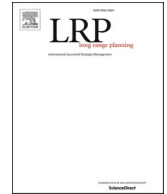




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Rivalry enablers in ecosystems: The role of dominant operating system platform openness across diverse national contexts

Claudio Giachetti 

Department of Management, Alma Mater Studiorum – University of Bologna, Via Capo di Lucca, 34, Bologna, Italy

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ABSTRACT

Digital technology has increasingly made hardware devices reliant on software, particularly operating system platforms. In an operating system platform ecosystem, the platform sponsor exercises property rights over its platform, while makers of platform-based devices (i.e., hardware products that run the operating system) serve as the channel through which the sponsor disseminates the platform to end users. By bridging industrial organization with the platform literature, our study examines how the sponsor of a dominant operating system platform may influence competition among platform-based device makers, particularly the concentration in the device maker market. We argue that a dominant platform's openness to device makers—the extent to which it imposes no restrictions on device makers in its development and use—has a competition-fostering effect, reducing market concentration. From an industrial organization perspective, platform openness reduces barriers to entry and growth for smaller device makers, enabling them to erode larger rivals' market power. Moreover, integrating insights from the platform multinational companies (PMNCs) literature, we contend that this effect varies across countries, shaped by ecosystem-, industry-, regulatory-, and socio-economic contingencies. We find support for our hypotheses using data on operating system platform sponsors and device makers in the mobile phone and tablet industries from 2009 to 2019 across 190 countries. Additional analyses show that some contingency effects are stronger when dominant platform sponsors hold leadership positions across multiple national markets, a construct we term multi-country dominance presence. Our findings contribute to industrial organization, international business, and platform literature.

1. Introduction

“Platform openness (i.e., how open should the platform be) is an important strategic decision for MNEs to broaden the participation of partners across the world. [...] the effectiveness of such decisional openness may be dependent on the local or regional culture that platform members belong to”—(Nambisan et al., 2019, p. 1481)

“We have access to the source code [of Google's Android]. To do that on any other platform would be very difficult”—Sanjay Jha, co-chief executive of Motorola (as quoted in Hansell, 2009)

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E-mail address: claudio.giachetti@unibo.it.

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“Partners [i.e., mobile phone makers] can’t replace; they can only add new things”—Joe Belfiore, Vice President of Microsoft’s Windows Phone program (as quoted in [Woyke, 2010](#))

The advent of digital technology has enabled the restructuring of various industries around operating system (OS) platforms, which have become key software components in the functioning of many hardware products ([Economides and Katsamakos, 2006](#); [Gawer, 2021](#); [West, 2003](#)). In devices like personal computers (PCs), mobile phones, tablets, and video game consoles, “an OS platform is a middle layer of software, in-between applications and hardware systems” ([Tanriverdi and Lee, 2008](#), p. 381). OS platforms function as interfaces between different actors and facilitate value-creation exchanges ([Gawer, 2014](#)). Four main types of actors typically interact within an OS platform ecosystem ([Van Alstyne, Parker, and Choudary, 2016](#)): (1) *end users*, who are the buyers of hardware devices with a particular OS installed; (2) *application (app) developers*, who create software components (apps) designed to execute specific functions on a device within the framework of an OS, such as mobile phone app developers; (3) *makers of platform-based devices*, who serve as the primary point of contact between the platform and end-users—for example, handset makers like Samsung—and who may face different levels of openness in how they are allowed to mount and customize OS platforms on their hardware devices, as illustrated in the opening quotes; and (4) *platform sponsors*, who hold property rights over the OS platform, such as OS owners for mobile phones, like Google and its Android. Research has focused on the strategies of OS platform sponsors (e.g., [Eisenmann et al., 2011](#)) and app developers (e.g., [Kapoor and Agarwal, 2017](#)). Emphasis has been placed on examining how sponsors create their OS platforms, attract end users and app developers, and achieve market dominance, as well as on how app developers’ strategy and performance are affected by their vertical relationships with sponsors (for a recent review, see [Rietveld and Schilling, 2021](#)). However, less attention has been devoted to understanding the relationships between OS platform sponsors and device makers (an exception is [Boudreau, 2010](#)).

Device makers and app developers are distinct types of complementors. While app developers enhance platform functionality without altering the user interface, device makers serve as the primary distribution channel, embedding the platform in hardware and shaping the user experience through integration and control over key features ([Van Alstyne et al., 2016](#)). Owing to this deeper co-specialization, a platform’s governance choices vis-à-vis device makers can influence their most powerful competitive asset—the platform itself—and may ultimately introduce selective entry barriers ([Boudreau, 2010](#)). Unlike governance toward app developers, which supports modular innovation, vertical relationships with device makers have structural implications for platform reach and user access, and therefore warrant distinct theorization. Yet the literature offers limited insight into how such relationships affect the competitive structure of the device maker market and—given the global nature of most OS platforms—how these dynamics unfold across nations, even though sponsor-complementor relationships are shaped by complex interdependencies that vary depending on local market conditions (as emphasized in the opening quote by [Nambisan et al., 2019](#)). This paper aims to fill these gaps.

In platform-based industries, a key phenomenon often involves the emergence of a *dominant OS platform*, that is, an OS platform (from now on “platform”) with an installed user base—or a number of end users—that is larger than other competing platforms ([Gawer and Cusumano, 2013](#); [McIntyre et al., 2021](#); [O’Mahony and Karp, 2022](#)). “Network effects” stand out as the primary determinant of a dominant platform: end users are inclined to gravitate toward the platform with the most extensive array of apps, while app developers perceive greater revenue potential by creating complements for the platform with the largest user base ([Lee, 2013](#)). Because of its market leadership, a dominant platform’s decisions about how to establish vertical relationships with ecosystem participants influence an industry’s growth and technological trajectories. A fundamental decision the sponsor of a dominant platform needs to make to sustain its leadership, and that at the same time has a profound impact on its ecosystem, concerns the platform’s level of *openness* to ecosystem participants ([Parker and Van Alstyne, 2018](#)). A platform’s level of openness—a sponsor-specific governance choice—depends on the extent to which restrictions are placed on participation in its development and use. Opening a platform is a way to access external capabilities that facilitate innovations ([Karhu et al., 2018](#); [Rietveld et al., 2020](#)).

In this paper, we focus on how the dominant platform’s level of openness to device makers impacts the competitive structure of their market, particularly its level of *concentration*, which is a function of the number of device makers and their market shares. Market concentration—which is common in the industrial organization (IO) ([Engelen et al., 2022](#); [Tirole, 1988](#)) and strategy literature ([Turner et al., 2010](#)), as well as routinely used by government agencies ([OECD, 2018](#))—is often studied as an alternative to analyzing a market’s competitive structure based on the number of firms entering or exiting a market. Importantly, it allows us to assess whether a dominant platform’s openness to device makers affects their attempts not only to enter the market, but also to weaken the market power of larger rivals. Low market concentration is a scenario in which many device makers have carved out a space at the expense of larger rivals’ market share. By bridging IO, which aims to examine the structural characteristics of an industry—and the product markets within it—that affect competition and firm performance ([Demsetz, 1982](#); [Tirole, 1988](#)), with the literature on platform leadership and platform openness, we argue that increased openness of the dominant platform to device makers reduces concentration in their market, as this openness effectively lowers two key barriers to the growth of smaller device makers and new entrants: (1) *legal* barriers to the adoption of the dominant platform and (2) barriers to modifying the dominant platform for use as an element of *product differentiation*.

Moreover, building within this framework, we draw on the emerging literature on platform multinational companies (PMNCs) (e.g., [Nambisan et al., 2019](#); [Parente et al., 2024](#)) and contend that the competition-fostering effect of the dominant platform’s level of openness to device makers is not uniform across countries. Instead, it depends on ecosystem-, industry-, regulatory-, and socio-economic-level contingencies. Regarding ecosystem-specific contingencies—that is, characteristics of the broader platform ecosystem that shape the strength of network effects—we focus on a platform’s *degree of dominance*, since “while economic models typically assume the platform to either be a monopolist or a duopolist, in reality, there are often multiple competing platforms with an

unequal distribution of market shares” (Rietveld and Schilling, 2021, p. 1548). A dominant platform is the result of *tipping* or a *winner-take-all* outcome, that is, a platform pulling away from rivals in popularity and taking most of the market due to stronger network effects for end users and complementors (Dubé et al., 2010; Eisenmann, 2006). We argue that the greater the dominance, the more attractive an open platform becomes to device makers, thereby amplifying its competition-fostering effect.

As for industry-specific factors—that is, structural characteristics of the industry in which platforms and platform-based devices compete—we focus on end-user engagement with platform-based devices from a specific industry relative to other platform-based industries, defined as the relative intensity with which end users in a nation utilize such devices to access the OS platform and its apps (Gregory et al., 2021). This factor captures evolving patterns of user familiarity across platform-based device industries. Prior studies have shown that higher end-user engagement increases users’ desire for content variety (Datta et al., 2018). We argue this creates opportunities for smaller device makers to serve new user niches, thereby reducing the market share of dominant incumbents and enhancing the pro-competitive impact of platform openness.

With respect to regulatory-specific factors, international business scholars have noted that “a number of exogenous forces—including [...] regulations (e.g., anti-trust law), [...] might moderate (or otherwise shape) the role of platforms and ecosystems” (Nambisan et al., 2019, p. 1482). We argue that strong regulatory enforcement constrains the ability of dominant platform sponsors to engage in discriminatory behavior or subtle self-preferencing, thereby preserving the effectiveness of openness, and lowering entry and differentiation barriers for device makers.

Finally, turning to socio-economic-specific factors—which PMNC scholars have argued deserve more attention (e.g., Parente et al., 2024)—we focus on end-user purchasing power in a nation. We argue that platform openness enables device makers to reduce the costs of accessing and developing for the platform, allowing them to adopt more aggressive pricing strategies. This is particularly advantageous in countries with limited consumer spending capacity.

Using data on platform sponsors and device makers in the mobile phone and tablet industries,¹ from 2009 to 2019 across 190 countries, we find support for our hypotheses. We make important contributions to the field of IO, platform ecosystems, and international business. First, we contribute to the emerging literature on PMNCs (e.g., Parente et al., 2024) by showing how platform sponsors—firms that operate across borders but retain centralized control over the governance of digital platforms—shape competition in host-country device markets. By responding to Nambisan et al.’s (2019) observation that “theories that postulate the combined (or interactive) effects of ecosystem-specific advantages, context-specific advantages, firm-specific advantages and country-specific advantages could potentially offer novel insights” (p. 1482), we shed light on how openness affects competitive dynamics across diverse national contexts.

Second, most prior studies have examined single industries and are disproportionately focused on Western economies, especially the U.S. By contrast, with our multi-industry, multi-country analysis we answer calls that “a greater range of industries [...] and geographic scope [...] would enhance the robustness of the platform competition research and potentially reveal important relationships or other sector-specific dynamics that have thus far been overlooked” (Rietveld and Schilling, 2021, pp. 1546–1547).

Third, we extend insights from IO by shifting attention away from dominance within a focal industry to dominance exercised by upstream actors—namely, platform sponsors—that shape the structure and competition of the downstream market (of device makers) across borders. This focus brings a novel international dimension to IO-style analysis. In doing so, we contribute to international business research on how the global strategies of digitally enabled firms influence competitive conditions in the market of complementors across diverse national environments.

2. Theory background and hypotheses

2.1. Factors shaping the outcomes of platform multinationals’ strategies

PMNCs represent “multinational corporations that strategically leverage digital platforms as integral elements of their business model and operational strategies, extending beyond the confines of national borders” (Parente et al., 2024, p. 2). Unlike traditional MNCs, PMNCs manage complex, multi-sided ecosystems, requiring centralized governance of platform architecture while simultaneously enabling diverse global participation. As Nambisan et al. (2019, p. 1469) note, “as a multi-sided marketplace, platforms offer shared access to different sets of users and customers from various countries.” This dual nature creates unique strategic challenges and opportunities, as PMNCs must balance global integration with local responsiveness while confronting adverse ecosystem dynamics, industry conditions, regulatory environments, and socio-economic contexts.

