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# **Platform competition and differentiation: Business choices in mobile platforms**

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# Platform competition and differentiation: Business choices in mobile platforms

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*This paper examines firms' choices to use mobile platforms — namely iOS and Android. Using Crunchbase® data on startups seeking external funding, we find that 16 of 47 business categories are likely to use mobile platforms. 10 of these 16 exhibit no platform preferences, implying substitutability. Businesses that are unlikely to use mobile platforms view the platforms as differentiated. iOS was more popular than Android: 60 percent of businesses choosing to be on mobile platforms chose to be only on iOS. In contrast, only 8 percent chose to be on Android only. Our finding of platform substitutability holds when accounting for businesses belonging to multiple categories.*

Keywords: platforms; network effects, competition; differentiation; startups

JEL codes: L26, L86, M13, O30

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## **I. Introduction**

Digital platforms are important features of modern economies. While traditional brick-and-mortar companies make profits by converting raw materials to finished goods, platforms bring two or more groups of participants into a common ecosystem, creating value for combinations of participants (Van Alstyne, Parker, & Choudary, 2016). Many of the most successful technology companies of today, including Facebook, Apple, Microsoft, Uber, Alphabet Inc.'s Google, and Amazon, have platform-based business models.

Platforms enhance social and economic interactions. Network effects are a critical feature. (Eckhardt, Ciuchta, & Carpenter, 2018) For example, Apple's App Store and Google's Google Play leverage positive network effects between users and app providers,<sup>1</sup> who value each other's presence on the platform. There are also positive network effects between some app providers whose apps are complements or whose presence creates a critical mass that enhances platform value. For example, Zoom works with Outlook, so the two apps serve as complements. There are also negative network effects: The addition of another app in a category (such as video conferencing) where there are already substitutes would be expected to lower existing rival apps' profits (such as those of Zoom). Platforms also encourage innovation by providing tools and systems for creating and marketing products. That Apple and Alphabet have risen to be two of the world's largest companies is evidence of their platforms' values.

We study choices made by businesses that use these platforms, some of which develop apps. The app economy — the range of economic activities surrounding apps — plays an increasingly significant role in innovation, business development, and economic growth. Statista (2021d) shows the worldwide app economy growing

<sup>1</sup> "App" is a term used to refer to software applications developed largely for mobile phones, but some apps are used on personal computers or tablet devices.

over 250 percent from 2016 through 2020. A recent ACT | The App Association report valued the app economy at \$950 billion and employing 4.7 million people. (Stephens and Mahesh, undated) A study by the app analytics firm App Annie valued the global app economy at \$6.3 trillion for 2021, up from \$1.3 trillion in 2020. (App Annie, 2020) In the fourth quarter of 2020, Google Play featured over 3 million apps, Apple's App Store offered over 2 million apps, Microsoft's Windows Store offered nearly 670,000 apps, and Amazon's app store provided nearly 500,000 apps. (Statista, 2021a)

There is an extensive academic and practitioner literature focused on digital platforms (e.g., Eisenmann, Parker, & Van Alstyne, 2009; Gawer & Cusumano, 2002). However, relatively less attention has been directed toward the types of businesses that choose to use these platforms. This topic is important for several reasons. First, the platforms enable businesses to further digitize marketing or other business functions, potentially improving productivity and lowering marketing costs. Second, platforms encourage the creation of complementary products that form their own ecosystems, enabling further business creation. Third, a platform's ability to profit from these businesses' choices affects its incentives to improve platform quality and create economic value. Fourth, the app economy plays an increasingly significant role in innovation, business development, and economic growth. Finally, the study of competition among platforms is incomplete without considering complementary businesses, given their importance within the larger ecosystems. For example, the European Commission concluded in 2018 that the Android operating system does not face competition from iOS. (European Commission, 2018) Epic claimed in its antitrust suit against Apple that iOS monopolizes the app distribution market. (Epic Games, Inc., 2020) Our paper challenges both claims.

