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Android and the demise of operating system-based power: Firm strategy and platform control in the post-PC world

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ABSTRACT

The emergence of new mobile platforms built on Google's Android operating system represents a significant shift in the locus of the platform "bottleneck," or control point, in the mobile industry. Using a case study approach, this paper examines firm strategies in a market where the traditional location of the ICT platform bottleneck—the operating system on a device—is no longer the most important competitive differentiator. Instead, each of the three firms studied has leveraged different core competencies to build complementary services in order to control the platform and lock-in users. Using platform theories around bottlenecks and gatekeeper roles, this paper explores these strategies and analyzes them in the broader context of the changing mobile industry landscape.

1. Introduction

The concept of technology "platforms" has emerged as a popular construct for understanding industry dynamics and firm strategy, especially in the information and communications technology (ICT) sectors. Drawing primarily from the literature on standards (David, 1985; Farrell & Saloner, 1985; Katz & Shapiro, 1985), network economics (David & Bunn, 1988; Katz & Shapiro, 1985, 1994), and multi-sided markets (Evans, 2003; Rochet & Tirole, 2003); researchers have developed an explicit platform theory to explain how some technology firms can control an industry's value chain and capture a disproportionate share of the total value, despite an interdependence in technologies and complementary assets (e.g., Gawer, 2000; Gawer & Cusumano, 2002).

While other ICT industries with strong platform dynamics, such as the PC industry (Cusumano & Yoffie, 1998) and video game console industry (Clements & Ohashi, 2005), have established relatively straightforward industry structures and firm roles within the ecosystem, the mobile telecommunications space is still in flux. One reason for this dynamism is that the mobile sector represents a large-scale industry convergence, with firms from the telephony, computing, and internet industries all trying to position themselves in a complex multi-layered technological space with different core competencies and platform strategies (Kenney & Pon, 2011). As a result, vectors of competition are multiple and varied, and smartphone platform firms that are competing head-to-head have very different business models (Ballon & Van Heesvelde, 2011). Another key distinction that has emerged in the smartphone industry is the apparent evolution of the technology platform

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itself. While the industry is currently dominated by two platforms, Apple's iOS and Google's Android, the recent emergence of two new platforms built on top of the Android operating system complicates our understanding of the nature of the smartphone platform, and may foreshadow similar developments across other ICT sectors.

In the smartphone industry, the major platforms from Google, Apple, and Microsoft are complex ecosystems that include a mobile device, operating system, online marketplace for apps and content, and a range of complementors such as app developers, network operators, and device manufacturers. As in many other ICT industries, the smartphone platforms have traditionally been defined and controlled by ownership of the respective operating systems (Kenney & Pon, 2011). In the platform literature, the operating system is the "bottleneck": that critical resource or position in the platform ecosystem which enables the firm to establish and sustain competitive advantage (Jacobides, Knudsen, & Augier, 2006; Tee & Gawer, 2009). However, the relative open-ness of Google's Android operating system—which has become dominant, with over 80% market share worldwide—has enabled two other firms, Amazon and Xiaomi, to build their own proprietary platforms on top of Android, thereby directly appropriating the extensive ecosystem of Android complementors, and indirectly, Android end-users. This development has implications for platform theory, as it represents a fundamental shift in industry structure and the basis for competition. When multiple firms can create proprietary platforms based on the same underlying operating system, that operating system is changed from a bottleneck to a commodity, and is no longer a competitive differentiator. Instead, these firms must look beyond the operating system to establish new bottlenecks that can control the ecosystem and deliver value to users.

This paper explores how firms are navigating this transition, using a comparative case study of the three platforms involved: (1) the official Google-sanctioned platform with Google-certified devices (e.g., Samsung Galaxy S5) and the Google Play online marketplace; (2) the Amazon platform, with the Kindle Fire tablets and the Amazon Appstore for apps, content, and other digital goods; and (3) the Xiaomi platform, with a number of smartphones, smart TVs, and a robust app market, MIUI. There is at least one other firm that has built a proprietary platform on top of Android, CyanogenMod, but at the time of this study it was considered too nascent to include. To give structure to the comparison we employ the concept of "gatekeeper roles," which has been used in the platform literature to describe and categorize the strategic operations of mobile platforms (Ballon, 2009; Ballon & Walravens, 2008; de Reuver, Bouwman, Prieto, & Visser, 2011). Applying the gatekeeper roles framework to each case, we explore the question, "Which services and roles do firms try to control in order to build a successful platform when the operating system is no longer the key competitive differentiator?"

Our analysis shows that all three firms have moderate to strong competencies in service provisioning and transaction processing roles, including online marketplaces and complementary cloud-based services for end-users. In addition, both Google and Amazon exert control and support their services through strategic management of the application programming interfaces (APIs) that enable external apps to connect with the operating system. The results suggest that in ICT platform industries without operating system differentiation, firms wanting to establish bottlenecks for platform control will focus on providing user-based services, and may incorporate interface control as part of that strategy.

The structure of the paper is as follows. First we review the relevant literature on platform theory, including bottlenecks and gatekeeper roles. Subsequently, we provide background on the Android operating system and the general context of the mobile industry. The next three sections are case studies of Google, Amazon, and Xiaomi, detailing the business model and relative strengths in the gatekeeper roles. We conclude with an analysis and discussion in the final sections.

Given the global penetration of mobile technology, the decisions, strategies, and successes of the smartphone platform firms are likely to frame the ecosystem for all other constituents, not only of the mobile communications industry, but for the entire ICT sector. For scholars interested in the transformation of economic spaces, platform competition, and industry convergence, the dynamics in this technological space can provide important contributions to theory building.