Parente et al. (2024) underscore the need to examine the “emerging changes and new challenges in international business brought by these platform companies” (Parente et al., 2024, pp. 1–2). Nambisan et al. (2019) suggest that the outcomes of strategies of platform companies operating in multiple countries are shaped by four types of factors: firm-specific, ecosystem-specific, context-specific, and country-specific. Firm-specific factors refer to the platform sponsor’s strategic postures and capabilities, such as governance and innovation choices. Ecosystem-specific factors refer to features of the platform ecosystem—such as network effects that lead to

¹ In this paper, we use “industry” to refer to broader economic activities, such as the mobile phone industry or the tablet industry. Within each industry, we distinguish between “product markets”—groups of firms supplying a specific type of product category—in our case, the “platform sponsor market” and the “device maker market.”

winner-take-all outcomes—that influence platform performance within an industry. Context-specific factors refer to characteristics of the “business context” (Nambisan et al., 2019, p. 1474) and capture industry-level influences. Finally, country-specific factors reflect broader national conditions that are not tied to a particular firm, industry, or ecosystem.

Parente et al. (2024) move the discussion forward by emphasizing not only firm capabilities and ecosystem dynamics but also the critical role of regulatory constraints. As they argue, “digital platforms are inherently disruptive to traditional industries, which makes it likely that the external contexts will have a more differentiated regulatory impact on platforms than they do on traditional organizations. [...] However, much of the existing research focuses on specific themes but fails to consider the rapid expansion of platforms across industrial boundaries and geographical borders, which brings significant institutional challenges to the international business landscape” (Parente et al., 2024, p. 2).

Building on these complementary frameworks, we refine the classification proposed by Nambisan et al. (2019) by further disaggregating context-specific factors into industry-specific and regulatory-specific factors. This distinction enables us to address Parente et al.’s (2024) call to consider the regulatory constraints that platforms face in different countries. At the same time, we add a focus on national socio-economic contingencies—such as income levels or cultural norms—whose importance has been noted in the platform literature but has not yet been systematically incorporated into empirical analyses. In doing so, we also respond to Nambisan et al.’s (2019, p. 1474) suggestion that “the interactions among these four types of advantages—firm-specific, ecosystem-specific, context-specific, and country-specific—could potentially give rise to novel patterns of capability building and novel resource recombination processes and critically shape mode of entry, scaling, and growth” of a platform’s ecosystem.

Table 1 presents our classification of the factors influencing the outcomes of the strategies adopted by platform sponsors competing globally, building on the conceptual frameworks proposed by Nambisan et al. (2019) and Parente et al. (2024). For each type of factor, we summarize the associated constructs that will guide hypothesis development in the following sections. In our study, the strategic choice under investigation is the dominant platform’s level of openness to device makers, which represents a firm/sponsor-specific factor. Next, we examine how the impact of this strategic choice on competition in a country’s device maker market is contingent on specific ecosystem-, industry-, regulatory-, and socio-economic factors unique to that country. Table 1 also provides a brief overview of the theoretical mechanisms through which each factor operates and a preview of their empirical operationalization, which we discuss in detail in the Methods section.

2.2. Openness to platform’s complementors: the distinct role of hardware device makers

Although research has enriched our understanding of dominant platforms’ openness to app developers,² our knowledge about dominant platforms’ openness to makers of devices running these platforms, and in particular, how openness influences the competition among device makers, remains limited. This is surprising because device makers and app developers are theoretically distinct types of complementors. First, their *functional roles in the ecosystem* differ: app developers expand the variety of services and functionalities available on the platform, whereas device makers embed the platform in physical products and serve as its primary distribution channel to end users (Van Alstyne et al., 2016). Second, their *influence on the user experience* is also asymmetric. App developers operate within software-level boundaries defined by the platform sponsor—such as limits on how apps interact with the system, rules for how they appear to users, and restrictions that keep them separate from core device functions—which limits their ability to shape the system-level experience. By contrast, device makers integrate the platform into their hardware, directly affecting core performance dimensions like screen quality, battery life, camera optimization, and OS responsiveness. They also control key aspects such as pre-installed apps, update policies, and after-sales support, giving them greater influence over the full user experience (Boudreau, 2010). Third, this deeper involvement makes device makers *co-architects of the ecosystem*. While app developers build modular software that rarely alters the platform’s core, device makers often adapt and customize the OS to match their hardware and brand strategies. This includes integrating specialized components and modifying user interfaces or default settings. As a result, the same platform can offer differentiated experiences across devices—variations made possible only if the platform sponsor maintains openness to hardware-level customization (Karhu et al., 2018). Fourth, the platform’s *strategic logic for openness* diverges across these complementors. To maximize the platform’s value proposition and cross-side network effects, the sponsor often benefits from being open to a broad population of app developers—there is little risk and much to gain from diversity and scale. In contrast, the point of contact with end users can be achieved through only a few successful devices (e.g., Apple relies only on its iPhones). From the platform sponsor’s perspective, working with a small set of capable device makers—or vertically integrating—can be sufficient for market reach and control, reducing the incentive to maintain broad openness toward hardware makers.

These differences across functional roles, user experience, ecosystem co-architecture, and strategic logic of openness have important implications for the *barriers to entry and growth affected by openness*. For app developers, openness typically involves access to standardized developer tools and distribution via app stores—mechanisms that are relatively inclusive and scalable. Legal constraints are minimal, and entry is largely procedural (e.g., registration, compliance with terms of service). Differentiation, while important for

² Studies have found that opening a dominant OS platform to app developers can increase its value by incentivizing them to innovate (Boudreau, 2012). However, this can increase coordination costs if multiple app developers innovate in ways that the sponsor would not have chosen (Schmeiss et al., 2019). Clear market leadership is necessary for a platform to stimulate app developer participation (O’Mahony and Karp, 2022), and app developers perform better when ecosystem complexity is high and they have more experience (Kapoor and Agarwal, 2017; Tavalaei and Cennamo, 2021).

Table 1

Factors influencing the outcomes of platforms' strategies, associated constructs in the proposed model, and their operationalization.

Factor	Definition	Construct used in the model (related hypothesis)	Theoretical mechanisms	Empirical measure of the construct (sources in parentheses)
Firm/sponsor-specific factors	Strategic and organizational traits of the platform sponsor, such as its governance and monetization choices, as well as its innovation capabilities. These represent firm-level advantages in managing ecosystem participation, distinct from characteristics inherent to the ecosystem, industry, regulatory environment, or socio-economic context of a nation.	Dominant platform's level of openness to device makers (Hypothesis 1).	Platform openness <i>reduces legal barriers</i> to entry and growth by easing device makers' access to the platform, allowing more firms to participate. At the same time, greater openness <i>lowers differentiation barriers</i> because it grants device makers the ability to customize the platform and tailor offerings to diverse consumer segments, enhancing their competitive distinctiveness.	Categorical indicator, ranging from 1 to 3, depending on the level of openness of the dominant platform: dominant open-source OSs (i.e., high openness), dominant proprietary licensable OSs (i.e., moderate openness), dominant proprietary non-licensable OSs (i.e., low openness) (Press releases by platform sponsors and articles in LexisNexis).
Ecosystem-specific factors	Features of the platform ecosystem—such as network effects resulting in winner-take-all outcomes—that influence platform performance within an industry. These factors capture variation across ecosystems within the same industry, rather than broader firm-level traits or cross-industry differences.	Platform dominance in a country, assuming the largest platform has the largest user base and portfolio of complements (Hypothesis 2).	Higher dominance (larger user base relative to rivals) increases platform <i>visibility</i> , <i>lowering uncertainty</i> for device makers. This boosts their propensity to use the platform competitively, more fully exploiting its openness in lowering legal and differentiation barriers, thereby intensifying competition.	Concentration in the platform sponsor market (Herfindahl index). It serves as a proxy for dominance when interacted with the dominant platform's openness. Calculated from the market shares of platforms in terms of user page views via mobile OS (StatCounter Global Stats).
Industry-specific factors	The structural characteristics of the industry in which platform-based firms operate. Relevant dimensions may include the industry pace of innovation, industry life cycle stage, user engagement intensity, product replacement cycles, and the structure of distribution channels. These factors reflect systematic differences across business contexts rather than firm-specific traits.	End-user engagement with platform-based devices of a given industry in a country, relative to platform-based devices in other industries (Hypothesis 3).	Higher end-user engagement with platform-based devices in an industry <i>fuels demand for more diverse and tailored products</i> . This creates opportunities for new and smaller device makers to enter the market and offer customized products for niche segments—opportunities that are amplified when the dominant platform is open, as it lowers legal and differentiation barriers to entry and growth.	Web page views by mobile phone and tablet users relative to page views by users of other platform-based devices (StatCounter Global Stats).
Regulatory-specific factors	Characteristics of a country's regulatory environment that shape how platforms can leverage their position and interact with rivals and other ecosystem participants. These factors capture the impact of regulatory interventions on platform competition in a country, rather than interventions that may target non-platform firms.	Intensity of regulatory enforcement against dominant platforms in a country (Hypothesis 4).	Without strong regulatory enforcement, sponsors of dominant open <i>platforms may act opportunistically</i> —undermining the benefits of openness through <i>subtle forms of discrimination</i> . In contrast, high regulatory enforcement curbs such behavior, preserving openness as a meaningful pathway for competition and thereby strengthening its negative effect on market concentration among device makers.	Number of ongoing cases in a country where national regulatory authorities have initiated legal action against software platforms for suspected abuse of market dominance (LexisNexis; company and regulatory press releases; major news outlets).
Socio-economic-specific factors	General country-level conditions that are not specific to an industry, regulatory body, platform ecosystem, or firm, such as economic development, national income, income inequality, inflation, educational level, and cultural traits in a country. However, these factors may influence platform strategies and outcomes by shaping economic constraints on ecosystem participation.	End-user purchasing power in a country (Hypothesis 5).	Lower end-user purchasing power in a country increases <i>price sensitivity</i> , making <i>affordability</i> a critical factor in hardware adoption. Open platforms lower legal and differentiation barriers for device makers by reducing licensing costs and enabling <i>cost-effective customization</i> . These savings allow makers to compete more aggressively on price—especially in price-sensitive markets—thereby intensifying competition.	GDP per capita at purchasing power parity (World Bank).

visibility and success, is achieved primarily through software design, feature innovation, and marketing—but within a tightly defined and shared operating environment. Thus, the scope for strategic differentiation is relatively bounded and not directly shaped by the platform sponsor's degree of openness.

In contrast, openness toward device makers entails access to the OS platform itself (or its licensable components), the legal and contractual terms under which it can be used (e.g., licensing fees, certification requirements), and the extent to which device makers are permitted to customize, brand, or extend the platform's functionality. These are legal and differentiation-related barriers that can significantly affect not just initial entry but also a firm's ability to compete effectively after entry. Limited openness may restrict a device maker's ability to create meaningful product differentiation or achieve cost-effective integration, while also raising the risks of exclusion if the platform sponsor changes its access policies or enters the hardware market directly—a concern central to antitrust cases such as *Google/Motorola Mobility* (European Commission, 2012) and *Microsoft/Nokia* (European Commission, 2013). Therefore, openness toward device makers plays a more consequential role in shaping the structure of downstream competition. It can either enable a diverse and competitive hardware ecosystem or reinforce concentration and market foreclosure. This makes openness toward device makers not only strategically distinct but also deserving of dedicated theorization.

2.3. Dominant platform's openness to device makers and the concentration in their market

In this section, we theorize on the relationship between a dominant platform's openness to makers of platform-based devices and their concentration. Platform openness refers to the extent to which the platform sponsor grants access to the platform and relinquishes some control over the platform itself (Boudreau, 2010; Gawer, 2021). *Access* refers to the degree to which a platform is legally open and useable by device makers, while *control* represents the right a device maker has to modify the platform usage and then extend its functionalities.

