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Competing with the platform: Complementor positioning and cross-platform response to entry

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Abstract

Research Summary: This study contrasts traditional entry dynamics with platform owner entry into a complementor market and examines cross-platform complementor response to competition with the platform. Generalists experience low repositioning cost and are more likely to shift effort away, while specialists focus their effort on the focal platform. We examine Apple's "Files" app entry and find support for our hypotheses: generalists shift effort toward the competing platform, while specialists double down on the focal platform. Moreover, empirically comparing Apple's entry with that of other large firms, we find that only the platform owner elicits a strong complementor response. This article contributes to the competitive and corporate strategy literatures, underscoring how complementor heterogeneity affects cross-platform allocation of effort when the platform owner becomes a competitor in complementor spaces.

Managerial Summary: Given the growing managerial and regulatory interest in competitive arenas on digital platforms, we analyze how firms respond to competition with the platform owner. We hypothesize that

platform-enabled firms (complementors) with an outside option—those who also operate on a different platform—reposition, while firms only focused on a single platform double down. Examining the case of the "Files" app on Apple's App Store, we find support for these predictions. We also study other large firm entries on App Store (by Microsoft and SanDisk), but do not observe a meaningful response by complementors. We describe how market entry by the platform owner differs from traditional entry and argue stakeholders may benefit from a deeper understanding of the unique nature of competing with a platform.

KEYWORDS

complementor heterogeneity, multihoming, platform owner entry, repositioning cost, specialist and generalist firms

1 | INTRODUCTION

At the intersection of competitive and corporate strategy, one of the canonical research questions is how an incumbent firm responds to entry (Fudenberg & Tirole, 1984; Thomas, 1999). Generally, the incumbent has two main paths: doubling down on its commitments in an affected domain or accommodating entry, for example, by repositioning to lean more heavily on alternative sources of revenue (Frank & Salkever, 1997; Simon, 2005). The industrial organization and strategy literatures on competitive interactions highlight the significant advantages of incumbents. First, a common assumption is that the incumbent has an established brand and advertising advantage (Geroski, 1995), since advertising is one of the central activities in competitive repertoires (Miller & Chen, 1994, 1996). Second, when the entrant is a dominant firm in a different market, it may have generic capabilities favorable to scaling (de Figueiredo & Silverman, 2007; George & Waldfogel, 2006; Wang & Shaver, 2016) but little knowledge of the incumbents' hard-won competitive information in a particular market (Kim, 2021), such as the identities of their customers, their preferences, or their purchasing habits. Finally, a general assumption is that all firms within an institutional context compete under the same rules of the game (Caselli & Coleman, 2001; Comin & Hobijn, 2010; Skiti, 2020), facing similar regulations and levies in a given market, and which the incumbents have mastered through their longer tenure (Dobrev & Kim, 2006; Singh et al., 1986).

Entry by a platform owner differs from a typical entry because the platform owner benefits from an advantageous position from the start. In situations where a platform orchestrates activities and establishes the rules for market exchange, it possesses a level of authority unmatched by any competitor in typical competitive environments (U.S. Congress, 2020; Zhu & Liu, 2018). As a result, when the platform owner is the entrant and a platform complementor is the incumbent, received findings in the competitive and corporate strategy literatures no longer apply. In a platform setting, it is the platform owner who has an unmatched branding and advertising advantage. It may choose to promote or preferentially rank products with full discretion, since

it is the designer of the algorithm that generates the rankings (Rietveld et al., 2019). Also, a platform owner has near-complete information about an incumbent complementor's product portfolio, including the technological specifications of its products, such as the code and nature of upgrades, as well as market-related information, such as pricing, the identities and contact information of customers, and their purchase histories (Zhu & Liu, 2018). Such information typically constitutes closely guarded trade secrets subject to time-compression diseconomies and legal protections (Castellaneta et al., 2017; Cunningham & Kapacinskaite, 2022; Dierickx & Cool, 1989), but it is easily accessible to the platform owner. Last, the entering platform owner is the maker of the rules of the game: it has an inherent technological advantage enabling it to change and reshuffle technological and compatibility requirements at its discretion, possibly with severe repercussions for complementors (Kapoor & Agarwal, 2017). It may also enjoy the additional benefit of charging platform complementors a levy on their revenues (for instance, a charge of 30% of revenues on Apple's App Store), a fee that the entering platform owner does not have to pay to any other firm, creating an uneven ground for competition.

Under these circumstances, how do incumbent complementors respond to platform owner entry? Answering this question in the context of platforms requires us to consider an important characteristic of competition in platform settings, related to the fact that complementors can specialize on a single platform or serve broader audiences, spanning several platforms. We define specialist complementors as those firms that operate only on the focal platform (singlehomers), while generalist complementors are those firms that operate both on the focal and on a competing platform (multihomers) (Cennamo et al., 2018). Specialists are likely to have highly specialized technological and downstream capabilities, while generalists have more fungible resources (Cennamo et al., 2018; Teodoridis et al., 2019). We believe this element of heterogeneity among incumbent complementors is crucial in answering the question we formulated above, as firms may respond to platform owner entry both on the focal platform and on other, competing platforms where they may also operate. The choice to specialize or generalize indeed has repercussions for the accumulated set of technological capabilities, familiarity with different markets, and thus repositioning cost, and we investigate where these different firms allocate effort in the aftermath of a platform owner entry. We compare the attractiveness of the affected and unaffected market sectors on both the focal and the competing platform for both groups of complementors. We hypothesize that specialist firms would be more likely to double down on the focal platform, while generalist firms would be more likely to divert their effort away from the focal platform, and toward the competing platform. For specialists, repositioning—reallocation of effort between different platforms—is costly: despite the increased competition on the focal platform and, in particular, the affected segment, high repositioning cost as well as specialized capabilities push them to double down, at least in the short to medium term, despite the potential benefit of accessing new markets on the competing platform. By contrast, generalists activate an outside option (Wang & Miller, 2020): they lean more heavily on the already developed technological and product market capabilities, given the low repositioning cost in accessing a competing platform. Importantly, our theorizing implies that incumbent firms respond to platform owner entry and do so heterogeneously, but we would not expect to observe this response to more typical entry, that is, entry by firms that are not the focal platform owners.

Our empirical setting is the mobile apps platforms, including Apple App Store and Google Play Store, which have been subject to prior research on digital platforms (Kapoor & Agarwal, 2017; Wen & Zhu, 2019). In line with prior literature, we use a difference-in-differences empirical design combined with matching, exploiting an entry by Apple in 2017

and comparing similar mobile apps pre- and post-entry.[1] We investigate complementor behavior on the App Store (focal platform) and the Play Store (competing platform). Apple entered its complementor domain for file organizing in the App Store in September 2017 by releasing the Files application, a file explorer and cloud storage management product. Focusing on this entry, we first analyze the overall change in effort allocation, which in this context is typically measured as product-related changes (Foerderer et al., 2018; Wen & Zhu, 2019). In particular, we study maintenance, upgrades, and new product release in a sample of applications in the Utilities category of the App Store, where Apple released its application. We also conduct analyses on the focal platform more broadly as well as on the competing platform, focusing on products (applications) that are affected or unaffected by the entry. In particular, we conduct both within and cross-category analyses, nuancing complementors' response across different product categories, beyond the focal one, on both platforms. We also examine the results at the firm level.

Consistent with our hypotheses, we find that following platform owner entry, specialist complementors increase their effort on the focal platform. In particular, they double down on their affected products while also allocating more effort to their other, unaffected products on the same platform. By contrast, generalist complementors decrease effort on both their affected and unaffected products on the focal platform while allocating more effort to the competing platform, in terms of both improving existing applications and releasing new ones. Notably, we also compare the platform owner entry to entries by other dominant, "behemoth" firms and show that a platform owner entry is indeed different from that of another large firm. Finally, we also provide evidence for ruling out alternative mechanisms of superior resources, demand, and quality.

In sum, this study highlights the distinct characteristics of competing with the platform owner and demonstrates a heterogeneous allocation of effort by platform complementors in response to platform owner entry into their market. We find that generalist firms tend to reposition away from the focal and toward the competing platform as they face a low repositioning cost, while specialist firms double down on the focal platform, relative to similar unaffected firms. We contribute to the competitive strategy literature on incumbent–entrant interactions in the platform context, highlighting structural differences in competitive conditions when the entrant is a platform owner and examining heterogeneous firm behavior both on the focal and a competing platform. By focusing on different product markets to which firms divert effort, the study also has implications for corporate strategy in platform-based settings, where entry barriers are often assumed to be low but where we show evidence for significant repositioning cost and a corresponding evolution in firm product portfolio when complementors compete with the platform.

2 | THEORY AND HYPOTHESES

2.1 | Market entry in the platform context

Entrant–incumbent interactions have a long history in industrial organization and competitive strategy studies. Some of the commonly received stylized facts are that entry is common, its

[1]Although we employ a difference-in-differences design to study the evolution of effort allocation across groups of firms, different developers and applications may have distinct characteristics; thus, we perform coarsened exact matching at different levels of analyses while also providing evidence on the unmatched samples.

patterns are similar across industries, entrant survival rates are low, and large-scale entries are typically penalized because of high adjustment costs (Dobrev & Kim, 2006; Geroski, 1995).

