Platform-based Disruption: The Dual Effect of Digital Platforms on Incumbent Firms

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ABSTRACT

We expand the perspective on disruption by studying how digital platforms can impact the competitiveness of incumbents by complementing their product offerings instead of substituting them. Platform market innovations provide a new technological architecture for aggregating and linking various product offerings from multiple providers and connecting to customers. We distinguish between peer-to-peer platforms introducing alternative services in adjacent markets (e.g., *Airbnb*) and platform marketplaces introducing a new marketing technology into the focal industry (e.g., *Booking.com*). We argue that as the platform-based services in adjacent markets increase, incumbents in the focal industry respond by doing increasingly more business through competing digital platforms (e.g., *Booking.com*). As this market shifting unfolds, platforms have the dual effect of enhancing the value of incumbents' core activities but disrupting incumbents by eroding the value of their downstream specialized complementary assets and increasingly commoditizing their core offerings. Using data from the hotel industry in the state of Texas, we find supporting evidence of this process showing that it is high-end hotel chains (rather than those competing more directly with Airbnb-based services) that are affected the most from an increase of Airbnb services in a city. We thus offer a new perspective on how digital platforms can disrupt established incumbents not through substitution of their offerings but through complements – by shifting the level of complementarity and unsettling established incumbents' positional advantage.

"*Uber*, the world's largest taxi company, owns no vehicles. *Facebook*, the world's most popular media owner, creates no content. *Alibaba*, the most valuable retailer, has no inventory. And *Airbnb*, the world's largest accommodation provider, owns no real estate"

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1. INTRODUCTION

Digital platforms like Uber, Airbnb and TaskRabbit have shaken up several industries. Often described as disruptive, these platforms manage to be successful without owning any of the assets generally considered necessary to operate, compete and succeed in the given industry, as exemplified in the opening quote (Goodwin, 2015). Instead, they provide new, digital marketplace infrastructures that enable the matching of independent service providers with potential buyers. Compared to disruptive innovations (Christensen et al. 2018) that threaten established firms' core assets, and eventually substitute them, platform technologies, in most cases, complement or leverage incumbents' assets (Ansari, Garud, & Kumaraswamy, 2016; Cozzolino & Rothaermel, 2018). This puts platform-based disruption at odds with the standard classification of the literature. Furthermore, research on technological discontinuity suggests that incumbents holding critical strategic assets can retain their positional advantage and protect it from competition and disruptive threats (Teece, 1986; Tripsas, 1997). This is because these assets can be important strategic bottlenecks to value production and/or delivery in the industry; they act as important barriers to competitive substitution by new entrants (Tripsas, 1997; Jacobides & Billinger, 2006). For instance, in the automotive industry, car manufactures have retained their power and market value, at least till now, by controlling key assets such as brand, marketing, distribution channels and supply chains, making themselves the ultimate guarantor of quality in the eyes of the final consumer (Jacobides et al. 2016). Furthermore, firms introducing disruptive innovations must often gain support by those incumbents holding the critical assets needed to successfully operate in the industry (Ansari et al. 2016; Ozalp et al. 2018). The contrasting phenomenological observation of "platform disruption" raises two interrelated questions: what kind of disruption do digital platforms produce, and to whom are they disruptive?

The debate on disruption has focused on competitive attacks to incumbents proceeding from new entrants to the same industry. In other words, focus has been on technological and core offerings' substitution within the same market. This neglects the potential disruption that can originate from adjacent markets, i.e., firms operating in markets that initially do not compete directly with incumbents (Cennamo 2019; Eisenmann et al. 2011), and from complementors, e.g., technologies that provide complementary value to incumbents' core offerings, but which over time can undermine a firm's ability to protect its premium position and profitability (Adner & Lieberman 2021; Ansari et al. 2016). One view holds that platforms like Uber and Airbnb introduce alternative services in adjacent markets that challenge the value of incumbents' core services and push them to lower their prices (Farronato & Fradkin, 2018; Zervas, Proserpio, & Byers, 2017) or reposition their offerings through price/quality adjustments (Chang and Sokol 2020; Seamans & Zhu, 2013). However, the focus on direct competition may mask the real disruption threat that these platforms pose: altering the level and sources of complementarities in the market (Ander & Lieberman 2021; Jacobides, Cennamo, & Gawer, 2018), which in turn will affect the value of incumbents' assets (Cozzolino & Rothaermel, 2018; Eisenmann et al. 2011) and erode their profitability (Adner & Lieberman 2021).

In this paper, we take this different perspective. Drawing on recent research taking an ecosystem perspective on disruption (e.g., Adner & Lieberman 2021; Ansari et al. 2016; Ozalp, Cennamo & Gawer 2018), we advance a complementarity view of platform-based disruption. In line with Adner and Lieberman (2021: 92), we conceive of disruption as a "substantial decline in the sales, market share, or profitability of established incumbents, resulting from actions taken by firms that are not initially direct rivals of the incumbent(s)". We conceptualize digital platforms as market-related technological innovations (Cennamo 2019; Tajedin et al. 2019), a distinct class of architectural innovations (Henderson and Clark 1990) that affect the structure of economic relationships by altering the way producers and consumers interact to exchange value[1]. In creating new ecosystems and managed marketplaces, digital platforms can enhance the value creation capacity of

[1] Platform technologies can create complementarities in production enabling the creation of new products and services from third-party actors and complementarities in consumption enabling consumers to access and benefit from a variety of offerings (Jacobides et al 2018).

participating firms by spanning across traditional industry and market boundaries; but they also affect the ability of firms to capture value (Jacobides et al. 2018; Panico & Cennamo 2020).

The main argument we advance in this paper is that as the value of new complementary services in adjacent markets increases as a result of platform innovation (e.g., Airbnb), incumbents in the focal industry will respond to the potential competitive threats they pose as a collective by doing increasingly more business and transactions through competing digital platforms (e.g., Booking.com). These dynamics shift the level of competition from individual offerings to platform-based competing complements (e.g., between Airbnb and Booking.com). This shift will affect incumbents' profitability to different extents. The negative effect will be strongest for those incumbents with a strong position in downstream complementary assets, which digital platforms will increasingly displace, reducing their value significantly and thus, eroding these incumbents' profitability. On the other hand, incumbents that have limited leeway downstream will see their profitability less affected by the shift to platform markets; digital platforms offer complementary value to their core assets, increasing their marketing ability (Jacobides et al., 2018).

We empirically test these ideas in the hospitality industry. This setting is particularly interesting because a number of digital platforms have recently taken hold as new market medium to reach out to consumers, and because there is high variation in the degree to which different incumbents have control over core and complementary downstream assets. While chain-affiliated hotels have traditionally benefited from owning both core assets (i.e., hotel rooms) and strong complementary assets (e.g., strong marketing- and sales-related assets), independent hotels typically have very limited, if any, specialized complementary assets. By exploiting temporal and geographical variation in Airbnb's entry over the period 2000-2016, we examine how Airbnb's entry in a city affects the performance of local hotels. We adopt a difference-in-differences approach that compares the hotels that are hypothesized to be affected the most (i.e., premium, chain-affiliated hotels that have strong downstream complementary assets) to the other hotels as supply on Airbnb increases. The geographic and temporal variation in entry allows us to tease out the effect on the performance of hotels from broader macro trends associated with the diffusion of digital services (and underlying changes in consumers' preferences). Overall, as supply of rooms on Airbnb increases, the usage of platform marketplaces by chain-affiliated hotels (i.e., Booking.com) increases compared to that of independent hotels; the increase is higher for up-scale hotel chains. Furthermore, we find that increasing supply on Airbnb has a significant negative effect on the performance of chain-affiliated hotels that operate at the higher end of the market.

We contribute to research on technological discontinuity and disruption in several ways, both phenomenologically and ontologically. We illuminate on the new phenomenon, documenting the dynamics and mechanisms of platform disruption. Rather than bringing just new competition to an industry, platform innovations change the rules of the competitive game by providing new marketplaces, and with them, new rules of interactions, that can ultimately unsettle a focal firm's positional advantage. This represents a different kind of disruption threat, which resides in technologies that have a value-enhancing complementary role but nonetheless can produce negative impacts particularly on those incumbents that enjoyed a strong position in the industry[2]. This has theoretical implications for how we (used to) see and categorize disruptive innovations.

Responding to recent calls to consider the impact of innovations on the relational interdependencies across the entire ecosystem (Kumaraswamy, Garud and Ansari 2018), we extend prior research arguing that ownership of strategic assets can buffer incumbents from the threat of new entrants (Jacobides et al. 2016; Tripsas, 1997) or induce them towards coopetitive relationships (Ansari et al. 2016; Cozzolino & Rothaermel 2018). When the value of those assets depreciates relative to the complementary value of the shared assets of the digital platform that all incumbents can access and leverage in the ecosystem, the positional advantage that incumbents derive from their own specialized complementary assets will consequentially get eroded with the shifting of supply and demand to the platform market. Thus, platforms have the dual effect of sustaining (complementing) their core assets and competencies for service production while disrupting their downstream assets and relative market competencies (e.g., brand positioning and customer relationships). Because this shifting in role and complementarities happens endogenously and in response to the threats to their core offerings coming from alternative market offerings, this value erosion, although it might be recognized ex ante

[2] By including the different types of competing digital platforms (peer-to-peer and business-to-consumer) in our analysis, we are able to analyze the effects on incumbents that go beyond performance and are instead related to adoption of digital marketplaces. This allows us to get a more complete picture of the effect that digital platforms have on incumbents.

by incumbents, is hard to escape and revert once the platform market becomes the new, established gateway to customers. A complementarity view helps us capture this disruption type by considering the complementarities in the demand-side (rather than just the competitive substitution effects in the supply-side) and how they affect the relative value of incumbents' core offerings.

2. THEORETICAL BACKGROUND

Core and Complementary Assets in the Face of Technological Change

The competitive interaction of incumbents and innovative entrants in the face of technological change has been studied extensively by scholars in innovation management and strategy (e.g. Lieberman & Asaba, 2006; Ethiraj & Zhu, 2008). The entry of small innovative firms into an industry is often seen as part of a cyclical pattern, in which incumbents are replaced by the producers of new technologies (Abernathy & Utterback, 1978; Tushman & Anderson, 1986). Several studies have provided explanations for why new entrants often dethrone incumbents. For instance, scholars have argued that incumbents are often unwilling to cannibalize their existing products (Christensen & Bower, 1996) or capabilities (Leonard-Barton, 1992), and that they tend to be limited by their traditional view of the economic environment (Tripsas & Gavetti, 2000) and therefore are reluctant to adopt new technologies and might be displaced by the new entrants (Gilbert, 2005). More recently, scholars have challenged the traditional view that incumbents are at a disadvantage compared to new entrants and emphasized that incumbents actually have several advantages. For example, incumbents generally have greater financial and market power (Chandy & Tellis, 2000), more experience (King & Tucci, 2002) and can often combine their accumulated knowledge with new technologies to prevent disruption (Bergek, Berggren, Magnusson, & Hobday, 2013).

An important distinction has been made in the literature between technological change that affects incumbents' core assets and technological change that affects incumbents' complementary assets. We follow Teece (1986) and define complementary assets as assets from which services such as "marketing, competitive manufacturing and after-sales support" are derived, as opposed to core assets which are directly related to the core product [3].

The majority of research has traditionally focused, explicitly or implicitly, on technological change that affects a firm's core assets (but see Cozzolino and Rothaermel 2018). For instance, scholars have studied how technological change can either enhance or destroy incumbents' competences in developing and producing a certain technology (Tushman & Anderson, 1986) depending on the radical or architectural nature of the innovation (Henderson & Clark, 1990) and how technologies that initially underperform compared to an incumbent's core technology can eventually surpass and replace it[4] (Christensen & Bower, 1996).

