network externalities. Thus, new downstream assets are likely to emerge as a new standard or a platform for downstream distribution (Schilling, 2002; Suarez, 2005). Downstream entrants emerging as platform leaders are companies gaining advantage by aggregating users into a large installed base and by matching multiple partners in a standardized and convenient way (Gawer & Cusumano, 2002, 2008; Greve & Song, 2017). Technological competition for distributive platforms tend to follow a winner-take-all logic (Cennamo & Santalo, 2013). Therefore, an incumbent attempting to build a platform in isolation is likely not to reach a sufficiently large critical mass, and thus, is unable to exploit externalities to develop effective standards (Farrell & Saloner, 1985). This implies that incumbents are unlikely to develop new downstream assets on their own.

Third, incumbents respond by cooperating among themselves to address the common threat that the downstream specialized assets introduced by entrants pose. The new downstream assets are specialized and inimitable, and thus, are not available on the open market (Teece, 2006). These new proprietary assets constitute a value appropriability hazard for all old-line incumbents. By representing a common threat, they induce incumbents to cooperate among themselves. This insight has been highlighted in prior literature on intra-industry consortia (Doz, 1996; Doz, Olk, & Ring, 2000). For instance, U.S. semiconductor manufacturers responded to the threat of high-quality, low-price products of Japanese manufacturers by forming a R&D consortium SEMATECH (Browning et al., 1995). Teece (1992, p. 12) argued that "horizontal alliances can assist in the definition of technical standards for systemic innovation. Horizontal alliances can also assist firms to overcome the appropriability (spillover) problem" (see also Ranganathan, Ghosh, & Rosenkopf, 2018). An additional reason for incumbent cooperation and more specific to complementary-asset discontinuities, is the possibility to create critical mass, and thus, to exploit network externalities. We expect incumbents to develop downstream complementary assets jointly because a common solution is necessary to compete against downstream entrants that are product neutral and orchestrate upstream producers. A related reason for incumbents to cooperate among themselves is that they can bundle their own product offerings on a proprietary platform. This bundling satisfies the customers' need to access key product offerings by visiting a single distributive platform (Gawer & Cusumano, 2008; Parker & Van Alstyne, 2005). A bundling strategy is especially effective if demand for the different products is negatively correlated to some extent (Bakos & Brynjolfsson, 1999). By bundling their differentiated products, incumbents are likely to increase net demand and to reduce the search-and-coordination costs (Amit & Zott, 2001; Williamson, 1991a, 1991b). Moreover, bundling core products on a proprietary platform allows incumbents to protect the value of their core knowledge, as opposed to a situation in which incumbents let their products to be exchanged on downstream entrants' platforms in perfect competition with a large number of suppliers offering products and services of widely varying quality.

1.6.1 | Complementary-asset discontinuity under a weak appropriability regime (Quadrant IV.b)

Under a weak appropriability regime, incumbents possessing upstream core knowledge have little or no incentive to cooperate with downstream entrants. Rather, the incumbents have a high incentive to cooperate among themselves. Indeed, in the absence of strong IP protection, inventions and other knowledge goods are easily imitable, and therefore, not tradable using contractual arrangements (e.g., patents, licenses, and copyrights). Therefore, when an effective market for ideas is absent (Gans & Stern, 2003), the possession and control of downstream specialized assets becomes critical to value capture from innovation. The absence of value protection mechanisms induces incumbents to cooperate among themselves to develop joint assets, ideally prior to downstream entrants imposing a dominant standard (Ranganathan et al., 2018; Schilling, 2002).

Two industry examples serve as brief illustrations of industries operating under a weak appropriability regime: newspapers and academia (Quadrant IV.b). The IP regime of newspapers is weak because news content can be easily imitated, copied, and redistributed. Similarly, most lectures in academia can be codified and publicly diffused and are thus easily imitable. Traditional publishers and universities both possess the relevant core knowledge to produce high-quality content or lectures online. The protection for these institutions traditionally derived from being integrated downstream to control specialized complementary assets such as classroom facilities and printing presses.[13] However, the internet has introduced new manufacturing and distributive assets that are vastly superior in terms of price/performance, efficiency, and other relevant performance attributes.

Regarding the news publishing business, examples of downstream entrants are Google News, Facebook Newsfeed, and Flipboard (*The Wall Street Journal,* 2016b),[14] but also technology companies operating as "ad exchanges" and "ad networks" in the online advertising space, such as DoubleClick, AppNexus, and AdRoll. These platforms specialize in improving the user experience and distribution efficiency of third-party content and ads. Incumbent publishers perceive these downstream entrants as a threat because they are able to capture significant value while not producing any content and ads on their own (*The Independent,* 2015), and also because they put incumbents and any upstream producer in competition with one another on their platforms (*The Wall Street Journal,* 2016b). In a special report about the future of journalism, *The Economist* (2017) stated that "there is no confusion about where the power lies [in the hands of Google and Facebook]…, although publishers are fighting back a bit."[15] Consistently with our prediction, incumbent newspapers responded to such complementary-asset discontinuity by forming consortia among themselves,

[13]Within the old technology, the printing presses of incumbent firms in the newspaper industry were specialized complementary assets; they could only be used to print newspapers, and only to pre-determined, highly detailed specifications. Important elements of differentiation derived from customized printing presses for each major publisher included the size of the newspaper (tabloid or broad sheet), color (full color, including ads, or black and white), type of ink (oil-based or water-based), and so forth. Owning specialized printing presses also allowed newspapers to optimize their supply chains in terms of shortest possible delivery times to newsstands, businesses, and homes as well as to optimize the size of the print run. As a consequence, most newspaper companies tended to be fully vertically integrated along the value chain, from content creation to point of sales.

[14]When being criticized for posting "fake news," Mark Zuckerberg, Facebook's co-founder and CEO, stated that "Facebook is a new kind of platform. It's not a traditional technology company. It's not a traditional media company.… We don't write the news that people read on the platform" (*Tech Crunch*, 2016).