Among the drivers of an entrant's disadvantage are high entry barriers, such as advertising (Geroski, 1995; Sutton, 1991). Incumbents usually possess higher established goodwill with customers, and the effects of advertising are in some models assumed to be infinitely lived (Schmalensee, 1983). However, when the entrant is the platform owner, it has an outsized power in the ability to promote products of its choice. Prior research shows that a platform owner may choose not to promote the best-performing complements but those it deems strategically important (Rietveld et al., 2019), and to promote products associated with the platform instead of those of independent complementors (Wu & Zhu, 2022).

In addition, a major relative disadvantage of a typical entrant is that it has a limited set of technical and market-specific capabilities: hence, incumbents perform better than entrants, and diversifying entrants typically do better than new entrants (Klepper, 2002; Klepper & Simons, 2000). Even large, dominating firms may face capable competition by more specialized and informed local firms (Wang & Shaver, 2014, 2016): the advantage of an incumbent stems from capabilities accumulated over time, having established a competitive position which rivals may not readily imitate (Ethiraj & Zhu, 2008; Kim, 2021). For instance, following the entry of the national edition of the behemoth *New York Times* in various local markets, readership for some local newspapers increased rather than declining altogether (George & Waldfogel, 2006). The authors suggest that specialist editions which focused on addressing local preferences preserved or increased their readership. Usually, technical information such as back-end code and market-related information such as consumer preferences, customer lists, and their purchase histories are closely guarded, valuable trade secrets (Castellaneta et al., 2017; Cunningham & Kapacinskaite, 2022) that inform an incumbent's strategy. In contexts where the entrant has simple access to an incumbent's valuable information, time-compression diseconomies that any other entrant would face shrink substantially (Dierickx & Cool, 1989). Prior research on platform owner entry indicates that a platform owner uses complementors' competitive information strategically. For example, Amazon is more likely to enter more successful product markets of its third-party sellers—namely, those with higher sales and better reviews (Zhu & Liu, 2018). Having access to purchase histories and contact information of complementors' clients, a platform owner can potentially also target the same or similar clients with its own product. As a result, a platform owner benefits from unparalleled advantages in accessing competitive information that even a large and well-resourced rival does not.

Finally, studies typically assume that competitors face a level playing field (Caselli & Coleman, 2001; Dobrev & Kim, 2006; Skiti, 2020; Zhu & Xu, 2006), or that the rules of the game are directly shaped by powerful incumbents (Jacobides et al., 2006; Jacobides & Tae, 2015), and are in any case rarely dictated by entrants. For example, relative to potential or recent entrants, incumbents may have established R&D leadership (Jacobides & Tae, 2015), access to powerful stakeholders such as the government (Hillman, 2005), established accounting departments that reduce levies paid in high-tax jurisdictions (Fisman & Wei, 2004), or belong to existing lobbying bodies (Barber IV & Diestre, 2019). Research on entrant–incumbent interactions is scant under circumstances where an entrant has considerable bargaining power over the upstream and downstream rules of the game—for example, technical specifications, market access, or ability to charge levies—relative to incumbents. Yet, when a platform owner is the entrant, an incumbent faces the paradoxical situation of playing by the rules of the entrant, whereby the entrant can alter technical specifications required to access a market (Kapoor & Agarwal, 2017) or

charge a commission on revenues, sometimes of considerable proportions (Geradin & Katsifis, 2021).

Thus, when the entrant is a platform owner, incumbents do not benefit from relative advantages in advertising, time-compression diseconomies, or proficiency in the rules of the game.

2.2 | Platform owner entry and complementor response

Platforms govern the creation and distribution of value among platform members through different means, such as enabling interactions among participating parties, that is, end users and complementors (Anderson Jr et al., 2014; Gawer, 2014; Tiwana et al., 2010; Yoo et al., 2010), as well as fostering competition or cooperation among complementors and the platform provider (Kretschmer et al., 2020). One approach adopted by platforms to create and appropriate value is direct entry into complementors' domains with own, first-party products. Prior studies have argued that platforms may strategically decide to enter complementors' domains to appropriate rents (Farrell & Katz, 2000; Huang et al., 2013; Zhu & Liu, 2018). Following entry, end users typically face lower search costs when using platform-offered complements, which drives higher demand and increased popularity for them (Zhu & Liu, 2018). For instance, He et al. (2020) find that in the e-commerce context, orders for complementors' products following platform owner entry decrease, whereas they increase for the platform owner now operating in the same domain. Similarly, Zhu and Liu (2018) find evidence for a decline in the activity of complementors on the Amazon marketplace following Amazon's entry into their markets. Scholars have argued that the threat of platform owner entry also shifts complementors' focus. In their empirical analysis of Google's potential entry into the Play Store, Wen and Zhu (2019) find that complementors engage less with the affected products and redirect their activities toward new or unaffected apps in the same category. They find that complementors also engage in accelerated rent-seeking from their affected complements by increasing prices on those complements to capture value in the short run (Wen & Zhu, 2019). Note that the finding that firms abandon a market following a competitor's entry contradicts prior research in competitive strategy showing that firms tend to double down when faced with increased competitive pressure (Chen, 1996; McGrath et al., 1998; Morandi Stagni et al., 2020).

2.3 | Scope and heterogeneity in complementors' response

Platform literature suggests that platform owner entry redirects firm effort away from the affected domain (He et al., 2020; Wen & Zhu, 2019; Zhu & Liu, 2018). However, it has focused on domains within the focal platform, whereas complementors often engage in activities spanning multiple product markets and platforms. For instance, an Uber ridesharing driver may operate on both Lyft and Uber Eats (Chung et al., 2024). Similarly, a merchant can potentially sell various products on both eBay and Amazon, or a software company can develop products for both iOS and Android platforms. Moreover, generalist complementors operating across different platforms are a relatively common occurrence (Cennamo et al., 2018). Therefore, focusing on the affected area within a product market (for instance, app category) on the focal platform alone (Wen & Zhu, 2019) may mask more nuanced firm responses: the scope of complementors' response to a platform owner entry may exceed the boundaries of the affected

market on the focal platform and indeed include a change in activity on both the focal and a competing platform.

In addition, prior literature on platform owner entry treats complementors as a monolith, but an important dimension of complementor heterogeneity that may affect their response to entry is their positioning: namely, the choice to operate on either one or multiple platforms, driving strategically important outcomes (Cennamo et al., 2018). Across different settings, firms differ in their expertise producing for different platforms (Rietveld & Schilling, 2021). The positioning decision can yield different outcomes for specialist and generalist complementors. For instance, entering a new platform can increase access to new customers (Wan et al., 2020) but result in lower quality and lower performance in the new market (Cennamo et al., 2018). This captures a well-documented generalist–specialist tradeoff: while generalizing enables market access spanning multiple domains, specialists are better at serving customized needs in any given area (Teodoridis et al., 2019). In the platform context, it is reasonable to expect that this positioning choice and the repositioning cost could influence complementor response to platform owner entry.[2]

2.4 | Response to platform owner entry contingent on positioning

Given the high bargaining power of a platform owner, firms are likely to prefer accommodating entry by reducing activity in the affected area (Wen & Zhu, 2019; Zhu & Liu, 2018). However, firms' prior positioning may drive their ability to reallocate effort. Generalists have a more fungible set of resources and thus face a lower repositioning cost in the face of platform owner entry. Therefore, given prior specialist or generalist positioning, we would expect to observe heterogeneity in complementors' effort allocation in response to platform owner entry.[3]

Prior literature suggests that following a change in competition dynamics, firms weigh the costs and benefits associated with continued competition in the focal domain against those of shifting to another market space in response to the change (Decker & Mellewigt, 2007; Harrigan, 1985; Menon & Yao, 2017; Wang & Shaver, 2014). Given the reduced room for value capture in the affected domain (He et al., 2020; Zhu & Liu, 2018), the potential risk of future entries by the platform owner on the focal platform (Wen & Zhu, 2019), and the benefit of accessing an unaffected market while incurring relatively low repositioning cost to the competing platform, we argue that generalist complementors will shift effort away from the affected area to the competing platform following platform owner entry. This move would manifest as a

[2]Consider the context of mobile-phone platforms such as iOS and Android. A developer (i.e., complementor) would incur repositioning costs when reallocating effort from one platform to the other, given the different software as well as hardware infrastructures required for developing an application on either platform. Whereas Apple App Store application development requires expertise in Swift programming as well as a Mac-based machine, Google Play application development requires proficiency in such programming languages as Java and a Linux-, Windows-, or Mac-based machine.

[3]This approach departs from prior literature focused on within-platform complementor responses following platform owner entry threat (Wen & Zhu, 2019), as threat and entry may have different strategic implications (Ethiraj & Zhou, 2019). We focus on the effort required for shifting between platforms as related to the prior positioning of the complementors and explore their differential responses in effort allocation after an actual, rather than a potential, platform owner entry. Given the dominant power of platforms relative to their complementors, platform entrants are highly likely to follow through with their announcement with an actual entry rather than being deterred by the complementors. We therefore theorize about actual rather than threatened entry by platform owners.

lower level of effort allocation on the focal platform and a higher level of effort on the competing platform.[4]

> **Hypothesis H1.** Following platform owner entry, affected generalist complementors will decrease effort on the focal platform relative to unaffected generalist complementors.