We focus on two mobile digital platforms — or ecosystems — that enable business development: Apple's iOS and Alphabet's Android. We study nearly

19,000 US enterprises that formed their business using either or both platforms. We consider how various categories of businesses cluster on platforms and differences between the two ecosystems in terms of types of companies that use them. Using data from Crunchbase, we find that of its 47 business categories, which we show in Appendix Table 1, 16 have statistically significant propensities to use mobile platforms to create or enhance their businesses, while 9 have statistically significant propensities to not use a mobile platform. We find that businesses in 10 of the positive-propensity categories consider iOS and Android platforms to be substitutes or complements and thus demonstrate no preference. Of the 22 business categories that do imply businesses having platform preferences, only 6 have positive and statistically significant propensities to use mobile platforms, and 8 have negative and statistically significant propensities to not use mobile platforms.

Because businesses tend to be in more than one category, we use factor analysis to examine interactions among the Crunchbase categories. We develop 10 factors — each a weighted linear combination of business categories — that account for most of the category interactions. Unsurprisingly, association with the factor led by the categories *Apps*, *Mobile*, and *Platform* provides the highest propensity to join a platform, with its effect being over 10 times that of the next most influential factor: the one characterized by *Advertising* and *Sales and marketing*. Association with this second factor implies that the firm is 9 percent more likely to use a mobile platform than associate with the cluster characterized by *Content and publishing* and *Media and entertainment*. The factor analysis also reveals that businesses largely view the platforms as substitutes or complements. Firms most strongly related to the cluster *Apps*, *Mobile*, and *Platform* tend to be on both platforms. Firms most closely associated with *Advertising* and *Sales and marketing* or with the *Content and publishing* and *Media and entertainment* clusters tend to not exhibit a preference for either iOS or Android, implying that they are viewed as substitutable.

We also study how business decisions imply platform differentiation. Thirteen business categories tend to include businesses that favor using iOS. For example, 205 businesses associated with the *Commerce and Shopping* category are on iOS only, versus 24 that are on Android only, and 186 in the *Content and Publishing* category are on iOS only versus only 19 on Android only. In contrast, businesses associated with the *Privacy and Security* category and the *Manufacturing* category tend to identify with Android but not iOS.

Our findings are consistent with theories of product differentiation. Hotelling (1929) described a situation in which two rival firms would choose to produce similar products, much like Apple and Alphabet do with respect to the value of their respective platforms for the business categories with the greatest propensity to use mobile platforms. d’Aspremont, Gabszewicz, and Thisse (1979) develop a variation on the Hotelling model and find situations in which rival duopolists would choose to be differentiated, much like Apple and Alphabet do with respect to the value each provides to businesses associated with categories that imply low propensities to use mobile platforms.

The rest of this paper is organized as follows. We begin with a brief literature review and then describe the data. That is followed by two sections. Each contains discussion leading up to a hypothesis, which is in turn followed by an examination of patterns in the data. The first of these two sections examines business choices to use mobile platforms. The second examines choices to favor iOS or Android. The next section uses our factor analysis to examine our hypotheses, accounting for firms’ tendencies to belong to more than one Crunchbase category. Finally, we summarize and discuss potential directions for future research.

## II. Literature Review

Management research regarding platforms may be broadly divided into three streams. One stream seeks to precisely define and characterize the nature of platforms and platform ecosystems. Another field attempts to understand predictors of platform success and competition at the level of platforms. Finally, a stream of research focuses on predictors of success for and competition at the level of complementors.

In the first stream — that of defining and characterizing platforms — Van Alstyne, Parker, and Choudary (2016) lay out the characteristics of platform businesses that set them apart from traditional pipeline businesses.<sup>2</sup> They note that while traditional, pipeline businesses convert inputs to outputs that are worth more, platform businesses bring producers and consumers together in high-value exchanges, creating and appropriating value through network effects. Adner (2017) introduces the “ecosystem as structure” viewpoint. He notes that ecosystems, including platforms, are characterized by certain common features. They have an alignment structure with mutual agreement among members on positions and flows, as well as compatible incentives and motives. They are multilateral, referring to a set of relationships that are not decomposable to bilateral interactions. In addition, partners within them have joint value creation as a general goal. Finally, the productive level of analysis is the value proposition of the ecosystem rather than value proposition of the individual entities it is comprised of.