2. The nature of smartphone platforms

Technology platforms are generally defined as comprising three elements: a core technology that serves as a foundation, additional modular technologies that integrate or connect with this core, and the interfaces in-between (Baldwin & Woodard, 2009; Tiwana, Konsynski, & Bush 2010). The core technology is typically formed around a specific standard (e.g., VHS, Ethernet) or arrangement of standards compiled into an operating system (e.g., Microsoft Windows, Sony PlayStation, Symbian) (see, e.g., David, 1985; Farrell & Saloner, 1985; Von Burg, 2001). Some technology platforms, including the smartphone platforms described here, also function as multi-sided markets (Economides & Katsamakas, 2006; Parker & Van Alstyne, 2005; Rochet & Tirole, 2003), where the platform serves as a marketplace or forum for distinct user groups to transact (Baldwin & Woodard, 2009; Eisenmann, Parker, & Van Alstyne, 2006). The presence of multiple user groups that transact with each other leads to indirect network effects, whereby the value of the platform increases for each user group when the number of users in the opposite group increases (e.g., if there are more buyers, ideally the platform should attract more sellers). Similarly, the smartphone platforms demonstrate same-side or direct network effects, whereby the value of using the platform increases for each additional user in the group (e.g., because they can better communicate or share similar experiences) (Katz & Shapiro, 1985; Shapiro & Varian, 1998). These network effects result in increasing returns to adoption of a technology platform, which can lead to self-reinforcing cycles of adoption and winner-take-all markets (Arthur, 1989; David & Bunn, 1988).

The literature suggests that platform owners face a key challenge in designing the structure of their platform such that they maintain ownership and control over the critical elements that deliver value. For example, platform owners must

determine the optimal "open-ness" of the platform in terms of interoperability, disclosure of IP, and collaboration with complementors that will spur innovation and network effects (Eisenmann, Parker, & Van Alstyne, 2008; West, 2003). The firm must balance these requirements with the need to maintain control of the platform in a way that allows it to capture value in a sustainable fashion (Boudreau, 2008; Elaluf-Calderwood & Eaton, 2011). This tension is present in strategies for day-to-day governance, which includes determining the boundaries of innovation and value capture by the platform owner and by complementors (Eaton, 2012; Ghazawneh & Henfridsson, 2013; Tilson, Sorensen, & Lyytinen, 2012), as well as pricing and other revenue generation strategies for each side of the market (Rochet & Tirole, 2003).

While much of the platform literature is focused on product-based platforms, recent work has started to examine how platform strategies apply to services (de Reuver & Bouwman, 2012; Gawer, 2011). For example, services can help mitigate adoption risk, provide improved integration possibilities, increase indirect network effects, and serve as a value-add that subsidizes one side of the platform market (Suarez & Cusumano, 2011). Furthermore, as product industries mature, the value capture can often shift from products to complementary services (Suarez & Cusumano, 2011), which echoes the industry lifecycle of dominant designs and product vs. process innovation (Abernathy & Utterback, 1978). However, the role of services in the platform literature is still underexplored, especially in the context of combined product-service platforms where competing platforms are employing different business models (Gawer, 2011).

2.1. Bottlenecks

The concept of a "bottleneck" has been widely used across disciplines such as supply chain management, transaction cost economics, and platform theory to describe a scarce resource that is key for controlling performance and competitive position within an industry (for a review, see Ballon, Walravens, Spedalieri, & Venezia, 2008). In the context of technology platforms, the bottleneck is seen as the critical asset or position that enables a firm to exercise control over the platform ecosystem (Jacobides et al., 2006; Tee & Gawer, 2009). This includes decisions about the boundary of the firm, such as whether to integrate complementary assets (Teece, 1986) and to what extent external firms should be invited to participate through "open" architectures and standards (Morris & Ferguson, 1993).

Taking an explicitly structural view, Jacobides et al. (2006) suggest that a platform firm can intentionally construct the value network in such a way as to create barriers of entry for its own position, while increasing competition in other nodes around its network location, thereby positioning itself as the bottleneck. This structure may best describe horizontal firm strategies, as exemplified by Microsoft and Intel, where the platform owner stays focused on one or more core competencies while actively facilitating competition among firms providing complementary assets adjacent to the bottleneck (in that example, encouraging many different hardware original equipment manufacturers (OEMs) and software developers to join the platform).[1]

Historically, the bottleneck in ICT industries has been the device operating system, as shown in the antitrust litigation by the federal government and European Union against Microsoft (see, e.g., Cohen, 2004). However, as this study describes, this is no longer always true. If the operating system is open and appropriable by other firms, then it loses value as the bottleneck, and firms have to find another critical position in the network to control. In the smartphone industry, the complex arrangement and interconnectivity among elements of the platform—i.e., the apps, OS, handsets, online marketplaces, services, and network operators—offers many potential bottleneck locations. Determining the optimal control point is shaped by the firm's core competencies, and therefore will vary across firms (Jacobides et al., 2006).

2.2. Gatekeeper roles

Proposed and developed primarily by Ballon (2009), gatekeeper roles are defined as those important functions undertaken by the platform owner in an effort to exert control over the platform. Writing specifically about the mobile industry, Ballon (2009) and Ballon and Van Heesvelde (2011) developed four important gatekeeper roles that provide a framework for analyzing mobile platforms: service creation environment (for 3rd-party developers), profile/identity management (for general user data), service provisioning/service brokerage (for end-users to access services), and charging and billing (for managing transactions). Ballon (2009) used these four roles to compare the structure of different mobile ecosystems, for example, network operator walled gardens vs. Apple's iOS and App Store. We extend that work here in an effort to help explore the different functions that firms using the same OS, Google's Android, must control for successful platform growth.

3. Android

The Android operating system was originally developed at Android, Inc., a startup founded in Palo Alto in 2003. Andrew Rubin and others built the OS on top of a Linux kernel, designing it from the ground up as an advanced mobile operating

[1] The literature has often focused on single core competencies as the key to control, while, in fact, the competency is often bundled with a set of complementary assets. For example, for years the focus of discussion was on the Microsoft operating system, when it was actually the OS-Microsoft Office interface that was the key. In the case of Intel, it controlled not only the microprocessor, but also the chip set of key components that interact closely with the microprocessor. Finally, Intel also produces some motherboards as a further control for its ecosystem.

system. Google purchased the company in 2005, and publicly announced the OS in 2007 along with the founding of the Open Handset Alliance. The latter is an industry association of handset OEMs, component makers, mobile network operators, and software developers, formed to promote open-source software for mobile phones. Since its launch in 2008, the Android OS has seen spectacular growth, currently adding around 1.5 million users per day and on track to reach 1 billion users by the end of 2014.[2] This makes Android the fastest-growing technology platform in history.[3]

A significant factor in Android's rapid adoption is that Google freely licensed the operating system under open-source terms,[4] enabling a wide range of handset makers to enter the high-end smartphone market without having to develop their own OS. Most of the major device manufacturers, including Acer, Asus, Dell, Fujitsu, HTC, Huawei, Kyocera, Lenovo, LG, Motorola, Samsung, Sharp, Sony, Toshiba, and ZTE, have enrolled in Google's Android Compatibility Program, which requires device OEMs to comply with certain hardware specifications and contract terms. For Google, the compatibility program is a way to help reduce the variation in hardware functionality across the very heterogeneous universe of Android devices, creating a more stable environment for developers and more familiar user experience for end-users. In return, certified-compatible OEMs can use the Android logo and trademark, and the more robust Google application programming interfaces (APIs) that offer access to Google services, including Gmail, Google Maps, Google+, and the Google Play marketplace.