> **Hypothesis H2.** Following platform owner entry, affected generalist complementors will increase effort on the competing platform relative to unaffected generalist complementors.

The competitive strategy literature suggests firms either accommodate entry or double down, and we have argued that generalists in the platform context tend to accommodate by reallocating effort to an alternative platform. We expect specialist complementors' reaction, however, to be different. While the benefit of accessing an unaffected market and additional source of revenue following repositioning to a competing platform is relevant for both groups of firms, the repositioning cost for specialists outweighs the benefit when technical and market characteristics are sufficiently different between alternative platforms. It thus confines specialists to the focal platform, pushing them to exert effort there. Prior research in non-platform settings suggests that firms are likely to focus their efforts in a market where they have made significant investments (Morandi Stagni et al., 2020). Moreover, the literature suggests that high repositioning cost can justify continued operation in a market domain even in the face of heightened competition (Decker & Mellewigt, 2007; Harrigan, 1985). Complementors weigh the costs of operating on additional platforms against the benefits of additional revenue (Cennamo et al., 2018). An important driver of costs is the degree of difference between the focal and the competing platforms (Cennamo et al., 2018; McIntyre et al., 2021). Platforms differ in their core functions (Anderson Jr et al., 2014; Zhu & Iansiti, 2012), and full compliance with competing platforms may require platform-specific investments by complementors to match distinct technological infrastructures (Anderson Jr et al., 2014; Claussen et al., 2015; Tiwana, 2015). Thus, when the difference between platforms is sufficiently high, despite the smaller market opportunities following platform owner entry, specialist firms will be more likely to increase investment on the focal platform, exerting greater effort. Therefore, they will be more likely to leverage their existing product portfolio on the focal platform. Summarizing the above arguments, we arrive at the following hypothesis:

> **Hypothesis H3.** Following platform owner entry, affected specialist complementors will increase effort on the focal platform relative to unaffected specialist complementors.

We thus aim to introduce a more nuanced view of complementor response to platform owner entry: firms may reposition away from the focal and toward a competing platform, but only if it comes at a low repositioning cost, that is, if they were a generalist. Specialists—firms with a narrower focus—on the other hand are more likely to concentrate their effort in the area

[4]Note that our reference to specialist and generalist complementors captures their specialization strategy (i.e., whether they possess the capabilities of operating on one or more platforms) before the entry happens. We also follow this definition in our operationalization of this construct in the empirics.

where they had previously operated, thus avoiding the high repositioning costs. In sum, considering a broader competitive landscape as well as heterogeneous ex-ante firm positioning can help uncover nuanced patterns in the rate and direction of effort allocation on digital platforms.

3 | EMPIRICAL CONTEXT AND DESIGN

The mobile application platforms Apple App Store (offering iOS-based applications) and Google Play Store (offering Android-based applications) serve as the context for empirical analysis in this study. Mobile application markets have been studied in prior research analyzing platform owner entry and innovation (Foerderer et al., 2018; Wen & Zhu, 2019), and we obtain data from Appfigures, a market intelligence firm whose data has been employed in prior research (Kapoor & Agarwal, 2017). For the purposes of this study, we use Apple App Store (referred to as App Store) and Google Play Store (referred to as Play Store) as the focal and competing platforms, respectively. This context is well suited to the study of complementor positioning and the effect on effort allocation in the aftermath of platform owner entry. We proxy specialist and generalist firms (our theoretical constructs) with the multihoming status of the complementors. In particular, we proxy specialist firms with singlehoming complementors—those that only have experience in working on the focal platform—and generalist firms with multihoming complementors—those that have experience in working on both the focal and the competing platforms.

We identify a platform owner entry into an existing complementor market and observe complementors' effort allocation in terms of their product maintenance, innovation on existing products, and new product release. In addition, the rich archival data on a broad range of applications (i.e., products) and developers (i.e., complementors) on the two platforms strengthens the empirical analysis since we can also examine complementor behavior in domains unaffected by platform owner entry.

3.1 | Platform owner entry in a complementor market

We analyze Apple's introduction of the Files application on its App Store, using data both before and after the entry. Apple announced the entry in June 2017 and released the Files application on the App Store in September 2017.[5] Per Apple's announcement, Files was aimed at improving user experience in exploring and accessing files as well as enhancing such cloud storage services as iCloud, OneDrive, Google Drive, Dropbox, and other features.[6] This entry constitutes a competitive move into an existing market: we identify 100 similar applications, discussed below, already active in this domain. Reviewing reports and reactions by developers and news agencies in the tech industry, we find that the release of Files was an unanticipated and particularly competitive event, as Apple embedded this application in its operating system by default.[7] Thus, the introduction of the Files application suits the purposes of this study. First,

[5]Apple did not enter Google's Play Store with its Files app.

[6]The full description of this application and associated notes about its release are in Appendix A.

[7]As a developer from our sample told us, "[I]n marketing they [Apple] have of course insane advantages [...] So they have on the marketing side just a huge power to push their apps on their platform. [...] And of course they take the good stuff from everybody else." Appendix C includes further evidence from the industry news and interviews regarding the competitive nature of this entry.

the app was embedded in the iOS operating system, becoming available shortly after the release. Second, we have clear information regarding the announcement and actual entry.[8]

3.2 | Empirical design

We use a difference-in-differences design to test our hypotheses, focusing on the period between December 2016 and January 2018, 14 months for which we have data available. December 2016 to May 2017 are the 6 months before the entry was announced (in June 2017) and constitute the pretreatment period. The remaining 8 months constitute the post-treatment period. Platform owner entry took place in September 2017. In the fast-paced industry of digital goods, this timeframe proves sufficient to observe short to medium-term responses to the entry. We conduct the analyses at the application (or product) level and at the developer (or complementor firm) level. First, we identify treated applications (those applications directly affected by Apple's entry) and control applications (comparable applications on the App Store not affected by Apple's entry). Apple released the Files application in the Utilities category of the App Store. We use a word-embedding approach[9] to run text analysis of the description of all applications in the Utilities category in the App Store to find those applications similar to the focal application. We measure application similarity with the focal Files application by calculating the Word Mover's Distance (WMD) for the description of each application and that of Files.[10] We run text analysis on all applications in the Utilities category with English descriptions. Following prior literature, we identify 100 affected apps (Wen & Zhu, 2019).[11]

To examine complementors' effort allocation and to assess the role of their positioning, we run three sets of analyses. First, we run an application-level analysis to test the effect

[8]Apple holds an annual conference around June each year, Apple Worldwide Developers Conference (WWDC), to announce news about its products and services, including product releases and software updates. WWDC 2017 was held on June 5, 2017, and Apple announced its plan for releasing the Files application. Apple is known for its secrecy preceding product announcements (Dufresne & Offstein, 2008; Fink et al., 2022), and developer blogs suggest this entry was unexpected. The full list of changes announced by Apple in the conference is included in Appendix A.

[9]Word embedding is a technique to transform text and convert it into a form processable by a machine. The transformation technique makes analysis of the text possible. Word embedding can capture similarities and relationships between words as well as their context in a document. This technique is increasingly used in the social sciences (Carlson, 2023; Evans & Aceves, 2016; Luo et al., 2024; D. (Andrew) Wu, 2023).

[10]We use the WMDSimilarity function from the "gensim" package using Python programming language. WMD learns words' representations from local co-occurrences in sentences by using the results of word-embedding techniques such as word2vec, which is suitable for large datasets. According to WMD, embedded word vectors have meaningful distances. It considers text documents as a "weighted point cloud of embedded words." The distance between two text documents is then calculated as "the minimum cumulative distance" that words from one document need to "travel" to match exactly those of the other document (Kusner et al., 2015).

[11]Wen and Zhu (2019) start with 100 similar apps and focus on 48 to 251 apps in different analyses. Reading the descriptions of the 100 apps in our sample, we found that the word-embedding algorithm worked well in identifying the affected apps. We also read through the descriptions of additional applications but found that the higher the included number of additional applications, the less similar to the focal application they were. Given the number of treated applications (ranging from around 50 to 250) studied in prior research, we use the 100 most similar applications as an appropriate number of applications to form the treatment group. We also repeated this analysis with 200 treated applications and found qualitatively similar effects. Moreover, we have included information on a sample of applications identified as treated by our algorithm in Appendix C, where we also discuss a comparison of our textual, tailored algorithm-based approach with the prior treatment in the literature.

of platform owner entry on effort allocation on the affected applications on the focal platform. Second, we run an application-level analysis on the unaffected applications on App Store, as well as multihoming complementors' applications on Play Store, to examine the response of affected developers with respect to their other applications. Finally, we run a developer-level analysis to study new-application release on both platforms. Descriptions of construct operationalization of treatment and control units for each analysis are provided in Table 1.

4 | ANALYSIS 1: DEVELOPERS' RESPONSE ON AFFECTED APPLICATIONS

For the application-level (i.e., product-level) analysis, we form a treatment group of the top 100 most similar applications to the Files application based on similarity scores using the word-embedding technique described above. The control group is subsequently formed using applications from the same Utilities category, with details on the coarsened exact matching to create a control group

TABLE 1 Terminology and samples.