More recently, the focus of research has extended to the effect of technological change that specifically affects incumbents' complementary assets. It has been argued that, in the face of technological change in complementary assets, incumbents reposition themselves in a way that allows them to benefit from their core assets (Benner & Waldfogel, 2016), and that they are more likely to cooperate among themselves, rather than cooperating with or acquiring new entrants, to ensure value capture from their core assets (Cozzolino & Rothaermel, 2018). Incumbents can be in an advantageous position if their complementary assets are needed by new entrants to commercialize their new technology (Ansari et al. 2016), as this allows incumbents to enter alliances with new entrants and benefit from their technological expertise through learning (Rothaermel, 2001; Rothaermel & Hill, 2005). However, when technological innovation changes the way product offerings are channeled to and exchanged with the customers, the value of incumbents' complementary assets is challenged, and so is incumbents' capacity to capture value through these assets. Platform technologies have the potential to do precisely this by introducing innovations in market-related technologies.

Platform Market Innovation

[3] In this study we are mostly interested in the distinction between core and complementary assets, rather than in the distinction of different types of assets. Similar to previous studies (Amit & Schoemaker, 1993), we therefore use the term "assets" in a broad sense to refer to both physical resources and the required knowledge and capabilities to use and benefit from them.

[4] As a reaction to technological change in their core assets, incumbents might have to reconfigure their existing capabilities. Depending on the type of technological change and the characteristics of the firm's capabilities, the set of possible reconfiguration modes ranges from slightly reshaping their capabilities to transforming their capabilities by incorporating established and new knowledge, or even substituting their capabilities altogether (Lavie, 2006).

Digital platforms are digital infrastructures that enable direct interactions and transactions between two or more sides, such as buyers and sellers or complementors and users (Hagiu & Wright, 2015; McIntyre & Srinivasan, 2017; Parker & Van Alstyne 2005). Through their digital tools and interfaces, they offer consumers and firms a way to connect, interact and coordinate their exchanges, allowing a better matching between consumers' heterogenous needs and firms' product offerings. Thus, the primary functionality and core value of the platform technology reside in its ability to intercept consumer preferences and match them with external firms' offerings through a managed marketplace (Cennamo, 2019; Tajedin et al., 2019).

Scholars have emphasized this agency unique aspect of platform-based markets by referring to digital platforms, for instance, as "firm-designed markets" (Tajedin et al., 2019), in which the firm controlling the platform governs the market by setting the rules for participation and interactions therein (Cennamo, 2019; Boudreau & Hagiu, 2009) to coordinate activities from the demand and supply sides (Hagiu & Wright 2015; Tajedin et al. 2019). They give rise to new structures of economic relationships between a multilateral set of firms and users bound by specific complementarities (Jacobides et al. 2018). Digital platforms are a new organizational solution to coordination and information asymmetry problems (Parker, Van Alstyne & Jiang 2017), distinct from the traditional market and hierarchy organizing modes, which proves superior particularly in contexts of increased interdependency of firms' economic activities and users' demand (Jacobides et al. 2018). They offer a superior coordination mechanism for internalizing these economic externalities (Hagiu & Wright 2015; Parker & van Alstyne, 2005; Rochet & Tirole, 2003). As maintained by Tajedin et al. (2019: 28), a platform marketplace "combines elements of the coordination mechanism of markets (the 'invisible hand') and the visible hand of hierarchies. It leverages the distributed decision making of individual participants, but is also able to influence and shape the context and direction of these decisions." The digital interfaces, tools, infrastructures, and the access and interaction rules that make up the platform marketplace technology are the different interconnected components of a unified innovation solution to market failure problems in a given industry (or across sectors and industries). Through platform technologies, platform providers offer a system solution to information and coordination problems between demand and supply sides, creating reinforcing cross-sides complementarities in consumption (or indirect network effects) (Jacobides et al. 2018) that facilitate the emergence and growth of a superior market (Hagiu & Wright 2015; Parker & Van Alstyne, 2005; Rochet & Tirole 2003).

Digital platform marketplaces are thus instances of market innovations; a distinct class of architectural innovation (Henderson & Clark 1990). We define platform market innovation as a firm-designed and managed marketplace technology infrastructure offering a novel way (compared to the current market structure) for customers and product/service providers to connect, interact and transact. Similar to product architectural innovations that change the way product components are linked together (Henderson & Clark, 1990), platform market innovations provide a new architecture for aggregating and linking various product offerings from multiple providers. In doing so, and making them directly accessible to customers, they help structuring multilateral (as opposed to vertical) complementarities and interdependencies among different economic actors (Adner 2017; Jacobides et al. 2018; Parker et al. 2017). Platform market innovations are technological architectures affecting not just the technological interactions between offers but also the interactions between interdependent actors across the supply and demand side (Cennamo 2019; Kapoor 2018). By setting "the rules of the game" (how members can access the marketplace, and what they can do in it) and enabling contextualized information signals (such as peer reviews of the product/service quality, information about its provider, alternative offerings etc…), the platform marketplace provides a context with lower information asymmetries[6] (between the two sides of the market), enhanced information above and beyond what prices can provide (Tajedin et al. 2019: 28), and thus potentially thicker and more efficient market structuring than traditional markets[7] (Hagiu & Wright, 2015; Jacobides et al., 2018; Tajedin et al. 2019).

[6] Information asymmetry refers to a condition where one of the parties of a transaction possesses more knowledge than the other parties involved; an issue that is common to many markets. Asymmetric distribution of information among the parties involved in transactions can produce inefficient results or prevent transactions to happen at all (Akerlof 1970).

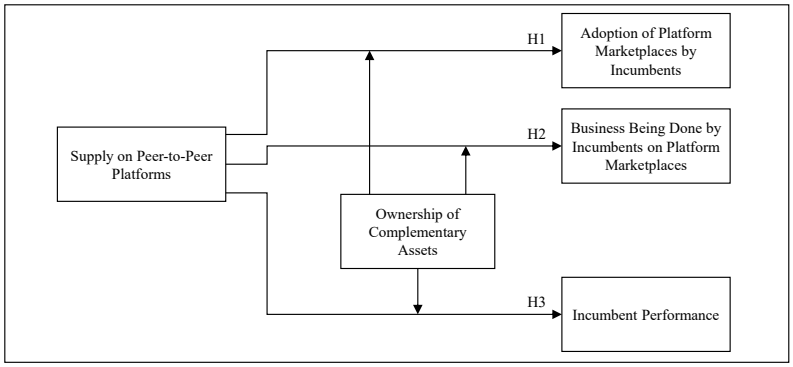
[7] Consider the traditional short-term house rental market. There has always been a high level of information asymmetry between the house owner and the prospective renter. Not only the structural characteristics of the accommodation but also safety and reliability of contractual agreements are all subject to potential information asymmetry issues. Platform-based marketplaces, such as Airbnb, have put in place a number of mechanisms to relieve these tensions. Specifically, Airbnb internalizes the information asymmetry by serving as the guarantor that establishes trust in the market.

As superior market alternatives, they represent a significant technological discontinuity to existing market-related technologies and to incumbents' specialized complementary assets (Cozzolino & Rothaermel 2018). Thus, they have the potential to destroy the existing relational linkages between the industry's main actors and customers (Ozalp et al. 2018), and the usefulness of a firm's established downstream position in the industry. Research has been agnostic about the broader effects that technological change can have on the sources of complementarities across ecosystem actors, and thus on the differential impact they can generate on incumbents' assets (but see Adner & Lieberman 2021). A focus on platform market innovation shifts the attention to these aspects.

3. HYPOTHESES

Fundamentally, platform-based structures shift the level of complementarities from vertical value chains - between upstream and downstream activities on the supply side, to multilateral value networks - between multiple complementors on the supply side and customers on the demand side, with the platform being the linking infrastructure and interface. This shift must be accounted for to fully understand the disruptive effect of platform innovation, and its underlying mechanisms. Our main arguments are illustrated in Figure 1, which characterizes the primary mechanisms through which platform innovation can affect profitability of incumbent firms. Essentially, we argue, incumbents have different incentives to adopt platform market innovations depending on the extent platforms complement their existing assets. Those lacking the specialized complementary assets to commercialize their core offerings derive complementary benefits from leveraging these technologies; thus, they tend to adopt them readily. Those controlling downstream specialized complementary assets would enjoy limited complementarities from platform markets (compared to using their own assets), and thus tend to reject the technology to preserve the current structure in which they enjoy strong complementarities and a dominant position. However, as platform-based alternative services in adjacent markets increase, they trigger an "innovation shock" (Argyres et al., 2015) in demand, which accelerate the adoption of platform innovation by all incumbents in the focal industry. This shift will make incumbents' downstream assets obsolete, and thus affect the performance of those controlling these assets more negatively.

Figure 1: Conceptual Model



Platform Market Innovation and the Shift in Complementarities

The effect of the entry of digital platforms has been studied in a variety of different settings, including classified ads in the newspaper industry (Seamans & Zhu, 2013), the music industry (Bhattacharjee, Gopal, Lertwachara, Marsden, & Telang, 2007; Liebowitz, 2008), hospitality (Farronato & Fradkin, 2018; Zervas et al., 2017) and car sharing (Abhishek, Guajardo, & Zhang, 2019). Broadly speaking, we must distinguish between peer-to-peer platforms and business-to-consumers (B2C) platform marketplaces. B2C platforms (which we will simply refer to as "platforms" or "platform marketplaces" from now on) such as online travel platforms, open online course platforms (Cozzolino & Rothaermel, 2018) or car-renting platforms (Abhishek et al., 2019), aggregate the product offerings of different incumbents and make them available to customers through a single interface. Their main advantage compared to traditional marketplaces is increased efficiency due to agglomeration economies, reduced search and transaction costs for customers, and an enlarged potential target market for service providers stemming from the cross-sides complementarities in demand as discussed earlier (Rochet & Tirole 2003; Parker & van Alstyne 2005; Tajedin et al., 2019). These platforms thus require the core complementary services from incumbents to provide and gain value in an industry. On the other hand, peer-to-peer platforms rely on the supply from peers that are willing to share some of their physical assets (Goodwin, 2015), usually in exchange for a fee. In contrast to other types of digital platforms, the supply on

peer-to-peer platforms is therefore provided mostly by non-professional individuals. This characteristic allows peer-to-peer platforms to overcome the entry barriers of traditional industries and to be more flexible when it comes to reacting to fluctuations in demand (Einav, Farronato, & Levin, 2016; Zervas et al., 2017). Therefore, they can grow very quickly in a relatively short period of time, which can make them a major threat for conventional firms to the extent that the services offered through the platform represent a valid competitive alternative to the services offered by incumbent firms. If there is sufficient overlap in the preferences of customers in the old and new market segments, the boundaries between these segments will increasingly blur and firms will be confronted with a much broader set of competitors than before[8] (Adner, 2002). Technological change can reveal heterogeneity in consumer preferences that was previously unknown to incumbents by introducing new options to consider (Adner & Snow, 2010).

These distinctions are important because they give us insights into why established firms often have a surprising degree of difficulty in adapting to technological change ensuing from platform innovations (Einav et al., 2016; Zervas et al., 2017). Much of what the firm knows and produces and the assets it controls are still valuable in the emerging new market technological regime, but some of its assets (i.e., complementary assets such as marketing and sales competences) are not only no longer valuable but may actually handicap the firm (Kim & Min, 2015; Leonard-Barton, 1992). The firm may react (more) slowly, tend to reject the new market technology and its engaging rules (Cozzolino & Rothaermel, 2018) until they become well established and cannot be ignored any longer.