Google also makes the basic Android source code available without certification restrictions. Called the Android Open Source Project (AOSP), it is open and available to anyone to download and modify. This is the version of Android that has been customized by Amazon and Xiaomi, but also by other companies for non-smartphone devices such as the Barnes & Noble e-reader, Nook, and a popular open-source gaming console, Ouya. Importantly, the Android Compatibility Program is mutually exclusive, meaning that if an OEM joins the program in order to launch an certified Android device, they also commit to not launching any device with a non-compatible (i.e., modified) version of Android.[5]

While there is no way of knowing the total number of AOSP devices, it is likely in the tens of millions of devices in China alone, where the manufacturer with the largest market share, Samsung, still only controls around 18% of the market, and the fragmented “other” category—which includes the AOSP device makers—makes up over 40% of the market.[6] When Google reports activations of new devices (the aforementioned 1.5 million per day), it is reporting the number of devices that are accessing its APIs for the first time, meaning that AOSP devices are not counted in those reports.

Despite the Android Compatibility Program, fragmentation with Android has been an issue. On the one hand, Google (and other OS firms) must continuously innovate and build new functionality into the operating system to remain competitive; these innovations are typically packaged into a stable major release and pushed out to users amid much marketing and media publicity. But each time Google released a new version of the operating system, there would be a significant lag time of weeks to months before OEMs and network operators were able to ensure compatibility with their own applications/devices and push out the update for the end-users. In many cases—e.g., for less popular, lower-end smartphones—the updates were never made at all, leaving many Android devices stranded on a wide range of outdated versions of the OS.

This diversity in the installed base challenged the ecosystem, as developers faced severe fragmentation in the functionality and APIs available when creating new apps. In 2013, Google quietly introduced a technical workaround to the fragmentation issue—instead of pushing out new versions of the operating system, it created a proprietary system application called Google Play Services, and transferred as much functionality as possible from the operating system to Google Play Services (GPS). Unlike normal apps, GPS has deep integration into core OS functionality and permissions, including the ability to update itself in the background, without any action from the user, device manufacturer, or the network operator. Now, whenever Google needs to update its maps API, for example, it simply pushes out a new version of GPS to the 98.7% of certified Android phones that can run GPS. By transferring these APIs from the OS itself to GPS, Google essentially moved the location of the key interfaces into its proprietary, non-open-source code base. While Google will likely continue to make the AOSP code freely available, it has reduced the level of investment it must make in keeping AOSP up to date. In this case, the interface, or API, has taken primacy over the core functionality; indeed, the interface absorbed most of the innovative functionality from the core, leaving behind a skeleton framework with far less value. This shift reflects the importance of interfaces in Google's strategy for balancing its need to control the operating system while enabling innovation and honoring its commitment to open source code.

[2] Larry Page, Google earnings call for Q2, 2013. This only includes “official” Android activations; if handsets running the Android Open Source Program OS were included, the activations would be far greater (Page, 2013).

[3] Users of the Android platform will reach 1 billion users in ~5 years, more quickly than even Facebook (~8 years), which is free to join (Dediu, 2013). However, the actual platformization of the Android ecosystem is more fragmented, as discussed later in this paper.

[4] Android is licensed under the GNU General Public License and Apache License 2.0. While Google does not charge OEMs for licensing Android, Microsoft has claimed patent infringement and has negotiated licensing terms for at least 20 hardware vendors selling Android devices, including Samsung, HTC, LG, and ZTE. Terms are private and may vary, but ZTE executive Santiago Sierra claimed that his firm paid $23–$31 per handset (Gilbert, 2013). Given the scope of firms Microsoft has arranged deals with, and the sheer size of the Android market, it is likely that in 2013, Microsoft is earning more revenue from sales of Android devices than with its own Windows Phone devices.

[5] Acer ran afoul of this stipulation when it tried to launch a smartphone using Alibaba's Aliyun OS; Google determined that Aliyun was a derivative of Android and thus blocked Acer from launching. Tech in Asia (Millward, 2012).

[6] There were 86 million smartphones sold in China alone in Q2 2013 (IDC, 2013).

4. Case studies

In this section we examine in more depth the official Google platform as well as the two Android-based alternatives, Amazon and Xiaomi, that have challenged the parent platform. We use the four gatekeeper roles defined by Ballon (2009) as a framework to guide the analysis of how, and where, each firm is trying to establish a bottleneck to lock-in users and control their proprietary platform.

4.1. Official Google ecosystem

Launched in October 2008 as the Android Market (rebranded to Google Play in March 2012), the official marketplace for Android apps has expanded to also include Google's streaming media services, including music, TV, movies, and books. As of July 2013, the Google Play store had over 1 million apps available (edging out the Apple App Store in reaching the million app milestone first), and has recorded over 50 billion downloads since its inception.[7] Paid apps and content on Google Play can be purchased in 134 countries, though a larger number of countries can access free apps/content. For online payment, Google uses its own Google Wallet functionality to process credit cards. Google has also reached agreements with a number of network operators for carrier billing, allowing users to purchase content and have it billed to their mobile account; this is more common in emerging markets, where credit card penetration is much lower.