Kretschmer et al. (2020) view platform ecosystems as meta-organizations. They argue platform ecosystems are hybrid structures whose governance does not fully resemble either markets or hierarchies. For instance, authority in platform

<sup>2</sup> Van Alstyne, Parker, Choudary define pipeline businesses as those that “create value by controlling a linear series of activities—the classic value-chain model. Inputs at one end of the chain (say, materials from suppliers) undergo a series of steps that transform them into an output that’s worth more: the finished product.”



ecosystems is not based on employment contracts as in traditional hierarchies. Rather, authority for the “hub” arises from control over the technological architecture, over who gets to participate, the rules, and allocation of rents. They also note that as opposed to traditional hierarchies, incentives for platform participants tend to be high-powered. At the same time, they are not fully market-like, as platform participants often have fewer degrees of freedom. Gawer (2014) blends engineering design and economic perspectives on platforms. She notes that the former has focused on innovation and the latter on competition. She suggests that integrating the two perspectives leads to a view of platforms as “evolving organizations or meta-organizations that: (1) federate and coordinate constitutive agents who can innovate and compete; (2) create value by generating economies of scope in supply and/or demand; and (3) entail a modular technological architecture comprised of a core and a periphery.”

Regarding the second stream, namely the predictors of success and competition, Anderson, Parker, & Tan (2014) argue that when investing in platform performance, platform managers face a tradeoff because high performance often requires complementors to make greater investments. They find that investing in better performance may be a losing strategy. Along similar lines, Ozalp, Cennamo, & Gawer (2018) consider the empirical context of the US videogame industry and find that incumbents introducing next-generation platform technologies face a tradeoff, as such technologies can make it more challenging for complementors to catch up. That may lead complementors to defect toward rival platforms, especially if their learning curves with the new technology are steep.

Corts & Lederman (2009) and Bresnahan, Orsini, & Yin (2015) study why single platforms often do not come to dominate. The former uses the empirical context of video games and argues that the presence of non-exclusive software gives an impetus to cross-platform network effects. That in turn discourages a monopoly. In

a similar vein, the latter notes that the reason there is often not a monopoly is that superstar applications tend to multihome.

Boudreau & Jeppesen (2015) consider unpaid complementors, common in contexts such as open-source software (e.g., the e-commerce platform osCommerce) and add-on functions for web browsers. In their empirical context of online multiplayer game engine platforms, they find that the number of complements does increase with an increase in the number of users, given signaling and reputational motivations. However, an increasing number of complementors exerts downward pressure on these opportunities as more complementors compete for the limited attention of users. Taken together, network effects fail to manifest.

Park, Seamans, & Zhu (2020) examine how consumers' tendencies to single-home or multi-home impacts platform responses to new rivals who enter their markets. They consider two platforms — TV stations and newspapers — and study how newspapers responded when TV stations entered their markets. They make predictions with a formal model and leverage a quasi-natural experiment (staggered rollout of TV stations that was temporarily halted during the Korean war) to test the theory. Results broadly suggest that firms do take consumers' multihoming tendencies into account when deciding how to respond to the entry of a rival platform. Specifically, after a TV station entered the newspaper market, newspaper firms with more single-homing consumers had lower subscription prices, circulations, and advertising rates.

Eisenmann, Parker, & Van Alstyne (2011) introduce the notion of platform envelopment. While barriers to entry may be high in platform markets due to network effects, a firm that has captured an overlapping user base in a different arena may be able to enter an incumbent's markets by leveraging shared users and common components. Examples are Microsoft's entries into markets of RealNetworks, Netscape, and Adobe's Flash software.

In the third stream — predictors of success and competition at the level of complements — Eckhardt, Ciuchta, & Carpenter (2018) study the conditions under which complementors of platforms (e.g., app developers) decide to commercialize their technology. They take an information-based approach to theorizing. They find support for (1) product information impacting whether app developers decide to commercialize their technology and (2) market information not impacting the same decision. Tiwana (2015) studies how input control and extension modularization impact market performance of that extension. He argues and finds that input control exercised by the platform owner and extension modularization come together to impact the acceleration of the extension's evolution which in turn impacts market performance of that extension (mediated-moderation model).