Panel A Terminology for units of analysis	
Terminology	**Definition**
Treated application	An application affected by Apple entry because of its similarity to the Files application
Unaffected application	An application across categories not identified as a treated application
Treated developer	A developer firm that has a treated application in their portfolio
Unaffected developer	A developer firm with no treated applications in its portfolio but with at least one app in the Utilities category

Panel B Composition of treatment and control groups across main analyses		
	Treatment group	**Control group**
Analysis 1	Treated Applications (Applications in the Utilities category similar to the "Files" application)	Matched sample of untreated applications in the "Utilities" category (non-similar applications to the "Files" Application)
Analysis 2—app store	Unaffected Applications in App Store across different categories (i.e., both the focal "Utilities" category and the other categories across the platform) developed by Treated Developers	Matched sample of Unaffected Applications in App Store across different categories (i.e., both the focal "Utilities" category and the other categories across the platform) which are developed by Unaffected Developers
Analysis 2—play store	Applications in Play Store developed by Treated Developers	Matched sample of applications in Play Store developed by Unaffected Developers
Analysis 3—developer-level analysis	Treated Developers (Developers with a Treated Application in their portfolio)	Matched sample of Unaffected Developers (Developers with No Treated Applications in their portfolio)

below. Using same-category App Store applications for the control group provides a comparable set of applications that can be used to control for such attributes as market size and target customers. The timeframe of the analysis is from December 2016 until January 2018: 14 months.

The first analysis examines the reaction of developers on their treated application, that is, how they change their effort allocation on the affected applications. For the difference-in-differences approach, we conduct a coarsened exact matching, or CEM (Blackwell et al., 2009), between the treatment and control applications based on their important attributes in the pretreatment period.[12] Appendix B includes complementary information on the matching procedure and the variables used for matching. CEM based on these factors matches treatment units with control units that are similar in their pretreatment trends. Having a matched control group helps establish parallel pretreatment trends as required in difference-in-differences analysis (Bao, 2022). The matching results in 17,894 matched applications out of 44,063 applications in the full sample.[13]

Having matched applications from the two groups, we use Model 1 for our analysis.

$$Outcome_{it} = \beta_0 + \boldsymbol{\beta_1}.Treatment_i.Post_t + \alpha_i + \tau_t + \epsilon_{it} \quad (1)$$

Variables of interest are explained in detail below. Given the timeframe of the study, there are 14 observations for each application, corresponding to each month in the timeframe, making up 250,516 observations total for the 17,894 matched applications.[14]

4.1 | Variables

4.1.1 | Dependent variables

$Outcome_{it}$ captures our dependent variables of interest. We are interested in studying complementors' effort allocation in response to platform owner entry. In line with relevant areas of focus in this context and prior literature (Wen & Zhu, 2019), we measure effort allocation in several ways, reflecting its main forms in this context. First, we measure product innovation with the number of updates which application i received in month t. We also examine product maintenance (i.e., whether a product was maintained or otherwise exited the market) by measuring whether application i appears as active in month t. This enables us to study the extent to which complementors allocate effort to their applications. An application marked as active (on either the focal or the competing platform) is one maintained by the respective developer and available to all users. An inactive application is not maintained and is no longer accessible for users to view or download. Keeping an application active, even without releasing updates

[12]The matching is done monthly over the whole pre-entry observation period instead of solely at the time of entry. Therefore, only units that share similar trends over the whole pre-treatment period are matched. This prevents from matching units which might otherwise be fundamentally different at a pre-treatment observation point.

[13]Table B1 in Appendix B includes information on the distribution of treated and control applications in the full and matched samples. We also run our analysis on the full sample without matching and find similar results, as reported in Appendix D.

[14]To bolster difference-in-differences analyses, we have followed the common practice in using matching techniques to compare treatment units with comparable control groups in fixed-effect regressions. We also report our results on the full sample without matching in Appendix D and find similar results (Bao, 2022).

TABLE 2 Summary statistics of dependent variables in the full sample.

Variable	Observations	Mean	Std. dev.	Min	Max	Median
Application-level analysis: Analysis 1						
Active status	616,882	0.852	0.355	0	1	1
Update count	616,882	0.075	0.377	0	16	0
Application-level analysis: Analysis 2—Unaffected applications on App Store						
Active status	5,211,024	0.849	0.358	0	1	1
Update count	5,211,024	0.06	0.327	0	22	0
Application-level analysis: Analysis 2—Applications on Play Store						
Active status	1,003,306	0.946	0.226	0	1	1
Update count	1,003,306	0.078	0.329	0	12	0
Developer-level analysis: Analysis 3						
New releases on Play Store	59,415	0.023	0.394	0	32	0
New releases on App Store	59,415	0.172	2.972	0	394	0

for it, requires effort allocation by developers.[15] Summary statistics for dependent variables across the three sets of analysis are included in Table 2.

4.1.2 | Treatment and post-entry variables

$Treatment_i$ is a binary variable equal to 1 if application i is identified as treated by entry, and 0 otherwise. $Post_t$ is a binary variable equal to 1 if the observation is in the post-treatment timeline (i.e., including and after June 2017, when the entry was announced), and 0 otherwise. Application and time fixed effects are captured by α_i and τ_t, respectively.[16]

In the analyses, we differentiate between singlehoming (specialist) and multihoming (generalist) complementors by conducting the analyses on a subsample of units based on the complementor positioning prior to the platform owner entry. Multihoming developers are identified as those also having applications on Play Store (i.e., the competing platform) prior to the entry. These developers would incur lower repositioning cost to the competing platform than those who have no prior experience on the competing platform. This is the case since the two platforms are considerably different in terms of their technological infrastructure; releasing applications on App Store and Play Store requires different software-related as well as hardware-related complementary resources and skills. We label developers with prior multihoming as MH (i.e., multihomers) and those singlehoming on the focal platform as SH (i.e., singlehomers).

[15]We also measure effort allocation in terms of complementors' new-application release as another main proxy for effort in this context. We describe this later in Analysis 3 (the complementor-firm-level analysis).

[16]The inclusion of application fixed effects accounts for any time-invariant application-level characteristics, such as developer firm quality, size, and headquarters location. The inclusion of time fixed effects accounts for dynamic shocks applicable across different apps, such as seasonality or other changes taking place on the platforms and in the app industry. The main effects of post-entry and treatment are excluded from the model since they are captured by the fixed-effect terms, which also makes our result presentation comparable to recent research in this area (Foerderer, 2020; Zhang et al., 2020). The error term is represented by ϵ_{it}.

4.2 | RESULTS

The results of the analysis for affected apps are presented in Table 3.[17] Our aim is to investigate how generalists approach effort allocation following platform owner entry into their market. Updates require effort from the developer firm and are a commonly used measure for studying innovation in digital settings (Chen et al., 2021; Wen & Zhu, 2019). Likewise, application maintenance, identified by active or inactive status, allows us to investigate further how complementors allocate effort across different domains. We analyze the effect on the dependent variables both on the full sample and by separately comparing the behavior of SH and MH developers with respect to their update and product maintenance behavior.[18] We report the percentage change in the dependent variable given the pretreatment baseline rather than percentage-point changes throughout this article, finding economically and statistically significant rates of updates and maintenance of treated applications.[19] Following the announcement of entry, we see an increase in updates on treated apps (Model 1). Notably, the result is entirely driven by SH firms in our sample (Model 2). The average number of monthly updates on the treated applications by SH developers increased by 126% following Apple's entry. By contrast, MH firms were no more likely to update their treated apps (Model 3). Figure 1 shows the monthly effect of entry on the number of updates for affected applications by SH firms, where the effects are mainly observed after the actual entry rather than post-announcement.[20]

The differential effect in updates would suggest that firms allocate effort differently, depending on their positioning strategy.[21] We further investigate this possibility by focusing on their likelihood of deactivating and thus shifting effort away from the affected apps. On average, affected applications are less likely to be maintained by complementors following platform

[17]We use OLS regression models for ease of interpretation and conduct the same analyses using alternative models in robustness checks (such as Poisson, Logit, and Probit), reported in Appendix E. Also, in this analysis we have clustered errors at the application level as the treatment unit, since observations for one application could be correlated across different months. We also find similar effects when clustering errors at the developer level (reported in Appendix F).

[18]We split the sample into SH and MH firms in line with the hypotheses, for ease of presentation, and for a more in-depth examination of the magnitude and direction of results across different types of firms. The subsample analyses have the benefit of detecting whether effects go in the same or different directions, so we are able to ascertain whether each group responded at all and by how much compared with their unaffected counterparts. We also run the analyses with the MH developer variable as the moderator and include the results in Appendix G. The results remain similar.

[19]We adopt this approach per *Strategic Management Journal* guidelines to report the economic effects of analyses. While percentage-point changes can be inferred from the tables, we believe that reporting percentage changes rather than percentage-point changes facilitates gauging the effect size and interpreting the results.

[20]Table C2 in Appendix C displays some information regarding the added features and improvements mentioned by developers who released updates for their treated applications following entry. Investing effort to improving functionality and features as well as reliability of applications, which are treated by entry, appears to constitute the main changes.