4.1.1. Business model

Google's business is advertising. In 2012, Google had $12.7 billion in operating income against $46.0 billion in revenue; of that revenue, 95% was from advertising.[8] Despite a decline in cost-per-click associated with mobile ads vs. desktop ads, ongoing growth in mobile web usage is continuing to build the mobile ad market, from $8.8 billion in 2012 to an estimated $15.8 billion in 2013, of which Google is estimated to have captured 56%.[9] As an advertising firm, Google's business model is fundamentally different from other platform firms such as Apple, Microsoft, and Amazon. While Android competes against other operating systems for market share, Google never intended to monetize the OS directly. Instead, Android was meant to increase the total number of internet users (via increased mobile usage), with the assumption that Google would capture a large share of the advertising revenue from those users (Kenney & Pon, 2011). Launching Android in 2008 was also a defensive move—not against Apple and its successful launch of the original iPhone in 2007, but against Microsoft. At that time, Symbian was still the dominant OS, and Palm and Research in Motion (Blackberry) also had significant market share. But Microsoft had begun to license its Windows CE operating system to OEMs and developers, trying to capture the market with the same horizontal strategy it had so successfully implemented in the PC industry. The threat to Google was that if Microsoft was able to dominate the market, Microsoft could control access to the mobile web and therefore be positioned to displace Google's services with its own (primarily, its search engine), and thus disrupt Google's core advertising revenue model.[10]

By licensing Android for free, Google immediately de-valued the OS as a potential bottleneck, and in doing so directly impacted the business models of Microsoft and others who were licensing and profiting from their mobile operating systems. Google has maintained its commitment to providing an open-source operating system, but has strategically used the Android APIs to shift the highest value innovations into the proprietary version of Android, leaving the AOSP as a less-capable shell. By increasing the divide between AOSP and certified Android, Google makes it more difficult for device manufacturers who may be considering building their own customized OS on top of AOSP, as the bare framework of the AOSP requires strong development resources to turn it into a robust operating system.

This change is mostly unnoticed to end-users, but represents a clear shift in Google's focus away from the base operating system and towards improving its cloud-based services, where it has very strong competencies and concentrates its monetization efforts. Its wide range of services is typically offered for free to users in exchange for displaying ads. While Google Search is still the firm's dominant source of advertising revenue, all of the individual services capture user information that can be connected and linked for robust user profiles of what people search for, send in email, watch on YouTube, bookmark in their Chrome browser, and so on. As a result, Google can serve increasingly targeted, and therefore profitable, ads. Of course, being based in the cloud, Google's services are not restricted to Android end-users (though other operating system platforms may have reduced or limited functionality).

It is important to note that Android is not Google's only operating system—the company launched the Chrome OS in 2009 as a lightweight, browser-focused OS for netbooks and other “thin client” computers that are used primarily for accessing the internet and media. The Chrome OS is also based on Linux, and, similarly to Android, Google manages an open-source version (the Chromium Project) that is free to download and use, as well as a proprietary version (Chrome OS) that is only available through licensing with Google. OEMs such as Samsung, Acer, and Lenovo have all released low-cost “Chromebooks” running the operating system, and Google released its own high-priced version, the Chromebook Pixel, in

[7] Google Senior VP Sundar Pichai, press event July 2013, in The Verge (Welch, 2013).
[8] Excluding revenues from Motorola of $4.1 billion (Google, 2013).
[9] In both 2012 and 2013, Facebook is estimated to be 2nd behind Google, with Pandora, YP, and Twitter also in the top 5 (eMarketer, 2013).
[10] For an excellent summary of this history, see Dediu (2011). A previous example was the ability for Microsoft to destroy Netscape (Cusumano & Yoffie, 1998).

2013. Google's long-term strategy with the two operating systems is unclear, although management has hinted at future convergence, and personnel decisions seem to support this.[11]

4.1.2. Gatekeeper roles

In terms of gatekeeper roles, Google is clearly strong in the service creation environment role; it developed the Android APIs, software development kit (SDK), and support documentation for app developers. As the official resource for Android development, Google continually refines tools that help complementors such as the OEMs and developers to build on the Android platform, though AOSP support is likely to decrease. As noted, Google actively develops its own apps and online services, giving them deep integration into the operating system through the Google Play Services APIs. Within the official Google Android ecosystem, Google has excellent data on its users for profile/identity management. When users download applications from the Google Play store, Google records information on the apps downloaded, the type of device used, the language on the device, and more, building it all into the user's profile. The tight integration of Google services within the operating system means users accessing Google services on an Android device provide even more detailed information by linking their account information to their behavior within the service.

In terms of service provisioning, Google Play is a less restrictive marketplace compared to the Apple App Store or Microsoft Windows Phone Store, and the company does not perform manual reviews of apps before posting them for download. True to the firm's core competencies, it instead uses algorithms to weed out the most suspicious apps, and relies on user ratings and comments to help users avoid poor quality or risky apps and content. Google does not require users—even users on certified Google devices—to use its marketplace, instead allowing them to download apps and content from any market in the world. Of course, Google has a wide range of popular online applications that it offers users, typically for free, though it is not restrictive about locking in users to any one application.

Finally, although Google has extensive profile/identity information on those Android users who have Gmail, Maps, Drive, and more, it only captures billing information if a purchase is made through the Google Play store. And if the user has enabled carrier billing, that transaction might not go through Google at all, instead being captured and managed by the network operator. Google Checkout, which was a 3rd-party payment processing service competing with PayPal and Amazon Payments, never achieved significant scale and was discontinued in 2013. All of this reflects Google's core business as an advertiser—it needs to know a lot about its users, but users do not actually tend to purchase items directly from Google, so it has less need for robust transaction processing and user billing information.