Incumbents will react differently to platform market innovations depending on their position in complementary downstream assets. Research shows that incumbents have different incentives with respect to new technologies as a function of their existing assets, competencies and market positions (Adner and Kapoor 2015; Ansari et al. 2016; Benner and Tripsas 2012, Kapoor and Klueter 2015; Ozalp et al. 2018). Incumbents that lack downstream specialized complementary assets have limited capacity to marketing their offerings and capturing value from their core assets (Teece 1986). Platform marketplaces are, for these incumbents, technologies offering a superior gateway to consumer demand in terms of reach, scale, and price/performance ratios compared to their existing alternatives (Cozzolino & Rothaermel 2018). They are thus complementary to their core assets, providing a sort of standardized, shared downstream complementary assets they can leverage to create value in the first place, i.e., to realize in the market the value of their core assets (Kapoor & Furr 2015; Priem 2007). Instead, for incumbents with a strong position in downstream complementary assets, such as hotel chains with established brands and sales channels in our research context, the value of the new technology offer is more ambiguous. First, these incumbents do not need these technologies to generate value in the market. They control the bottleneck assets in the industry needed to successfully commercialize their core offerings, which grant them superior market positioning and value capture (e.g., Jacobides et al. 2006). Thus, the value-added of platform digital market technologies can be perceived as marginal in the instantiation phase. Second, because of the strong position in the existing ecosystem, these incumbents are initially reluctant to shift to the new platform market technologies, which can imply a change also in the underlying ecosystem, potentially threating their current sources of superior performance (e.g., Adner & Kapoor 2015; Ansari et al. 2016). Instead, they tend to block and resist the technological change to preserve and keep sustaining their current ecosystem and underpinning technologies to retain greater control over the strategic bottlenecks, hence superior value capture (Adner & Kapoor 2015; Jacobides et al., 2016; Masucci, Brusoni & Cennamo 2020). They do so by adopting "hybrid" solutions, parts of the new technology's functionalities (e.g., online reservation and hotel chain app in the case of firms in our context), as a way to extend the value of their current downstream complementary assets, and keep extracting superior value from it (e.g., the "brand equity" and direct customer relation). Therefore, these incumbents tend to have little incentives to shift their business to digital platforms (Wu et al., 2014).

However, when these market technologies increase in value with their wider adoption (in adjacent market and by other incumbents in the broader ecosystem) to the extent of becoming a default point of access on the demand side for the customer, the relative complementary value of their own specialized complementary assets compared to the platform technology will increasingly reduce (e.g., Seamans & Zhu, 2013). At this point, these incumbents will increasingly need to shift to those new platform market structures to be able to generate value from their core assets. We argue that this shift in relative complementarity value for those incumbents occurs

[8] Often, the main driver behind this effect is customers' decreasing marginal utility from technological improvements, which makes their valuation of differences between products decline as technologies evolve.

as the penetration of competing alternative offerings from adjacent markets through peer-to-peer platforms increases – which induces incumbents to respond by adopting similar distribution technologies to keep sustaining the performance trajectory of their own core offerings (e.g., Adner & Kapoor 2015). This might be due also to the "innovation shock" (Argyres et al., 2015) associated with these new technologies, which can lead consumers to prefer these technologies because of a desired set of elements. Similar to the case of product architectural innovations, for which a particular configuration or component may instantiate an innovation shock and trigger a sudden consumer adoption of the new technology (Argyres et al., 2015), platform innovations in adjacent markets may trigger a sudden increase in platform usage, inducing consumers to use platform markets as the desired, default modality of access to the service. Literature shows that when consumers become accustomed to consuming the goods in a specific way, they form strong preferences for consuming similar goods in the same way. These consumption habits dominate consumers' behavior even when they hold intentions to act otherwise (Labrecque, Wood, Neal, & Harrington, 2017; Zauberman, 2003; Neal, Wood, Labrecque, & Lally, 2012). Thus, prospective customers that are looking for offerings on peer-to-peer platforms are likely to use other platforms to look for competing offerings from more traditional incumbents (Luca, 2017; Sorensen, 2017)[9]. A recent consumer survey finds that, despite the increasing efforts of large hotel chains to pull customers back to their own websites, consumers prefer using platforms. About 47% of survey respondents choose to book through platform marketplaces because they find them easy to use while 37% of the survey respondents claim that they prefer platform marketplaces over hotel websites because they are used to booking travel this way (Phocuswright, 2015)[10].

Thus, we expect that, as supply on peer-to-peer platforms increases, incumbents' offerings through platform marketplaces will increase; this effect will be stronger for those incumbents owning downstream specialized complementary assets compared to incumbents with limited complementary assets.

> *H1: Compared to incumbents that do not own downstream specialized complementary assets, incumbents with strong downstream specialized complementary assets adopt platform marketplaces increasingly more as the supply of alternative services on peer-to-peer platforms in adjacent markets increases.*
>
> *H2: Compared to incumbents that do not own downstream specialized complementary assets, incumbents with strong downstream specialized complementary assets increase their usage of platform marketplaces more as the supply of alternative services on peer-to-peer platforms in adjacent markets increases.*

Platform Market Architectural Shift and Incumbents' Performance

Research has shown for example that hotels which are owned by a hotel chain that has access to marketing and sales capabilities perform significantly better than their competitors (Ingram & Baum, 1997). Incumbents, in other words, can leverage their downstream specialized complementary assets to control strategic bottlenecks to market entry and penetration (Ansari et al. 2016; Kapoor & Furr, 2015), preserve their consumer-facing role as guarantor of quality (Jacobides et al., 2016), isolate their offerings from competitive threats (Tripsas 1997) and capture superior value form their core assets (Teece 1986). Our complementarity view provides a different perspective.

The multisided relational structure of platform marketplaces shifts the role of these incumbents from "system integrators" controlling the strategic bottlenecks in the industry and acting as quality guarantors (Jacobides et al. 2006) to complementors – providers of services that, while complementing the value of the core platform technology, become increasingly substitutable among consumers (Adner & Lieberman 2021; Jacobides et al. 2018). As argued, peer-to-peer platforms offer customers an alternative way to access the service (i.e., through digital platforms) that can increasingly re-shape their consumption behavior and perception of the value of the core product offerings. The peer reviews system of products and services is by now a well-established mechanism by which customers "certify" value of the product/service and its provider (Mudambi & Schuff, 2010; Sun, 2012). These reviews enable consumers to draw inferences about product quality from other

[9] Consumers have been observed to prefer platform marketplaces because they find other consumers' evaluations more reliable than expert's judgments or corporate messages of companies, and because they can publicly evaluate their experience with the services or products after the consumption (Luca, 2017; Sorensen, 2017).

[10] In the appendix, we also plot search trends for keywords "Hilton booking.com" and "Marriott booking.com" over time to provide further support for our argumentation.

consumers' choices and highly affect customer purchasing decisions particularly for less popular products (Zhu & Zhang, 2010). By organizing the consumer-provided reviews and ratings, platform-based marketplaces thus both lead to a discovery of lesser-known products and reduce the information asymmetry for the consumers regarding these products (Sorensen, 2017).

As incumbents that own downstream complementary assets do more and more business through platform marketplaces, they will face more head-on competition from *other* similar incumbents in these new markets that occupy the same complementor role on the same platform market (Cennamo and Santaló 2013, 2019). While they used to shelter from competition by leveraging their own downstream specialized complementary assets in traditional markets and interacting with customers directly through their own channels, they will now have to engage in direct price competition with other incumbents on the same platform marketplace, all using the same platform marketing tools, and all exposed to the same, standardized rules of engagement and transactions. Customers will thus be able to compare different offerings on the same digital platform much more easily than interacting with each incumbent through its own downstream complementary assets. Not being able to benefit from the exclusivity of their complementary assets anymore decreases the competitive advantage of these incumbents significantly more and will ultimately have a negative effect on their performance compared to other incumbents. As the complementary value of the platform becomes relatively greater than that of the individual offerings of these incumbents, it drives down their added value in the ecosystem (compared to the pre-platform market context) and make them less unique or differentiated and more fungible. The incumbents' core assets lose the central influence and role as "quality guarantor" in the value system (Jacobides & McDuffie 2013); a value shaping role that is now exerted by the platform as the new orchestrator of the ecosystem (Jacobides et al. 2018). Thus, compared to the pre-platform technology market context, these incumbents will experience a reduction in bargaining power, market influence and margins, which lead to increasing commoditization of their role and offerings[11] (Adner & Lieberman 2021).

Thus, compared to those incumbents that have limited leeway downstream and for which platforms can rise competitiveness by providing a larger customer base, for incumbents that used to enjoy rents through their downstream complementary assets, price competition will be much stronger (Seamans & Zhu 2013) than the positive market expansion effect they might achieve through platform marketplaces. Thus, we expect the performance of incumbents with upscale position and strong downstream complementary assets to be affected negatively the most by the shifting towards platform marketplaces.

> *H3: Compared to incumbents that do not own downstream specialized complementary assets, the performance of incumbents with strong downstream specialized complementary assets decreases more as the supply of alternative services on peer-to-peer platforms in adjacent markets increases.*

4. METHODS

Empirical Setting and Data

The empirical setting for this study is the hotel industry, which is particularly suitable because in recent years different types of digital platforms have entered this industry. On the one hand, platform marketplaces such as *Booking.com* allow hotels to market their rooms on the internet, while on the other hand peer-to-peer platforms such as *Airbnb* have allowed even non-professional individuals to make their rooms and houses available for rent. Furthermore, the hotel industry is particularly suitable because there is a high degree of variation in the extent to which incumbents (i.e., hotels) have control over assets. In the simplest case, hotels can be run by an individual hotelier who has control over everything related to that hotel, ranging from the building itself to the marketing of hotel rooms to potential customers. Hotels can also be affiliated to a hotel chain, which gives them access to the chain's complementary downstream assets to promote hotel rooms. Traditionally, their strong marketing and sales assets have made it easier for chain-affiliated hotels to promote their physical assets and gain a competitive advantage over independent hotels. An overview of common operation types in the hotel industry can be found in Table 1.

[11] In our research context this implies, e.g., a gradual shift in the locus of differentiation (in the eyes of customers) from a hotel chain's brand (booking a luxury room at a Sofitel) to the platform (booking a luxury accommodation "experience" by choosing one of the hotels and complementary travel services provided through Booking.com).

Table 1: Asset Ownership of Different Players in the Hotel Industry

		Ownership of …	
		Core Assets (e.g. building, operations)	**Complementary Assets** (e.g. sales & marketing, brand)
Hotels	**Independent Hotels**	Hotelier	-
	Chain Affiliated Hotels	Hotelier / Hotel Chain	Hotel Chain
Digital Platforms	**Platform Marketplaces (e.g. *Booking.com)***	Hotelier	Platform
	Peer-to-peer Platforms (e.g. *Airbnb.com)*	Mostly non-professional individuals	Platform

From Table 1**Error! Reference source not found.** it can also be seen that platform marketplaces like *Booking.com* offer complementary value for independent hotels because they provide the complementary downstream assets that these hotels were traditionally lacking. On the other hand, these platforms are potential substitutes for the downstream assets that chain-affiliated hotels own and have traditionally benefited from. Instead, peer-to-peer platforms such as *Airbnb* are a potential substitute for both the complementary downstream assets that hotels might possess, and their core assets and services. With regards to the hypotheses developed above, we expect that chain-affiliated hotels will be affected the most in their performance by peer-to-peer platforms as they will increasingly use platform marketplaces such as *Booking.com* after the supply on peer-to-peer platforms such as *Airbnb* increases.

To provide empirical evidence for our claims, we use data on the hotel industry in the ten largest cities in the state of Texas. We have chosen this setting for a number of reasons. First, across the largest cities in Texas, *Airbnb* has become popular at different points in time and to different degrees, which leads to both geographic and temporal variation that we can exploit for the identification strategy. Second, all hotels in Texas are required by law to disclose their monthly revenues. This gives us access to 17 years of monthly, hotel-level revenue data for all hotels in the state of Texas. For these reasons, the Texas hotel industry has been the subject of several studies in the past (Vroom & Gimeno, 2007; Zervas et al., 2017). We complement this information with additional hotel-level data on hotel class (low-end hotels, high-end hotels), operation type (independent, chain-affiliated) and chain affiliation (e.g. *Hilton*) that we obtained from STR Global, a market research company that focuses on the hotel industry. We also used web-scraping techniques to obtain data from the *Airbnb* website, as well as from *Booking.com*, one of the United States' largest online booking platforms, which will allow us to get a more complete picture of the industry. For each hotel in our sample, we manually matched the information gathered from these websites with the data that we obtained from STR Global and the data that we received from the tax authorities. Taken together, this gives us a unique dataset to study hotels' reactions to new competitors such as *Airbnb*, and the effect on their performance.