[15]*The Economist* (2017) also reported that: "In America a consortium of nearly 2,000 news organizations, the News Media Alliance, is asking Congress for an antitrust exemption to allow publishers to negotiate collectively with the two firms [Google and Facebook]." This corresponds with our prediction of how the cooperative dynamics are expected to unfold over time in Proposition 6a.

both in the news and advertising business. Examples are the Premium Publisher Network (PPN) and Gold5, formed, respectively, in 2009 and 2014 by Italian newspaper publishers as consortia to develop technology platforms to pool proprietary classified ad spaces and video ads (to countervail Google's AdWords, YouTube, and similar video distribution platforms). Equivalent alliances among publishers have been formed in France (e.g., La Place Media), Germany (e.g., AdAudience), Spain (e.g., Aunia), United States (e.g., Local Media Consortium; News Media Alliance), and in most other countries.

In academia, examples of downstream entrants include Udemy (in 2010) and Udacity (in 2011).[16] In creating large-scale digital platforms, the downstream entrants offer third-party courses, enabling instructors (upstream knowledge owners) to produce and distribute content online (*Forbes,* 2013). Within academia, the reaction by elite universities has been the creation of intra-industry consortia aimed to pool some of the best online courses onto their own proprietary platforms. Currently, most of the top-ranked universities worldwide are organized into two global consortia: Coursera and edX. Coursera was founded in 2012 by two Stanford professors and counted more than 130 universities by 2016, while edX was founded as a joint venture between Harvard and MIT in 2012 and counted 42 universities by 2016.

In sum, a weak appropriability regime is likely to exacerbate the value appropriation and value protection concerns of incumbents facing complementary-asset discontinuities. This is a more extreme case of the general theoretical mechanism discussed above. Absent the intellectual property mechanisms to safely license the core knowledge to downstream entrants, incumbents are likely to form horizontal alliances among one another to develop new proprietary complementary assets (value capture), and to protect incumbents' upstream core knowledge from downstream platforms' misappropriation and commoditization (value protection). The development of common proprietary platforms also helps to better serve the needs of customers to achieve more efficient consumption; furthermore, it mitigates the technological uncertainty for each incumbent in the immediate aftermath of the discontinuity.

Following a complementary-asset discontinuity in an industry characterized by a weak appropriability regime (Quadrant IV.b)…

> **Proposition 2a (P2a)** *Incumbents are more likely to form strategic alliances with other incumbents (rather than with downstream entrants).*

1.6.2 | Complementary-asset discontinuity under strong appropriability regime (Quadrant IV.a)

We argue that when the IP protection is strong, the owners of the core knowledge (incumbents in Quadrant IV) have stronger incentives to cooperate with the owners of the new complementary assets. We predict this outcome because, when IP regimes work properly, incumbents have recourse to the legal system and can sue distributors in cases of illegitimate value misappropriation (through imitation, lack of payments, etc.) (Williamson, 2000). This makes incumbents more prone to commercialize their products jointly with the new owners of complementary assets (see Quadrant IV.a in Figure 2).

Other challenges and dynamics discussed earlier, however, remain relevant under a strong appropriability regime. Regardless of the IP regime, incumbents face the same challenges following a complementary-asset discontinuity: the need to reach a large critical mass due to

[16]The online education platform Udacity was founded by Stanford professor Sebastian Thrun after co-teaching a free online course (Introduction to Artificial Intelligence), where some 160,000 students enrolled (Gans, 2016).

improvements in manufacturing and distribution; the need to facilitate more efficient consumption; and the need to limit misappropriation by the new owners of specialized downstream assets. Therefore, we expect that the cooperation between incumbents and downstream entrants in Quadrant IV.a is likely to occur alongside cooperation among incumbents to compete with downstream entrants. We predict this "hybrid" dynamic of competition and cooperation for at least two reasons. First, incumbents can increase their bargaining power by cooperating among themselves and then allying with the downstream entrants. This can be done, for example, by creating common legal entities among incumbents to coordinate IP licensing decisions in order to exert more bargaining power over the downstream distributors or to collectively bargain for more favorable legislation. By developing a proprietary downstream platform, incumbents can also introduce additional competition at the downstream distribution level, and thus, further strengthen their bargaining position. Second, incumbents can reduce their resource dependence and exposure to technological uncertainty (Abernathy & Utterback, 1978; Katila et al., 2008) as well as hedge against potential platform failure by simultaneously developing their own distribution network (Schilling, 2002).

Two global industries, such as music and movies, are good examples of industries within Quadrant IV.a. In comparison to news and education, music and movies just are examples of a stronger IP regime. Once a news article is read or a lecture delivered, the central meaning can be plagiarized or paraphrased almost immediately in many different formats. News products are additionally characterized by a short lifespan that makes it difficult to seek legal recourse before the copyright protection expires, and discontinuous technological advancements in distribution make imitation faster than recourse to protection for individual infringements.[17] Music and movies are, instead, more difficult to imitate and more easily discovered when imitated. The much lengthier shelf life of music tracks and movies makes any inappropriate use apparent and makes legal recourse much more likely.[18] The legal process in the music sector is supported by global nonprofit organizations that monitor, collect, and redistribute royalties (e.g., ASCAP—the American Society of Composers, Authors, and Publishers). Movies are more costly to imitate technically, and this is why they are distributed without any repackaging or modifications, quite similarly to music but differently from online news and lectures. As a consequence, inappropriate third-party distribution can be easily detected in the case of music and movies. Certainly, copyright infringements happen in these industries. However, the nature of the knowledge goods and the higher effectiveness of legal mechanisms (two key conditions for appropriability in Teece, 1986, 2006) make the IP regime in these industries strong enough to induce the owner of the upstream knowledge (e.g., music publishers or TV networks) to license to third-party distributors.

Take, for instance, the case of Spotify and traditional music publishers (record labels). Spotify, a Swedish startup founded in 2008, is a downstream entrant in the music industry. The company developed a platform to distribute music through online streaming. From the perspective of vertically integrated record labels, Spotify entered the downstream distribution level rather than the upstream content production part of the value chain. Music publishers collaborate with Spotify to distribute their music through its platform; in turn, Spotify pays royalties to the publishers. Interestingly, the major music publishers own an equity stake in Spotify (*The Wall Street Journal,* 2016a). In this way, major incumbent labels such as Universal Music, Warner Music, and EMI, can

[17]Large-scale and persistent copying of news headlines and article summaries such as that of Google News has led to legal judgments restricting such wholesale copying activity.