4.2. Amazon.com

Launched in 1994 as an online book retailer, Amazon has grown into a retail giant of both physical and digital goods with increasingly global reach. In 2011, Amazon customized a version of Android (originally 2.3 Gingerbread, later upgraded to 4.0 Ice Cream Sandwich) to run its new eBook reader/tablet, the Kindle Fire. The Amazon operating system, officially branded "Fire OS" version 3.0 in 2013, provides a completely different user interface to stock Android, one that is focused on showcasing Amazon content and services. Selling the device at what many analysts assume is at, or even slightly below, cost (originally $199), Amazon quickly secured significant adoption with what has become the 2nd-best selling tablet after the iPad, and accounts for one-third of all Android tablets sold in the U.S.[12] Reports suggest that Amazon is partnering with HTC to launch its first smartphone in 2014.[13]

4.2.1. Business model

Amazon created its own walled garden online marketplace, the Amazon Appstore, the only source for Kindle Fire users to download and install apps and digital media. While Kindle users must go through the Amazon Appstore, the store is also available to any user of Android smartphones and tablets (certified Android or AOSP). In fact, Amazon has aggressively pursued pre-load agreements with network operators in the United States, such that the Amazon Appstore comes pre-loaded on certain models of Android phones, including the Samsung Galaxy S4 from Verizon, putting it in direct competition with the Google Play store. In April of 2013, Amazon expanded its Appstore from the original 7 countries to 200 countries, and the next month launched its Appstore in China with both free and paid apps (and in doing so, become the first Western technology firm to offer paid Android apps in China). In addition to Android apps, Amazon is now also listing HTML5 apps in its Appstore. These mobile apps, written in the next-generation open web standard for displaying content, are OS-agnostic, and work on most smart devices, including iPhones and Windows devices.[14] New operating systems by Firefox and Ubuntu are designed to run HTML5 apps natively, and could therefore benefit from the increased visibility and promotion of HTML5 by Amazon.

[11] In 2009, co-founder Sergey Brin stated that he expected the two to merge (Ricker, 2009). In 2013, Google replaced Android head Andy Rubin with Chrome VP Sundar Pichai, making Pichai the head of both units. CNet (Cooper, 2013).

[12] Based on data from Localytics, reported in ReadWrite (Rowinski, 2013).

[13] Financial Times (Bradshaw, 2013); The Verge (Welch, 2014).

[14] The international internet standards body, the World Wide Web Consortium (W3C), is aiming to have the HTML5 standard formally defined in 2014 (W3C).

The evolution of the Amazon Appstore demonstrates Amazon's intent to expand its reach beyond the U.S., and beyond only Kindle devices. Listing HTML5 apps may simply represent another part of Amazon's general retail strategy of offering the widest selection possible of products, even when it means allowing third-party sellers to participate and capture more of the value.[15] An interesting question is whether Amazon would, if given the opportunity, sell iOS or Windows apps as a way of providing more choice to its customers. The offering of HTML5 apps that can be used by any operating system may be a step in that direction. As of October 2013, the Amazon Appstore carries only around 100,000 apps in total, compared to 1 million on Google Play. Like Apple's and Microsoft's marketplaces, but unlike Google Play, developers must submit their apps for manual review by Amazon before they are accepted into the Appstore.

For most Kindle Fire users, the operating system running on the tablets is probably inconsequential—the users are purchasing an Amazon device that they can use to access the wide library of ebooks, music, movies, and other Amazon digital products. This is probably an especially compelling value proposition for those customers already comfortable using Amazon.com to order physical products. In essence, Amazon leveraged its strong brand, trusted reputation, and deep customer account data to create a new category of consumption among its customers, while also attracting new customers looking for an affordable but trusted alternative to the iPad or other tablets.

Furthermore, like Apple, Google, and Microsoft, Amazon created online services for cloud storage and streaming media, and integrated all of these to the user's personal account. As a result, when a Kindle Fire user purchases a digital music album on Amazon.com, the.mp3 files are automatically stored in the user's Amazon cloud storage account, where they can be downloaded or streamed to the Kindle Fire or any other mobile device. Because Kindle Fire users can just as easily perform “one-click” purchases of apps as they can with books, Amazon is continuing to blur the line between physical and digital distribution channels. Therefore, while the Amazon “platform” may be built on the Android operating system loaded on the device, the real bottleneck of the platform is the Amazon.com environment, cloud services, and the Amazon Appstore, all tied to customers' user accounts.

4.2.2. Gatekeeper roles

As the creator of Android, Google owns and manages the official Android APIs, SDKs, and other developer tools that provide the service creation environment; the 1 million Android apps are a testament to how successful this environment has been in enabling developers to create apps. But Amazon has slowly built up a subset of alternative APIs and SDKs that tie into specific Amazon services, such as in-app purchases and mobile ads. Because the Fire OS, as an AOSP, cannot connect to Google Play or other Google services, some of these APIs are alternatives to the official Android APIs. Many, however, are specific to unique Amazon services. For example, Amazon recently launched its “affiliate” program for mobile apps, which allows app developers to link to a physical product in the Amazon store within their mobile app, and earn a small commission when users follow the link and purchase the product. More strategically, Amazon has leveraged its suite of infrastructure-as-a-service (IaaS) and platform-as-a-service (PaaS) offerings to provide mobile app developers with ready-made libraries and tools for building apps that are optimized for the Amazon Kindle devices. This includes tools such as optimized push notifications and databases to power mobile applications from Amazon's Elastic Beanstalk PaaS or SC3 cloud services. And in a recent effort to encourage developers to build apps that use Amazon's APIs, the company has launched the Appstore Developer select program, which provides marketing and promotional incentives to developers that create Amazon-specific apps.[16]

Like Google, Amazon has extensive profile/identity management capabilities that it employs across its ecosystem. For its more than 200 million customers, Amazon has deep knowledge about purchase history and other consumer behavior, all tied explicitly to user accounts. Unlike Google, this information is limited to behavior on the Amazon website or that of its partners (e.g., Zappos.com or Goodreads.com). However, Amazon is able to leverage this purchase behavior in its strong recommendation engine, which suggests products that a user might be interested in based on past preferences. These recommendation algorithms may help Amazon address the problem of app discovery, which is a significant challenge across all the app marketplaces—when there are hundreds of thousands of apps, how do users find the most relevant for their needs? Therefore Amazon excels at service provisioning and helping its users (on both the developer side and end-user side) connect with the most relevant and appropriate products and services. In contrast to Google, Amazon has excellent billing information on its users. As a pioneer in online retail, Amazon has continued to refine its transaction process, including the patented “one-click” purchase process. Consumer trust for the retailer is high enough that Amazon has also started to provide its purchasing engine as a 3rd-party service to other organizations, competing with PayPal and Google Wallet.