Independent Variables

The main independent variable in this paper is accommodation supply on *Airbnb*, which measures the extent to which incumbents face competition from peer-to-peer platforms. Following Zervas et al. (2017), we collected the date of the first review of each room listed on *Airbnb* in the 10 cities in our sample and used this date as a proxy for the point in time when this room became first available to consumers. Based on this data, we then infer the total accommodation supply by *Airbnb* at a given point in time by counting the number of rooms that have received their first review before this point in time (*CumAirbnbSupply*). The other main variable is the dummy variable *ChainAffiliated*, which is equal to 1 if a hotel is affiliated to a chain and 0 if it is independent. This variable reflects the differences in hotels' chain affiliation, which capture the extent a hotel controls/can leverage strong downstream specialized complementary assets such as brand of the chain, marketing tools, sales channels and booking services (e.g., direct booking services through the chain's booking system and preferential linkages and booking via contractual relationships with premier booking agencies).

Dependent Variables

The main dependent variable that we use to measure hotel performance is monthly hotel revenue (*TotalRoomReceipts)*, which we obtained from the Texas tax authorities. To assess the extent to which hotels use platform marketplaces, we collected the date when hotels were first active on *Booking.com* (which is reflected in the variable *Adoption*), as well as the number of reviews (*Reviews*) that hotels received on this

website. Data on the first month of activity was gathered from each hotel's main page on *Booking.com*, which displays this information in a standardized sentence at the end of the hotel description (e.g., "*Hyatt Regency San Antonio Riverwalk has been welcoming Booking.com guests since Mar 23, 2012*"). We used *archive.org* to collect data on the number of reviews for each hotel at different points in time in the past. The number of reviews for a given hotel on *Booking.com* will be used as a proxy for the number of bookings that have been made through these websites (as opposed to bookings made through other sales channels). We believe that the number of reviews on *Booking.com* is a reasonable proxy for the number of bookings because it is possible to post a review for a given hotel only for customers who actually made a booking through this website and only for a limited period of time after the trip. Contrary to many other review websites (e.g., *Tripadvisor.com)*, *Booking.com*, does not allow people to post reviews without having made a reservation for the given hotel through their website. Therefore, the number of reviews allows us to infer the extent to which hotels use platform marketplaces, as opposed to other distribution channels, to promote their physical core assets.

Table 2: Variable Definition and Sources

Variable Name	Definition	Source
$TotalRoomReceipts_{it}$	Revenue of hotel *i* in month *t*	Texas Tax Authorities
$Reviews_{it}$	Number of reviews that hotel *i* received on *Booking.com* in month *t*	Booking.com
$Adoption_{it}$	Dummy variable that is equal to 1 if hotel *i* was listed for the first time on *Booking.com* in month *t* and 0 otherwise. Observations after the month of adoption are omitted in the analyses	Booking.com
$TArating_{it}$	TripAdvisor rating of hotel *i* in month *t*	Tripadvisor.com
$CumAirbnbSupply_{jt}$	Cumulative number of rooms listed on *Airbnb* until time *t* in city *j*	Airbnb.com
$ChainAffiliated_{i}$	Dummy variable that is equal to 1 if hotel *i* was affiliated to a hotel chain when the first listing became available on *Airbnb* in the respective city and 0 otherwise	STR Global
$RoomSupply_{jt}$	Total number of hotel rooms available in city *j* in month *t*	STR Global
$Unemployment_{jt}$	Unemployment rate in city *j* in month *t*	U.S. Bureau of Labor Statistics
$MedianWage_{jt}$	Median wage in city *j* in month *t*	U.S. Bureau of Labor Statistics
$AirPassenger_{jt}$	Number of inbound air passengers in city *j* in month *t*	Bureau of Transportation Statistics

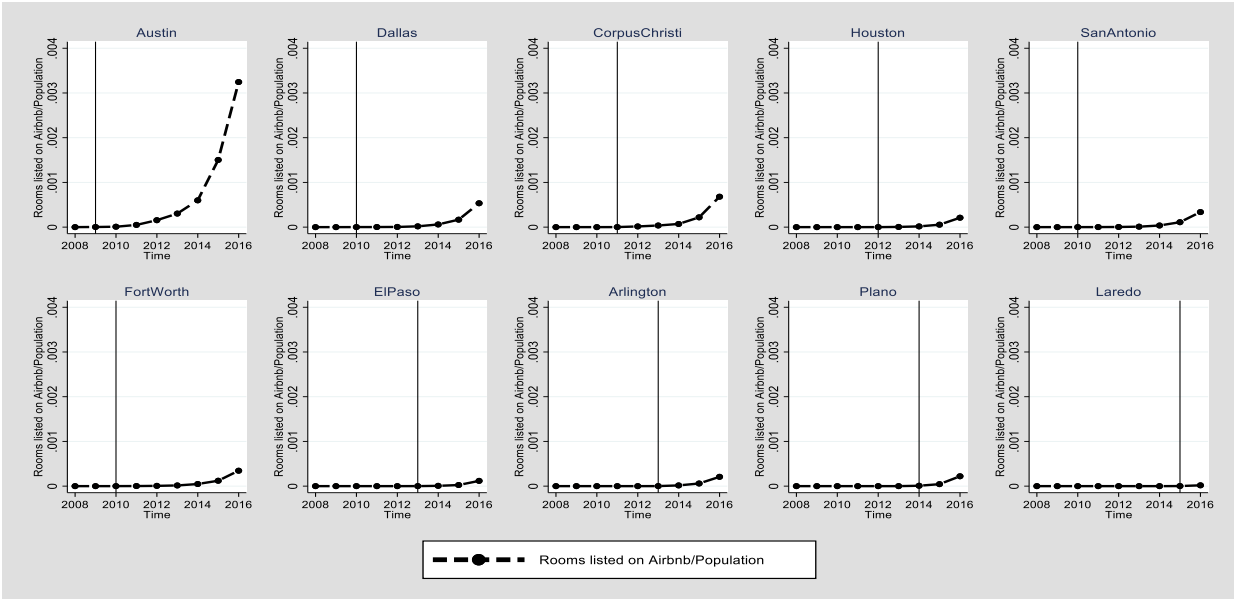
Control Variables

We control for the variable *RoomSupply,* which represents the total number of hotel rooms available in the city and accounts for differences in the supply of hotel rooms over time. Furthermore, following previous research (Zervas et al., 2017), we also include the variables *Unemployment* and *MedianWage* to account for variations in the incentives of potential hosts to list their rooms on *Airbnb*, *AirPassenger* to account for changes in the amount of tourism and travelers, as well as *TArating* to account for changes in hotels' quality over time. An overview of our variables can be found in in Table 2.

Empirical Models

We use a difference-in-differences approach with varying treatment intensity to control for other possible macro trends (e.g., greater use of digital devices) that may affect both the adoption of peer-to-peer platforms and the shift of incumbents' business to platform marketplaces. This allows us to reduce possible spurious correlation between our key variables of interest by exploiting the fact that the supply of rooms on *Airbnb* has increased at different times and to different extents across cities in Texas (see Figure 2). Similar to the design used by Seamans and Zhu (2013), we compare independent and chain-affiliated hotels as the supply of rooms on *Airbnb* increases.

Figure 2: Penetration of Airbnb across different cities in Texas (Collapsed to annual data for expositional purposes, solid black line indicates entry date)



Depending on the hypothesis that we are testing, the dependent variable in our difference-in-differences approach is a dummy variable indicating adoption of *Booking.com* (to test H1), the number of reviews that hotel *i* has received on *Booking.com* (for to test H2) or the monthly revenue of hotel *i* at time *t* (to test H3). The model is as follows:

$$\boldsymbol{DV_{it} = \beta_1 \ln(CumAirbnbSupply_t) + \beta_2 \ln(CumAirbnbSupply)_t} \\ \boldsymbol{* ChainAffiliated_i + \beta_X C_x + \delta_i + \gamma_t + \theta_{jt} + City_j * \gamma_t + u_{it}} \quad (1)$$

DV_{it} is our dependent variable of choice, C_x are our control variables, δ_i are hotel fixed effects, γ_t are time fixed effects, θ_{jt} are city-month fixed effects, and $City_j*\gamma_t$ are city-time trends, which capture possible changes over time that are city-specific (e.g., increases in a city's attractiveness, etc…). The coefficient of interest is β_2, which indicates the change in revenues (or reviews or adoption) of chain-affiliated hotels compared to independent hotels as the supply of rooms on *Airbnb* increases. As our main independent variable, we use *ln(CumAirbnbSupply)*, which measures the number of rooms available on *Airbnb* in a given city at time *t*. In an alternative specification, we also use *ln(CumAirbnbSupply)* lagged by 3 time periods to account for the required reaction time of incumbents and consumers after the entry of *Airbnb*. In other words, this alternative approach allows us to understand how our dependent variable of choice in time *t* is affected by the supply of rooms on *Airbnb* three months earlier (i.e., *t-3*).

5. DESCRIPTIVE INDUSTRY ANALYSIS

Our sample consists of 2,169 hotels, of which 753 are independent hotels and 1,416 are chain-affiliated hotels (see Table 3 and Table 4 for information on sample composition and summary statistics). Table 3 shows that the majority of independent hotels belong to the low-end class, whereas chain-affiliated hotels are distributed more evenly among low-end and high-end class.

Table 3: Sample Composition

	Independent Hotels	Chain-affiliated Hotels
N	753	1,416
Observations	82,231	214,255
Low-End Class	93.2%	72.5%
High-End Class	6.7%	27.5%
Monthly Revenues per Room in 2007 (Standard Deviation)	1024.77 USD (1377.97)	1710.6 USD (1897.77)
Monthly Revenues per Room in 2016 (Standard Deviation)	1241.94 USD (2776.02)	1993.52 USD (1938.26)

Independent and chain-affiliated hotels are very different in terms of the core and complementary assets that they own (see Figure 3). Traditionally, independent hotels owned the hotel building and its rooms (i.e. the core assets) but often had to rely on third party reservation providers who had the required complementary downstream assets. More specifically, third party reservation providers helped independent hotels with the reservation process and allowed them to access so-called global distribution systems, electronic systems through which travel agents and other professional users are able to make reservations (Green & Lomanno, 2012). Chain-affiliated hotels on the other hand owned both core and complementary assets. While a small portion of bookings was also handled through third party reservation providers, the majority of reservations was handled through chain-specific reservation systems that were directly connected to the global distribution systems. Moreover, chain-affiliated hotels received additional reservations through brand-specific hotlines and, starting from the late 1990s, brand-specific websites (Green & Lomanno, 2012). With the entry of platform marketplaces however, the situation has changed significantly as the digital tools and infrastructures of platform marketplaces have increasingly substituted those intermediation services, making those downstream complementary assets obsolete.

Table 4: Summary Statistics

Variable Name	Observations	Mean	Std. Dev.	Min	Max
$TotalRoomReceipts_{it}$	296,798	215728.8	419770.4	0	2.43e+07
$Reviews_{it}$	63,941	2.98526	9.815595	0	254
$Adoption_{it}$	192,537	0.0062066	0.0785373	0	1
$CumAirbnbSupply_{jt}$	296,798	345.908	990.2527	0	8034
$ChainAffiliated_{i}$	296,486	0.7226479	0.4476925	0	1
$TArating_{it}$	224,450	3.31713	1.40755	1	5
$RoomSupply_{jt}$	296,798	28231.75	16132.27	2180	57991
$Unemployment_{jt}$	296,798	5.660589	1.414885	2.8	10
$MedianWage_{jt}$	255,796	15.18156	2.032725	9.54	18.49
$AirPassenger_{jt}$	259,404	1.90e+07	3.00e+07	5175	8.82e+07

It can be seen from Table 3 that, throughout the sampling period, the revenue that chain-affiliated hotels generate per room and month is constantly higher than the revenue generated by independent hotels. This can be attributed at least in part to their superior complementary assets (e.g., marketing and sales, brand) that have traditionally provided them with a competitive advantage over others. However, the monthly revenue per room of independent hotels has increased by 21.2% in the period from 2007 (the year before the entry of *Airbnb*) to 2016, whereas the revenue of chain-affiliated hotels has only increased by 16.5% in the same period. This provides some preliminary evidence that the competitive advantage of chain-affiliated hotels is eroding over the years, while independent hotels are catching up.