### **III. Data**

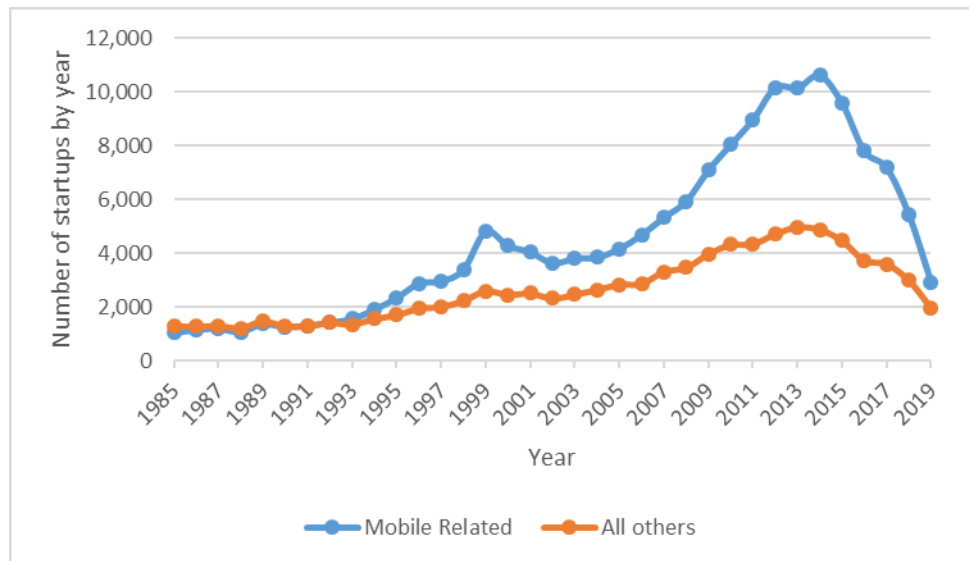
We rely on the secondary data source Crunchbase for our research. It provides detailed business information on over 1.15 million businesses across the world, including both privately held and publicly listed companies. The data encompasses acquisitions, funding rounds, investors, initial public offerings (IPOs), organizations, and other features. Crunchbase obtains its data from over 3,500 global investment firms that submit monthly portfolio updates, and a community of executives, entrepreneurs, and investors actively contribute information. Subject matter experts, artificial intelligence (AI), and machine learning algorithms validate and curate the data. (Crunchbase, 2021)

Crunchbase focuses on early-stage, innovative companies that are planning to, are currently, or have raised external funding, particularly early-stage funding like seed capital, angel investors, and accelerators. This limits our research to companies that currently have or previously had plans to become sufficiently large or grow suitably fast to need outside capital.

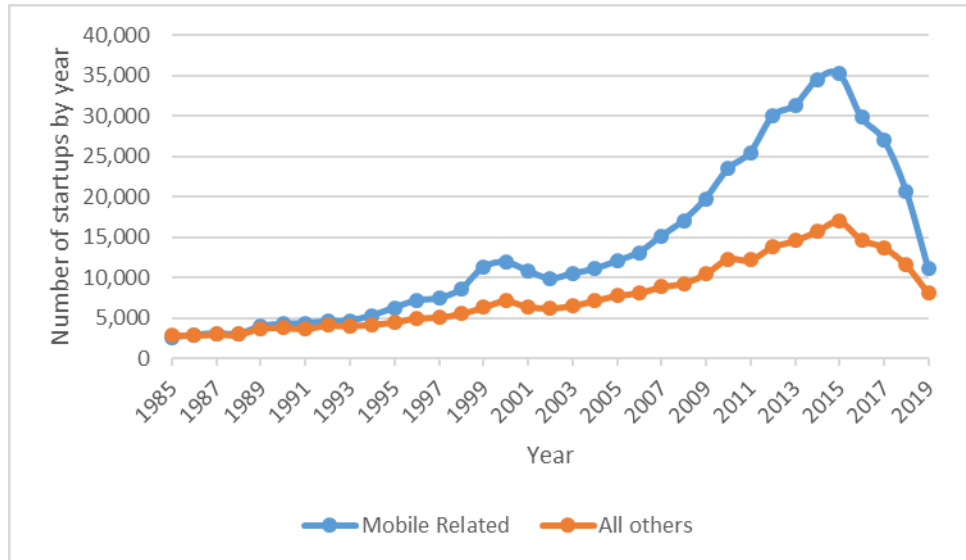
Crunchbase’s 47 categories of business are comprehensive and are thus not limited to companies developing apps. Indeed, many of the businesses appear to develop software applications that are useful for businesses that do develop apps. This expands our results beyond just apps into all businesses that utilize mobile platforms.