We consider two important barriers to entry and growth that contribute to market concentration, as identified by industrial economists: *legal barriers*, which refer to the legal impediments to the adoption of a technology protected by intellectual property rights, and *product differentiation barriers*, which relate to the difficulties for firms, particularly smaller firms and new entrants, to discover new market niches by offering unique features and customization options (Demsetz, 1982; Schmalensee, 1982). Our reasoning is that the increased level of openness offered by the sponsor of the dominant platform to device makers leads to decreased legal and product differentiation barriers to entering and growing in the device maker market. These two factors help smaller device makers diminish the market power of larger device makers, consequently resulting in a lower concentration of device makers. More specifically, building on the concepts of access and control (Boudreau, 2010), and bridging insights from IO and platform competition literature, the theoretical mechanisms at play can be explained as follows. *Easier access*—i.e., lower legal barriers to adopting the platform—strengthens network effects by enabling a larger number of device makers to join the platform, which increases its overall attractiveness to app developers and end users, thereby reinforcing the platform's value. *Greater control*—i.e., lower barriers to using the platform as a vehicle for device-level differentiation—allows device makers to modify and customize the platform, which lowers perceived direct competition that would otherwise arise among highly similar devices. This differentiation enables device makers to serve potentially untapped or niche market segments, easing entry and, in turn, reducing concentration. Together, these mechanisms—amplified network effects through access, and reduced direct rivalry through control-driven differentiation—reshape the internal dynamics of device firms, making the market more competitive and contestable, particularly for smaller or newer entrants.

Research on OS platforms has identified three main types of platforms based on their level of openness to device makers: (1) *proprietary non-licensable*, where the platform sponsor does not license the platform to any other firm, thus acting as the sole maker of devices running its platform, and since no access to device makers also implies no control, this results in the lowest possible level of openness to device makers; (2) *proprietary licensable*, where the platform sponsor grants access (license) to a selected number of device makers, often upon payment of a license fee, and usually allows them to perform minimal modifications to the platform; or (3) *open source*, where potentially all device makers can access the platform, for free, and have relatively high freedom to modify it because, contrary to the two previous types of platforms, the sponsor makes the “source code” freely available, which is a set of human-readable instructions necessary to third parties to modify the platform. This three-level classification is used by scholars (August et al., 2021; Cusumano et al., 2019; Economides and Katsamakos, 2006; West, 2003), industry experts (Bock et al., 2015), and international institutions (European Commission, 2012).

IO theorists have long argued that the largest firm's legal control over key assets necessary for competition can constrain rivals' attempts to adopt such assets and, in turn, use them to differentiate their offer, thus hindering competition (Scherer and Ross, 1990; Tirole, 1988). In our context of vertical relationships between platform sponsors and device makers, if the sponsor of the dominant platform does not grant any access—and consequently, any control—to device makers, and then operates as the sole device maker for its platform (e.g., proprietary non-licensable OSs for mobile phones like Apple's iOS), it is likely to be (one of) the largest players also in the device maker market. In this scenario, two factors lead to a high concentration of device makers. First, considering its market dominance as a platform, stronger network effects for app developers and end users mean that the dominant closed platform offers greater technical performance to its platform-based products than products working with rival platforms (Gawer and Cusumano, 2013; Rietveld et al., 2020). Consequently, the limited opportunities for differentiation available to rivals' platform-based products strengthen the dominant platform's market share in the device maker market. Second, because the sponsor of the dominant platform does not license its platform to other device makers, it creates legal barriers to their entry and growth, limiting their ability to diminish its market power as a device maker.

If the dominant platform grants a moderate level of openness to device makers (e.g., proprietary licensable OSs for mobile phones such as Symbian OS³ or Windows Phone⁴), this is likely to foster a lower concentration in the device maker market compared to the aforementioned scenario of lower openness. This is because, although the dominant platform remains, to a certain extent, under the control of its sponsor, its goal is to use device makers as a vehicle to diffuse the platform and monetize through license fees and other revenue-generating services (Cusumano et al., 2019). Moreover, given the market share dominance of this moderately open platform, stronger network effects for app developers and end users will make it better performing than smaller rival platforms, thus attracting a wider number of device makers (Casadesus-Masanell and Ghemawat, 2006). On the other hand, some factors constrain the adoption of a dominant platform by new and smaller device makers, thus hindering their attempts to grow at the expense of larger incumbents. First, a moderate openness in terms of access to device makers means that the platform sponsor is not willing to license its platform to all device makers, granting access only to those that agree to (a) match the sponsor's specifications, and (b) pay a license fee. Second, because device makers have limited flexibility to build innovations on a dominant platform when it is installed in their products, they cannot easily use it to differentiate from rivals, making the platform a relatively weak competitive weapon.⁵

Finally, if the dominant platform grants a high openness to device makers, as in the case of open-source OSs like Google's Android, we expect that, with respect to the two aforementioned levels of openness, this is likely to give new and smaller device makers more opportunities to weaken larger device makers' market power, thus decreasing the device maker market concentration. First, if potentially all device makers can access the platform, strong network effects for app developers and end users make the dominant, open platform the most attractive option to several device makers (Karhu et al., 2018). Second, because the dominant open platform is accessible at lower cost to device makers, they will have greater incentives to adopt it. For example, in the case of open-source OSs, device makers pay little to no fees to sponsors, and have access to the OS's source code, thus saving the initial development costs they would have had to bear if they developed the OS from scratch (Barnett, 2011). Third, since the sponsor of the dominant, open platform grants device makers flexibility to modify the platform, smaller device makers are attracted by this platform because they can either adopt it in its basic form, without investing in any substantial modifications, or differentiate their platform-based products to target new or unserved consumer segments (Parker and Van Alstyne, 2018). In fact, allowing device makers to “offer innovative versions of platform products, rather than simply creating clones,” may help them to serve “user segments with differentiated needs” (Eisenmann et al., 2009, p. 140). This flexibility is particularly important in the context of PMNCs, as user preferences and usage profiles can vary significantly across countries, making it valuable for handset makers to tailor the open platform to local market demands. For example, in the mobile phone industry, where Android OS has dominated in many countries since the early 2010s, the majority of device makers have their own “skinned” (custom) version of Android, with the aim of offering end users a differentiated look, usability, and set of functionalities in diverse national contexts where they compete (Brown, 2022).⁶ Finally, it is worth noting that the performance of platforms with high levels of openness can be weakened because when multiple parties try—and have the freedom—to innovate simultaneously, multiple derivatives of the original open platform may lead to a reduction of coherence and compatibility across platform variants (Almirall and Casadesus-Masanell, 2010).⁷ However, in the case of a *dominant*, open platform, these drawbacks are likely to be less evident in the eyes of device makers because of the aforementioned opportunities they can exploit (Karhu et al., 2018). Hence, we posit:

Hypothesis 1. All other things being equal, there is a negative relationship between the dominant platform's level of openness to device makers and the concentration in the device maker market.

2.4. The moderating effect of the degree of platform dominance in the sponsor market

Being the largest platform does not necessarily mean solidly dominating the market, and thus generating significantly stronger network effects for app developers and end users than rival platforms (Rietveld et al., 2020). In fact, the extent to which a platform can generate greater network effects vis-à-vis competing platforms depends on the relative size of its installed user base. For example, being the largest platform with a 15% market share is not the same as being the largest platform with a 50% market share. Likewise, for a dominant platform with a 50% market share, its degree of dominance changes if the second largest has a 49%, 25%, or 5% market share. When the largest platform holds a strong market share advantage over its rivals—its *degree of dominance*—it indicates that competitive dynamics have largely settled, with one platform establishing a commanding lead. In such settings, the dominant platform

³ Symbian OS, developed in the late 1990s and fully owned by Nokia since 2008, was initially proprietary licensable, briefly open source in early 2010, before Nokia shut down public access to the source code later that year and reverted to a proprietary licensable model. The last Symbian-based phones were launched in 2013 (Siilasmaa, 2018).

⁴ Windows Phone, a proprietary licensable OS developed by Microsoft as the successor to Windows Mobile, was launched in 2010. Its final release appeared in 2015, and Microsoft exited the mobile OS market the following year.

⁵ For example, since the late 2000s, mobile phone makers using proprietary licensable OSs such as Windows Phone or Symbian were required to comply with strict hardware specifications (e.g., display resolution, processor speed, camera quality) and were allowed only limited customization of start-screen tiles (Woyke, 2010).

⁶ Some Android handset makers customize the OS to integrate proprietary features. For example, Amazon's Fire Phone used a modified version of Android to support its Firefly app, which enabled object recognition and direct purchasing on Amazon's e-commerce platform—an option unavailable on proprietary licensable OSs.

⁷ OS openness to device makers can encourage “forking”—the creation of altered copies of an open-source OS—which may limit handset makers' ability to exploit the original platform's features (Karhu et al., 2018).

maintains a persistent edge over smaller competitors—a condition often referred to as market tipping (Dubé et al., 2010) or a winner-take-all outcome (Eisenmann, 2006), in which powerful network effects reinforce the leader's position and constrain challengers' opportunities to gain ground.

We expect that the negative relationship between the dominant platform's openness to makers of platform-based devices and the concentration in the device maker market is strengthened the higher the platform's degree of dominance in the sponsor market. The reason for this is that if the dominant, open platform holds a solid market share advantage (i.e., significantly larger user base) with respect to the competing smaller platforms, it will be more *visible* to device makers, who will face lower uncertainty about which platform to adopt, since they will have a clearer perception about its superiority (O'Mahony and Karp, 2022). From an IO perspective, this means that *winner-take-all* outcomes stemming from large market share in the platform sponsor market increase the opportunities for device makers to exploit the low legal and product differentiation barriers to entry offered by the dominant, open platform. This is because device makers—in light of the largest, open platform dominance—easily realize that the most effective means of penetrating the market is by adopting a dominant platform that is legally accessible to device makers and offers customization opportunities. In other words, the largest platform's degree of dominance strengthens the competition-fostering effect of the dominant platform's openness, leading to a lower concentration in the device maker market. Hence, as the dominant platform's level of market dominance varies across countries, we posit:

Hypothesis 2. The negative relationship between the dominant platform's level of openness to device makers and the concentration in the device maker market is strengthened (i.e., becomes more negative) by the degree of platform dominance in the sponsor market within a given country.

2.5. The moderating effect of end-users' engagement with platform-based devices in a focal industry relative to engagement in others

End-user engagement refers to the time and attention an end user invests in interacting with a product or technology, with the aim of satisfying pragmatic and hedonic needs (Bijmolt et al., 2010; Rietveld and Ploog, 2022). Research on platforms has described end-users' engagement with a platform as a key metric that platform sponsors and developers of complementary apps must monitor. This is because their revenues are often generated through advertising or transaction-based charges, and thus, user engagement increases the effectiveness of such monetization methods, making the platform a digital space in which it is worth investing (Claussen et al., 2013).

However, end-users' engagement with platforms is a matter of attention not only for platform sponsors and app developers, but also for device makers. Since, in many industries, OS platforms represent a key component of platform-based products and a competitive weapon for device makers, growing user engagement is a signal to device makers that platforms themselves are likely to be the key driver of end-users' choice among competing platform-based products (Suarez and Kirtley, 2012). The intensity with which end users utilize devices from a given industry to access the platforms that such devices are equipped with, and the related apps, represents the *end-users' engagement with platform-based devices of that industry* (Gregory et al., 2021). This construct is often described as *across-industry*, meaning that end-users' engagement with platform-based devices from one industry should be assessed relative to their engagement with devices from other industries. For example, while up until the end of the 2000s consumers mainly used PCs to surf the internet and download applications, with the smartphone and tablet revolutions triggered by the introduction of Apple's iOS installed on its iPhones and iPads and Google's Android in both the mobile phone and tablet categories, the time end users spent using mobile phones and tablets to surf the internet and download apps has increased exponentially. At the end of the 2010s, in some countries, users' engagement with mobile phones was already greater than users' engagement with PCs (Bock et al., 2015). Because end-user engagement with platform-based devices of a given industry is expressed relative to other industries, it also represents the engagement life cycle of that industry. The transition from PCs to smartphones and tablets illustrates how relative engagement levels capture the evolving patterns of user familiarity and habitual usage across different platform-based device industries over time.

Authors have noted that as end users increase their engagement with platform-based devices to access the platforms installed on such hardware products, user segments with differentiated needs usually emerge (Rietveld and Eggers, 2018), and “a single firm may be unable to create a sufficiently broad array of products to satisfy increasingly diverse needs” (Eisenmann et al., 2009, p. 140). This is because end users become increasingly familiar with the platform and its apps, and this increases their demand for content variety and specificity (Datta et al., 2018; Gu et al., 2022). Such differentiated needs create opportunities for device makers to cater to specific user segments and meet their distinct requirements (Karhu et al., 2018). However, such (differentiation) opportunities can be exploited by device makers only if they can adopt an open platform. In fact, in the case of a dominant, closed platform owned by a sponsor who is also the sole maker of devices running its platform, this vertically integrated firm would exploit all opportunities, creating legal barriers to adoption by rival device makers.