Figure 3: Core and Complementary Assets in the Hotel Industry

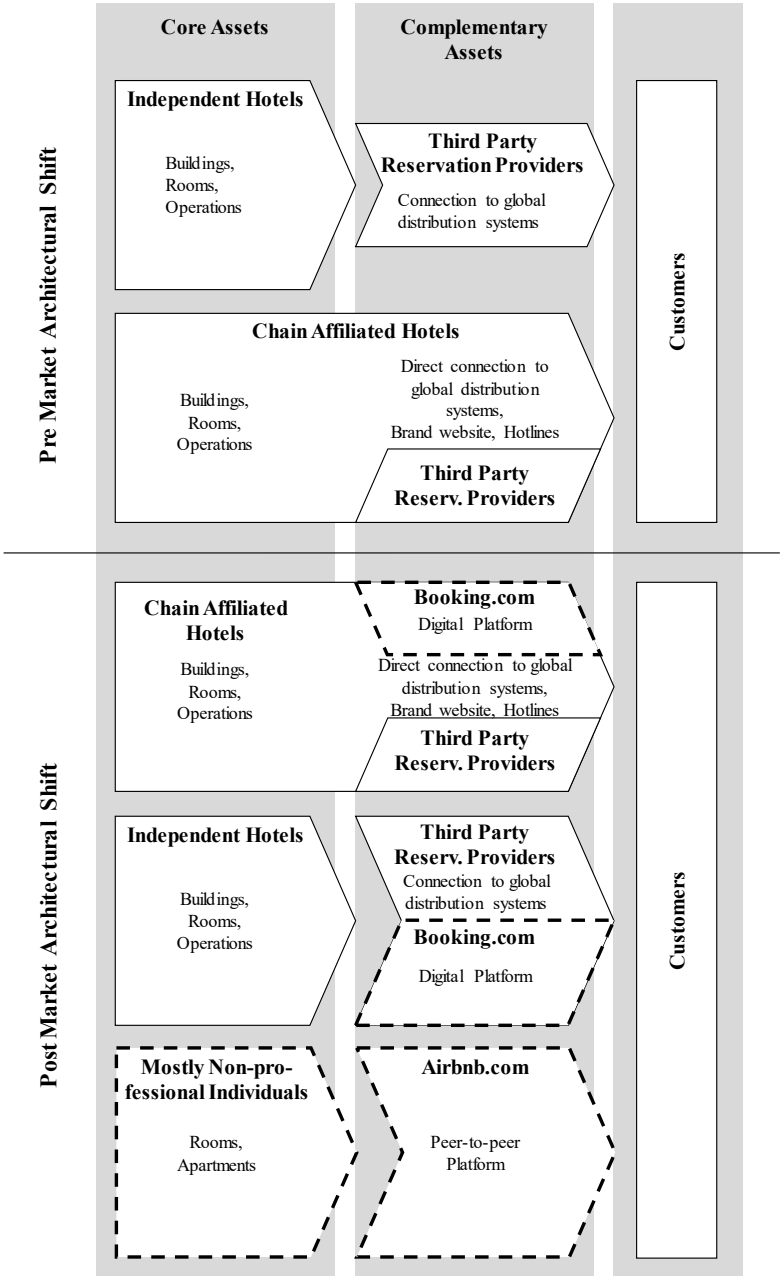
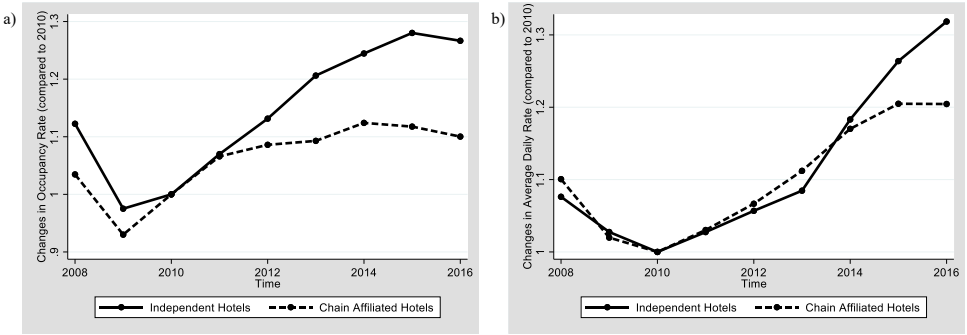


Figure 4: Changes in Occupancy Rate and Average Daily Rate over Time



Our interpretation is that this effect is caused by the increasing availability of platform markets that gives independent hotels access to a larger customer base that they can reach through the platform and that was out of their reach because of their lacking complementary downstream assets before. The competitive advantage that chain-affiliated hotels used to have in promoting their physical assets because of their strong complementary downstream assets is therefore decreasing over time. Some initial evidence for this reasoning

is provided by Figure 4a). Taking the year 2010 as a baseline, the graph shows the changes in occupancy rates (i.e. the number of rooms sold divided by the total number of rooms in a given hotel) over time for independent and chain-affiliated hotels. While both types of hotels follow similar economic trends, the occupancy rate of independent hotels has grown much more than the occupancy rate of chain-affiliated hotels over the past years.

Figure 4b) shows that, as time progresses, the average daily rate (i.e., the room revenue divided by rooms sold) of chain-affiliated hotels grows much less than that of independent hotels, suggesting that it is becoming more and more difficult for chain-affiliated hotels to maintain their prices at a comparatively high level. Our interpretation of these trends is that, as chain-affiliated hotels are pushed to use platform marketplaces more and more, they face increasing head-on competition with other hotels on the same platform, which will force them to adjust their prices accordingly.

6. RESULTS

Table 5 shows the results from the estimation of model (1) with *Adoption* as the dependent variable, which estimates the effect of *Airbnb* on the adoption of *Booking.com* by hotels. It can be seen from column (I) that there is no statistically significant effect if we do not differentiate between independent and chain hotels. However, column (II) shows that chain-affiliated hotels are significantly more likely to adopt *Booking.com* than independent hotels as room supply on *Airbnb* increases, and that the net effect on their adoption is positive. The pattern of results remains similar if we use *CumAirbnbSupply* lagged by three months to account for potential reaction times. Taken together, this provides evidence in favor of our first hypothesis. As more and more rooms are available on *Airbnb*, incumbents that own both core and complementary assets are increasingly adopting platform marketplaces.

Table 5: Airbnb Supply and Hotel Adoption of Platform Marketplaces

Dependent Variable	Adoption			
	(I)	(II)	(III)	(VI)
ln(CumAirbnbSupply)	-0.0003 (0.772)	-0.0039*** (0.000)		
ChainAffiliated X ln(CumAirbnbSupply)		.00443*** (0.000)		
ln(CumAirbnbSupply)[t-3]			-.00063 (0.625)	-.00423*** (0.001)
ChainAffiliated X ln(CumAirbnbSupply)[t-3]				.00445*** (0.000)
ln(TArating)	.00303** (0.042)	.0028* (0.059)	.0031** (0.042)	.00287* (0.058)
ln(RoomSupply)	-.00208 (0.888)	-.00046 (0.975)	-.00288 (0.847)	-.001 (0.947)
Unemployment	.0034** (0.047)	.00334** (0.039)	.00342* (0.053)	.00341** (0.045)
ln(MedianWage)	-.06242 (0.206)	-.05213 (0.273)	-.05223 (0.261)	-.04341 (0.332)
ln(AirPassenger)	-.00507 (0.718)	-1.1e-05 (0.999)	-.00323 (0.829)	.00211 (0.893)
Constant	.24649 (0.416)	.13174 (0.676)	.20107 (0.522)	.08306 (0.797)
Observations	114301	114301	113086	113086
Within R^2	0.0002	0.0016	0.0002	0.0016

p-values in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Difference-In-Differences specification based on model (1), contains hotel fixed effects, time fixed effects and city time-trends, standard errors are clustered at the hotel level

In Hypothesis 2, we argued that increasing supply on peer-to-peer platforms should lead to more usage of platform marketplaces by incumbents that own complementary assets, as both supply and demand are moving to these platforms. To test this hypothesis, we estimated model (1) with *ln(Reviews)* as our dependent variable.

The results of this estimation can be found in Table 6. Similar to our results from the previous model, we do not find a statistically significant effect of *Airbnb* supply on the number of reviews received on *Booking.com* if we consider all hotels, but we do find a statistically significant positive difference between chain-affiliated and independent hotels. However, the net effect of Airbnb supply on the reviews that chain-affiliated hotels receive is not positive.

While this result may seem surprising, we believe that it is consistent with our theoretical reasoning. As we argued above, an increasing supply of core assets on peer-to-peer platforms (i.e., rooms on *Airbnb*), leads to both more direct competition and to an increasing usage of platform marketplaces by hotels. While more competition likely leads to less business, and therefore less reviews on *Booking.com*, a shift towards doing more business on platform marketplaces (as opposed to conventional channels) likely leads to more reviews. Therefore, an increasing supply of core assets can result in two opposing effects: An increase or a decrease in the number of reviews. Consistent with our theory however, we find that the usage of platform marketplaces by chain-affiliated hotels decreases less than that of independent hotels, suggesting that they can counterbalance the competitive effect at least in part.

Table 6: Airbnb Supply and Usage of Platform Marketplaces by Hotels

Dependent Variable	ln(Reviews)			
	(II)	(IV)	(VI)	(VIII)
ln(CumAirbnbSupply)	-0.1122 (0.168)	-0.2101** (0.013)		
ChainAffiliated X ln(CumAirbnbSupply)		.10771*** (0.000)		
ln(CumAirbnbSupply)[t-3]			-.08598 (0.118)	-.18127*** (0.003)
ChainAffiliated X ln(CumAirbnbSupply)[t-3]				.10473*** (0.000)
ln(TArating)	-.00772 (0.346)	-.00857 (0.293)	-.0074 (0.370)	-.00831 (0.312)
ln(RoomSupply)	-.31288 (0.751)	-.28013 (0.773)	-.36993 (0.691)	-.33661 (0.712)
Unemployment	.11388* (0.080)	.11536* (0.075)	.1238* (0.076)	.1254* (0.071)
ln(MedianWage)	7.6637*** (0.001)	7.5805*** (0.001)	7.4569*** (0.000)	7.3806*** (0.000)
ln(AirPassenger)	-1.0994* (0.055)	-1.0574* (0.061)	-1.0248* (0.091)	-.98243 (0.101)
Constant	-1.7875 (0.888)	-2.4919 (0.842)	-1.9211 (0.876)	-2.6557 (0.826)
Observations	45365	45365	45355	45355
Within R^2	0.0014	0.0024	0.0013	0.0023

p-values in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Difference-In-Differences specification based on model (1), contains hotel fixed effects, time fixed effects and city time-trends, standard errors are clustered at the hotel level

To test our last hypothesis, we used *ln(TotalRoomReceipts)* as our dependent variable in model (1). The results reported in column (I) of Table 7 show that there is a statistically significant negative effect of increasing *Airbnb* supply on the monthly revenue of hotels. Somewhat different from what we expect in our hypothesis however, we do not find any statistically significant difference between independent and chain-affiliated hotels (see columns (II) and (VI)). It is important to note however, that in our models we do not include differences in hotel class (i.e., high-end hotels vs. low-end hotels) as control variables. Since hotel class does not change over time, we cannot include these variables in our difference-in-differences model with individual fixed-effects. For this reason, we ran additional analyses, which are reported in columns (III-IV) and (VII-VIII), and which provide some insights into what might be driving our results.