Figures 1 and 2 show the number of startups from 1985 through 2019 in Crunchbase for the US and for the world. The patterns are quite similar, implying that the forces driving startups were nearly the same for the US as for the rest of the world. In each graph, the blue line represents the number of startups that fall into the categories that our research finds are significantly related to mobile platforms. The red line is all other startups. The red and blue lines coincide from 1985 until 1994, at which time the number of startups in platform-related categories begins to be greater than all others. It is beyond the scope of this paper to explain this divergence, but it is worth noting that the first internet browser, Mosaic, was released in 1993. This was also the year that the National Science Foundation began its process to privatize the internet.

**Figure 1. Number of US Startups in Crunchbase by Year, 1985-2019**



**Figure 2. Number of Startups Worldwide in Crunchbase by Year, 1985-2019**



The patterns in Figures 1 and 2 show the growth of startups during the dot com bubble from 1995 to 2000, the drop during the dot com crash in 2000, and the decline and subsequent climb during the recession and economic recovery following the terrorist attack on New York's World Trade Center in 2001. Business creation for companies documented in Crunchbase peaked in 2015 and then declined rapidly. The 2015 peak is consistent with a study by Engine (2021) regarding the startup ecosystem in the US. Engine termed the decline in 2016 as a correction, apparently from a change in startup capital markets.

In contrast to the post-2015 steady declines in Crunchbase-reported startups, the number of startups in the Engine report resumed its rise after 2016. One reason for the differences in patterns is that Engine and Crunchbase study sets of startups: Engine considers all startups and Crunchbase tends to consider only those seeking outside funding. Crunchbase (2019) explains its decline as resulting from a change in sizes of firms seeking funding: Crunchbase (2019, 2020) found that the number of small financing deals began declining in 2016 while the number of larger deals

continued to increase. There are at least two possible reasons why these might lead to a decline in the overall number of startups seeking funding. First, there might be a limited amount of capital available for investing in startups, so an increase in deal size would necessarily mean a decline in the number of deals. Second, there could have been a change in preferences for entrepreneurs starting small enterprises after 2015; namely, they might have preferred selling their businesses rather than grow them with outside capital, or they might have preferred keeping their firms under their control by not having outside investors. Examining the relative importance of these possible reasons and others is beyond the scope of our study.

But there remains the possibility that this post-2017 decline in startups in Crunchbase affects our results. To examine this, we ran our models discussed in the next two sections with two overlapping datasets: One from 2007 through 2017 and the other from 2007 through 2020. We found that the results for the two datasets were nearly identical, except for the business category *Agriculture and farming*: The longer dataset found *Agriculture and farming* was associated with a statistically significant preference for iOS while the shorter dataset did not, implying that the years 2018–2020 were different for this category relative to earlier years, and that the newer firms had a much greater propensity than earlier firms to choose iOS. Because the smaller and larger databases otherwise give similar results, we use the longer dataset for our analysis.