By integrating these studies with IO's arguments about the role of low legal and product differentiation entry barriers as drivers of market share fragmentation (Porter, 1980; Schmalensee, 1982; Tirole, 1988), we argue that the differentiated needs of end-users, resulting from their engagement with platform-based products, contribute to the opportunities for device makers to exploit product *differentiation* offered by a widely *accessible* dominant platform. This, in turn, means that the competition-fostering effect of a dominant platform's openness to device makers will be enhanced by end-users' engagement with platform-based devices. There are primarily two reasons why end-users' differentiated needs fueled by end-users' engagement represent an opportunity, particularly for smaller device makers and new entrants, to penetrate the market and weaken the market power of larger device makers. First, smaller device makers and new entrants can serve end-users' heterogeneous needs by leveraging their flexibility to customize (“control”) the dominant, open platform. In fact, designing ad hoc contents for new end-user niches would be a daunting task for device makers if they

must rely on a relatively closed platform (Boudreau, 2010). Second, such end-users' heterogeneous needs represent an opportunity to target segments of users not served by larger device makers, whose retaliation may represent an obstacle to the growth (Giachetti and Li Pira, 2022). As end-users' engagement with platform-based devices from a given industry varies across countries, we thus propose:

Hypothesis 3. The negative relationship between the dominant platform's level of openness to device makers and the concentration in the device maker market is strengthened (i.e., becomes more negative) by end-users' engagement with platform-based devices in that industry, relative to others, within a given country.

2.6. The moderating effect of the intensity of regulatory enforcement against dominant platforms

Regulatory authorities in many countries are increasingly scrutinizing dominant platforms for potential abuses of market power, particularly in platform-based industries where network effects and access control can create entry barriers. The intensity of regulatory enforcement against dominant platforms reflects how actively regulators monitor, challenge, and sanction anticompetitive practices such as exclusivity agreements, refusal to license, or unfair contract terms imposed on complementors and end users (Sokol and Van Alstyne, 2021).

From an IO perspective, regulatory institutions play a critical role in shaping market outcomes by influencing firms' incentives to compete or cooperate. IO scholars have long emphasized that, in markets prone to concentration and entry barriers, the presence and credibility of regulatory oversight can deter anticompetitive behavior and sustain conditions favorable to rivalry (Jacobides and Lianos, 2021). In this view, regulation acts as a structural counterbalance to market power and strategic conduct, especially where dominant firms control essential inputs or access points, as is often the case with digital platforms.

In *Hypothesis 1*, we argued that the openness of OS-dominant platforms to device makers tends to foster greater competitive intensity in the device maker market, as it lowers legal and product differentiation barriers to entry by enabling more firms to access and meaningfully customize the platform. However, here we expand this argument, contending that the extent to which openness translates into lower concentration among device makers critically depends on the intensity of regulatory enforcement against dominant platforms in a given country.

When regulatory enforcement is low, the sponsor of a dominant platform may engage in opportunistic behaviors that undermine the benefits of openness (Bradford, 2023). For instance, it may enter the device maker market with its own platform-based devices and, despite offering access to third-party device makers, subtly degrade their ability to rely effectively on the open platform through practices such as delayed access to updates, limited technical support, or selective enforcement of licensing terms. These actions reintroduce legal and differentiation-related barriers to entry, and can foreclose competition in the device maker market by tilting the playing field in favor of the sponsor's own devices or a few preferred third-party device makers, thereby weakening the expected inverse relationship between openness and concentration.

In contrast, in countries with high regulatory enforcement, sponsors of dominant platforms perceive themselves as more constrained in their ability to act opportunistically (Bostoen and Petit, 2024). Active and credible regulators are more likely to detect and sanction discriminatory behavior or subtle forms of self-preferencing that would otherwise undermine open access and obstruct meaningful product differentiation. Regulatory scrutiny helps preserve the mechanisms through which openness reduces barriers to entry: it compels platform sponsors to maintain inclusive licensing practices and provide uniform technical resources that empower diverse device makers to compete. As a result, high regulatory enforcement ensures that the benefits of openness—such as broader access and meaningful opportunities for differentiation—materialize more fully, thereby reinforcing the negative relationship between platform openness and market concentration among device makers. Therefore, we posit:

Hypothesis 4. The negative relationship between the dominant platform's level of openness to device makers and the concentration in the device maker market is strengthened (i.e., becomes more negative) by the intensity of regulatory enforcement against dominant platforms within a given country.

2.7. The moderating effect of end-users' purchasing power

Open platforms allow device makers to reduce the costs associated with accessing and developing (or controlling) the platform to be installed on their products. This is because, first, high openness to device makers means that they have cheaper accessibility to the platform, in the form of lower or non-existent license fees that must be paid to platform sponsors (Barnett, 2011). Second, high openness to device makers means that they have all the necessary information (e.g., the source code, in the case of open-source OSs) to modify and customize the platform, so as to facilitate its integration with their hardware, which can be produced at greater efficiency (AlphaBeta, 2017). Derivatives ("forks") of original open-source platforms can help device makers save millions of dollars in initial development costs and in subsequent upgrades (Barnett, 2011). In turn, this allows device makers adopting a highly open platform to be more aggressive in terms of pricing to end users (Bock et al., 2015). For example, in the mobile phone industry, at the end of the 2000s, sponsors of proprietary licensable OSs, like Nokia with its Symbian OS and Microsoft with its Windows Phone, charged handset makers from nearly \$5 to \$10 per phone (Virki, 2008), forcing them to sell their handsets to end users at relatively high prices. Instead, Google's Android open-source OS was free to all handset makers, most of which set competitive prices, especially in the price-sensitive markets of developing countries, where Android quickly became the dominant platform (Eaton, 2011; Lee, 2011).

By integrating these studies with IO's arguments about entry barriers, we argue that the cost-saving opportunities available to device makers through the use of a dominant platform that grants them low-cost access and significant customization, contribute to their ability to exploit low legal and product differentiation entry barriers. This is particularly evident in countries where end users

have weak purchasing power. This, in turn, implies that the competition-fostering effect of the dominant platform's level of openness to device makers is likely to be stronger the weaker the end-users' purchasing power is, and then the higher the end-users' price sensitivity. This is because countries with weak end-user purchasing power are ideal targets for price-competitive platform-based products, such as open-platform hardware, which offer cost savings to device makers. By contrast, the stronger the purchasing power of end users, the less effective the price advantage offered by firms making products equipped with a dominant, open platform, and thus, the lower the incentive possessed by device makers to use that platform to strengthen their market share vis-à-vis larger rivals. Indeed, this latter scenario will result in greater concentration in the device maker market. Hence, we posit:

Hypothesis 5. The negative relationship between the dominant platform's level of openness to device makers and the concentration in the device maker market is weakened (i.e., becomes less negative) by end-users' purchasing power within a given country.

3. Methods

3.1. Setting and sample

We test our hypotheses with data from the global mobile phone and tablet industries, from 2009 to 2019, an excellent laboratory for analyzing how sponsors of dominant platforms affect the device maker market's competitive structure. First, although putting the hardware over the software had been the right approach for simple mobile phones and tablets (Giachetti et al., 2017), since the smartphone revolution triggered by Apple with its iPhone in 2007 and the introduction of Google's Android OS in 2008, software, and especially the OS (i.e., the platform), has become the key competitive weapon for device makers (Van Alstyne et al., 2016). With regard to mobile phones, at the end of the 2000s, the dominant OS for handsets in most countries was still Symbian, a proprietary OS developed by Nokia, which the Finnish company used on its smartphones and licensed to competing handset makers. Symbian was progressively dethroned by Apple's iOS and Google's Android, both of which had access to a significantly larger app ecosystem. Advanced OSs were mounted on tablets in 2010, when Apple gave birth to the modern tablet category with the launch of its iPads, which, like its iPhones, are based on iOS. Google followed this approach by making Android available to tablet makers.

Second, multiple OSs coexisted and were available at different levels of openness to hardware device makers. Moreover, multiple changes in the market leadership of OSs occurred over time, depending on the country. For example, in the mobile phone industry, Nokia's proprietary licensable Symbian OS was the leading OS in most countries at the end of the 2000s; however, it was later dethroned by Google's open-source Android OS and by the proprietary non-licensable Apple iOS. In the tablet industry, Apple initially dominated the market with its iOS, but it later lost its number one position in many countries to Android. The performance of a given OS in a given country is primarily influenced by the strength of its app portfolio. In fact, although mobile phone and tablet users can use their device—and then the OS installed on it—in multiple countries, the number of apps available for a certain OS may markedly change from country to country, thus affecting the attractiveness of the OS for users. A recent study of mobile phone developers in 37 countries showed that about one-third of app developers appear only in their domestic country (Caribou Digital, 2016).⁸ Similarly, previous studies have noted that several apps are only available on a single OS, making OSs' value propositions to device makers broadly heterogeneous (e.g., Singh et al., 2021).

Third, mobile phones and tablets each constitute a separate product market (European Commission, 2012). This is because (a) they are sold through different channels, (b) customers view tablets more like computing devices, (c) due to the differences in screen size, the usage of mobile phones and tablets is different, with tablets preferable for apps that work better with a large screen or with a pen, and (d) app design is often specific to either mobile phones or tablets due to the need for optimization based on screen size differences. Therefore, testing our hypotheses in both markets enhances the generalizability of our findings.

3.2. Data sources and structure

Country-level market share data on mobile phone and tablet makers and OS platform sponsors was used to identify the dominant platform in each country, as well as to measure the concentration in both the platform sponsor and device maker markets. Such data was collected from StatCounter Global Stats, a web analytics service provided by StatCounter, a web traffic analysis website. Every month, StatCounter records billions of pageviews to websites all over the world, analyzing the device type (e.g., whether it is a mobile phone or a tablet), the brand of the device (e.g., whether it is an Apple, Samsung, or Xiaomi, among others), the OS installed on the device (e.g., whether it is Android, iOS, etc.) connecting to a given webpage from a given country. Therefore, market shares of OSs and device makers are based on the number of page views by end users of a certain device brand that has installed a given OS.

Measuring the market shares of OS owners and OS-based device makers in terms of page views has advantages over measures based on units sold or revenues. Regarding OSs, after the smartphone revolution in 2007, their sponsors mainly earn revenue through pay-per-click advertising and app downloads, which cannot be captured by measures based solely on the number of devices that mount a particular OS. However, they can be reasonably approximated by the extent to which end users access internet pages with platform-based products mounting that OS (Competition and Market Authority, 2022). With regard to device makers, one of the key factors that

⁸ App availability may be restricted to a limited number of countries due to several entry barriers, including compliance with national tax and content regulations, copyright licensing requirements (e.g., for music and media), language localization, dependence on country-specific services (such as U.S.-only banking apps), and the need to conduct initial testing in limited geographic markets to avoid negative reviews.

end users consider when choosing a modern mobile phone and tablet brand is the OS installed on the device, particularly the way the device maker has adapted the OS platform to its hardware system. In fact, such hardware-software integration affects device usability and ease of access to the OS platform and its apps, which, in turn, fosters users' purchases of and willingness to spend on that hardware brand (Atluri et al., 2012). Accordingly, the intensity with which users access the OS installed on the hardware device relative to competing devices can be used as a proxy for the extent to which end users value the brand of a platform-based product relative to competitors. Finally, StatCounter captures the market share data of almost the entire population of OSs and device makers (with the "Others" category always below 1%), in nearly all existing countries, allowing for precise market concentration indexes.

To give an idea of StatCounter's coverage, in 2015, its tracking code was installed on more than 2 million sites globally, covering various activities and locations. In September 2015, StatCounter's sample consisted of more than 16 billion page views, of which more than 6 billion were accessed by mobile phones.⁹ Industry analysts consider the StatCounter market share databases to be among the largest in terms of sample size (Schenker, 2007). As a result, they have been used to conduct analyses published in major business magazines like the *Wall Street Journal* (Alcántara, 2021), *Bloomberg* (Kim, 2021), and *The Economist* (The Economist, 2013), in academic research (Cusumano et al., 2019), as well as by competition regulators (Competition and Market Authority, 2022; US House Judiciary Committee, 2022) and management consulting firms (Manyika et al., 2013).