[18]Please recall that Apple's iTunes was not allowed to carry songs by The Beatles for a decade because Sony/ATV Music Publishing, which owns most of the Beatles music, was not willing to license it to Apple.

coordinate among themselves in regards to revenue sharing and to negotiate better licensing deals with this downstream entrant. Supporting this strategic intent, Spotify indeed pays relatively high royalties to music publishers (about 70% of its revenues). Therefore, the structure of the cooperation is such that incumbents indirectly cooperate among themselves (through common equity participation and de-facto control of a common downstream entrant), and then cooperate with the same new entrant to use its new infrastructure for product commercialization. Following a complementary-asset discontinuity, the existence of a relatively strong appropriability regime evinces cooperation between incumbents and new entrants.

An example from the movie industry is the relationship between Netflix and incumbents like TV broadcasters or Hollywood studios. Founded in 1997 as a postal distributor of DVDs, by 2007 Netflix entered the video-on-demand industry by developing a streaming platform. Netflix, therefore, is a downstream entrant in the value chain of the motion picture and TV industry. During the first decade of Netflix's existence, movie producers collaborated with the downstream entrant by licensing their content in exchange for royalty payments. The global expansion and rapid growth of Netflix into a major digital platform in combination with intensified internet competition (e.g., Amazon Prime, Apple's video services) has gradually induced movie producers and TV broadcasters to be much more cautions with Netflix (and similar downstream entrants). By 2013, Netflix decided to integrate backward by producing its own content (e.g., *House of Cards*) because traditional movie studios and TV producers were charging Netflix too much for its content.[19] The backward integration by Netflix also reveals its desire to reduce its dependence on traditional content producers (*The New York Times,* 2014). The strategic reaction of established incumbent studios and TV broadcasters has been the formation of alliances among themselves (and against Netflix) to develop their own proprietary platforms. In 2014, the two Hollywood studios, Lionsgate and Tribeca, launched an online video service, Tribeca Short List, to compete against Netflix. In the same year, the two TV broadcasters CBS and HBO also announced their own stand-alone streaming service (*The Washington Post,* 2014). A further example is video-on-demand service Hulu, a joint venture created by Disney, 21st Century Fox, NBC Universal, and Time Warner (*Fortune*, 2016). These intra-industry cooperative arrangements among incumbents are put in place, while continuing to distribute their content through Netflix.

In sum, we expect that, under a strong appropriability regime, incumbents are more likely collaborate with downstream entrants to access their new complementary assets (because the incumbent's core knowledge can be protected by a fairly strong IP regime). At the same time, we also expect that incumbents are likely to cooperate among one another to develop their own downstream assets to compete more effectively with downstream entrants (in order to reduce the value appropriation by downstream entrants and maintain a certain amount of control over the value chain).

Following a complementary-asset discontinuity in an industry characterized by strong appropriability regime (Quadrant IV.a)…

> **Proposition 2b (P2b)** *Incumbents are more likely to form alliances with other incumbents and also to cooperate with downstream entrants introducing the new complementary assets.*

1.7 | Firm-level heterogeneity

Until now, we followed the approach of earlier research on the dynamics of technological change by focusing on incumbents as a more or less homogenous group (Christensen & Bower, 1996;

[19]Reed Hastings, co-founder and CEO of Netflix, 2016 WSJDlive conference in Laguna Beach, CA, October 26, 2016.

Foster, 1986; Henderson & Clark, 1990; Tushman & Anderson, 1986). This important line of research has clearly advanced our understanding of technological change and the performance implications for incumbent firms. In the perspective taken in most of prior work, however, differences across incumbent firms are not fully considered because incumbents are often viewed as a group that is either successful or unsuccessful in adapting to technological change. We submit that additional insights for strategy researchers can be gained by unpacking firm-level heterogeneity. One major benefit of studying technological discontinuities is that they create a natural laboratory for the researcher because all incumbent firms are exposed to the same exogenous treatment effect (i.e., the discontinuity). However, given internal firm differences in terms of resources and capabilities (Barney, 1991; Teece et al., 1997), we predict some variance in firm-level performance in the post-discontinuity time period.

We posit that one source of firm-level heterogeneity that affects the dynamics of cooperation and competition is firm status. Podolny defined a firm's status as "the perceived quality of that producer's products in relation to the perceived quality of that producer's competitors' products" (1993 p. 830). Research on status reveals that high-status firms enjoy numerous benefits, including higher growth rates, the ability to charge premium prices, and cost advantages (Benjamin & Podolny, 1999; Podolny, 1993; Stuart et al., 1999). A firm's status can be a signal of value, and as such, reduces the uncertainty about the quality of its products and services (Podolny & Stuart, 1995). In our analysis on firm-level heterogeneity, we focus on Quadrant IV (in Figure 1) because we submit that the effect of a complementary-asset discontinuity on the coopetitive dynamics between incumbents and entrants presents the more novel theoretical contribution.[20]

1.7.1 | High-status incumbents

By making available more performing manufacturing and distribution technologies, a complementary-asset discontinuity induces product abundance, market fragmentation, and with it, a high level of uncertainty: all of which makes product search, selection, and comparison much more challenging. Therefore, the identification of a producer's perceived quality becomes a crucial signal for customers (Connelly, Certo, Ireland, & Reutzel, 2011). In a condition of product abundance, therefore, perceived quality and brand names are important competitive differentiators (D'Aveni, 2010; Lee, 2001). As such, we expect that the status of an incumbent organization becomes an especially useful proxy to signal a product's quality (Podolny, 1993). When faced with high uncertainty, incumbents are likely to rely on status as a strategic lever to protect the value of their upstream core knowledge. This reliance is necessary because the incumbent firms' product and service offerings are at the risk of commoditization caused by product abundance.