4.3. Xiaomi

Xiaomi is a relatively young Chinese company, founded in 2010. It designs and sells smartphones and TVs that run its own custom build of the Android OS, called MIUI, and operates its own online marketplace for apps. In just 3 years Xiaomi

[15] *Harvard Business Review*, interview with CEO Jeff Bezos, October 2007 “[W]e have this website where we sell things, and we want to have vast selection. One of the ways to get vast selection is to invite other sellers, third parties, onto our website to participate alongside us, and make it into a win-win situation (Kirby, 2007)”.

[16] TechCrunch (Perez, 2013).

has become a major handset OEM in the domestic Chinese market, overtaking Apple in market share in 2013 (5% to 4.8%)[17] and continuing to grow rapidly: Xiaomi shipped 7.03 million smartphones in 2012, 18.7 million in 2013, and is expecting to ship 60 million in 2014.[18] Its smartphones tend to have cutting-edge specifications, but are sold at a retail price as low as half of competing smartphones from Samsung or Lenovo.[19] Selling high-end phones at very slim margins direct to the consumer has proven a successful model for attracting users to the platform, and Xiaomi smartphone pre-orders often sell out batches of 100,000 units in just minutes.[20] Xiaomi reports that users are more engaged with its platform, with higher levels of app downloads compared to Android users on Google Play or even iOS users, and its app store has risen to the top 5 in China with 17 million active users.[21] Part of the reason for this ongoing engagement is that Xiaomi crowd-sources innovation from its user base to continuously update its OS and even the device hardware itself. The OS team will release a new incremental build every week, incorporating the best ideas from the user base, and each batch of smartphones may have small incremental improvements or changes in the hardware from the previous batch of the same model.[22]

A large factor in Xiaomi's growth to date is the result of state regulation in China, where a putative conflict over censorship with the Chinese government forced Google to scale back operations in the country in 2010, leaving a diminished online presence.[23] This has enabled local search provider Baidu to extend its dominance in desktop search to the mobile market, such that Baidu is now the installed search engine on 80% of all Android phones sold in China.[24] The absence of Google Play has prompted the network operators, large technology firms, and hundreds of smaller 3rd-party firms to build app stores in a battle for users.[25] This has large implications for Google's revenues, as China has overtaken the United States as the largest market worldwide for smartphones, with approximately 224 million smartphones sold in 2012, or approximately 25% of the global total, and growth expected to stay over 100% a year.[26]

4.3.1. Business model

While Xiaomi is often referred to as “the Apple of China” for its slick marketing and branding, its business is not based on selling high-margin hardware, but instead on selling low-cost devices as vehicles for consumption of digital content and services provided through a curated online marketplace. As Xiaomi co-founder Bin Lin has stated, “We have never compared ourselves to Apple—we are more like Amazon. The future of mobile internet is really about services.” This focus on selling digital products and services, such as games, media, and commissions on in-app purchases, netted the company $3.3 million in the month of August 2013.[27] Xiaomi doesn't have a cloud IaaS or PaaS, but it does have a few cloud-based services such as sync/storage MiDrive, and a popular chat application, MiTalk. In early 2014, Xiaomi announced it was entering 10 new national markets, including Indonesia, India, Russia, Brazil, and Mexico.[28]

4.3.2. Gatekeeper roles

Like Amazon, Xiaomi has little control over the original Android SDK or APIs, but it doesn't have the level of supplemental developer support offered by Amazon, so its role in the service creation environment is limited. In terms of profile/identity management, Xiaomi lacks the breadth of services and thus tracking opportunities that Google has, and it lacks the depth of purchase behavior that Amazon collects on its users. Instead its profile management is limited to only what it can capture through its online marketplace. Like Amazon, Xiaomi has built a curated online marketplace that offers a subset of the total universe of Android applications; in the case of Amazon, only those apps which are suitable for a Kindle tablet are currently available, while for Xiaomi, the available apps target the smartphone form factor. By offering a smaller, curated selection of smartphone apps, Xiaomi is trying to control service provisioning by helping its users with app discovery. Because Xiaomi smartphones are sold directly to end-users over the internet, Xiaomi has purchase history and billing information for many of its customers. Additional app or content purchases through its app store are also collected and added to its customer database.

[17] From Canalys data for Q2 2013 (Hong, 2013).
[18] Tech in Asia (Millward, 2014).
[19] For example, its MI 2S was sold for around $277, vs. about $600 for Samsung's Galaxy S4, which has similar specs.
[20] In October and November 2013, Xiaomi sold 100,000 units of its Hongmi smartphone in 4 min and 5 s; 100,000 units of the Mi3 smartphone in 1 min 26 s; and 150,000 units of the Mi3 in 9 min 55 s through a collaboration with Tencent's WeChat.
[21] Tech in Asia (Bischoff, 2013).
[22] Xiaomi minimizes costs by managing production in discrete installments; it takes pre-orders for a build and then only orders materials to cover that volume.
[23] Google Search, for example, operates from servers in Hong Kong, and Gmail, Maps, and the Google Play store all suffer from slow loading times and other issues (Metz, 2010). The Chinese government also intervened in 2012, when it made a condition of approval of Google's purchase of Motorola Mobility that for the following 5 years Google must continue to offer Android for free, and must not discriminate against any handset device maker, a move generally recognized as a way to ensure Chinese manufacturers such as ZTE and Huawei were given access to new code releases and other development information at the same time as market leaders Samsung and HTC (Letzing, 2012).
[24] According to Baidu, reported by The China Perspective (Guang, 2013).
[25] Estimate by TechCrunch (Cutler, 2013).
[26] An estimated 88 million smartphones were sold in China in Q3 2013 alone (Canalys, 2013).
[27] Economist (2013).
[28] Tech in Asia (Horwitz, 2014).

	Gatekeeper roles			
	Service creation environment	**Profile/identity management**	**Service provisioning**	**Billing information**
Google	Strong: controls all official APIs and developer tools	Strong: has broad and deep information on millions of users that it leverages for advertising revenue	Strong: marketplace has largest selection, but is not curated; other services are best-in-class	Moderate: has transaction service, but some purchases go through carrier; more concerned with user data
Amazon	Moderate: offers alternative APIs and tools for developers	Strong: has deep information on Amazon customers' purchase behavior	Strong: customer data fuels recommendation engine; content-based cloud services	Strong: has trusted and sophisticated transaction processing
Xiaomi	Weak: does not have its own development environment or tools	Weak: has information only on its small user base; only app behavior	Moderate: curated marketplace, but fewer selections; limited additional services	Moderate: has data on app and smartphone purchases

Fig. 1. Respective firm strengths in gatekeeper roles.