These columns contain the results that we obtained by running the same difference-in-differences model on subsamples that either contain only hotels that operate at the lower end of the market, or only hotels that operate at the higher end of the market. The idea behind this grouping is that low-end hotels are the ones that are most likely to compete directly with *Airbnb* for the same customer segment, whereas high-end hotels operate in a different market segment. The results show a negative difference between chain-affiliated hotels in the high-end class as supply on *Airbnb* increases, but no such difference in the low-end class. Furthermore, we find that the net effect of *Airbnb* supply on chain-affiliated hotels in the high-end category is negative. While the difference is only marginally statistically significant if we use the non-lagged independent variable, it does become statistically significant once we consider the supply of rooms on *Airbnb* lagged by three time periods. We believe that the importance of the time lag is consistent with our theoretical reasoning. We argued that the effect of *Airbnb* supply on the performance of hotels can be attributed to the increasing adoption and usage of platform marketplaces. We would not expect this effect to fully unfold immediately after *Airbnb* supply increases, but rather after a certain period of time, during which hotels and consumers have time to react.

Table 7: Airbnb Supply and Hotel Revenues

Dependent Variable	ln(TotalRoomReceipts)							
Sample	All Hotels		Low-End Hotels	High-End Hotels	All Hotels		Low-End Hotels	High-End Hotels
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
ln(CumAirbnbSupply)	-0.0479**	-0.0510**	-0.0618***	-0.0073				
	(0.017)	(0.015)	(0.007)	(0.719)				
ChainAffiliated X ln(CumAirbnbSupply)		.00373	.0056	-.01929				
		(0.598)	(0.557)	(0.109)				
ln(CumAirbnbSupply)[t-3]					-.03638**	-.03676**	-.04143**	-.00702
					(0.021)	(0.029)	(0.020)	(0.717)
ChainAffiliated X ln(CumAirbnbSupply)[t-3]						.00055	.00199	-.01977*
						(0.947)	(0.854)	(0.088)
ln(TArating)	.02465**	.02443**	.02764**	.00296	.02619**	.02616**	.02893**	.00671
	(0.029)	(0.029)	(0.029)	(0.803)	(0.021)	(0.020)	(0.022)	(0.585)
ln(RoomSupply)	-.92341**	-.92379**	-.88834**	-.8738**	-.877**	-.87704**	-.85903**	-.798*
	(0.031)	(0.031)	(0.039)	(0.041)	(0.032)	(0.032)	(0.037)	(0.055)
Unemployment	-.08334**	-.08325**	-.084**	-.084**	-.08205**	-.08201**	-.08094**	-.08767**
	(0.027)	(0.027)	(0.027)	(0.045)	(0.032)	(0.031)	(0.031)	(0.036)
ln(MedianWage)	1.1945	1.1986	1.235	1.0474	1.1044	1.1039	1.044	1.1246
	(0.147)	(0.145)	(0.139)	(0.216)	(0.165)	(0.166)	(0.193)	(0.201)
ln(AirPassenger)	.40613**	.40716**	.42171**	.43551*	.39615**	.3962**	.41291**	.39569
	(0.037)	(0.037)	(0.023)	(0.070)	(0.038)	(0.038)	(0.020)	(0.127)
Constant	12.48***	12.458***	11.384**	13.13***	12.357***	12.357***	11.66**	12.758**
	(0.008)	(0.008)	(0.013)	(0.005)	(0.008)	(0.008)	(0.011)	(0.012)
Observations	193934	193934	142327	51607	192580	192580	141421	51159
Within R^2	0.0127	0.0128	0.0142	0.0129	0.0129	0.0129	0.0135	0.0147

p-values in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Difference-In-Differences specification based on model (1), contains hotel fixed effects, time fixed effects and city time-trends, standard errors are clustered at the hotel level

While we cannot directly test the driving forces behind these results, the most likely explanation is related to hotel quality. While all chain-affiliated hotels suffer from the increasing devaluation of the chain's complementary downstream assets, low-end hotels also have several benefits derived from chain affiliation, particularly in the face of increasing competition from *Airbnb*. Besides providing access to their downstream assets, chains provide the hotels that are affiliated to them with several other benefits, such as overall higher quality standards or additional services for customers. For hotels at the lower end of the market, which are affected by direct competition from *Airbnb*, providing high quality standards or additional services can be an important way to differentiate themselves from listings on *Airbnb*, which in general offer less service and potentially lower quality standards. This in turn might explain why being affiliated to a chain is less detrimental for the performance of low-end hotels, particularly in the face of increasing direct competition from *Airbnb*. On the other hand, all high-end hotels, regardless of whether they are affiliated to a chain or not, provide a

certain level of service and have in fact traditionally competed on quality, rather than prices, at least to some extent. For this reason, high-end hotels have no major differentiation advantage to gain from chain affiliation but will at the same time suffer from the increasing loss in value of the chain's complementary downstream assets. Additionally, high-end hotels have traditionally been the ones that charged the highest price premium to customers and are therefore the ones that have the most to lose from the decreasing value of their exclusive downstream assets. Taken together, this suggests that major differences in the quality among hotels might indeed be responsible for differences in the effect of chain affiliation between the high-end and low-end hotels. Overall, we believe that the results in Table 7 provide support for our third hypothesis.

7. ADDITIONAL ANALYSES

Test of Parallel Trends Assumption

The validity of difference-in-differences analysis relies on the assumption that there are parallel trends between the treated and the control (yet to be treated group in our case) groups before the treatment. To verify this assumption, we used a variation of model (1) where we replace the continuous treatment (i.e., supply on *Airbnb*) with a binary treatment (i.e., before/after the entry of *Airbnb*). We followed the strategy by Autor (2003) and augmented this specification with lead and lag values of treatment. We conducted this exercise with the subsamples of low-end and high-end hotels with hotel revenue as the dependent variable[12]. If the parallel trends assumption is justified, we should find lead values, i.e., values prior to the treatment, to be close to zero. Table 8 shows the results from this analysis. In the case of low-end hotels, for which we do not find any statistically significant difference in performance between independent and chain-affiliated hotels, the coefficients remain close to zero and similar in terms of magnitude and p-values throughout the lead and lag periods. In the case of high-end hotels, we find that the coefficients become significantly larger around the treatment period and decrease in terms of p-values in the periods after the treatment. This suggests that the changes in revenue only occur after the entry of *Airbnb*.

Additional Robustness Checks

We conducted several additional analyses to assess the robustness of our findings and exclude some of the potential alternative explanations. First, we used alternative difference-in-differences approaches. Instead of using different sub-samples that only include certain classes of hotels, we used a 3-way diff-in-diff over the full sample. Second, we control for possible differences within some hotel classes, such as specific market trends over time or differences in hotel characteristics within the same class, as possible factors driving our results. To rule out this possibility, we ran one model including class-specific time trends. Finally, we analyzed a possible mediation effect (i.e., the negative effect of *Airbnb* on chain affiliated hotels being mediated by the shifting of demand and supply to platform marketplaces). Details and results of these analyses are reported in the appendix.

[12] Note that this specification is estimated using a hotel-year sample (rather than a hotel-month sample) for simplicity and exposition purposes.

Table 8: Test of the Parallel Trends Assumption following Autor (2003)

Dependent Variable	ln(TotalRoomReceipts)			
Sample	Low-End Hotels		High-End Hotels	
	(I)	(II)	(III)	(IV)
ChainAffiliated X $After_{t-3}$	.01061	.01047	.02214	.02118
	(0.592)	(0.670)	(0.542)	(0.564)
ChainAffiliated X $After_{t-2}$	.02326	.01075	-.00208	-.00818
	(0.571)	(0.727)	(0.962)	(0.858)
ChainAffiliated X $After_{t-1}$	.02011	.00527	-.01442	-.02007
	(0.685)	(0.901)	(0.757)	(0.687)
ChainAffiliated X After	.01871	.0064	-.0434	-.05289
	(0.629)	(0.877)	(0.417)	(0.357)
ChainAffiliated X $After_{t+1}$	.04706	.02248	-.03765	-.0453
	(0.239)	(0.608)	(0.490)	(0.469)
ChainAffiliated X $After_{t+2}$	.06076	.02432	-.07216	-.07073
	(0.241)	(0.685)	(0.290)	(0.358)
ChainAffiliated X $After_{t+3}$	.04937	.0056	-.09957	-.08727
	(0.310)	(0.918)	(0.180)	(0.283)
ChainAffiliated X $After_{t+4\ forward}$	.07689	.00541	-.16595*	-.15845
	(0.346)	(0.942)	(0.097)	(0.134)
ln(TArating)		.04583**		-.01348
		(0.041)		(0.728)
ln(RoomSupply)	-.83301*	-.97618**	-1.4597**	-1.3092**
	(0.083)	(0.030)	(0.011)	(0.018)
Unemployment	-.03155	-.06457	-.04789	-.04605
	(0.339)	(0.121)	(0.107)	(0.112)
ln(MedianWage)	1.0772	.52894	.07865	.0904
	(0.192)	(0.517)	(0.916)	(0.918)
ln(AirPassenger)	.69013*	.58806*	.83507	.40786
	(0.093)	(0.083)	(0.247)	(0.505)
Constant	6.5488	11.47*	15.581	20.31**
	(0.289)	(0.066)	(0.123)	(0.037)
Observations	17755	12256	4740	4386
Within R^2	0.0077	0.0119	0.0238	0.0208

p-values in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Difference-In-Differences specification based on modified version of model (1), contains hotel fixed effects, time fixed effects and city time-trends, standard errors are clustered at the hotel level

8. DISCUSSION AND CONCLUSION

We document how digital platform technologies in adjacent markets, such as peer-to-peer platforms like *Airbnb*, can produce significant disruption effects not through competitive substitution, but rather through the complementary effects that they trigger, which lead to changes in the relative value of incumbents' offer in the ecosystem. These platforms do not simply bring new alternative offerings to incumbents' core offerings. Also, and more importantly, they induce a change in the configuration of the value system and the level of complementarities therein for incumbents as they establish themselves, and competing platform marketplaces (e.g., *Booking*.com), as the mainstream new technology for connecting and transacting. This shift affects incumbents' performance differently, depending on the extent the new platform-based ecosystem enhances the value-creation potential of incumbents' core assets and erodes the value of incumbents' downstream specialized complementary assets.

Prior literature has overlooked this aspect and has often applied conventional competitive dynamics logics to study the effects of digital platforms on traditional firms (e.g., Farronato & Fradkin, 2018; Zervas, Proserpio, & Byers, 2017). However, platform-based disruption involves more intricate dynamics than simply competitive substitution effects of incumbents' core-technologies and offerings – they bring in new dynamics affecting consumer preferences and customer experience, as well as the rules and roles for actors in the supply-

side to connect and provide value to customers. The new platform-based ecosystem configuration breaks the established value chain linkages, modularizing and standardizing part of those intermediate steps, mainly marketing and distribution in our research context, thus eroding the value of incumbents' downstream complementary assets (Cozzolino & Rothaermel 2018). Thus, those incumbents with strong position in these assets are the ones most negatively affected by the partitioning of the value system and standardization of some of its core elements operated by the platforms – they lose "architectural control" over these critical bottleneck assets in favor of the platform provider, upon which they now rely for realizing the value from their core assets.

Our study thus reveals an important variation of disruption in relation to digital platform technologies. While platform marketplaces are value-enhancing to incumbents' core-activities, they are value-destroying for incumbents' established linkages to customers, making their cospecialized complementary assets obsolete. Accordingly, for those incumbents with strong positions in downstream assets, platforms have the dual effect of sustaining (complementing) their core activities and competencies in the service production and delivery while disrupting their marketing activities and competencies (e.g., brand positioning and customer relationships). With the disruptive effect (commoditization and reduced profitability) being greater than the complementarity (market expansion) effect, these technologies end up being a net-negative for those incumbents. These dynamics help explain also the apparent paradox we uncover in the analysis that those with strong positions in downstream assets might be the ones most affected by platform-based disruption. Contrary to traditional vertical value-chain contexts in which the value network's architecture does not change and thus incumbents can retain their role in the ecosystem and leverage their assets to fend off the competitive threats from entrants (e.g., Jacobides and McDuffie 2012; Tripsas 1997), platforms do affect the structure of the value system and with it, the level of complementarities and the value of incumbents' assets.