A second critical feature of organizational status in our context is that status transfers from one entity to another through affiliations (Stuart et al., 1999). When a high-status organization enters in an exchange relationship with a lower-status partner, the status of the former organization can decline by transferring to the latter (Podolny, 1993). To avoid this negative spillover effect, high-status organizations typically affiliate with other high-status organizations, in particular, when entering strategic alliances to build their networks (Greve, Rowley, & Shipilov, 2014).

Two interesting theoretical questions that arise following technological discontinuities are: Although homophily predicts that high-status actors are more likely to cooperate with other high-status actors, how does a high-status incumbent chose a high-status partner among the two possible

[20]We do not distinguish between the strengths of different appropriability regimes explicitly, but we can expect that status affiliation acts in the same direction. In a weak appropriability regime, however, status becomes even more important in predicting who is partnering with whom.

options that present themselves after a discontinuity? Should the high-status incumbent partner with another high-status incumbent or partner with a high-status entrant?

We expect that high-status incumbents are more likely to cooperate with other high-status incumbents than with high-status entrants. This is because incumbents in Quadrant IV face a similar threat, moreover, they benefit from increasing their status perception as producers by allying among themselves (rather than with a high-status distributor such as a downstream entrant). By pooling their product and service offerings on a joint proprietary platform, high-status incumbents can reciprocally strengthen and reinforce their status due to positive feedback signals. Status accumulation, in turn, has been linked to higher market performance (Shipilov & Li, 2008). The synergies from the cooperation of similarly high-status incumbents, therefore, do not exclusively result from learning, cost and risk sharing, as emphasized in prior work on consortia, networks, and alliances (Browning et al., 1995; Doz et al., 2000; Gulati, 1998; Hagedoorn, 1993), but perhaps even more important, derive from a mutual recognition in the market for being part of a select group consisting of high-quality producers. Such interfirm cooperation among high-status incumbents is used to signal differentiated product value to potential buyers, and to ultimately protect the upstream core knowledge and resulting products and services of the high status incumbents.

In each of the industries previously considered, the initial consortia as a response to the downstream technological changes were all formed by high-status actors in the respective industry. The publishers' consortia (e.g., Premium Publisher Network, Gold 5, AdAudience, Aunia, and Pangaea Alliance) represent exclusive coalitions of high-status news media in each country.[21] Universities have followed a similar association path when forming early joint ventures in their response to the digital disruption of their traditional business model (e.g., AllLearn, among Oxford, Princeton, Stanford, and Yale) and in their most recent global consortia edX and Coursera.[22]

Taken together, we submit that high-status incumbents are more likely to cooperate among themselves than with high status-entrants to send a unified quality signal regarding their core products, reciprocally enhance their superior reputation, and to protect their upstream core knowledge.

Following a complementary-asset discontinuity (Quadrant IV)…

> **Proposition 3 (P3)** *High-status incumbents are more likely to form strategic alliances with other high-status incumbents (rather than with high-status downstream entrants).*

1.7.2 | Low-status incumbents

For low-status incumbents, in contrast, the partnering options in the aftermath of a complementary-asset discontinuity are quite different. Low-status incumbents are in need to increase their status through affiliations with more reputable partners. The theoretically relevant question, therefore, is: Will low-status incumbents search out alliances with high-status incumbents or with high-status entrants?

We submit that low-status incumbents are unlikely to attract high-status incumbents as alliance partners. This inability is because the perceived inferior quality products of the low-status incumbents could potentially damage and dilute the standing enjoyed by the more prestigious high-status

[21] The global revenue director of *The Guardian* commented: "Pangaea's uniqueness lies in the quality of its partners. We know that trust is the biggest driver of brand advocacy, so we have come together to scale the benefits of advertising within trusted media environments" (*The Guardian*, 2015).

[22] For example, edX (formed by Harvard and MIT) states its goal to "offer the highest quality courses from institutions who share our commitment to excellence in teaching…" and that "member institutions are a carefully selected group of universities…" (edX website, accessed on July 27, 2016).

incumbents (Podolny, 1993). What is more interesting theoretically is to consider the possibility of low-status incumbents allying with high-status new entrants. Low-status incumbents are frequently underperforming, and as such, are more likely to take the risk of partnering with unfamiliar firms (Baum, Rowley, Shipilov, & Chuang, 2005). This implies that low-status incumbents view their chances of continued survival in the face of a complementary-asset discontinuity reduced, and are thus more willing to compromise their core knowledge by entering alliances with downstream entrants, providing the new complementary assets. Low-status incumbents, therefore, face a strategic decision point much sooner than high-status incumbents.

Low-status incumbents, moreover, often do not have sufficient access to capital and other resources to go it alone (Powell, Koput, & Smith-Doerr, 1996; Stuart et al., 1999). Low-status incumbents, therefore, are likely not able to build the new downstream complementary assets needed to commercialize their upstream core knowledge, even in a consortium among peers. Given this situation, entering an alliance with a leading downstream entrant might be an attractive alternative for low-status incumbents. In particular, entering an alliance with a high-status new entrant entails several benefits for the low-status incumbents. First, low-status incumbents may use a partnership with a leading new entrant to technologically leapfrog high-status incumbents in the post-discontinuity time period (Schilling, 2003). Second, entering an alliance with a high-status new entrant might increase the perceived standing of the low-status incumbent through the endorsement effect (Stuart et al., 1999). In their study of Formula One racing, Castellucci and Ertug (2010) showed that low-status engine suppliers partner with high-status race teams to improve their standing in exchange for higher effort by the low-status actor. Similarly, in the context of a downstream digital discontinuity, we expect that a lower-status university or newspaper is more likely to partner with a high-status new entrant such as Google. Low-status incumbents are motivated to enter such partnership to not only benefit from Google's technological excellence, but also to demonstrate to its stakeholders that it is able to engage with the best-in-class technology company, thus bolstering its own status. In turn, a high-status downstream new entrant is likely to partner with a low-status incumbent because the entrant is in need of access to content, and unlikely to persuade high-status incumbents to provide access to their core knowledge. High uncertainty in the aftermath of a discontinuity combined with constraint resources makes it likely that low-status incumbents reach such a decision point sooner than later.