5. Analysis

Building proprietary platforms on top of Android has meant that Amazon and Xiaomi—and to some extent Google itself—have had to find ways to create differentiation and value beyond the operating system and available apps. Using the key gatekeeper roles defined by Ballon (2009) as a framework to analyze each case reveals the extent to which each firm has developed services and resources that help them lock-in users to their platform and control the way in which value is captured. Unsurprisingly, the gatekeeper roles where each firm has strengths and weaknesses reflect the more fundamental business models of the firms, specifically showing the difference between the advertising model of Google and the retail content delivery model of Amazon (and, to a lesser extent, Xiaomi). See Fig. 1 for a summary of respective firm strengths.

As the original platform owner, Google by default assumes specific gatekeeper roles, especially in regards to creating the development environment that allows developers to create applications and other digital products for Android. By opening the source code and licensing of Android, Google allowed firms such as Amazon and Xiaomi to appropriate not only the operating system, but this vast installed base of developers and end-users. Having this critical mass of users already in place meant these firms could avoid the challenge of simultaneously attracting both groups of the two-sided market to the platform (Evans, 2009), instead allowing them to focus their strategies on providing value-added services and finding ways to lock-in users. That other large firms, such as Microsoft, have struggled with the initial growth stage of their platforms underscores the difficulty in bringing both sides on board in a coordinated manner.[29]

Owning the development or service creation environment has allowed Google to control the evolution of not only the operating system, but also how applications and services connect to it through the various APIs. As the key interfaces with the operating system, Google must keep the APIs flexible enough to accommodate new innovations, yet stable enough to support ongoing interoperability with the core operating system (Farrell and Saloner, 1992; Baldwin & Clark, 2006). The strategic importance of the interface is heightened in this scenario, where the operating system itself is being used across different firms. For all three firms involved, control of the APIs may be more important than control of the operating system itself (Baldwin & Woodard, 2009; Schilling, 2000).

By creating the Google Play Services (GPS) system application and shifting key functionality from the core OS to GPS, Google is solving the OS fragmentation problem in an innovative way. Not only does this approach allow more handsets to receive updates by bypassing the traditional channel of pushing updates through network operators and OEMs, but it also transfers key innovations from the OS—which is open source—to the GPS application, which is proprietary. Google seems to be reducing investment in the core OS in favor of the interface, which may represent the least overtly aggressive course for it to exert more *de facto* control over Android. The end goal for Google may be less about reducing fragmentation per se, and more about ensuring that as many devices as possible are able to run the most recent version of Google's services, such as Google Maps and Google+. Google's business model requires it to engage users with its services in order to capture data for more targeted advertising, so its ability to continuously push out updates for its key services to as many users as possible is

[29] This has implications for theory around market entry in a platform industry; application of theory from dominant design (Abernathy & Utterback, 1978) and complementary assets (Teece, 1986) could be interesting ways to extend this analysis.

essential for its revenues. However, Google will have to moderate this desire for continuously updating the APIs, as the interface must remain relatively stable in order to retain compatibility and not alienate complementors (Baldwin & Woodard, 2009).

Just as Google is using the interface to try to rein in fragmentation and exert control over Android, Amazon is using its own alternative interface APIs to try to fortify its position. By developing its own version of many of the Google APIs, and connecting them to services within the Amazon Web Services suites (e.g., push notifications, mobile ads), Amazon aims to leverage its highly popular IaaS and PaaS services to incentivize developers to focus on Kindle applications. Extending Amazon's cloud-based development environments with direct connections into the Fire OS enables new categories of innovative services that Amazon can offer both developers and end-users. The aforementioned new affiliate program that allows direct in-app purchases of physical goods from Amazon's retail catalog is a prime example of a unique service that other Android platform firms cannot match. The cases of Google and Amazon show that while firms use interface development and control as a strategy to strengthen their architectural positions, the more important end goal of the strategic API development is to enable and improve the value-added services that may be competitive differentiators for end-users.

The analysis of Xiaomi suggests that while it has similar business model aspirations as Amazon, it has much weaker levels of control in the key gatekeeper roles, especially around the service creation environment. Its strength is in transaction processing and billing, which it does exclusively online. Compared to most of the approximately 200 app stores in China, Xiaomi has an advantage in that it also sells millions of smartphones direct to the end-user, and therefore has already established a trusted transaction relationship with a large number of potential app users. This challenges the network operators, who have been slowly ceding this gatekeeper role to the platform owners, yet still have much better reach across the end-user population through their subscription services (de Reuver & Bouwman, 2012).

Despite these billing relationships, Xiaomi doesn't have the data and services offered by Baidu (the leading search provider in China), or the cloud services and backend IaaS/PaaS infrastructure of Amazon, leaving it to compete as a thin layer or “skin” on top of stock Android, with little user lock-in and only rudimentary user data. While it may be able to continue attracting users with its low-cost hardware and strong brand, its lack of control over the service creation gatekeeper role means it is more dependent on the certified Android ecosystem and the development path determined by Google.

6. Discussion

The emergence of new proprietary platforms built on the Android operating system has created a unique industry structure that shapes our understanding of platform dynamics. The case studies presented here use the framework of gatekeeper roles to compare how firms try to establish bottlenecks for platform control when the operating system is no longer a competitive differentiator. Our analysis shows that when the OS is commodified, firms try to differentiate and lock-in users with cloud-based services, including online marketplaces, communication services, and cloud storage. Strategic development of the interfaces, or APIs, can help firms create more control and differentiation with these services.