More broadly, this variation reveals a critical but often overlooked dimension of disruption proceeding from technologies that complement incumbents' core knowledge and offerings rather than replacing them (e.g., Adner & Lieberman 2021; Ozalp et al. 2018). Mainstream literature on technological discontinuity has emphasized several factors in relation to the market (like heterogeneous customer preferences and underserved markets – e.g., Adner, 2002; Christensen, 1997), or the technology characteristics (like competence-destroying or architectural nature of the technological change – e.g., Tushman & Anderson 1986; Henderson & Clark 1990) as key drivers of disruption. It has though largely ignored the role of complementors and how the strength (or lack thereof) of complementarities in the ecosystem affects the joint value creation capacity of the interdependent firms as a collective, and their individual value capture ability. Exceptions are recent advances such as Ansari et al. (2016), Ozalp et al. (2018) and Adner & Lieberman (2019), which have highlighted the importance of inter-firm linkages in the ecosystem in which the value of a given technology must be understood in the context of its system's use – that is, in relation to the complementary products and services with which it forms an integrated solution and value proposition for the final customer. Our study extends this line of research by considering the broader impact that systemic innovations such as platform market innovations have on the relational interdependencies across the entire ecosystem, in line with recent calls raised in the literature (Kumaraswamini, Garud and Ansari 2018).

Expanding the view to include the technology's ecosystem and the level of interdependencies and complementarities it engenders among the ecosystem actors illuminates on new strategic dynamics of relevance. First, and foremost, is the strategic trade-off that some incumbents face when deciding to adopt digital platforms to anticipate or respond to the digital transformation of the value chain that might be triggered by inroads of digital platforms in adjacent markets. While platforms may offer a potent, standardized and efficient tool to coordinate demand and supply and channel their offerings more effectively to customers, as platforms grow in adoption and thus in their complementary value, incumbents also become more reliant upon the platform (and its ecosystem) to realize the market value from their assets (Ozcan & Hannah 2021). Second, the increasing dominance of platform markets shifts the value network of incumbents from vertical value chains to multilateral structures (Adner 2017; Hagiu & Wright 2015) in which all incumbents act as complementors to a joint value proposition to the customer that the platform provider orchestrates (Jacobides et al. 2018). While this structure guarantees increasing complementarities in the form of cross-sides (between demand and supply) network effects, thus enlarging the pie for the collective, it also poses value appropriation challenges for high-quality complementors (Cennamo and Santaló 2013, 2019), and tensions over the distribution of value between the platform provider and these complementors (John & Ross 2021; Panico & Cennamo 2020). Third, particularly for those incumbents holding strong positions in the current value chain structure, the main dilemma is about losing architectural control when moving to the platform and becoming

a complementor in the platform-based new ecosystem (Ozcan & Hanna 2021; Hanna & Eisenhardt 2018). At the same time, this is a choice over which they might have no full control. If they resist from adopting those technologies, how can they respond to the evolving competitive context? Launching their own individual platforms is hardly an option; by definition, platform technologies must aggregate an array of complementary products and services to be valuable to customers (Cennamo & Santaló 2013; Hagiu & Wright 2015; Rochet & Tirole 2003). Thus, they should either invite direct competition to their services from other service providers into their own platform or ally with their all-time competitors in their industry to build a shared platform (Cozzolino & Rothaermel 2018). Either choice involves coopetitive relations (Ansari et al. 2016) and value creation-capture tradeoffs that are not minor to those they experience by joining a third-party player's platform. The case of Free Now, a mobility platform combining ride-haling and car-sharing services, jointly owned by two key incumbent leaders in the automotive industry, BMW and Daimler (Mercedes-Benz's group), offers a counter example of the attempt of these incumbents to respond to possible disruption by Uber and other similar platforms. Whether that is enough to blockade a similar "Airbnb-Booking moment" remains to be seen. What also this example exemplifies is that the strategic dilemma that incumbents face in the wake of emerging platforms are indicative of the different nature of "platform disruption", and why its impact can be greater than the impact of product-based disruptive innovations.

Managerial Implications

Our findings illustrate the challenges faced by incumbent firms when responding to platform entrants to their sector. First, because much of the technological innovations they introduce is about digital tools that enable more direct and efficient interactions and transactions between customers and product/service providers, incumbents face the strategic dilemma of whether and to what extent they need to shift their core offerings towards these new marketplace infrastructures. On one hand, platform markets can allow incumbents to reach out to a larger market, in a more efficient way and possibly at lower costs. On the other hand, once the platform market becomes the new, established gateway to customers, thus containing most of the transactions, the firm controlling the platform can exercise an indirect control over the whole market and have a disproportionate market power vis-à-vis the firms operating through its market. In other words, incumbent firms will have to increasingly rely on the platform firm's infrastructures for their business, and will have to abide to, and customize and optimize their business operations and market activities according to the market rules set by the platform firm. Incumbents will thus respond differently depending on their existing position in the market and in downstream complementary asset ownership, with firms holding strong position in those assets being more resistant to those market innovations.

Second, our findings show that, by facilitating the emergence of a market for a new service that albeit different in its characteristics and providers can be a competing alternative to the service traditionally offered by the incumbents in the industry, peer-to-peer platforms may shakeout the industry, and bring in not just a new type of competitors but a new type of platform-level competition, in which rival ecosystems of services providers organized around the competing platforms compete for customers. Therefore, incumbents are likely to be unprepared for competition from peer-to-peer platforms if they continue to rely, as they have largely done over the past, on the traditional industry and product-market boundaries to identify their competitors. Most of these boundaries are usually "negotiated" through top-down regulations or associations representative of industry categories, which generally fail to capture the entire spectrum of consumer preferences, let alone changes in customer behavior. Platform markets instead, are innovations aimed precisely at intercepting and matching customer preferences and needs, and largely shaping customer behavior and experience.

More generally, our work can help build an understanding of why incumbent firms are not only slow to respond to shocks in market innovations coming from platform entry, but also inadequate in their responses. Because peer-to-peer platforms operate in adjacent markets and much of the value of incumbents' core offerings and operations are not directly affected by their entry, it will be hard for incumbents to anticipate the real major disruptive threat that the market shifting can have: making their downstream complementary assets obsolete, thus severely undermining their value capture ability in the new market technology regime. This is particularly the case for incumbents situated in the high-end market segments. While they might not be directly affected by competition from alternative services offered through peer-to-peer platform markets, they will be exposed to more intense direct competition from their traditional competitors when transacting within the platform market, with limited ability to eschew price competition. These firms might then likely be ill-prepared for competing in platform markets, continuing to apply their traditional product/service differentiation strategies in a changed, new market context subject to different competitive dynamics. Indeed, many high-end hotel

chains have attempted to compete against the digital platforms through loyalty programs and aggressive marketing campaigns to steer consumers and induce them to book directly through their own websites. For instance, Hilton and Marriott have invested heavily in mobile apps that enable guests to earn reward points and offer them to choose their exact room and make digital check-ins without waiting in line[13]. Despite these efforts, hotel online gross bookings of Marriott and Hilton hotels in the US decreased of 37% and 6% respectively in 2016 and 2017[14]. These examples suggest that incumbent firms will need to elaborate more sophisticated platform market strategies by understanding how to best reconfigure their business operations and market activities such to tailor them to the new platform market dynamics rather than trying to bypass platform markets. The sooner managers engage into such strategy formulation, the better will be their ability to respond to a platform market shifting, or even anticipate it and lead such transformation.

Limitations

While the analyses presented above provide evidence for our claims, this study also has some limitations. As with many studies, a potential limitation to the generalizability is posed by the fact that we focus only on one industry and one geographic region. While we cannot fully rule out all potential concerns, there are a few factors that might alleviate them. The fact that similar phenomena can be observed in other industries (e.g., the entry of Uber and the increasing popularity of taxi apps in the transportation sector, or the increasing shift of banking and financial services to digital platforms in response to increased popularity of peer-to-peer landing and payment systems) and the fact that our sample includes a very diverse set of cities (e.g., touristic and non-touristic cities) make the results more generalizable. Further and deeper analysis on how specifically the different types of complementary assets are affected by the different types of platform marketplaces can be an interesting venue for future research to build a more complete understanding of the heterogeneity in the effects and strategic responses across firms in the wake of market architectural changes. This may inform to great extent also the activities that firms are engaging in as part of their digital transformation process.

A second limitation of this paper is the fact that we do not directly observe supply and demand of hotel rooms on platforms. Ideally, we would like to observe how many rooms of a given hotel are made available online and how many potential customers look for hotel rooms online. As these data are unavailable to us, we believe that our proxy is the best possible measure to quantify the usage of platform marketplaces.

Finally, we do not account here for possible preferential linkages between the platform provider and some of the hotel firms because of lack of data on such contractual agreements. The literature on platform markets indicates that firms gain large benefits in platform markets from exclusivity clauses – marketing the product/service exclusively for the platform in exchange of lower royalty fees and marketing support (e.g., Cennamo & Santaló, 2013) or selective promotion - cooperative arrangements wherein the platform will invest in and promote the products/services of few, select providers (Rietveld et al. 2019). To the extent such arrangements are in place in our context but do not change over time by hotel, our fixed effects at the hotel level will control for differences in performance that can be attributed to them. Also, we might expect to be the premium, high-end chain hotels the one likely to strike such deals with the platform firm if any. In that case, this will bias downwards our results – that is, our results will offer conservative estimates. Nonetheless, we think that properly accounting for variation in such arrangements across hotels might add additional insights and reveal also a broader set of strategic responses by firms. We leave such analysis to future research.

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10.APPENDIX: ADDITIONAL ANALYSES

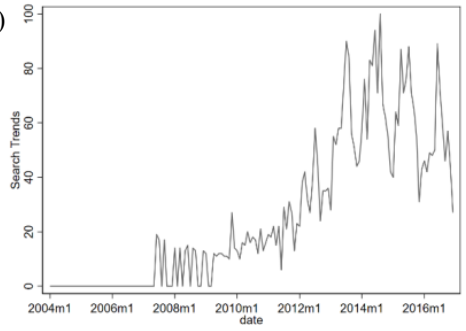
We conducted several additional analyses to assess the robustness of our results and exclude some of the potential alternative explanations.

Evidence for Change in Consumer Behavior

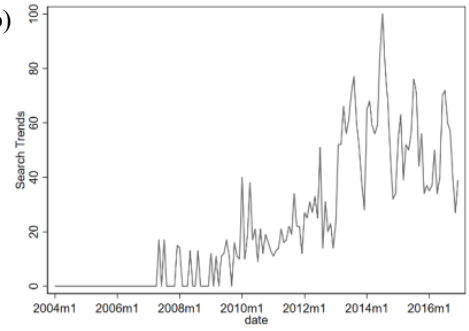
Google search trends provide accompanying insights to our argumentation. The search trends indicate that users increasingly use combinations of the name of the hotels and platform names. As an example, we plot the search trends for "Hilton booking.com" and "Marriott booking.com" in Figure A1. As the figure shows, consumers are increasingly looking for accommodation on platform marketplaces.