An illustrative example here is the Local Media Consortium in the United States, founded by newspapers such as MediaNews Group, Hearst, Belo, Scripps, Journal Register, Lee, and Cox. The origin of this multi-partner alliance dates back to 2006, when some 200 local newspapers joined a consortium and then partnered with Yahoo to develop a proprietary ad network. In 2010, a media analyst explained that "it was the ad tech (by Yahoo) that made the deal appealing to newspaper companies, who couldn't afford to develop those platforms on their own" (*Nieman Journalism Lab,* 2014).[23] By 2016, the consortium included more than 1,600 daily newspapers as well as local radio stations and TV broadcasters. It further extended its downstream collaborations to also include Google, Monster (a leading employment website), and other high-status tech platforms. In line with our conjecture, however, none of the four most prestigious newspapers in the United States—*The Washington Post, The New York Times, The Wall Street Journal,* and *The Los Angeles Times*—decided to join this specific consortium.[24]

[23]In 2006, although only a shadow of its former self and up for sale, Yahoo was still considered to be one of the leaders in online advertising. Indeed, in 2008, Microsoft offered $48 billion to acquire Yahoo. In 2017, Verizon paid a mere $4.5 billion when acquiring Yahoo.

[24]Local Media Consortium website, accessed July 27, 2016.

Following a complementary-asset discontinuity (Quadrant IV)…

Proposition 4 (P4) *Low-status incumbents are more likely to form strategic alliances with high-status downstream entrants (rather than with high-status incumbents).*

1.8 | Time dynamics and cooperative equilibria

To understand how enduring the predicted cooperative equilibria are over time, we now take a closer look at the intertemporal dynamics across the cooperative diagonal (Quadrants III and IV in Figure 1).

1.8.1 | Time dynamics following core-knowledge discontinuities

We posit that the cooperative equilibrium between incumbents and entrants in following a core-knowledge discontinuity (Quadrant III in Figure 1) becomes less stable as time progresses. We also argue that each group, incumbents and entrants, strives for vertical integration over time in order to enhance value capture (Chandler, 1990; Teece, 1992).[25]

The synergies driving alliance formation between incumbents and entrants in Quadrant III result from comparative advantages across different, yet matching parts of the value chain. In particular, entrants concentrate on their strength in new upstream core knowledge, while incumbents focus on specialized downstream complementary assets. These types of synergies can be a source of relational rents because they rely not only on the matching of complementary resources and knowledge sharing routines, but also tend to be idiosyncratic to the specific collaboration (Dyer & Singh, 1998). Relational rents, moreover, generally increase with the degree of complementarity of across the resources being shared (Lavie, 2007).

As time progresses, however, the degree of asset specificity and complementarity is likely to decline for a host of reasons (Dyer et al., 2018). Asset specificity and complementarity of partner resources may diminish over time because of increasing redundancies in the alliance, commoditization, and environmental changes. Knowledge resources might become redundant as partners learn from each other (Hamel, 1991) and resources may become commoditized as other firms imitate them (Peteraf, 1993). Last, knowledge also diffuses over time across organizations (Appleyard, 1996). The case of genetic engineering and recombinant DNA is apt to consider here: What was hailed as a breakthrough invention in 1973 when a research team around Stanley Cohen and Herbert Boyer published their findings (Cohen, Chang, Boyer, & Helling, 1973) is today taught in entry-level college biology courses.

Perhaps an even greater threat to any cooperative equilibrium in Quadrant III is that the partner firms have an incentive to learn from one another (Hamel, 1991). Here, the firm that is faster in learning the partner's knowledge has an incentive to exit the alliance in order to create and capture value within the new technology on their own. Careful theoretical work has emphasized the role of private and public benefits to collaboration as predictors of alliance termination (Khanna, Gulati, & Nohria, 1998). Private benefits are skills that the focal firm acquires from its partner and applies internally to areas unrelated to the alliance. Common benefits, in contrast, are a function of the joint knowledge creation in an alliance and accrue to each partner, albeit not necessarily in equal parts. Khanna et al. (1998) demonstrated that the greater the ratio of private benefits to common benefits,

[25]We analyze time dynamics and cooperative equilibria without distinguishing between weak and strong appropriability regimes. We submit, however, that the directions of propositions hold in either case, with the incentives for faster vertical integration being stronger in weak appropriability regimes.

the more unstable an alliance and vice versa. Applying this theoretical lens to the vertical alliances ensuing in Quadrant III, we note that the potential for common benefits tend to be small and that for private benefits to be rather large, especially as time progresses. The main reason is that the collaboration is based on a simple division of labor by joining matching parts of the value chain, rather than on an attempt to jointly create knowledge. This type of collaboration necessarily limits the potential for common benefits in alliances between incumbents and new entrants following core-knowledge discontinuities.

Taken together, both parties have a fairly strong incentive to learn from one another. Old-line incumbents are highly motivated to learn the capabilities underlying a core-knowledge discontinuity to ensure continued survival and competitiveness (Sosa, 2011). Indeed, incumbents may even acquire new technology ventures to ingest the new core knowledge (Capron & Mitchell, 2012), an option that is becoming more attractive as time progresses and the value of new entrants reveals itself more clearly. New entrants, in turn, are motivated to acquire the know-how behind downstream specialized complementary assets to no longer share the value created upstream, and more important, to protect their intellectual property underlying the new upstream technology more effectively (Gans & Stern, 2003; Rothaermel & Deeds, 2004). Consequently, over time, we submit that the ratio of private to common benefits increases and the collaborative equilibrium in Quadrant III is becoming commensurately unstable. We thus submit that, as time progresses and uncertainty surrounding the new core knowledge is reduced, incumbents are more likely to backwardly integrate by developing new core knowledge. Conversely, new entrants are more likely to forwardly integrate by building downstream complementary assets.

The more recent history of the biopharma industry provides evidence for these conjectures. Today, all the major old-line pharmaceutical companies engage in internal R&D to discover, develop, and commercialize new biotech compounds. As they engage in more acquisitions, the large pharma firms commensurately exit strategic alliances with new biotech ventures (*Financial Times*, 2016). At the same, the most successful biotech ventures such as Amgen are now fully vertically integrated, stand-alone pharma companies.