[21]One of the affected MH firms from our sample we interviewed reported, "And then came 2017 and for the file manager, I have to tell you honestly, you can see, I think I've updated the last time 5–6 years ago, so you can see our commitment there [...] in 2017 with the Files app [...] it was clear to me, hey, what should I do? I can't compete with Apple. That was a very clear thing for me [...] when Apple then said, we're doing the Files app, it was clear to me, 'Okay, not worth it anymore.' [...] 'Yes, now I'm not investing anything at all.' [...] the big swing to say 'Ok, we really do nothing more,' was the launch of the Files App from Apple." Similarly, another MH affected developer told us, "when Apple enters with its resources, it is usually no longer worth doing anything [...] with the entry of Apple, of course, the point had come where it was no longer worth it [...] if you know that Apple will follow suit after a short time, development is no longer worthwhile." We were not able to obtain interviews from affected SH firms.

owner entry (Model 4). Further investigating the heterogeneity, we run Models 5 and 6 and find that the drop in maintenance is driven by MH firms, which are less likely to maintain their affected applications by 14% following platform owner entry. Figure 1 demonstrates the monthly effect on product maintenance of applications released by MH firms. Similar to the observed effect on updates, the drop in maintenance is also observed after the actual entry rather than post-announcement. This suggests that affected firms did not immediately react

TABLE 3 App Store: Complementor effort allocation on products in the focal category on the focal platform.

	Full sample (1)	Specialist developers (2)	Generalist developers (3)	Full sample (4)	Specialist developers (5)	Generalist developers (6)
	Updates	Updates	Updates	Keep active	Keep active	Keep active
Treated application × Post	0.0658 (0.0275) [.0166]	0.1011 (0.0420) [.0162]	0.0118 (0.0240) [.6231]	−0.0521 (0.0350) [.1363]	0.0009 (0.0416) [.9826]	−0.1332 (0.0607) [.0281]
Constant	0.0972 (0.0122) [.0000]	0.1373 (0.0195) [.0000]	0.0359 (0.0069) [.0000]	1.0000 (0.0091) [.0000]	1.0000 (0.0095) [.0000]	1.0000 (0.0179) [.0000]
Observations	250,516	190,848	59,668	250,516	190,848	59,668
R-squared	.0131	.0188	.0058	.1208	.1392	.0985
Number of applications	17,894	13,632	4262	17,894	13,632	4262
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
App FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors clustered at the product (i.e., application) level are reported in the parentheses, with *p*-values in the brackets. Results are also robust to clustering at the developer (i.e., firm) level (reported in Appendix F). Models 1 and 4 report the results on the full sample of matched applications. Models 2 and 5 only include applications by specialist firms, while Models 3 and 6 are limited to those by generalist firms.

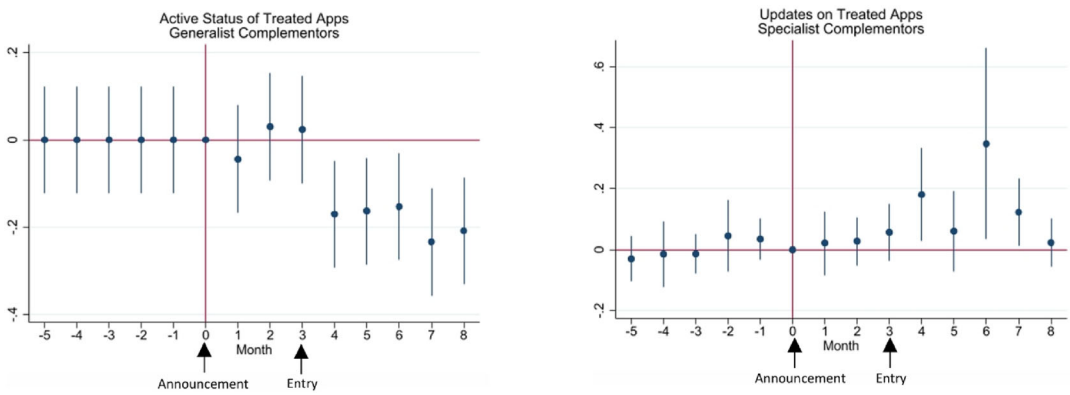


FIGURE 1 Generalists and specialists response on treated applications (App Store).

following the announcement of the entry, although they might have invested effort, for instance on updates, which is observed later.[22]

In sum, these findings are consistent with H1, which argues that generalist complementors are more likely to decrease their effort allocation on the treated applications on the focal platform. Specialist developers, by contrast, find it more costly to shift effort to a different platform; therefore, they double down on their activity on the focal platform. They also do not drop maintenance on their treated applications but instead increase their effort on the affected domain, consistent with H3.[23]

5 | ANALYSIS 2: DEVELOPERS' RESPONSE ON UNAFFECTED APPLICATIONS

The second analysis investigates the effect of entry on other applications that developers have on the focal and competing platforms. Our proposed hypotheses argue that MH complementors treated by platform owner entry will shift part of their effort to the competing platform while decreasing effort on the focal platform. To further probe our argument, we observe that complementor product portfolios typically span multiple products, including those unaffected by platform owner entry. Similarly, the resources of a programmer or a machine are likely divided among several products: a developer may program several applications for the same firm using the same computer, office, and training. Therefore, firm reaction in terms of effort allocation across different domains might not be confined to treated applications, as firms may shift effort to the unaffected applications, creating spillover effects. Here, we further extend the literature by showing that platform owner entry spurs a shift of effort away from affected products, including both within- and cross-category unaffected applications that complementors may have.[24]

Thus, we next study the change in the same dependent variables (updates and active status) on a different sample: the other applications that developers have on the focal and competing platforms. We label these applications *unaffected applications by treated developers*, meaning that although they are not directly affected by the focal platform's entry, their developers are

[22]Our interviews with experienced iOS developers, as well as our review of professional online iOS forums, show that, contrary to what one may expect in markets with zero marginal costs, keeping applications active even when not publishing updates for them is not costless for developers. Low-quality applications could receive negative ratings from users and undermine developers' reputations. Moreover, platforms could mandate that developers occasionally publish updates to comply with additional terms and policies introduced by the platform. In our interviews with developers, we were told, "We do not have the resources to be updating all the time to comply with changing policy in the future." Active applications are required to adhere to both current and upcoming platform rules, to provide support for all users who have installed the app, and to respond to raised issues and users' comments, all of which require effort allocation. Hence, dropping maintenance on applications by making them inactive means lower effort allocation by firms to the respective domain.

[23]Our evidence shows that the complementor response does not seem to be triggered by, and subsequently directed at, each other but rather by the entry of the platform owner into their domain. For instance, if specialists' increased updating of affected apps were triggered by generalists' exit, some delay would be expected between the two events. However, Figure 1 shows that the exit of generalists and the increased updates by specialists of affected apps take place at the same time. Moreover, details in Appendices A and C provide further evidence for the competitive nature of the entry and the direct response of complementors to the platform owner's product through imitation of some of the Files features.

[24]Complementors' product portfolio can include other applications which are also in the same Utilities category (in which Apple entered) or those which are positioned in other product market categories. This includes 26 categories on each of App Store and Play Store platforms available in our data. See footnote 31 for further details.

affected by having treated applications. We analyze both unaffected applications that complementors have on App Store and their applications on Play Store—the competing platform—in turn.

5.1 | Unaffected applications on App Store

For the unaffected application analysis, we follow an approach similar to that of the treated applications. The main difference is in the formation of treatment and control groups. Whereas in the treated application-level analysis the treated applications were identified directly using text analysis of their descriptions, here the treatment group is formed based on the developer identity of treated applications, by analyzing whether the respective developer has a treated application. Appendix X includes information on our sample creation for the unaffected application analyses. Table 1 includes the description of treatment and control samples, with the summary statistics for dependent variables reported in Table 2.

5.1.1 | Results for updates on the unaffected apps on App Store

Results are in Table 4.[25] We first examine the effect of platform owner entry on complementors' innovative activity: updates carried out on the unaffected applications. Results are reported in Models 1 through 3 of Table 4. We do not observe meaningful effects.[26]

5.1.2 | Active status of unaffected apps on App Store

Next, we study whether SH and MH developers are more or less likely to maintain their unaffected applications. We do not find a meaningful average effect on the full sample (Model 4) but observe opposing effects between SH and MH developers by separately considering the subsamples of their unaffected applications. Model 5 suggests that unaffected applications by SH developers are more likely to remain active by 7.7% following entry. By contrast, Model 6 shows that unaffected applications by MH developers are less likely to remain active following entry by 9.7%. Figure 2 demonstrates this effect over time across the subsamples.[27]

[25]We report results in this analysis with errors clustered at the developer level, as behavior across multiple unaffected applications by one developer can be correlated. We also find similar results with errors clustered at the application level, as reported in Appendix F.

[26]As part of our robustness checks, we replicate the analysis on the full sample without matching (Table D2 in Appendix D) and also with errors clustered at the application level (Table F2 in Appendix F). Model 5 in both tables suggests an increase in updates on unaffected applications by SH developers. Together, these analyses suggest that if there is any effect of entry on updates on unaffected applications, it would be an increase in updates by SH developers, while MH developers are no more likely to update their unaffected applications on the focal platform.