Figure 5: Search Trends for the keywords "Hilton booking.com" (a) and "Marriott booking.com" (b)

a)



b)



Three-Way Difference-In-Differences Approach

As an alternative for conducting the difference-in-differences analysis using different subsamples that only include certain classes of hotels, we also used a three-way difference-in-differences approach. In this approach (see model (2)), we compare the performance of chain affiliated or independent hotels in the lower or higher end of the market as supply on *Airbnb* increases.

$$\begin{aligned} \boldsymbol{DV_{it}} = \boldsymbol{\beta_1}\ \mathbf{ln}\ (\boldsymbol{CumAirbnbSupply_t}) + \ \boldsymbol{\beta_2}\ \mathbf{ln}\ (\boldsymbol{CumAirbnbSupply})_t \\ * \boldsymbol{ChainAffiliated_i} + \boldsymbol{\beta_3} * \boldsymbol{ln}(\boldsymbol{CumAirbnbSupply})_t * \boldsymbol{HighEnd_i} + \ \boldsymbol{\beta_4} \\ * \boldsymbol{ln}(\boldsymbol{CumAirbnbSupply})_t * \boldsymbol{ChainAffiliated_i} * \boldsymbol{HighEnd_i} \\ + \ \boldsymbol{\beta_X}\ \boldsymbol{C_x} + \boldsymbol{\delta_i} + \ \boldsymbol{\gamma_t} + \ \boldsymbol{\theta_{jt}} + \boldsymbol{City_j} * \boldsymbol{\gamma_t} + \ \boldsymbol{u_{it}} \end{aligned} \quad \textbf{(2)}$$

In Table 10, we show the estimation results for different variations of this model in which we increasingly add interaction terms. Columns (III) and (VII) show that hotels at the higher end of the market perform better than their counterparts at the lower end of the market as supply on *Airbnb* increases, suggesting that they are less affected by direct competition. It can also be seen from the two columns that the three-way interaction term carries a negative sign. While the effect is only marginally significant, we believe that this is consistent with the idea that chain-affiliated hotels at the higher end of the market perform worse than their independent counterparts as supply on *Airbnb* increases, which replicates the findings presented above.

Table 9: Airbnb Supply and Hotel Revenue (3-way Difference-In-Differences Approach)

Dependent Variable	ln(TotalRoomReceipts)							
Sample	All Hotels							
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
ln(CumAirbnbSupply)	-0.0479**	-0.0510**	-0.0519**	-0.0563***				
	(0.017)	(0.015)	(0.012)	(0.010)				
ChainAffiliated X ln(CumAirbnbSupply)		.00373		.00547				
		(0.598)		(0.564)				
HighEnd X ln(CumAirbnbSupply)			.03214**	.03646*				
			(0.024)	(0.063)				
ChainAffiliated X HighEnd X ln(CumAirbnbSupply)			-.01852	-.02398				
			(0.129)	(0.215)				
ln(CumAirbnbSupply)[t-3]					-.03697**	-.03736**	-.03982**	-.04111**
					(0.018)	(0.023)	(0.013)	(0.018)
ChainAffiliated X ln(CumAirbnbSupply)[t-3]						.00056		.00192
						(0.944)		(0.856)
HighEnd X ln(CumAirbnbSupply)[t-3]							.03108**	.03259*
							(0.022)	(0.097)

ChainAffiliated X HighEnd X ln(CumAirbnbSupply)[t-3]							-.01923 (0.101)	-.02115 (0.283)
ln(TArating)	.02465** (0.029)	.02443** (0.029)	.02293** (0.031)	.0226** (0.031)	.02631** (0.021)	.02628** (0.020)	.02477** (0.022)	.02466** (0.021)
ln(RoomSupply)	-.92341** (0.031)	-.92379** (0.031)	-.92388** (0.031)	-.92438** (0.031)	-.87712** (0.032)	-.87716** (0.032)	-.87858** (0.032)	-.87869** (0.032)
Unemployment	-.08334** (0.027)	-.08325** (0.027)	-.08316** (0.028)	-.08306** (0.028)	-.08225** (0.031)	-.08221** (0.031)	-.08181** (0.033)	-.08169** (0.033)
ln(MedianWage)	1.1945 (0.147)	1.1986 (0.145)	1.1985 (0.144)	1.2048 (0.141)	1.1106 (0.163)	1.1101 (0.165)	1.1032 (0.163)	1.1018 (0.166)
ln(AirPassenger)	.40613** (0.037)	.40716** (0.037)	.40556** (0.038)	.40693** (0.037)	.39618** (0.039)	.39623** (0.039)	.39488** (0.040)	.39504** (0.039)
Constant	12.48*** (0.008)	12.458*** (0.008)	12.482*** (0.008)	12.45*** (0.008)	12.343*** (0.008)	12.344*** (0.008)	12.393*** (0.007)	12.395*** (0.007)
Observations	193934	193934	193934	193934	192580	192580	192580	192580
Within R^2	0.0127	0.0128	0.0161	0.0163	0.0130	0.0130	0.0160	0.0160

p-values in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; 3-way Difference-In-Differences specification based on model (2) , contains hotel fixed effects, time fixed effects and city time-trends, standard errors are clustered at the hotel level

Hotel Class Time-Trends

An alternative explanation for our findings might be that there are specific market trends in some hotel classes over time, which drive our results. This could in principle lead to an increase in the revenues of hotels in certain segments, as well as to an increase in the amount of business that they do on digital platforms. To rule out this possibility, we extended the difference-in-differences specification described in model (1) by adding class-specific time trends. The results of this analysis can be found in Table 9. It can be seen that, compared to the results displayed in Table 7, the magnitude of the effects changes slightly but the overall pattern of results remains unchanged.

Table 10: Airbnb Supply and Hotel Revenues (Controlling for class-specific time trends)

Dependent Variable	ln(TotalRoomReceipts)							
Sample	All Hotels		Low-End Hotels	High-End Hotels	All Hotels		Low-End Hotels	High-End Hotels
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
ln(CumAirbnbSupply)	-0.0480** (0.014)	-0.0480** (0.021)	-0.0623*** (0.008)	-0.0053 (0.792)				
ChainAffiliated X ln(CumAirbnbSupply)		-6.9e-05 (0.993)	.0042 (0.676)	-.02144* (0.070)				
ln(CumAirbnbSupply)[t-3]					-.05187*** (0.008)	-.05145** (0.013)	-.06742*** (0.004)	-.00398 (0.835)
ChainAffiliated X ln(CumAirbnbSupply)[t-3]						-.0005 (0.953)	.00405 (0.695)	-.02298** (0.048)
ln(TArating)	.02181** (0.038)	.02181** (0.038)	.02649** (0.036)	.00378 (0.762)	.02411** (0.027)	.02413** (0.026)	.02844** (0.028)	.00738 (0.566)
ln(RoomSupply)	-.90018** (0.029)	-.90017** (0.029)	-.86604** (0.038)	-.87371** (0.041)	-.86103** (0.031)	-.86094** (0.031)	-.84019** (0.039)	-.79786* (0.056)
Unemployment	-.08376** (0.023)	-.08377** (0.023)	-.08443** (0.022)	-.08432** (0.045)	-.08752** (0.019)	-.08754** (0.019)	-.08883** (0.017)	-.08809** (0.036)

ln(MedianWage)	1.2867	1.2866	1.3513	1.0385	1.4249*	1.4244*	1.5041*	1.1129
	(0.118)	(0.118)	(0.108)	(0.221)	(0.087)	(0.086)	(0.074)	(0.208)
ln(AirPassenger)	.43403**	.43402**	.45492**	.43562*	.44584**	.44575**	.48403**	.39505
	(0.025)	(0.025)	(0.014)	(0.071)	(0.026)	(0.026)	(0.011)	(0.128)
Constant	11.682***	11.682***	10.46**	13.153***	10.77**	10.772**	9.4054**	12.799**
	(0.008)	(0.008)	(0.016)	(0.005)	(0.014)	(0.014)	(0.028)	(0.012)
Observations	184625	184625	133018	51607	183271	183271	132112	51159
Within R^2	0.0131	0.0131	0.0151	0.0129	0.0151	0.0151	0.0175	0.0150

p-values in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Difference-In-Differences specification based on model (1), contains hotel fixed effects, time fixed effects, city time-trends and class time-trends, standard errors are clustered at the hotel level

Mediation

We have analyzed the effect of *Airbnb* on online reviews and the effect of *Airbnb* on hotel revenues in separate models. While we do not expect the effect of *Airbnb* on hotel performance to be driven entirely by an increasing shift onto digital platforms, there might be a mediating effect. To test this, we ran an additional analysis in which we first replicate the 3-way difference-in-differences approach presented in columns (III) and (IV) of Table 10. We then included the number of reviews on *Booking.com*, as well as interaction terms with the $HighEnd_i$ and $Chain_i$ dummies, as additional independent variables (Baron and Kenny, 1986). It can be seen that, upon inclusion of hotel reviews and related interactions terms as independent variables, the main effect of *Airbnb* supply, as well as the three-way interaction term with $HighEnd_i$ and $Chain_i$ become increasingly smaller in magnitude and their p-values increase. At the same time, we find a statistically significant negative interaction between the number of reviews, $HighEnd_i$ and $Chain_i$ in the full model. This suggests that chain-affiliated hotels at the high end of the market are affected more negatively in their performance by increasing usage of platform marketplaces than their counterparts, and provides some evidence for a mediation effect.

Table 10: Mediation

Dependent Variable	ln(TotalRoomReceipts)							
Sample	All Hotels							
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
ln(CumAirbnbSupply)	-0.0519**	-0.0563***	-0.0503**	-0.0607**	-0.0107	-0.0130	-0.0108	-0.0129
	(0.012)	(0.010)	(0.015)	(0.020)	(0.437)	(0.327)	(0.436)	(0.330)
ChainAffiliated X ln(CumAirbnbSupply)		.00547		.0118		.00262		.00241
		(0.564)		(0.447)		(0.809)		(0.825)
HighEnd X ln(CumAirbnbSupply)	.03214**	.03646*	.01478	.02529	-.01585	-.0135	-.0205	-.01835
	(0.024)	(0.063)	(0.415)	(0.270)	(0.561)	(0.587)	(0.469)	(0.478)
ChainAffiliated X HighEnd X ln(CumAirbnbSupply)	-.01852	-.02398	-.00603	-.01791	.00313	.00054	.00852	.00612
	(0.129)	(0.215)	(0.716)	(0.429)	(0.900)	(0.981)	(0.741)	(0.795)
ln(Reviews)			.01441**	.01428**	.00305	.00302	.00285	.00282
			(0.016)	(0.015)	(0.363)	(0.373)	(0.395)	(0.405)
ChainAffiliated X ln(Reviews)					.00925***	.00921***	.01099***	.01093***
					(0.000)	(0.000)	(0.000)	(0.001)
HighEnd X ln(Reviews)							.01878	.01879
							(0.125)	(0.125)
ChainAffiliated X HighEnd X ln(Reviews)							-.0234*	-.02334*
							(0.050)	(0.051)
ln(TArating)	.02293**	.0226**	.02261**	.02224**	.01471**	.0147**	.01476**	.01475**
	(0.031)	(0.031)	(0.031)	(0.031)	(0.047)	(0.047)	(0.046)	(0.047)
ln(RoomSupply)	-.92388**	-.92438**	-1.0003**	-.99909**	-1.0352***	-1.0345***	-1.033***	-1.0324***
	(0.031)	(0.031)	(0.034)	(0.034)	(0.007)	(0.007)	(0.007)	(0.007)

Unemployment	-.08316**	-.08306**	-.09738**	-.09728**	-.15425***	-.15419***	-.15416***	-.1541***
	(0.028)	(0.028)	(0.031)	(0.030)	(0.000)	(0.000)	(0.000)	(0.000)
ln(MedianWage)	1.1985	1.2048	1.4442	1.4477*	1.6266**	1.6278**	1.6274**	1.6285**
	(0.144)	(0.141)	(0.101)	(0.099)	(0.013)	(0.012)	(0.013)	(0.012)
ln(AirPassenger)	.40556**	.40693**	.53308**	.53231**	.62269*	.62319*	.62344*	.62389*
	(0.038)	(0.037)	(0.018)	(0.018)	(0.065)	(0.065)	(0.065)	(0.064)
Constant	12.482***	12.45***	11.102**	11.091**	9.9868	9.969	9.951	9.9348
	(0.008)	(0.008)	(0.014)	(0.014)	(0.175)	(0.174)	(0.175)	(0.174)
Observations	193934	193934	118081	118081	58872	58872	58872	58872
Within R^2	0.0161	0.0163	0.0199	0.0204	0.0386	0.0387	0.0389	0.0389

p-values in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; 3-way Difference-In-Differences specification based on model (2), augmented to assess potential mediation effect, contains hotel fixed effects, time fixed effects, and city time-trends, standard errors are clustered at the hotel level