Following a core-knowledge discontinuity (Quadrant III)…

Proposition 5a (P5a) *Over time, incumbents are more likely to backwardly integrate, and commensurately, more likely to exit alliances previously entered with upstream entrants.*

Proposition 5b (P5b) *Over time, upstream entrants are more likely to forwardly integrate, and commensurately, more likely to exit alliances previously entered with incumbents.*

Noteworthy is that attempts of incumbents to backwardly integrate is not a function of upstream entrants exiting vertical alliances with incumbents (and vice versa). This implies that backward integration by incumbents is not triggered by upstream entrants exiting alliances, nor is forward integration triggered by upstream entrants as a reaction to incumbents terminating alliances. Rather, the incentives to vertical integration are strong ex ante because they allow full capture of the value generated by the innovation (Gans & Stern, 2003; Teece, 1992), and thus, benefits to full integration frequently outweigh its costs (Chandler, 1990). Indeed, attempts by incumbents and upstream entrants to vertically integrate should be seen as more or less independent strategic decisions. Although both old-line incumbents and new entrants each have strong incentives to vertically integrate in order to capture the full value creation of the innovation and to mitigate transaction hazards

(Williamson, 1991b), we posit that backward vertical integration for incumbents is likely to be easier than forward integration for new entrants. Integration is easier for incumbents because they tend to be the larger, more resource-rich firms that can more easily enter new technology fields on their own, especially if they own specialized complementary assets (Mitchell, 1989; Tripsas, 1997). In contrast, new upstream entrants are generally resource-constraint startups with a high cash burn rate because their research is frequently R&D intensive, and thus, expensive (Rothaermel & Deeds, 2004). Although a few of the upstream entrants might be able to forwardly integrate, most will not. The few upstream entrants that might accomplish forward vertical integration, however, stand to gain significantly.

Again, the pharmaceutical industry after the emergence of biotechnology provides an apt illustration. While all of the leading pharmaceutical companies are now active in-house in the new biotechnology field, only a few standout firms such as Amgen, Genentech, and Gilead Sciences were able to forwardly integrate and become standalone biopharma companies. Among the top-10 biopharma companies in 2016 by revenues, only one (Gilead Sciences) was an upstream entrant, while all others were old-line pharma companies. Amgen, another outstanding upstream entrant, came in number 11. All three of the mentioned star performers in biotech (Amgen, Genentech, and Gilead Sciences) had morphed into stand-alone pharma companies through forward vertical integration.[26]

Following a core-knowledge discontinuity (Quadrant III)…

> **Proposition 5c (P5c)** *The likelihood of successful backward integration by incumbents is higher than the likelihood of successful forward integration by upstream entrants.*

1.8.2 | Time dynamics following complementary-asset discontinuities

Earlier, we argued that, in the aftermath of a complementary-asset discontinuity, incumbents are likely to cooperate among themselves to build new proprietary downstream assets and protect their upstream core knowledge (Quadrant IV in Figure 1). Here, we argue that, if a downstream entrant should over time succeed in establishing a dominant platform, incumbents are then more likely to cooperate with the new entrant.[27]

Downstream entrants are likely to emerge as platform leaders for a number of reasons. First, new entrants do not face the replacement effect, and thus, do not have to worry about cannibalizing any existing business (Arrow, 1962; Gans, 2016). Second, new entrants are not encumbered by the difficulties of implementing architectural innovations that span upstream core knowledge and downstream distribution (Henderson & Clark, 1990). Barnes & Noble, for example, was unable to develop a downstream digital platform despite its early advantage in access to upstream content (books), and ultimately, lost against Amazon.com, a downstream entrant. Third, and perhaps most important, downstream entrants as pure distributive platforms are producer neutral regarding the source of upstream products, and thus, are likely to benefit from greater network externalities (Cennamo & Santalo, 2013; Parker & Van Alstyne, 2005). In contrast, incumbents typically develop proprietary platforms to distribute only their own products, as in the case of universities' or publishers' consortia, and therefore, their potential scale is limited. Given that positive network effects increase often exponentially with the number of product offerings and users, downstream entrants'

[26]After a set of different alliances with old-line pharma companies and subsequent successful forward integration, Genentech was acquired by Novartis, another old-line pharma company.

[27]This relationship holds regardless of the incumbent's status, which we highlighted earlier as one potential source of firm-level variance.

platforms reaching larger network sizes are likely to become leaders through the winner-take-all dynamic (Schilling, 2002).

The platform leader controls access to the end consumer, which puts it in a strong position to capture a significant amount of the value created upstream (Gawer & Cusumano, 2008). Indeed, we submit that a platform leader has a similar effect on an industry evolution as does a dominant design in technology development (Abernathy & Utterback, 1978), the third building block identified by Teece (1986) that determines who profits from innovation. If a downstream entrant is able to become the platform leader following a complementary-asset discontinuity, upstream incumbents eventually may have no choice but to cooperate with the downstream entrant. The emergence of a dominant platform can create a bandwagon effect and incumbents may ultimately need to ally with the platform leader, the new de facto standard for distribution and commercialization. Recently, both the venerable *New York Times* and CNN, the former leader in cable news, entered an alliance with Facebook to license some of their content to the social network (*The Wall Street Journal*, 2016b). With some 2 billion users, Facebook is a platform leader and has become the de facto "news and media" outlet for many of its users (see also, *The Economist,* 2017).[28]

Commensurately, to complete a picture of industry evolution following a complementary-asset discontinuity, we advance the proposition that downstream entrants are more likely to backwardly integrate over time if a platform leader does not emerge. The digital disruption in the TV industry provides an apt illustration: Downstream entrant Netflix integrated backwardly into developing its own content, while old-line incumbents succeeded to form the proprietary TV and movie-streaming service Hulu.