On StatCounter, data on mobile phones are available from 2009, while data on tablets are available from 2012, two dates that correspond more or less with the birth of modern smartphones and tablets, respectively. The final database includes a set of variables based on market share data on 26 mobile phone OSs, 193 mobile phone makers, 12 tablet OSs, and 112 tablet makers, from 190 countries. Notable OS platforms, either because of their market share and/or international footprint, include Android, Bada, BlackBerry OS, Firefox OS, iOS, KaiOS, LiMo, Linux, Maemo 5, MeeGo, Series 40, Symbian OS, Tizen, webOS, and Windows, some of which were present in both the mobile phone and tablet industries. Notable device makers include Acer, Alcatel, Apple, Asus, BlackBerry (RIM), Dell, Google, HP, HTC, Huawei, Lenovo, LG, Motorola, Nokia, Oppo, Palm, Samsung, Sony, Tecno, Vivo, and Xiaomi, some of which were operative in both the mobile phone and tablet industries. We supplemented data collected from StatCounter with country-level data collected from the World Bank, for example, about GDP per capita growth and the rule of law. Our panel consists of industry-country-year observations, with each industry (i.e., mobile phone and tablet) having a number of observations equal to the number of countries times the number of years. The panel is unbalanced because the World Bank's data was not available in all years and countries of our study period (2009-2019).

3.3. Dependent variable

Device maker market concentration. Consistently with previous studies, concentration in the device maker market was measured using the Herfindahl index (e.g., Engelen et al., 2022; Turner et al., 2010). The index is computed as the sum of the squared shares of the firms in a given market, in a given country, in a given year, as follows:

$$DMC_j = \sum_i^{N_j} S_{ij}^2$$

where S_{ij} is the market share of firm i in market j in year t . The higher the index (which can reach the maximum level of 1 in case of a monopoly), the greater the level of market concentration, meaning that the demand for the use of a certain type of platform-based device (i.e., mobile phones or tablets) is served by a few relatively large device makers. Instead, the lower the index (i.e., the more it approaches zero), the more the market is occupied by a large number of device makers of relatively equal size, none of which have a relevant market share.

3.4. Independent variable and moderators

Dominant platform's level of openness to device makers. Drawing upon Boudreau (2010), to capture a dominant platform's level of openness to device makers, we first measured the extent to which each platform sponsor (OS owner) granted device makers: (a) *access* to the platform, i.e., allowing them to install the platform on their products, and (b) *control* of the platform, i.e., the freedom to modify the platform and extend its core functionalities. However, we did not develop two separate measures for the level of access and control because our research into the market revealed that those sponsors granting device makers greater access also granted greater control. The result of this data coding was that, consistently with extant observations from scholars (e.g., August et al., 2021; West, 2003), industry experts (e.g., Bock et al., 2015), and international institutions (e.g., European Commission, 2012), in many platform-based industries, OS platform policies of openness to device makers can be divided into three categories, ordered in terms of their level

⁹ Although StatCounter primarily reports market share data, it also published page view counts for September 2015. We correlated these data with World Bank indicators to assess whether page views reflect underlying internet usage patterns across countries. The number of mobile phone page views was strongly correlated with both a *country's mobile cellular subscriptions* ($r = 0.61$) and *population size* ($r = 0.63$) in 2015, suggesting that page views scale with country size and mobile usage.

of openness: (1) proprietary non-licensable OS, (2) proprietary licensable OS, or (3) open-source OS. Based on these, we developed a categorical measure, ordered from 1 to 3, ranging from the lowest to the greatest level of openness.¹⁰

To assess whether a given OS belonged to a given category in terms of openness, we conducted a detailed review of press releases by platform sponsors and articles in *LexisNexis* (a comprehensive repository of global news articles) commenting on the sampled OSs. Moreover, to validate our data coding strategy, we conducted in-person and phone interviews with a variety of industry practitioners. First, we interviewed actual and former managers of Samsung and Nokia, two device makers who have been adopters of all the main leading licensable OSs in our sample (i.e., Symbian, Windows, and Android). Additionally, we conversed with managers from newer entrants Xiaomi and Oppo, whose growth was in part due to their custom versions of Android. Furthermore, we interviewed people working for small device makers and start-ups who entered the industry by targeting consumer niches thanks to marked Android customizations. Our interview process was extended to include two application developers. This was undertaken to gain insight into the technical constraints and opportunities that OS owners provide to developers. Lastly, we conducted interviews with the mobile phone and tablet category buyer from a prominent chain of consumer electronics stores. Online [Appendix A](#) contains quotes obtained from our informants during interviews, providing additional insights and perspectives related to the topics discussed in the main text.

Next, we identified the dominant platform in an industry in a country as the platform with the largest market share ([Cennamo and Santaló, 2013](#); [Suarez and Kirtley, 2012](#)). The *Dominant platform's level of openness* was then operationalized with a categorical indicator, ranging from 1 to 3, depending on the level of openness of the dominant platform. In the mobile phone industry, dominant open-source OSs (i.e., high openness) account for nearly 73% of panel data points, and dominant proprietary licensable OSs (i.e., moderate openness) account for nearly 12% of panel data points, while dominant proprietary non-licensable OSs (i.e., low openness) account for nearly 15% of panel data points. In the tablet industry, dominant open-source OSs account for nearly 43% of panel data points, although there are no dominant proprietary licensable OSs, while dominant proprietary non-licensable OSs account for nearly 57% of panel data points.

Degree of platform dominance. The largest platform's degree of dominance was measured by assessing the extent to which the dominant platform operates in a concentrated market. In fact, if the dominant platform operates in a highly concentrated market, it means that it is among the few platforms—if not the only platform sponsor—that strongly dominate the market, with solid market share gaps with respect to smaller platforms ([Dubé et al., 2010](#); [Eisenmann, 2006](#)). We used the Herfindahl index in the same way we measured concentration in the device maker market. However, while the concentration in the device maker market was used to assess the competitive structure of the device maker market, concentration in the platform sponsor market permitted us to assess *tipping*. This is consistent with [Dubé et al.'s \(2010, p. 220\)](#) observation that “a more useful and general definition of tipping should be based on measuring the degree of market concentration.”¹¹

End-users' engagement with platform-based devices in a given industry. As suggested by scholars and industry experts, a potential method of measuring user engagement with OS platforms, is the number of site visits (or “page depth”), namely the frequency users of a given platform-based product category utilize that platform to access the internet or open apps, during a given period of time ([Gu et al., 2022](#)). To capture the extent to which end users utilize products of a given device maker industry (i.e., mobile phones or tablets, in our case) to access the OS platforms installed on such products and then their available apps, we employed the *relative* size of a given platform-based product category in terms of webpage views. Thus, we assumed that the number of webpage views by end users on a device with a given OS installed corresponds to the extent to which end users use that OS. In fact, to provide end users with the functions of their OS (e.g., download and use apps, access their email, surf the web), platform-based devices (like mobile phones and tablets) must be connected to the internet. StatCounter does not provide data on the number of webpage views per product category, but provides data on the relative number (i.e., market share) of webpage views by end users of the main four internet-connected platform-based devices in consumer electronics: mobile phones, tablets, PCs (including both desktops and tablets), and consoles. The greater the market share of a platform-based product category (mobile phones or tablets, in our case) relative to the other three categories, the more that product category is used to access the internet relative to the other three product categories, and thus we assume the greater end-users' engagement with that platform-based product category.¹²

Intensity of regulatory enforcement. Opportunistic behavior by sponsors of dominant platforms in a country is influenced by how actively regulatory authorities monitor and address potential abuses of market power in platform-based industries. To measure the strength of regulatory enforcement against dominant platforms, we compiled data on ongoing investigations and legal actions related to alleged market dominance abuses by software companies, limited to cases involving sponsors of platforms in our sample. Our primary sources included official records from regulatory authorities, such as the European Commission and the U.S. Department of Justice, industry reports from business intelligence firms, company websites, and media articles collected from *LexisNexis*. For each

¹⁰ This measure is similar to that proposed by [Boudreau \(2010\)](#), with one key difference. While Boudreau distinguished two levels of openness among *proprietary licensable OSs* based on whether licenses were restricted to specific market niches, we use a single category because, in our sample, no proprietary licensable OSs were targeted exclusively at particular niches.

¹¹ Alternative measures of winner-take-all outcomes, such as the largest platform's market share or the gap between the largest and second-largest platforms, have limitations because they do not capture overall market share distribution or competitive pressure from other platforms. Nevertheless, we used these measures as robustness checks and obtained consistent results.

¹² To give an example, in the US in 2019, though the largest relative number of webpage views was still generated by PC users (48.35%), the relative number of page views from mobile phones was only four percentage points smaller (44.38%), after having grown monotonically since 2009, when it was only 1.4%. In the US, the tablet market share reached its peak in 2014 (8.91%), and then decreased monotonically until 2019 (7.06%). Finally, the console market share remained very low, only 0.2% in 2019.

case, we recorded the year it was initiated and the date it was resolved or remained active. We then aggregated this information annually by country, producing a count of active regulatory cases each year.

End-users' purchasing power. We captured the purchasing power of end users in a country with the (natural logarithm of the) country's GDP per capita corrected for purchasing power parity (Ghemawat, 2003), which was collected from the World Bank.

3.5. Control variables

To rule out alternative explanations for our findings, we controlled for key factors likely to influence the concentration in the device maker market.

Growth of the dominant platform as a device maker. The dominant platform is often operative also in the device maker market. The more the dominant platform strengthens its market share in the device maker market, the more the other device makers might perceive their competitive position as being at risk, resulting in retaliations against the dominant platform's business in the device maker market (European Commission, 2012). We thus controlled for the annual growth rate of the dominant platform's market share in the device maker market.

Dominant platform fixed effects. Although we theorize platform openness as our primary firm-specific factor, we acknowledge that the existing literature has identified other firm-specific attributes of dominant platform sponsors that may influence market concentration among device makers (in addition to the above-described control related to the growth of the dominant platform as a device maker) (e.g., Parente et al., 2024). We treat these additional firm-specific factors as fixed. Accordingly, we include dominant platform fixed effects in our models. This approach allows us to isolate the influence of ecosystem-, industry-, regulatory-, and socio-economic-specific factors, along with our firm-level factor (openness), across the national contexts where dominant platforms operate, while controlling for other sources of firm-specific heterogeneity.

Sponsors' market share instability. Although the dominant platform is expected to be the primary OS influencing the competition in the device maker market, platform performance is often not stable over time, which may create uncertainty for device makers and affect their competition dynamics. We accounted for this uncertainty by calculating platforms' market share instability, which is the summation of the absolute value of the annual percentage point market share changes of all platforms in a given country, following Hymer and Pashigian (1962).

Android growth. Authors have found that new platforms that trigger technological discontinuities can successfully leapfrog a dominant platform, even when its network effects are strong (e.g., Eisenmann et al., 2011; Sheremata, 2004). In the mobile phone and tablet industries, though Apple's iOS represented the starting point of a digital revolution in both industries, it was with Google's open-source Android that hardware makers could easily access and take advantage of an iOS-like platform, thus intensifying competition in the hardware industry. We used the annual growth rate of Android's market share in a country to account for technological discontinuities and related opportunities in the device maker market. In fact, Android's growth rate was very high when the revolutionary OS was introduced, creating significant opportunities for those hardware makers who were willing to be early adopters (Giachetti and Marchi, 2017). Android's growth thus progressively decreased as it became the industry standard.

Device makers' design heterogeneity. From an IO perspective, the extent to which platform-based devices have different aesthetic designs should help them to differentiate their hardware to find new customer segments at the expense of larger rivals' market shares (Porter, 1980; Scherer and Ross, 1990). By contrast, if all devices are nearly aesthetically identical, it should be more difficult for challengers to weaken rivals' market power. Essential elements that may affect a mobile phone or tablet's design are its size and form factor. StatCounter does not provide data on device size or form factor, but does include display resolution, which refers to the number of pixels displayed on a screen, and is usually quoted as width \times height. A device's size and form factor affect its resolution—a smaller screen needs fewer pixels. StatCounter provides market shares of the various types of display resolutions,¹³ in each country. We controlled for device makers' design heterogeneity with a variable capturing the extent to which devices are heterogeneous in terms of display resolution, measured as 1 minus the Herfindahl concentration index based on the market shares of the display resolutions. Assuming that display resolution influences device size and form factor, great resolution heterogeneity (i.e., values of the measure close to 1) reflects a scenario in which products are aesthetically very different. In line with the theoretical mechanisms underpinning our argument, this variable helps account for underlying country-specific variation in differentiation-related factors that may influence the degree of concentration in device maker markets.