[27]We also conduct a complementary analysis studying treated developers' behavior regarding their unaffected apps. We investigate how their effort allocation differs given that their app is in the same category the platform entered or in another category within the focal platform. We report this analysis with the results in Appendix U. Interestingly, in these analyses, including a moderator for whether the unaffected app is in an "external" category (other than Utilities), we find that SH developers tend to focus their effort in categories other than Utilities following platform owner entry with Files. This suggests that while they remain active on the focal platform, they divert part of their effort to unaffected categories.

TABLE 4 App Store: Complementor effort allocation on unaffected products on the focal platform.

	Full sample (1)	Specialist developers (2)	Generalist developers (3)	Full sample (4)	Specialist developers (5)	Generalist developers (6)
	Updates	Updates	Updates	Keep active	Keep active	Keep active
Unaffected application by treated developer × Post	0.0101 (0.0099) [.3073]	0.0131 (0.0136) [.3330]	0.0016 (0.0090) [.8594]	0.0286 (0.0178) [.1082]	0.0730 (0.0132) [.0000]	−0.0937 (0.0371) [.0116]
Constant	0.0250 (0.0029) [.0000]	0.0170 (0.0032) [.0000]	0.0469 (0.0060) [.0000]	1.0000 (0.0040) [.0000]	1.0000 (0.0049) [.0000]	1.0000 (0.0058) [.0000]
Observations	3,695,866	2,559,135	1,136,731	3,695,866	2,559,135	1,136,731
R-squared	.0037	.0054	.0040	.1460	.1582	.1140
Number of applications	263,991	182,800	81,196	263,991	182,800	81,196
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
App FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors clustered at the firm (i.e., developer/complementor) level are reported in the parentheses, with *p*-values in the brackets. As the developer is the treated unit, number of updates and the active status across its unaffected applications can be correlated. Results are also robust to clustering at the application level (reported in Appendix F). Models 1 and 4 report the results on the full sample of matched applications. Models 2 and 5 only include applications by specialist firms, while Models 3 and 6 are limited to those by generalist firms.

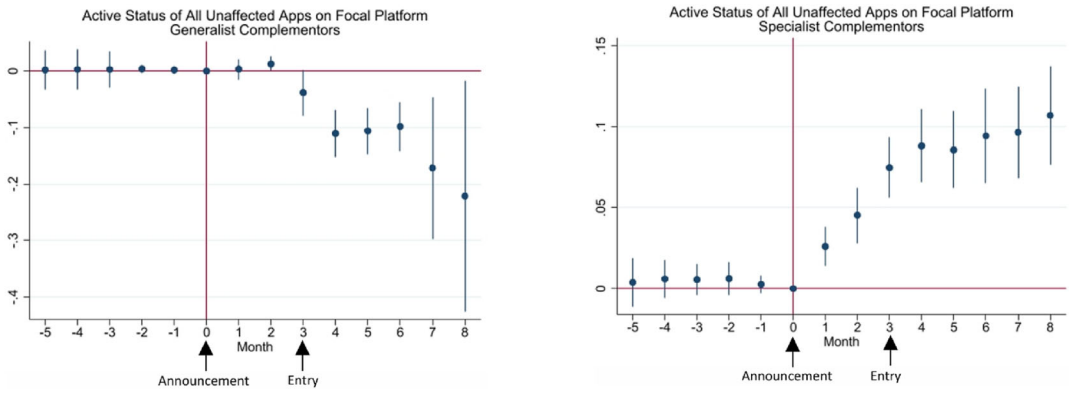


FIGURE 2 Active status—Treated-developer unaffected applications (App Store).

In sum, applications by SH developers on App Store were more likely to be maintained while those by MH developers were more likely to be abandoned. Provided MH developers also update their treated apps less and are less likely to maintain them, the results are consistent with shifting effort to the competing platform if MH developers display a higher rate of activity on the competing platform (per H2). We investigate this next by studying products on the Google Play Store.

5.2 | Applications on Play Store

We run the same analysis on applications in Play Store, the competing platform. This analysis is limited to applications developed by MH developers—developers who had applications on Play Store in May 2017—before the treatment.[28] We aim to analyze generalists' effort allocation on their overall product portfolio on the competing platform. Therefore, our sample includes applications that MH developers had across different product categories on the competing platform. The treated and control groups are defined per the prior analysis and explained in Table 1. We conduct matching following the same procedure and end up with 16,361 matched applications out of 71,661 in the full sample.[29]

5.2.1 | Results

The regression results are reported in Table 5.[30] Consistent with H2, treated developers increased their effort, in terms of innovation on their applications, on the competing platform. They also allocated more effort by being more likely to maintain their products. Model 1 suggests that the number of updates by affected MH developers on the competing platform increased by 83%, on average. Furthermore, Model 2 shows that affected MH developers were more likely to keep their applications active by 5.5% relative to the baseline. Figure 3 displays the effects at the monthly level.[31] The results, taken together with a decline in activity on the affected and unaffected applications on the focal platform, are consistent with the interpretation that MH developers shifted effort away from the affected area (H1) and toward the competing platform (H2).[32]

[28]Note that we fix SH and MH groups prior to Apple's entry and observe their activity on the competing platform in its aftermath. Thus, the two groups of firms remain fixed over the observation period.

[29]We report all the main analyses on the full, unmatched sample as well in Appendix D. We find similar results for the full sample. The distributions of treated and control applications across samples are provided in Table B4 in Appendix B.

[30]We cluster standard errors at the developer level to control for potential correlation across multiple unaffected applications by the same affected developer. We also conduct robustness checks with errors clustered at the application level in Appendix F and find similar results.

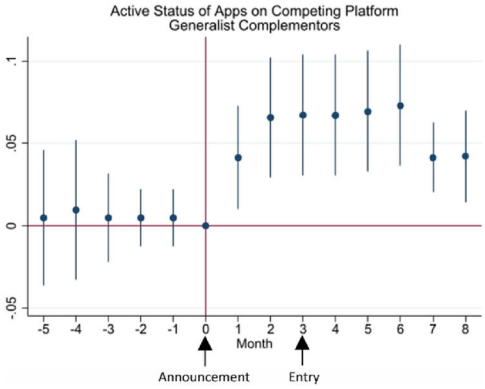
[31]As mentioned in the beginning of this analysis, our sample includes all applications that these MH developers have across 26 different categories for which we have data on the competing platform. This also includes those apps that are related or unrelated to the Files product with which Apple entered. In our post hoc analyses, we further nuance the behavior of MH developers by analyzing outcomes across their related and unrelated products (with respect to the Files app) on the competing platform. We find that the increase in generalists' effort allocation on the competing platform is driven by their unrelated applications, that is, applications with descriptions unrelated to the Files app. Moreover, we also observe that generalists actually decrease their effort on their related applications—those products with a description similar to the Files app, and thus belonging to the same product domain—by releasing fewer updates to them. This further shows that generalists prefer to move away from the related product domain also on the competing platform. We elaborate this analysis in Appendix V.

[32]Our evidence from interviews also suggests that affected firms consider reducing their dependence on the focal platform following platform owner entry. As an affected MH firm told us, "[the platform owner entry] has actually led to a more positive sentiment toward other platforms [...] entry of Apple is one aspect when you consider whether you want to depend on the platform."

TABLE 5 Play Store: Complementor effort allocation on products on the competing platform.

	Generalist developers (1)	Generalist developers (2)
	Updates	**Keep active**
Application by treated developer × Post	0.0394 (0.0155) [.0111]	0.0536 (0.0151) [.0004]
Constant	0.0549 (0.0186) [.0031]	1.0000 (0.0093) [.0000]
Observations	229,054	229,054
R-squared	.2464	.7177
Number of applications	16,361	16,361
Month FE	Yes	Yes
App FE	Yes	Yes

Note: Robust standard errors clustered at the firm (i.e., developer/complementor) level are reported in the parentheses, with *p*-values in the brackets. As the developer is the treated unit, the number of updates and the active status across its unaffected applications can be correlated. Results are also robust to clustering at the application level (reported in Appendix F). Both models are based on the sample of matched applications by generalist firms.



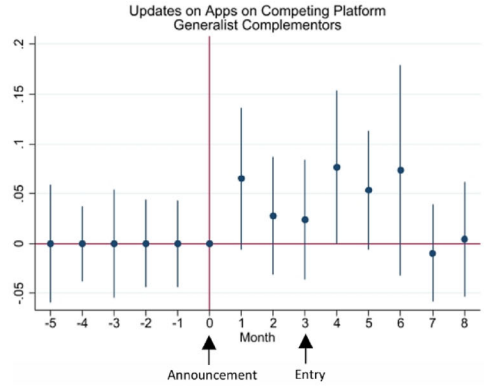


FIGURE 3 Active status and updates—Treated generalists' applications (Play Store).