Following a complementary-asset discontinuity (Quadrant IV)…

Proposition 6a (P6a) *Over time, if a downstream entrant emerges as a platform leader, incumbents are more likely to enter strategic alliances with the platform leader.*

Proposition 6b (P6b) *Over time, if incumbents succeed in jointly developing new complementary assets, downstream entrants are more likely to backwardly integrate.*

2 | DISCUSSION

We present an integrative framework of the interplay of competition and cooperation following distinct types of technological discontinuities (core-knowledge vs. complementary-asset discontinuities). To ground our theoretical contribution, we focus on the questions of *how, when,* and *why* (Bacharach, 1989) to explain and predict the dynamics of coopetition between incumbents and entrants after different discontinuous changes. We posit that the type of a technological discontinuity and the strength of the appropriability regime (strong vs. weak) in an industry are important antecedents to the unfolding dynamics of competition and cooperation (see Figures 1 and 2). We establish contingent propositions explaining different cooperative outcomes, especially vertical alliances between incumbents and entrants and horizontal alliances among incumbents.

We posit that when incumbents face a core-knowledge discontinuity in industries with a strong appropriability regime (Quadrant III.a), incumbents possessing complementary assets that retain

[28]If a platform leader should not emerge over time, however, incumbents are likely to form intra-industry alliances to forwardly integrate by jointly building downstream complementary assets (see Proposition 2a).

their value form vertical alliances with upstream entrants introducing the new core knowledge (Proposition 1a). We extend this baseline prediction by considering the case of a weak appropriability regime (Quadrant III.a) when we argue that incumbents tend to acquire upstream entrants (Proposition 1b)—because a market for ideas is not available for alliances to form. We then complete this extended, yet still partial view of core-knowledge discontinuities, when we introduce the opposite case of complementary-asset discontinuities. This second type of discontinuity is one in which the upstream core knowledge of incumbents is mostly preserved, but their downstream complementary assets for manufacturing and distribution are no longer needed to commercialize within the new technology (Quadrant IV.a and IV.b). This vantage point allows us to contribute a fresh theoretical insight: Rather than searching out cooperation with new entrants, incumbents cooperate primarily among themselves in the aftermath of a complementary-asset discontinuity (P2a and P2b). The difference between Propositions 2a and 2b is contingent on the strength of the appropriability regime. When the regime is strong (Quadrant IV.b in Figure 2), incumbents exclusively cooperate among themselves to compete against entrants (P2a). When the regime is weaker (Quadrant IV.a), incumbents cooperate among themselves to cooperate with entrants from a stronger bargaining position (P2b). In sum, the permutations depicted in Figure 2 allow us to analytically explore the variance in Quadrants III and IV at different levels of the appropriability regime.

Taken individually, not all of our propositions are entirely novel because the dynamics in Quadrant III (in Figure 1) has received some prior attention in the literature. The notion that incumbents and downstream entrants form alliances in the aftermath of a core-knowledge discontinuity within a strong appropriability regime (Quadrant III.a) has been well documented in the pharma industry after the emergence of biotechnology (Arora & Gambardella, 1990; Rothaermel, 2001). The notion that incumbents acquire new downstream entrants after a core-knowledge discontinuity when the appropriability regime is weaker (Quadrant III.b) can be supported by evidence in Tripsas' (1997) careful work on the typesetter industry or Mitchell's (1991) in-depth study of the medical diagnostic industry. Notwithstanding, we added more fine-grained and integrative theoretical explanations and also formalized the result. Yet, the dynamic following a complementary-asset discontinuity (Quadrant IV) remains the more under-researched phenomenon. This newly introduced type of discontinuity is of particular relevance for scholars and managers due to the radical transformations of manufacturing, distribution and sales by internet technologies.

We submit that our theorizing and integrated model can aid future empirical work in the areas of competitive and cooperative strategy, incumbent adaptation after technological change, industry dynamics and entry, platform competition, and technological standard emergence. Where we make a novel theoretical contribution is in the joint consideration of the competitive and cooperative dynamics between incumbents and entrants evinced by different types of technological discontinuities under different appropriability regimes. Such a joint consideration reveals an integrated theoretical model (depicted in Figures 1 and 2). Taken together, the integrative framework is useful not only for research on competition and cooperation (Doz, 1996; Dyer & Singh, 1998; Reuer et al., 2002; Speckbacher, Neumann, & Hoffmann, 2015), but also for studying resource reconfigurations and dynamic capabilities (Lavie, 2006a; Teece et al., 1997), because it addresses when, why, and how firms access, build, and develop new resources while protecting old ones (Capron & Mitchell, 2012). Moreover, we contribute to the relatively sparse literature on intra-industry cooperation and consortia (Browning et al., 1995; Doz, 1996; Doz et al., 2000; Ring & Van de Ven, 1994) and on the antecedents to and dynamics in horizontal alliances (Baum et al., 2005; Lavie, 2006b; Speckbacher et al., 2015). Different cooperative strategies might complement one another when incumbents face different types of technological changes and need to develop or protect different capabilities

(Helfat et al., 2009; Lavie, 2006a; Lavie, 2006b). For instance, our prediction that incumbents ally among themselves to cooperate with entrants (P2b) extends Shipilov, et al.'s (2014) concept of relational pluralism, according to which an actor can maintain multiple kinds of relationships and develop multiple identities. Incumbents in Quadrant IV.a maintain their identity as upstream knowledge producers by cooperating among themselves, but they gradually absorb the identity of platforms by simultaneously cooperating with downstream entrants. This insight offers evidence for Tripsas's (2009) argument that technology and identity co-evolve. Our study also contributes to growing research on platforms and ecosystems in two ways. First, we establish a link between complementary-asset discontinuities and the emergence of platforms and ecosystems (Adner & Kapoor, 2010) through the mechanisms of enhanced network externalities and technological standards in manufacturing and distribution (Farrell & Saloner, 1985; Marshall, 1920; Schilling, 2002). Second, we contribute to platform competition literature (Cennamo & Santalo, 2013; Gawer & Cusumano, 2008; Greve & Song, 2017) by carefully relating winner-take-all dynamics to the interplay of competition and cooperation. Our predictions are also likely to apply to non-internet related technological changes that do not necessarily lead to platform emergence. An example is the recent electric car revolution where incumbent automakers are cooperating among themselves (e.g., the U.-S. *Alliance of Automobile Manufacturers*; the German consortium *Terra E Holding*) to confront Tesla's downstream network of recharging stations, its manufacturing plant for batteries, and its direct sales and distribution (Bloomberg, 2017; Electrek, 2017). These changes can be seen as downstream complementary-asset discontinuities for traditional car manufacturers.[29]