Rule of law. To account for the broader institutional environment in which platform strategies unfold, we include the rule of law index from the World Bank's Worldwide Governance Indicators (Kaufmann et al., 1999). This variable captures the general strength of a country's legal and judicial institutions—such as contract enforcement and property rights protection (Giachetti et al., 2024). Including it allows us to control for baseline differences in legal infrastructure that may shape competition dynamics.

GDP per capita growth. Research has suggested that industries in countries with low economic growth are likely to have a more fragmented competitive structure than industries in countries with high economic growth (Ghemawat, 2003). To control for this concern, we included the annual percent growth rate of GDP per capita of a country in our analysis, as reported in the World Bank database (Berry, 2013).

¹³ The 14 and 10 display resolution types with larger market shares, respectively, for mobile phones and tablets.

3.6. Statistical method and analysis

Descriptive statistics are reported in Table 2. To reduce potential multicollinearity caused by multiple interaction effects, the independent variables and controls were standardized prior to forming the interactions (Cohen et al., 2003). In addition, they were lagged by one year to make realistic inferences about their effects on our dependent variable.

Given the structure of our database, in which we have observations in multiple countries over time for both the mobile phone and tablet industries, we used panel data regression analyses. The Hausman test suggested that a fixed-effects regression was preferable over random-effects. We thus tested our hypotheses using a fixed-effects panel (industry and country fixed-effects), with robust standard errors. The fixed-effects estimation method addressed issues in longitudinal panel analyses, such as unobserved heterogeneity and its association with model variables (Greene, 2003). We also added year dummies and dominant platform dummies.

We checked for multicollinearity using variance inflation factors (VIFs). In our full model, VIF values ranged from 1.01 to 5.80, with an average VIF of 2.16, below the recommended threshold of 10 (O'Brien, 2007). Despite the low VIFs, three pairwise correlations among the independent variables presented coefficients above 0.6. As reported in Table 2, these correlations include the control variables *sponsors' market share instability*, *device makers' design heterogeneity*, and *rule of law*. Since the overall VIF did not change with the removal of these three controls, we included them in our estimates because they are important in ruling out alternative explanations.

4. Results

4.1. Hypothesis tests

Table 3 presents Stata coefficient estimations from the fixed-effects panel regressions. In Model 1, only the control variables were included. In Model 2, we added the main independent variable, namely the dominant platform's level of openness, and the main effects of the four moderating variables. Model 3 is the full model. In Model 3, the main effect of a dominant platform's level of openness on device maker market concentration is negative and significant ($\beta = -0.012$; $p = 0.001$), thus supporting Hypothesis 1.

As shown in Model 3, the coefficient of the interaction between a dominant platform's openness and platform dominance is negative and significant ($\beta = -0.015$; $p = 0.000$). Consequently, Hypothesis 2 is supported. Fig. 1 displays the marginal effects of a dominant platform's openness on the device maker concentration for different levels of platform dominance in the sponsor market. As can be noted, the negative effect of a dominant platform's openness on device maker concentration becomes more negative as the platform dominance increases; however, for very low levels of platform dominance, the effect of the dominant platform's openness is positive, suggesting a "competition-dampening" effect on the device maker market (as subsequently discussed). With respect to the economic significance of our findings, as shown in Fig. 1, when platform dominance moves from its theoretical mean (0) to one standard deviation (SD) above the mean (1)—values based on standardized independent variables—the negative marginal effect of a dominant platform's openness increases in magnitude (it becomes more negative) by about 100% (from -0.015 to -0.03).

As for our third hypothesis, although the coefficient of the interaction between a dominant platform's openness and end-users' engagement is negative but marginally insignificant ($\beta = -0.004$; $p = 0.138$), the marginal effects analysis in Fig. 2 reveals a consistently negative and statistically meaningful effect of openness across the observed range of end-users' engagement. The margins plot shows that the effect of openness remains negative, with 90% confidence intervals excluding zero throughout. This suggests that even if the interaction is not strong enough to reach conventional significance in the regression, the conditional effect is substantively relevant and stable across values of the moderator. This offers partial support to our Hypothesis 3. As for the economic significance of this interaction, when end-user engagement moves from its mean to 1SD above the mean, the negative marginal effect of a dominant platform's openness is increased in magnitude by nearly 40% (from -0.01 to -0.014).

With regard to our fourth hypothesis, the coefficient of the interaction between a dominant platform's openness and intensity of regulatory enforcement is negative and significant ($\beta = -0.003$; $p = 0.014$), thus supporting Hypothesis 4. Marginal effects are illustrated in Fig. 3. As for the economic significance of this interaction, when the intensity of regulatory enforcement moves from its mean to 1SD above the mean, the negative marginal effect of a dominant platform's openness is increased by nearly 30% (from -0.01 to -0.013).

Finally, the coefficient of the interaction between a dominant platform's level of openness and end-users' purchasing power is positive and significant ($\beta = 0.008$; $p = 0.000$), thus supporting Hypothesis 5. Fig. 4 illustrates the marginal effects of the interaction. As can be noted, the negative effect of a dominant platform's openness on device maker concentration becomes less negative as the end-user's purchasing power increases; however, the relationship becomes insignificant for high levels of end-user purchasing power. Regarding the economic significance of this interaction, when end-user purchasing power moves from its mean to 1SD above the mean, the negative marginal effect of a dominant platform's openness is reduced in magnitude (it becomes less negative) by about 31% (from -0.016 to -0.011).

4.2. Additional analyses: multicountry dominance presence

Dominant platforms in our sample operate across multiple countries and, more interestingly, often hold leadership positions in several national markets simultaneously. To further explore the geographic dimension of platform dominance, we conduct additional analyses examining whether the relationship between platform openness and device maker market concentration varies with the platform's leadership presence across multiple countries. We introduce the concept of *multicountry dominance presence*, defined as the

Table 2
Descriptive statistics and correlations.

		Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12
1	Device maker market concentration	0.33	0.14	0.11	0.88	1.00											
2	Dominant platform openness	2.23	0.93	1.00	3.00	-0.57***	1.00										
3	Platform dominance	0.51	0.15	0.13	0.92	0.36***	0.07***	1.00									
4	End-users' engagement	19.93	23.08	0.23	96.40	-0.24***	0.35***	0.11***	1.00								
5	Intensity of regulatory enforcement	0.25	0.65	0.00	4.00	0.11***	-0.10***	0.10***	-0.09***	1.00							
6	End-users' purchasing power	9.33	1.18	6.51	11.95	0.29***	-0.19***	0.16***	-0.19***	0.41***	1.00						
7	Growth of the dominant platform as a device maker	0.80	20.24	-1.00	608.22	0.02	-0.07***	-0.00	-0.02	-0.00	0.00	1.00					
8	Sponsors' market share instability	24.49	21.24	0.24	152.24	-0.33***	0.07***	-0.64***	0.08***	-0.25***	-0.34***	-0.02	1.00				
9	Android growth	0.64	1.65	-0.80	31.00	-0.05*	-0.08***	-0.32***	-0.08***	-0.12***	-0.14***	-0.03	0.36***	1.00			
10	Device makers' design heterogeneity	0.80	0.15	0.20	1.00	-0.75***	0.60***	-0.46***	0.37***	-0.20***	-0.36***	-0.03	0.43***	0.20***	1.00		
11	Rule of law	49.76	28.09	0.47	100.00	0.27***	-0.27***	0.10***	-0.18***	0.44***	0.73***	0.01	-0.25***	-0.13***	-0.36***	1.00	
12	GDP per capita growth	1.89	4.67	-62.38	121.78	-0.02	-0.01	-0.01	-0.00	0.00	-0.04 ⁺	-0.01	0.02	0.11***	0.01	-0.01	1.00

Mean, SD, Min, and Max values based on unstandardized variables. All variables lagged by one year, except *device maker market concentration*.

$N = 2552$.

Significance: ⁺ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3
Fixed-effects regression for device maker market concentration.

	Full sample			Subsample: Multicountry dominance >1st perc.	Subsample: Multicountry dominance >5th perc.
	Model 1	Model 2	Model 3	Model 4	Model 5
Dominant platform openness		-0.0008 (0.0019)	-0.0122** (0.0038)	-0.0148*** (0.0039)	-0.0147*** (0.0041)
Platform dominance		0.0107* (0.0042)	0.0209*** (0.0054)	0.0232*** (0.0052)	0.0233*** (0.0053)
End-users' engagement		0.0015 (0.0059)	0.0057 (0.0058)	0.0068 (0.0059)	0.0069 (0.0062)
Intensity of regulatory enforcement		0.0027 (0.0019)	0.0022 (0.0017)	0.0023 (0.0017)	0.0027 (0.0018)
End-users' purchasing power		-0.0422 ⁺ (0.0232)	-0.0319 (0.0226)	-0.0336 (0.0227)	-0.0340 (0.0233)
Dominant platform openness × Platform dominance			-0.0146*** (0.0034)	-0.0161*** (0.0035)	-0.0150*** (0.0036)
Dominant platform openness × End-users' engagement			-0.0037 (0.0025)	-0.0048 ⁺ (0.0026)	-0.0059* (0.0028)
Dominant platform openness × Intensity of regulatory enforcement			-0.0026* (0.0011)	-0.0023* (0.0011)	-0.0028* (0.0012)
Dominant platform openness × End-users' purchasing power			0.0078*** (0.0020)	0.0077*** (0.0022)	0.0084*** (0.0023)
Growth of the dominant platform as a device maker	-0.0028 (0.0025)	-0.0026 (0.0024)	-0.0031 (0.0027)	-0.0032 (0.0028)	-0.0059 ⁺ (0.0035)
Sponsors' market share instability	-0.0042 (0.0026)	-0.0011 (0.0024)	-0.0006 (0.0024)	0.0018 (0.0027)	0.0021 (0.0027)
Android growth	-0.0003 (0.0353)	0.0039 (0.0341)	0.0013 (0.0334)	-0.0051 (0.0361)	0.0003 (0.0374)
Device makers' design heterogeneity	-0.0459*** (0.0048)	-0.0375*** (0.0066)	-0.0294*** (0.0070)	-0.0288*** (0.0071)	-0.0304*** (0.0074)
Rule of law	0.0317 (0.0436)	0.0416 (0.0432)	0.0424 (0.0424)	0.0358 (0.0422)	0.0433 (0.0438)
GDP per capita growth	-0.0135 (0.0253)	-0.0041 (0.0266)	-0.0080 (0.0246)	-0.0076 (0.0240)	-0.0185 (0.0217)
Constant	0.2856*** (0.0076)	0.2970*** (0.0098)	0.3187*** (0.0108)	0.3221*** (0.0118)	0.3149*** (0.0125)
Dominant platform dummies	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
N	2552	2552	2552	2509	2311
Within R-squared	0.3736	0.3822	0.4010	0.4039	0.4165

Panel fixed effects at industry-country level; year and dominant platform dummies included. Results based on standardized variables. Robust standard errors reported in parentheses. All independent variables lagged by one year. Significance: ⁺ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

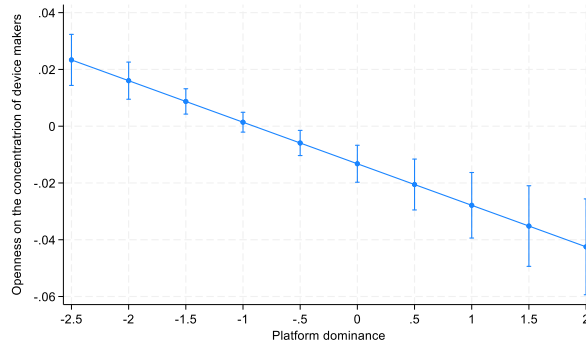


Fig. 1. Average Marginal Effects of Dominant Platform's Openness for Different Levels of Platform Dominance (with 90% CI)
 Note: Results based on standardized variables.