This shift in importance from the operating system to services is supported by other trends within the industry. At the device level, there is clear convergence in hardware design and function, with signs that a dominant design (Abernathy & Utterback, 1978) based on the original iPhone has been adopted. At the level of the operating system, this paper describes three Android-based platforms that are very similar, but even between Android and the other major operating systems, there is decreasing differentiation in terms of available apps and core functionality. For example, both Blackberry and Jolla designed their operating systems (BB10 and SailFish, respectively) to run Android apps in addition to native apps, leveraging the existing corpus of Android apps to attract end-users and build traction with their platform.[30] This increase in cross-platform interoperability can also be seen in the multi-homing of developers—today's developers are building apps for an average of 2.9 different platforms—and app availability—of the 100 top-grossing apps in the Apple App Store in March 2013, approximately 50% were also available on Google Play, an increase from 30% a year before.[31] The result is that the most popular apps and services are available to more users, regardless of the underlying hardware and operating system platform. An interesting extension of this study would therefore be to assess how Android platform firm strategies compare to the other proprietary smartphone platforms, primarily Apple's iOS and Microsoft's Windows Phone, where the bottleneck is still located in the operating system. This analysis suggests that with relative parity at the level of the handset and the OS, it could be that what matters most for users is not what's on the device, but what the device allows them to connect to.

The uniqueness of this platform case study lies in the firms' shared use of the same operating system. A key question is whether this scenario is an outlier, or represents a likely future landscape in the mobile industry—or ICT in general—and therefore deserves further exploration. One perspective is that Android has already become dominant in the mobile industry, and will continue its convergence with the PC and mobile industry while spreading to other sectors such as M2M (machine-to-machine) communication and completely new applications. In this case, extending or adapting platform theory to consider firm strategy where newer entrants appropriate the fundamental platform technology and complements would be helpful, especially in terms of envelopment (Eisenmann, Parker, & Van Alstyne, 2011) and tipping (Gawer & Cusumano, 2008, 2014) strategies across sectors.

[30] See Segan (2014) and Jolla (2013).

[31] For multi-homing, see VisionMobile (2013). App availability on different platforms based on author's calculations using App Annie store rankings.

Another perspective is that regardless of the fate of Android, there is a quantifiable rise in the number of open or partially open technology platforms in the mobile industry, such as Firefox, Tizen, Ubuntu, and SailFish. The open licensing terms of these alternative operating systems suggests that like Android, they could also be appropriated by multiple firms trying to create independent platforms. Mozilla's Firefox, for example, is built on open web standards and is designed to run HTML5 apps as if they are native. This open-source operating system therefore already has a large corpus of apps and hundreds of thousands of developers around the world, with no proprietary lock-in to any one firm (including Mozilla). It is certainly possible to imagine another firm leveraging this ecosystem to build its own proprietary platform, just as Amazon and Xiaomi have done with Android. These "platforms within a platform" may symbolize a post-OS era, where open standards, interoperability, and virtualization are devaluing the operating system as a bottleneck of control and value capture.

If the observed shift away from the operating system as bottleneck extends beyond these cases, it could also have implications for industry regulators. The multi-sided platforms in the mobile industry already pose significant challenges for consistent and effective policy. With firms from different industries competing with different business models, developing sector-specific or technology-specific regulation around issues such as subsidized pricing, bundling, and net neutrality may affect the competitive positions of specific firms and sectors unevenly (Ballon & Van Heesvelde, 2011). For example, internet service providers may face regulations that firms outside the industry do not, creating asymmetric competition in situations when, for example, Google competes with telecommunications firms.

If the operating system ceases to be the platform bottleneck, this could change long-standing policy approaches to regulating anti-competitive bundling, representing a shift from the theories of the last half century that motivated the IBM and Microsoft anti-trust actions of the late 1970s and 1990s, respectively. With users demanding interoperability of software across operating systems—e.g., Gmail on Windows Phone, or OneDrive on iPhone—the traditional tying of key software to the operating system may be disappearing. Alternatively, the lock-in and bundling may just shift to higher layers in the stack. For example, instead of tying certain services to the operating system, a platform firm could tie its own services to each other, offering increased functionality or other benefits to those users who subscribe to multiple services, though this type of tying presumably would allow users to choose to mix and match services with some degradation in functionality. If the services operate across all operating systems, they could avoid the historical scrutiny levied at the OS level of the stack, yet still result in what might be considered anti-competitive practices (Carlton & Waldman, 1998). On the developer side, a scenario was described in this paper wherein Amazon offers developers incentives for using its APIs over a competitor's. Because Amazon holds a dominant market position with its IaaS/PaaS services, any tying or bundling of its services could be seen as potentially anti-competitive practice forcing developers toward single-homing.

Implications for security and privacy issues are less clear. The 2013 revelations of the U.S. National Security Agency (NSA) surveillance programs have raised serious questions about the industry's ability to resist state spying. Already existing concerns around cloud-based services and data storage (e.g., Kshetri, 2013) have increased with the perception that much of the wired and wireless communications passing through the U.S., including emails, text messages, voice calls, VoIP, and documents, are inspected by the U.S. government. Reports show that the major mobile platform owners (Google, Microsoft, and Apple) and network operators (AT&T, Verizon) cooperate with the NSA. While there are no indications that the NSA has targeted mobile operating systems themselves, there are allegations that the agency has tried to install "backdoors" into proprietary hardware and software products, including encryption algorithms. In these situations, the security advantages of open source software—which is often regarded as more secure than proprietary software because of the visibility of the code (Payne, 2002)—such as AOSP may offer advantages over proprietary, closed platforms. It is not easily predictable whether this will assist the open-source version of Android, or possibly another entirely open, nonproprietary operating system—especially if national governments or consortia of governments mandate its use.

7. Conclusion

Google's Android operating system is a rich subject for studying the changing nature of technology platforms and the strategies used for control and value capture. Its open licensing terms spurred explosive global adoption, yet also enabled other firms to build proprietary platforms on top of the operating system. These firms have been able to leverage the robust ecosystem of existing Android complementors and end-users, yet must find ways to lock-in users and capture their own share of the value network. By examining the official Google Android platform and two alternative cases also built on Android, this paper offers new insights into how firm strategies shift when the operating system on a device is no longer the key competitive differentiator. The analysis reveals that while the two larger firms, Google and Amazon, are developing proprietary APIs to control the interface to their respective platforms, all firms are relying on competencies in service provisioning and transaction processing, which translate into value-added services for users. These findings suggest that in ICT industries where the operating system is no longer a competitive differentiator, the bottleneck for platform control moves higher up the stack, away from the operating system and device and toward user services.

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