In a second step of our study, we move beyond the more common industry-level analysis in strategy and technology research (Christensen & Bower, 1996; Foster, 1986; Henderson & Clark, 1990; Tushman & Anderson, 1986), and we introduce firm-level variance and time dynamics as additional contingencies into our conceptual model. One major benefit of studying technological discontinuities is that they create a natural laboratory for the researcher because all incumbent firms are exposed to the same exogenous treatment effect (i.e., the discontinuity). Moreover, given internal firm differences in terms of resources and capabilities (Barney, 1991; Teece et al., 1997), we can explore variance in firm-level outcomes. In particular, we attempt to unravel firm-level heterogeneity in the post-discontinuity time period by emphasizing the role of status in alliance formation (Greve et al., 2014; Podolny, 1993). We posit that high-status incumbents search out other incumbents of similar status (rather than high-status downstream entrants) when forming horizontal alliances after complementary-asset discontinuities (P3). In contrast, low-status incumbents tend to be more willing to take risks and search out vertical alliances with downstream entrants of high-status (P4). Besides hoped-for benefits such as positive status spillovers and endorsements from allying with high-status entrants, the low-status incumbents may face a point of "no choice" but to ally with downstream entrants much sooner than high-status incumbents.

We also make an effort to provide insights concerning the stability of the cooperative equilibria observed in the immediate aftermath of a discontinuity. In particular, we argue that the equilibria in the cooperative diagonal (in Quadrants III and IV in Figure 1) are not stable over time. Following a core-knowledge discontinuity, both incumbents and new entrants engage, as time progresses, in

[29]Tesla is an interesting case because, in its early days, the startup operated upstream only with an innovative design of the battery pack, and it allied with car manufacturers like Daimler (car engineering) and Toyota (lean manufacturing) (Hoang & Rothaermel, 2016). These alliances between an entrant with a new upstream core knowledge and incumbents possessing specialized complementary assets are in line with P1a. Over time, however, Tesla forwardly integrated downstream and exited the previously formed alliances with incumbents (as predicted by P5b). Tesla's newly built downstream assets (specialized charging network, radically advanced battery plant) represent a complementary-asset discontinuity for incumbents, and in line with P2a, incumbents responded cooperating among themselves (Bloomberg, 2017; Electrek, 2017).

vertical integration along the value chain. Incumbents eventually integrate backward (P5a) while new entrants integrate forward (P5b). Furthermore, we suggest that integration is easier for incumbents than for entrants (P5c) because incumbents tend to be larger, more resource-rich firms with a documented ability to enter new technology fields on their own, in particular, if they possess specialized complementary assets (Mitchell, 1989).

Interestingly, as time elapses after a complementary-asset discontinuity, incumbents and entrants react somewhat differently (compared to the case of a core-knowledge discontinuity). Incumbents in Quadrant IV might be left with no choice but to ally with a downstream entrant, if the venture becomes a platform leader over time (P6a). This would mean that incumbents deviate over time from their first-best strategy of competing against entrants through cooperation among themselves (see P2b). Rather than vertically integrating, incumbents pursue as their next-best strategy alliances with downstream entrants (differently from the case of core-knowledge discontinuities in QIII; see P5a). Vice versa, if incumbents succeed over time in developing jointly new complementary assets through horizontal collaboration among themselves, downstream entrants are more likely to backwardly integrate (P6b). These propositions contribute to the handful of studies on the intertemporal dynamics of alliances (Lavie & Rosenkopf, 2006), alliance terminations (Asgari, Tandon, Singh, & Mitchell, 2018; Reuer & Zollo, 2005), and vertical integration decisions concerning “make-or-buy” choices (Jacobides, Knudsen, & Augier, 2006; Leiblein, Reuer, & Dalsace, 2002). Moreover, our theoretical insights resonate with Hannah and Eisenhardt (2018) because these scholars examine cooperation and competition of entrepreneurial firms in nascent ecosystems (see also Moeen & Agarwal, 2017), whereas we look at the problem of incumbents facing an ecosystem in which a downstream entrant emerges as a platform leader.

Our theoretical framework offers several practical implications for managers of incumbent firms needing to respond to technological changes. For instance, both types of cooperation—vertical with new entrants and horizontal with other incumbents—are certainly options for organizational arrangements to benefit from innovation or core-knowledge production; however, we explain that the effectiveness of each strategy is highly contingent. Managers should navigate the provided matrices (Figures 1 and 2)[30] and consider the type of technological change they face and the industry appropriability regime, but also take into account the status of their organization and the point in time in which to make strategic decision (the aftermath of the discontinuity vs. the long term).

As any study, this work has limitations that might offer promising avenues for future research. First, it is a theoretical study that aims to develop an integrative and contingent model of cooperation and competition after different types of technological change. Empirical research is needed to test this conceptual model, ideally in different industries and under different types of technological changes. We add contingencies to make sure that our predictions are rigorous under specific conditions, but it is possible that additional boundary conditions are needed to further refine some of the predictions. Second, the types of complementary-asset discontinuities we consider is limited to radical changes in manufacturing, distribution and sales that enhance network effects. This assumption is reasonably grounded in the literature (Farrell & Saloner, 1985; Marshall, 1920; Schilling, 2002) and supported by evidence from several industry contexts and transformations; however, there might be cases of complementary-asset discontinuities that do not lead to similar effects. Also, we

[30]In addition to the several industry examples provided in the article and matrices, the framework is likely to apply also to other contexts. An example can be the online distribution of video games (a downstream change with strong IP regime) in which incumbent producers of video games for PCs are cooperating with an entrant like *Steam*, which developed an online delivery platform to distribute video games (in line with P2a). A different and more extreme example is the case of open source software (OSS) for mobile device manufacturers—an upstream change in which incumbent manufacturers like Samsung and LG have cooperated with the upstream open source operating system *Android*.

specifically considered complementary assets in downstream manufacturing and distribution, consistently with a tradition that separates upstream knowledge production (or invention) from downstream knowledge commercialization; however, the category of complementary assets could also include brand or reputation, and future studies may examine the destructive effects on these intangible assets.

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