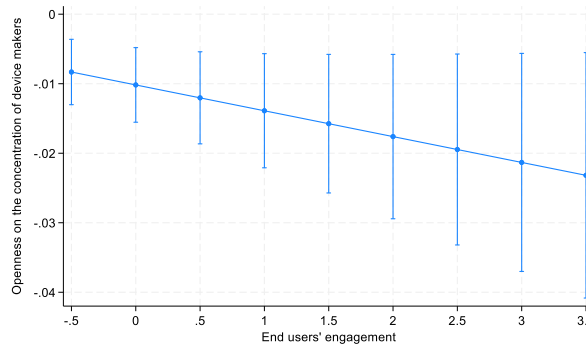


Fig. 2. Average Marginal Effects of Dominant Platform's Openness for Different Levels of End-Users' Engagement (with 90% CI)
 Note: Results based on standardized variables.

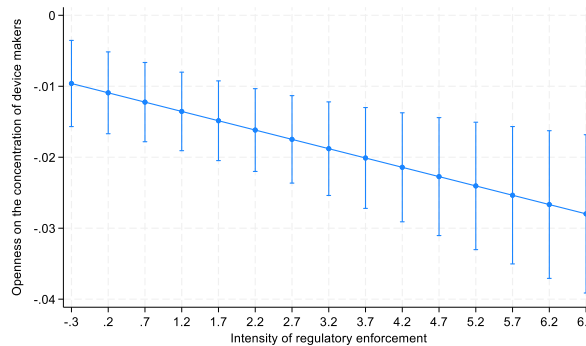


Fig. 3. Average Marginal Effects of Dominant Platform's Openness for Different Levels of Intensity of Regulatory Enforcement (with 90% CI)
 Note: Results based on standardized variables.

number of nations in which a given platform is the dominant player in a given year. This variable reflects the platform's geographic breadth of market leadership and captures its ability to operate as an internationally recognized leader. In our sample, this variable ranges from 1 to 170 countries in the mobile phone industry, and from 26 to 161 countries in the tablet industry.

We re-estimate our main models by restricting the sample to observations where the dominant platform holds a leading position in more than the 1st percentile of the multicountry dominance distribution (i.e., more than 3 and 26 countries for the mobile phone and tablet industries, respectively) and above the 5th percentile (i.e., more than 10 and 68 countries for the mobile phone and tablet industries, respectively). These cutoffs exclude observations where the platform has a relatively limited international footprint—cases in which its ability to leverage cross-national network effects and scale efficiencies may be constrained—while retaining sufficient variation for meaningful estimation. In Models 4 and 5 of Table 3, we observe increases in coefficient significance—indicated by lower *p*-values—compared to the full Model 3. The most notable improvements occur in the main effect of platform openness, whose *p*-value falls below 0.001, and in the moderating effect of end-user engagement, whose *p*-value drops below 0.1 in Model 4 and below 0.05 in Model 5. We find only marginal gains in significance (within the same significance range) for the moderating effect of platform

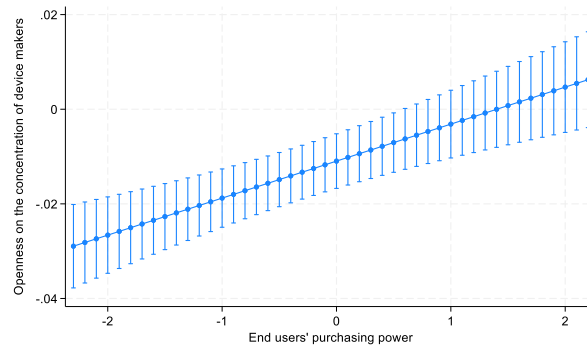


Fig. 4. Average Marginal Effects of Dominant Platform's Openness for Different Levels of End-Users' Purchasing Power (with 90% CI)
Note: Results based on standardized variables.

dominance. By contrast, we observe slight increases in p -values—indicating marginal reductions in significance—for the moderating effects related to regulatory enforcement intensity and end-users' purchasing power. To assess whether these changes in significance are meaningful, we conduct joint hypothesis tests using an extended specification that includes interactions among platform openness, each moderating factor, and multicountry dominance presence. These tests evaluate whether the full set of coefficients for each interaction term differs significantly across groups defined by the geographic breadth of platform dominance. The joint tests employ the Wald test framework (Baum, 2006). Consistent with the changing significance levels observed in Models 4 and 5, the Wald test results indicate that higher multicountry dominance can both strengthen and weaken the predicted relationships.

As for the more significant main effect of platform openness and of the moderating effect of the degree of platform dominance, one explanation is that when a dominant platform holds leadership positions in a large number of countries, it can exploit the scale and credibility accumulated across multiple ecosystems to make openness more effective in facilitating competition. For example, greater platform dominance in a focal country, when backed by success in many others, reduces uncertainty for local device makers even further and enhances their willingness to adopt the dominant, open platform. Similarly, in countries where end-user engagement with platform-based devices in an industry relative to devices in other industries is high, a globally dominant and open platform enables local device makers to more effectively target differentiated user demands—especially when the platform's wide adoption ensures broader app availability and compatibility. By contrast, regulatory enforcement is not significantly strengthened when the dominant platform holds leadership positions in many countries. This suggests that, even when platforms have more at stake globally in terms of legitimacy, strong regulatory oversight in a focal country does not consistently enhance the effectiveness of openness as a mechanism for promoting fair competition among device makers. Similarly, in countries with lower end-user purchasing power, a dominant platform with multicountry dominance does not substantially improve device makers' access to modular solutions and cost-saving complementarities developed elsewhere. As a result, their ability to compete on price is not significantly enhanced, and openness does not exert a stronger effect in facilitating market entry or intensifying competition in price-sensitive environments.

4.3. Endogeneity test

Potential simultaneous causality between the dominant platform's degree of openness and the concentration in the device maker market could bias our results. For example, if the concentration in the device maker market is driven by a leading device maker that relies on its own closed platform, the fact that it is the market leader in the device maker industry would also affect the (low level of) openness of the dominant platform. In order to address the potential endogeneity of our independent variable, we thus used instrumental-variable regression. A legitimate instrument must meet the exclusion restriction condition (Cameron and Trivedi, 2009); this condition requires that the instrument be correlated with the endogenous regressor but uncorrelated with the time-variant error term. In other words, the effect of the instrument on the dependent variable should be mediated by the potential endogenous regressor.

We used two instruments. The first was the *degree of platform heterogeneity in an industry*, which captures the extent to which the platform sponsor market, in a given country, is not dominated by OSs with a given level of openness, but instead end-users' preferences tend to be well distributed across the three OS types discussed previously. Since each OS type inherits a different ecosystem complexity (Kapoor and Agarwal, 2017),¹⁴ greater platform heterogeneity reflects a highly uncertain technological environment in terms of which OS type will prevail. This uncertainty increases the incentive for platform sponsors to open their platforms to third-party device makers to encourage adoption and build ecosystem scale. Therefore, when there is technological uncertainty, open-source OSs are more likely to become dominant (Kapoor and Agarwal, 2017). An industry's platform heterogeneity was measured by subtracting 1 from the Herfindahl concentration index based on the market shares of the three *types* of OSs in terms of their openness to device makers. The second instrument was the *individuals using the Internet as a percentage of the population*, a country-level variable provided by the World

¹⁴ For example, in Apple's iOS ecosystem, app developers interact with a single firm that both sponsors the platform and manufactures the devices, whereas in Google's Android ecosystem they engage with multiple handset makers and customized versions of the open-source OS, making Android's ecosystem more complex.

Bank. The logic is that opportunities for sponsors of internet-centric OSs, as those concerning phones and tablets, increase with the diffusion of the internet among end users (Bock et al., 2015).

Regarding the relevance of the instruments, the under-identification test (the Kleibergen-Paap rk LM test) suggests that our instruments are correlated with the potentially endogenous variables ($\chi^2(2) = 42.86; p = 0.000$). We then conducted the endogeneity test (the C test) to determine whether our independent variable is endogenous. The results of this test ($\chi^2(1) = 0.34, p = 0.56$) suggest that a dominant platform's openness should be treated as exogenous. Therefore, the fixed-effects estimation should be preferred over the instrumental-variable estimation (Cameron and Trivedi, 2009). As shown in Model B1 of Table B1 in online Appendix B, the results of the instrumental-variable estimation remained consistent.

In addition, we have implemented several other corrective measures to tackle potential endogeneity issues. First, our fixed-effects models allow us to isolate time-variant variables from static differences among dominant platforms, industries, and countries. By accounting for unobserved heterogeneity that remains constant over time, we control for specific dominant platform, industry, and country characteristics that may be correlated with both the explanatory variables and the error term, thereby reducing the likelihood of omitted variables.

Second, we use time-variant controls at various levels, including the dominant platform level (e.g., growth of the dominant platform as a device maker), sponsor market level (e.g., sponsors' market share instability, Android growth), device makers level (e.g., device makers' design heterogeneity), and host country level (e.g., rule of law), all well-established in the extant literature. Incorporating time-varying controls is crucial for addressing evolving unobserved heterogeneity over time (Foss et al., 2015). We aim to minimize the risk of omitted variable bias and confounding factors by capturing fluctuations in covariates.

Third, we utilize lagged independent variables to alleviate concerns regarding reverse causation. This approach helps address the potential impact of the dependent variable on the independent variables, thereby ensuring more robust causal inferences.

Finally, contextualized arguments supporting the patterns in the data are provided in Appendix A, wherein we present quotes from the interviews we conducted with industry experts.

4.4. Robustness tests

We conducted several tests to assess the robustness of our findings, which are reported in the online Appendices B-F. A first set of tests, based on alternative samples, measures, and model specifications, is reported in Table B1 of the online Appendix B. First, we replicated our main models separately for the mobile phone and tablet industries. Second, we considered an alternative specification of platform openness by using the average openness to both device makers and app developers. Third, we tested alternative indicators of platform dominance, including the dominant platform's market share and its lead over the closest competitor. Fourth, we re-estimated the models without lagging the independent variables. Fifth, we constructed an alternative Herfindahl index based on units sold (instead of page views) for mobile phones, using data from Euromonitor International. In all cases, results remained fairly consistent.

Moreover, we present a model that considers a reduction in the influence of Android dominance in the sample (Appendix C), variations in product design heterogeneity in countries with high versus low end-users' purchasing power (Appendix D), an industry-level analysis of the plots of the interaction effect related to Hypothesis 2 (Appendix E), and the use of sponsors' market share instability instead of sponsor market concentration (Appendix F).

5. Discussion

5.1. Implications for theory

Our study contributes to the existing literature in various ways. First, our results showed that a dominant platform's openness to device makers in a country reduces their concentration. In response to calls to develop theories that employ the IO logic to better understand competitive dynamics in today's platform-based industries (McIntyre and Srinivasan, 2017), we bridge platform literature with IO to explain this phenomenon. With these findings, on the one hand, we complement previous studies that demonstrated that greater platform openness to device makers unleashes creativity, thereby increasing device makers' innovativeness (Boudreau, 2010; West, 2003), a powerful competitive weapon for market penetration. On the other hand, we complement studies in the platform leadership literature that examined how a dominant platform's decisions to establish vertical relationships with ecosystem participants may play a key role in fostering or foreclosing their competition (Lee, 2013; O'Mahony and Karp, 2022; Rietveld et al., 2020).