6 | ANALYSIS 3: DEVELOPER-LEVEL ANALYSIS

In the third and final analysis, we study firm behavior at the complementor-firm (developer) level. Developer-level analysis allows us to further examine complementors' effort allocation across the two platforms. We use the groups of treated and control developers formed in Analysis 2. Descriptions of treatment and control groups are also provided in Table 1. We match developers in the treatment and control groups based on their key attributes to ensure parallel

pretreatment trends. The matching results in 11,538 matched developers out of 11,883 in the full sample.[33]

At the firm level, we are able to study the release of new products, a measure of effort allocation in terms of innovative activity frequently employed in the innovation literature (Gambardella et al., 2017; Klingebiel & Rammer, 2014; Laursen & Salter, 2006). The dependent variable of interest in this analysis is the number of new applications released by developers on the focal and the competing platforms. Table 2 includes the summary statistics.[34]

6.1 | New releases on App Store

Table 6 includes the results of this analysis. We study the number of new applications released by affected firms, examining the results given complementors' prior positioning. This is important because releasing new applications would likely, on average, require more substantial innovation effort than releasing updates on the existing ones. Models 1 through 3 include results for new-application release on the focal platform (App Store). We do not find any meaningful effect in terms of new-application releases on the App Store either on the full sample (Model 1) or on subsamples of SH and MH firms (Models 2 and 3). Treated firms do not seem to release more new products on the focal platform following a platform owner entry.

6.2 | New releases on Play Store

We also analyze whether developers adjust their new-application release behavior on the competing platform (Play Store). Models 4 through 6 include results for this test. We do not find a meaningful effect for SH developers (Model 5): SH firms are no more likely to release new applications on the competing platform following focal platform owner entry than the control group of similar, non-treated developers. However, we do find that the number of new applications released on the competing platform by MH developers increases tremendously: specifically, by 360% following platform owner entry on Apple (Model 6) relative to the control group of similar, non-treated developers. This finding presents further support for H2: generalist firms increase their effort on the competing platform by shifting effort following entry, while specialist firms do not.[35,36] Summing up our arguments and both main and complementary analyses

[33]The distributions of treated and control applications across samples are provided in Table B5 in Appendix B.

[34]Given the longer development cycle for releasing new applications relative to updating existing ones, we conduct this analysis at the developer-quarter level, with each observation including data on a developer for the three-month intervals. The timeframe of analysis is the same as in Analyses 1 and 2: 14 months from December 2016 to January 2018. In addition, we fix SH and MH groups prior to Apple's entry (May 2017) and observe their activity on the competing platform in its aftermath. Thus, the two groups of firms remain fixed over the observation period.

[35]Summarizing our three analyses together reveals interesting impacts of platform owner entry on the product portfolio of affected developers on both platforms. At the end of our observation period, affected SH developers in our sample had, in total, 7.7% more applications on the focal platform than unaffected SH developers, mainly due to higher maintenance of their products on the focal platform. On the other hand, due to the exit of both affected and unaffected applications by affected MH developers, affected MH developers experience a 10% decrease in the number of active applications on the focal platform compared with unaffected MH developers. Moreover, a higher maintenance rate of existing applications as well as the releasing of new ones on the competing platform by these developers resulted in a 30% increase in the number of applications on the competing platform following platform owner entry compared with unaffected MH developers.

[36]In our robustness checks, we further explore the nature of the newly released applications on Play Store with respect to their relatedness to the Files app. We report the results in Appendix W. We distinguish new app releases with respect

TABLE 6 App Store and Play Store: New-application release on the focal and competing platforms.

	Full sample (1)	Specialist developers (2)	Generalist developers (3)	Full sample (4)	Specialist developers (5)	Generalist developers (6)
	New Apps on App Store	New Apps on App Store	New Apps on App Store	New Apps on Play Store	New Apps on Play Store	New Apps on Play Store
Treated developer × Post	0.0523 (0.0877) [.5511]	0.0933 (0.0715) [.1920]	−0.0747 (0.1697) [.6596]	0.0407 (0.0220) [.0638]	0.0046 (0.0083) [.5752]	0.1048 (0.0465) [.0243]
Constant	0.4686 (0.0196) [.0000]	0.5223 (0.0243) [.0000]	0.2680 (0.0187) [.0000]	0.0270 (0.0020) [.0000]	−0.0000 (0.0006) [1.0000]	0.1280 (0.0088) [.0000]
Observations	57,690	45,870	11,820	57,690	45,870	11,820
R-squared	.0151	.0156	.0252	.0066	.0008	.0583
Number of developers	11,538	9174	2364	11,538	9174	2364
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors clustered at the firm (i.e., developer/complementor) level are reported in the parentheses, with *p*-values in the brackets. Models 1 and 4 report the results on the full sample of matched developers. Models 2 and 5 only include specialist firms, while Models 3 and 6 are limited to generalist firms.

located in the Appendix for specialist and generalist complementors across the two platforms, we report the summary of findings in reduced form in Table 7, Panel a.[37]

7 | NON-PLATFORM OWNER ENTRY

Our theorizing posited that platform owner entry is a significant and distinct event worthy of focused study, as it fundamentally differs from entry by any other competitor. This reasoning would imply that firms should respond less strongly to the entry of another big player, not the

to the product category in which the new apps are released. We find that both groups of complementors are more likely to allocate their effort to product market domains which are unrelated to the affected Files segment, thus shifting away from the affected area.

[37]The results are consistent with the evidence from our interviews as well. An MH developer told us, "The two platforms are fundamentally different ... you can't expect a sole iOS developer [SH developer in our terminology] to move into Android platform in the short term.... If you lack the experience with another platform, I mean both in terms of technology and business, then it takes time to gain that. You can't just switch." This suggests that working with another platform requires extensive technological and managerial knowledge, and MH complementors are more likely to innovate on the competing platform than SH complementors who are unlikely to consider the competing platform as an option. The high costs of MH and operating on a competing platform in this setting become more salient when we observe the limited resources available to firms. As an interviewee told us, "Most development firms in mobile platforms [i.e., App Store, Play Store, and so forth] are small teams ... if we are to invest in our Android portfolio, we will use what we have now, say current machines, team members, servers." Such indivisibility of resources further discourages SH developers from investment in the competing platform in the aftermath of focal platform owner entry.

TABLE 7 Panel a—Effort allocation in related and unrelated areas across platforms and firms. Panel b—Traditional incumbent advantages and platform owner entry.

Panel a

	Focal platform	
Related	**Specialist**	**Generalist**
	Doubling down given high exit barriers due to significant existing investments	Low likelihood of effort allocation due to lack of domain-specific capabilities and low-cost repositioning
Unrelated	Benefits of reducing competitive pressure justify an increase in effort allocation	Expanding beyond related segment is costly due to lack of specialized capabilities
	Competing platform	
Related	Costs likely too high, especially in the short to medium term	Higher relative fixed costs and potential entry balanced by overall shift of effort to related, low-repositioning-cost areas
Unrelated	High entry barriers limit or prevent entry	Beneficial space for effort allocation post-focal-platform entry due to low repositioning cost and low risk of platform entry

Panel b

	Typical entry	**Platform owner entry**
Advertising advantage	Incumbent holds the advantage	Entrant holds the advantage
Accessing technology and market proprietary information	Costly for the entrant	Near-costless for the entrant
Rules of the game	Either level playing field or incumbent can influence rules of the game	Entrant sets rules of the game

platform owner. Thus, we analyze the response of developers to entries by other market players. We first examine an entry by a major and recognized market player: Microsoft's entry with the To Do application in the App Store. We follow a similar approach as in Analysis 1. Results are reported in Table 8, with a full description of the methodology reported in Appendix I. We find no meaningful effect of this entry either in the full sample or in the subsamples of SH or MH. In addition, we examine an entry by a major developer in the same market as the Files app: the SanDisk Cloud app by SanDisk in the App Store. We find no meaningful response to this entry either, while there are statistical differences between coefficients when comparing the response to Apple entry vis-à-vis Microsoft and SanDisk entries.[38] Together, these results bolster our prior intuition that platform owner entry is a different competitive event than entry by another complementor. The theoretical arguments in the literature highlight what could be considered a platform's privileged or dominant position vis-à-vis competitors, and our empirical findings on complementor entries support this argument. To probe this result, we contacted

[38]A full description and results for the analyses are reported in Appendix I.

TABLE 8 Complementor effort allocation in response to a large firm entry (Microsoft to-do list App).

	Full sample (1)	Specialist developers (2)	Generalist developers (3)	Full sample (4)	Specialist developers (5)	Generalist developers (6)
	Updates	Updates	Updates	Keep active	Keep active	Keep active
Treated application × Post	−0.0207 (0.0277) [.4548]	−0.0280 (0.0330) [.3967]	−0.0006 (0.0503) [.9903]	−0.0044 (0.0310) [.8864]	0.0167 (0.0380) [.6608]	−0.0625 (0.0504) [.2150]
Constant	0.1611 (0.0133) [.0000]	0.1591 (0.0159) [.0000]	0.1667 (0.0235) [.0000]	1.0000 (0.0028) [.0000]	1.0000 (0.0038) [.0000]	1.0000 (0.0014) [.0000]
Observations	783,228	511,176	272,052	783,228	511,176	272,052
R-squared	.0085	.0121	.0241	.1309	.1581	.0651
Number of applications	65,269	42,598	22,671	65,269	42,598	22,671
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
App FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors clustered at the product (i.e., application) level are reported in the parentheses, with *p*-values in the brackets. Appendix I reports the procedure followed for this Analysis. Models 1 and 4 report the results on the full sample of matched applications. Models 2 and 5 only include applications by specialist firms, while Models 3 and 6 are limited to those by generalist firms.

some of the developers from our affected apps list, and they corroborated these results.[39] Table 7, Panel b, also provides a summary of our arguments regarding the differences between the platform owner and a big player entry. To the best of our knowledge, our paper is the first to provide large sample empirical evidence regarding the differences between platform owner and non-platform owner entries.