Moreover, drawing from the emerging literature on PMNCs (Nambisan et al., 2019; Parente et al., 2024), we theorized on and provided evidence of ecosystem-, industry-, regulatory-, and socio-economic-specific factors in a country that may influence device makers' chances to exploit low legal and product differentiation barriers to entry provided by a dominant, open platform. First, we find support for our argument that when a dominant, open platform *takes all or most* of the market (Cusumano et al., 2019), device makers will more clearly perceive the superiority of the dominant, open platform. Accordingly, this perception strengthens the competition-fostering effect of openness, which reduces the concentration among device makers. Our findings are important because, while a growing body of studies has outlined the conditions under which *winner-take-all* outcomes occur in platform markets (e.g., Cennamo and Santaló, 2013; Dubé et al., 2010; Eisenmann, 2006), there is a shortage of knowledge about how and why a platform's degree of dominance vis-à-vis competing platforms in a country can influence the structure of the device maker market. In particular, our findings shed new light on how *winner-take-all* outcomes among platform sponsors affect competition in the *downstream* market of device makers. Interestingly, though our findings suggest that the degree of dominance of the largest platform strengthens the negative effect of the platform's openness on the concentration in the device maker market, we also observed that for very low levels of

concentration in the sponsor market—when multiple platforms coexist with similar market shares—the level of openness of the dominant platform has a positive effect on the concentration of device makers (Fig. 1, E1 and E2). Ex post, we interpret this pattern as a coordination–fragmentation trade-off faced by device makers, arising from the platform governance choices of PMNCs operating across heterogeneous national markets. In countries characterized by fragmented market shares among competing platforms, the openness of the largest platform—whose dominance is not yet clearly established—increases coordination costs and strategic uncertainty for device makers, particularly regarding which platform will ultimately prevail. Under such conditions, only a small number of large device makers possess the resources, capabilities, and risk tolerance required to commit to the largest open platform while also experimenting with smaller rival platforms. As a result, these handset makers are likely to remain the only firms able to exploit the potential of the largest open platform, leading to higher concentration in the handset maker market. As sponsor-market concentration increases within a country, uncertainty declines, coordination becomes easier, and a broader set of device makers—especially smaller and later entrants—can leverage platform openness to enter and compete, reversing this effect. An illustrative example is Google's Android in the early 2010s. In countries where platform competition was still unsettled, Samsung was among the few handset makers willing to make a strong commitment to Android, which contributed to its rapid rise in market share leadership (Giachetti and Marchi, 2017). As Android subsequently consolidated its dominance across countries, coordination improved, and uncertainty declined, attracting many additional handset makers and reducing concentration in the device maker market at the expense of early leaders' market power.

Second, we found that end-users' engagement with platform-based devices in an industry strengthens the competition-fostering effect of the dominant platform's openness to device makers. Our results advance recent platform research that has focused on the effect of end-user-level factors, like the heterogeneity among end-users' attitudes towards OS platforms, to examine competition in platform-based industries. For example, Rietveld and Eggers (2018), in their study investigating early and late adopters of video game consoles, found that early adopters tend to buy a larger number of games, as well as more novel games, than late adopters. Likewise, Cennamo and Santaló (2013, p. 1346) noted that the heterogeneity of user preferences towards platform apps “creates the potential for market segmentation and makes room for different positioning in the market.” Other studies have ascertained that end-users' engagement fosters differentiated needs among users (Eisenmann et al., 2009; Rietveld and Ploog, 2022), creating opportunities for device makers to increase their installed user base (Karhu et al., 2018). Building on this literature, we shed light on how the demand for product variety, driven by end-users' engagement, intensifies the negative effect of the dominant platform's openness on concentration in the device maker market.

Third, our findings indicate that the negative relationship between a dominant platform's openness to device makers and market concentration in the device maker market becomes more pronounced in institutional environments characterized by strong regulatory enforcement. These findings enrich recent legal and policy-oriented research emphasizing the risks of self-preferencing and structural conflicts of interest in digital platform ecosystems (e.g., Jacobides and Lianos, 2021; Parente et al., 2024; Sokol and Van Alstyne, 2021). While these studies have primarily focused on how antitrust remedies and ex ante regulation can discipline dominant platforms, our study is the first to examine how regulatory interventions in a country shape the effect of platform openness on competition dynamics among complements.

Fourth, we showed that the competition-fostering effect of a dominant, open platform is weaker in countries where end users have greater *purchasing power*. While recent conceptual work (e.g., Nambisan et al., 2019; Parente et al., 2024) has called for greater attention to how national socio-economic conditions shape platform ecosystem dynamics, our study is the first to empirically demonstrate how a specific macroeconomic variable—individuals' purchasing power—moderates the competitive implications of platform openness. This finding highlights the important role of cross-country variation in national socio-economic environments in shaping the consequences of platform strategy.

Finally, as an additional analysis, we examined whether our results were influenced by the degree of the platform sponsor's multicountry dominance—that is, whether the sponsor of a dominant platform in a country held market share leadership across multiple national markets. While we did not theorize this effect, we find that some of the relationships we identified are strengthened when we exclude sponsors with limited multicountry dominance. This suggests that the cross-national reach of dominant platform sponsors may amplify both the competition-fostering effect of openness, as well as the national-level contingencies we examined. These findings contribute to the emerging PMNC literature by highlighting the importance of a sponsor's international experience, visibility, and strength of network effects in the eyes of device makers, which in turn more strongly shape their competitive dynamics. In fact, as Stallkamp and Schotter (2021, p. 59) aptly observe, “this literature has generally disregarded national borders, implicitly assuming that platform firms operate in a single, homogeneous market.” Our findings underscore the need to pay closer attention to the heterogeneity in multicountry platform dominance, which may condition how sponsors of dominant platforms affect the market structure of downstream complementary markets.

5.2. Implications for practice and policy

One key insight from our analysis for managers of OS-platform-dependent device makers is that the emergence of OS platform ecosystems has fundamentally transformed competitive dynamics, as traditionally described by Porter (1980), particularly for firms operating across national markets. Cost-leadership strategies based on scale economies in hardware production are increasingly supplanted by advantages derived from low legal barriers to accessing dominant open OS platforms. Such access allows device makers to leverage large, often global, user bases and app ecosystems, thereby spreading fixed development costs associated with OS and ecosystem participation across countries. In this context, growth increasingly depends on a firm's ability to exploit network economies embedded in dominant open platforms. For example, we observed that the diffusion of the open-source Android OS enabled smaller

and new device makers to participate in the smartphone revolution initially catalyzed by Apple, including in countries where entry would otherwise have been particularly difficult.

Similarly, conventional differentiation strategies—historically centered on proprietary hardware innovation and brand-building investments—have been redefined in the context of PMNCs. In platform ecosystems, innovation increasingly relies on collaborative development with ecosystem partners operating across countries. While brand strength remains important, our findings indicate that a critical source of differentiation lies in how effectively device makers leverage customization opportunities offered by dominant open OS platforms to address heterogeneous local demands. Open-source platforms such as Android thus allowed smaller device makers to target specific market segments in different national contexts and compete more effectively against larger incumbents.

Our study also highlights that the impact of platform governance on competition varies significantly across countries, shaped by ecosystem-, industry-, regulatory-, and socio-economic-level factors. For managers, understanding the degree of platform dominance in each country is essential. When a platform sponsor holds strong local leadership, device makers benefit from richer app ecosystems, higher user engagement, and stronger network effects, which enhance scaling opportunities. Accordingly, managers should align product development and market strategies with the dominant platform's ecosystem strengths in each national context. For regulators, our results reveal a structural tension: platform dominance tends to increase concentration by entrenching leading hardware firms (as shown in Table 3, Model 3), whereas openness lowers entry barriers and reduces concentration. Importantly, when dominant platforms adopt open strategies, openness can counteract the competition-reducing effects of dominance. This suggests that regulators should assess not only platform market shares but also governance choices, and that incentivizing openness—through mechanisms such as interoperability standards—may be an effective policy lever to manage concentration among complementors.

Moreover, our findings indicate that end-users' engagement with platform-based devices shapes competitive outcomes. Managers should leverage high engagement levels to identify and serve differentiated user needs through platform-enabled customization. For example, as user engagement shifted over time from PC-based to mobile-first usage following the diffusion of iOS and Android, device makers that adapted platform customization to mobile-centric usage patterns were better positioned to capture emerging user segments. Because this shift varied across countries, managers of PMNCs should tailor platform-based strategies to local engagement trajectories rather than assuming uniform global adoption.

The regulatory environment further conditions competitive dynamics. In countries with strong enforcement against dominant platforms, sponsors are less likely to engage in discriminatory behavior toward device makers. Managers of PMNCs should therefore recognize that collaboration with open, dominant platforms in such environments can help safeguard access to a key competitive asset.

Finally, our results show that end-users' purchasing power matters. In lower-income markets, open dominant platforms allow device makers to emphasize cost efficiency and price competitiveness, increasing their market shares at the expense of larger rivals. For regulators, this highlights the importance of considering local economic conditions when evaluating platform strategies. Ensuring that open platforms remain accessible and free from discriminatory licensing or technical barriers is particularly important in price-sensitive markets. A case in point is Google's Android One initiative, launched in 2014 to provide handset makers in emerging markets with access to a streamlined, secure, and regularly updated version of Android optimized for low-cost smartphones.

5.3. Limitations and suggestions for future research

Our study has some limitations that provide opportunities for future research. First, while our study advances the PMNC literature by examining how the relationship between platform openness and device maker market concentration is shaped by national-level contingencies, we recognize that our framework captures only a subset of the relevant factors. Specifically, we highlight one contingency in each of four domains—ecosystem, industry, regulatory, and socio-economic. Future research could build on our framework by exploring additional contingencies within these domains. For example, at the ecosystem level, future studies could examine how the maturity of the dominant platform's ecosystem varies across countries. At the industry level, researchers might consider the pace of technological evolution in a given category of platform-based devices—such as how frequently platform sponsors release new OS versions—which can influence how device makers innovate within that category. Regulatory-level contingencies could include industrial policies favoring domestic hardware producers or platform neutrality mandates. Finally, socio-economic contingencies could include digital literacy, urban–rural divides, or national attitudes toward domestic versus foreign technology providers. By incorporating a broader range of such contingencies, future studies could offer a more nuanced understanding of how openness of dominant platforms influences competitive dynamics within their ecosystems.

Second, although our hypotheses present theoretical mechanisms about app developers, our study lacks data on these actors. This prevents us from controlling for the number of applications available in each dominant OS, in each country, and the extent to which applications are available in multiple OSs. Moreover, although we assume that dominant platforms are more competitive in terms of their available apps, it is plausible that platforms with lower market shares may also have a relevant portfolio of apps or apps of better quality. These could be the examples of Apple's iOS and Google's Android, which triggered a technological discontinuity at the beginning of our observation period. We managed to account for this issue by controlling for the growth rate of Android OS (which triggered a technological discontinuity in the late 2000s), but we acknowledge that further research capturing these effects is required.

Third, our study does not capture the heterogeneity among competitors to Google's Android that are based on its open architecture, which may markedly differ across countries. This includes true forks such as Amazon's Fire OS and the initial versions of Huawei's HarmonyOS, as well as custom Android builds with proprietary user interface (UI) layers developed by manufacturers such as Xiaomi (MIUI) and Samsung (One UI). These variants—whose market shares were not available from StatCounter—may differ substantially in terms of control over ecosystem components, but are not disaggregated in our dataset and are thus all coded under the generic “Android” label. Future research could explore how differences in market power among Android-based variants influence platform

competition and ecosystem outcomes.

Fourth, while our use of the Herfindahl index to capture concentration is consistent with established practice in IO research, it does not account for other dimensions of competition—such as shifts in average selling prices (ASP). Significant declines in ASP may signal a “race to the bottom” in product quality, potentially harming end users. This issue is particularly relevant in international markets where PMNCs depend on local device makers to scale. Exploring how platform openness shapes not just market structure but also quality-adjusted pricing and user outcomes would be valuable for both regulators and platform scholars.

Finally, we ended our observation period in 2019 due to increasing market concentration thereafter—by that time, Android had already captured the vast majority of the global market, limiting cross-country and cross-platform variation. While this decision helps avoid results skewed by extreme dominance, we recognize that recent developments, including the growing role of AI-driven platforms and devices (Parente et al., 2024), may alter the competitive equilibrium among dominant platforms. As such, future studies may soon find a new empirical playground to investigate how emerging technologies reshape rivalry in platform ecosystems.

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Online appendices. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.lrp.2026.102620>.

Data availability

Some data used in this study come from public sources, and samples are available on request to the author. Others are confidential or from providers with sharing restrictions and cannot be disclosed.

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Claudio Giachetti is a Professor of Strategy at Alma Mater Studiorum – University of Bologna (Italy). Previously, he was a Professor of Strategy at Ca' Foscari University of Venice, where he earned his Ph.D. in Business. His research interests include competitive dynamics in rapidly changing technological environments. Claudio's work has been published in several leading journals, including the *Academy of Management Journal*, *Strategic Management Journal*, *Organization Science*, *Journal of International Business Studies*, *Journal of Operations Management*, *Strategic Organization*, *Research Policy*, *Long Range Planning*, and *Global Strategy Journal*.