8 | ALTERNATIVE MECHANISMS: RESOURCES, DEMAND, AND QUALITY

Firms make strategic choices when deciding on their positioning to be a specialist or generalist. In this article, we are interested in studying how such prior strategic choices can inform the

[39]One affected developer responded to our question about a potential response to a big player entry, such as one by Microsoft, in the following manner: "[The reaction] is Apple-specific. So Microsoft wouldn't have scared me. Would be just another vendor [...]. [Apple] have the technical possibility to act differently, let's say, to offer other features that would not be available now to third parties like Microsoft or us." Similarly, another affected developer mentioned, "When Apple or Google come along, it's usually all over, because they bring it out directly with the operating system. Then no one needs to do that anymore [...] Whether it's Microsoft or small app developers who program something for the market, it doesn't change much. What's annoying is when Apple enters the market, because they have absolute access to their devices and to the developers [...] Apple is a difficult partner in this regard, but they have absolute market power." This is consistent with evidence from industry news regarding the competitive nature of this platform owner entry, as reported in Appendix C.

response to platform owner entry. We acknowledge that this choice is driven by firm strategies that we cannot observe. Importantly, the fixed effects in our panel regressions account for firm-specific characteristics that may be associated with selecting into these categories. To probe the results about the differential impact of platform owner entry on similar SH and MH firms (as proxies for specialist and generalist firms in our context), we first analyze if there are systematic differences in terms of key attributes between the SH and the MH firms, reporting our findings in Appendix H.[40] Next, to understand whether our results are driven by developers' differences in terms of resources, demand, or quality, we analyze the subsample of observations with similar values based on each of these attributes across different developers, that is, SH and MH with a similar number of apps on the focal platform (Appendix J), similar total demand (Appendix K), and similar product quality (Appendix L). Our results remain robust. In an additional robustness test, we extended our CEM matching to match observations based on these attributes (Appendix M) and find similar results.[41]

9 | ADDITIONAL ROBUSTNESS TESTS

To further test our argument regarding shifting effort across the focal and competing platform by generalists, we analyze how multihomers' ratio of active applications on the competing versus the focal platform changes following platform owner entry to capture both the effect of dropping app maintenance (i.e., completely exiting some applications) and new-application release simultaneously. We also study the effect of platform owner entry on the ratio of new applications released on the two platforms as well as the ratio of updates released on the two platforms. Results are reported in Appendix N. The results remain robust.

In addition, we address several different alternative explanations that may affect our results. We report the results on full, unmatched samples in Appendix D. In Appendix E, we include different model specifications using Logit, Probit, and Poisson models. Furthermore, we replicate our results clustering standard errors at alternative levels in Appendix F. We also report the results using the MH status of developers as a moderator and estimate the results on the full sample instead of subsamples in Appendix G. In Appendices O and P, we confine the post-treatment period to announcement and entry periods only, respectively. In Appendix R, we consider only the treated units, contrasting the response by SH and MH firms. In Appendix S, we adopt a one-to-one matching instead of one-to-many matching. In Appendix T, we investigate whether firms respond only with minor or also major updates (Foerderer et al., 2018; Wen & Zhu, 2019) and find that the results are not driven by minor updates. The results remain robust.

[40]Prior literature suggests that MH and SH can differ in terms of their product quality (Cennamo et al., 2018), resources (Bresnahan et al., 2015), and user base and demand (Cennamo et al., 2018; Corts & Lederman, 2009). We find that MH firms have, on average, slightly lower-quality products (as indicated by their lower average user rating, SH = 37.96, MH = 35.89, p-value = .000). They appear to have more resources (as indicated by a bigger portfolio of products on the focal platform, SH = 9.48, MH = 11.29, p-value = .104) and higher total demand (as indicated by a higher total number of user ratings across all their products on the focal platform, SH = 3329.12, MH = 4281.17, p-value = .246), but these differences lack statistical significance.

[41]Together, our robustness checks suggest that even controlling for these differences, SH and MH adopt different effort allocation strategies in response to platform owner entry. We posit that this evidence bolsters the mechanism driving the difference in responses of the two groups of complementors. The pre-existing positioning and subsequently different level of repositioning cost shape their effort allocation between the focal and the competing platform.

10 | DISCUSSION AND CONCLUSION

Digital platforms increasingly constitute a new competitive ground with implications for both firms and society at large. In this study, we analyze complementor response to platform owner entry. A platform owner's entry into the complementor spaces that it also governs creates unusual competitive dynamics because a platform may exploit asymmetric information about profitability across markets (Zhu & Liu, 2018) and benefit from high bargaining power, for example, in its ability to promote products of its choice.[42] A platform owner's access to proprietary information, which may constitute what would typically be considered trade secrets (e.g., customer lists, pricing strategy, past revenues, or yet unreleased proprietary code), is unprecedented, and platform owners may act on their privileged availability of valuable knowledge in ways that are self-preferential (U.S. Congress, 2020). Thus, studying platform owner entry and complementor response across a range of product markets may offer important novel insights into understanding competitive and corporate strategy in platform-based settings.

We theorize and find that specialist complementors, defined as singlehoming firms without prior experience on a competing platform, are more likely to allocate effort to the focal platform, increasing updates on existing products and keeping more of them active than similar firms following platform owner entry. In contrast, generalist complementors, defined as multihoming firms with prior experience on a competing platform, are more likely to reduce effort on the focal and increase it on a competing platform. This latter group is particularly likely to increase updates to existing products on the competing platform and also to release new products there. Also, we do not find that firms respond to entries by other large firms. This nonfinding highlights that platform owner characteristics as an entrant are different from those of other large firms and likely have heightened competitive implications for incumbent complementors.

Overall, the findings suggest that generalist firms activate an outside option once faced with a competitor who is the platform owner, whereas specialists double down on the affected area but also keep their options open in unaffected areas. Interestingly, entry into a complementor's market can be a double-edged sword for the entering platform owner. On the one hand, entry can create rents for the platform owner while also increasing effort in the target domain by specialists. On the other hand, generalists with experience on competing platforms are also more likely to shift their effort to them. Remarkably, even products not directly affected by the platform owner entry see a higher likelihood of being abandoned by generalist firms. This suggests that while platform owner entry can encourage effort on the focal platform by specialist firms, it could be also pushing generalists to increase their effort on competing platforms. Platform owner entry thus directly shapes complementor behavior and outcomes as well as the industry structure at a much broader scope than previously known (Chen et al., 2022; Rietveld & Schilling, 2021). While we study two competing and dissimilar platforms, we may expect that the presence of more outside options further exacerbates the generalists' response and confines the specialists, but only if repositioning cost is sufficiently high.

[42]The Digital Markets Act, which came into force in 2023 in the EU, aims to limit the platform owners' ability to promote own comparable products: "the gatekeeper should not engage in any form of differentiated or preferential treatment in ranking on the core platform service, and related indexing and crawling, whether through legal, commercial or technical means, in favor of products or services it offers itself or through a business user which it controls." (Regulation (EU) 2022/1925, Art. 52). To extent to which this and similar regulations globally will be implemented remains to be seen.

This study has a number of limitations. First, rather than study truly exogenous treatment and control groups, we rely on machine learning word-embedding techniques to create the two groups and matching procedures to ensure that we focus on observations that are indeed comparable. In addition, we do not observe the specific effort allocated and shifted by firms. And while we rely on some anecdotal evidence from interviews, uncovering the importance of both technical and managerial effort when publishing products on a platform, future work could explore the mechanisms driving the results more deeply. Also, firms select into the experience they accumulate on either one or more platforms. While we attempt to rule out alternative explanations such as firm size or quality, studying the drivers of selecting into single- or multihoming groups in the first place is beyond the scope of our analysis. Indeed, our approach is akin to taking a specialist or generalist orientation as given and studying different responses in the face of a shock (Teodoridis et al., 2019). Also, even if the platform owner entry is plausibly unanticipated by the complementor firms, it is not truly exogenous in the sense that it likely is not random. The Files release is also a specific type of entry: one where the product is tied to the operating system by default instead of available for download separately. This type of entry is likely more consequential regarding both repercussions for complementors and potential policy implications, given the higher switching costs (Edlin & Harris, 2013). Finally, the type of platform owner entry we study is a competitive one. Firms may respond differently to more accommodating or complementarity-enhancing entries.

In sum, this study has shown that average responses to platform owner entry may mask considerable heterogeneity when different types of firms and a broad competitive landscape, including several categories within a platform and several platforms, are considered. As digital platforms drive an increasing number of firm and societal outcomes, both managers and policymakers may benefit from a deeper understanding of the unique nature of competing with a platform.

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DATA AVAILABILITY STATEMENT

Data subject to third party restrictions.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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