We considered 151,536 businesses that were founded in the United States from 2007 through 2020. We chose 2007 as the starting year because that is the year Apple introduced the iPhone. The first successful Android phone followed about two years later. We consider businesses that use the keywords Mobile, Apps, Mobile apps, iOS, and Android as choosing to be on mobile platforms even if they did not otherwise indicate it. 18,884 businesses were associated with mobile platforms, with 3,412 of those specifically identifying with either iOS and Android

— or both.<sup>3</sup> Of these, 2,046 were associated with just iOS, 282 were associated with just Android, and 1,084 were associated with both. That these platform choices skew heavily towards iOS is surprising given that Google’s app store, Google Play, has about twice as many apps as Apple App Store. (Statista, 2021a) There could be several reasons. One is that many apps do not lead to business formation. Developers often build apps without an intent to commercialize them. It is possible that those who wish to commercialize apps and launch businesses based on them may prefer iOS. Another is that businesses associated with mobile platforms were not necessarily only building and selling apps. While many were providing apps, others were brick-and-mortar businesses that had begun using mobile platforms for their services or operations. Yet some others were software consulting firms that provided software development services to both entrepreneurs and established businesses interested in building apps.

#### **IV. Choice to be on a Mobile Platform**

##### *A. Discussion and Hypothesis*

We begin our analysis by studying categories of businesses that are most likely associated with using mobile platforms. We identify 12.5 percent of the Crunchbase startups as using a mobile platform.

We are interested in whether a firm’s association with specific categories predicts the likelihood of the business associating with mobile platforms or not. It is possible that there are some categories of businesses that mobile platforms have not penetrated deeply. On the other hand, some successful mobile platform businesses in some categories may have attracted competitors so that those spaces may be

<sup>3</sup> We assume that when a company is only associated with “iOS” in Crunchbase, its offerings are only available on the iOS platform. Likewise, when a company is only associated with “Android”, we assume its offering are only available on the Android platform. If a company is associated with both, we assume its offering are available on both platforms.

crowded. Highlighting what types of businesses are more or less likely to be associated with mobile platforms is useful both because it can point to potential underexplored entrepreneurial opportunities, lead platform companies to consider the possibility of incentivizing apps-based entrepreneurship in certain areas, and help us understand the mobile platform value proposition.

Regardless of whether iOS and Android compete for businesses in the most profitable business categories, or collude and divide the market, we would expect that the businesses that find mobile platforms most helpful for their businesses to demonstrate a stronger preference for using mobile platforms than do businesses associated with other business categories. These mobile-oriented business categories could include categories such as *Navigation and mapping*, that are able to provide more valuable services if they are featured on mobile phones. Knowing that these categories are likely to be the largest users of mobile platforms, the platform providers are likely to design their platforms accordingly, for example, by emphasizing appropriate functionality and low costs. This leads to Hypothesis 1.

*Hypothesis 1: Categories of businesses benefit differently from the use of mobile functionality, and these differences result in differences in propensities to use one or more mobile platforms.*

## *B. Analysis and Results*

We test Hypotheses 1 using a logistic regression to predict whether a firm's association with particular business categories predicts its choice of whether to use one or more mobile platforms:

$$\mathbf{y}_l = \beta_0 + \mathbf{c}\boldsymbol{\beta}_c + \mathbf{Z}\boldsymbol{\beta}_Z + \varepsilon \quad (1)$$

where  $\mathbf{y}_l$  is an  $n \times 1$  vector of values  $\log\left(\frac{p_i}{1-p_i}\right)$ ,  $p_i$  is the probability of firm  $i$  being on one or more mobile platforms,  $n$  is the number of firms,  $\mathbf{c}$  is an  $n \times \bar{c}$  vector of business category dummies that take on the value 0 if  $i$  is not in the



category and the value 1 if  $i$  is in the category,  $\bar{c}$  is the number of Crunchbase business categories,  $\mathbf{Z}$  is an  $n \times \bar{z}$  vector of exogenous variables often associated with predicting business startups where each row corresponds to firm  $i$  in the year it started,  $\bar{z}$  is the number of exogenous variables,  $\boldsymbol{\beta}_z$  and  $\boldsymbol{\beta}_c$  are respectively  $\bar{z} \times 1$  and  $\bar{c} \times 1$  vectors of estimated coefficients,  $\beta_0$  is an  $n \times J$  vector of the estimated constant, and  $\varepsilon$  is an  $n \times 1$  vector of error terms. We excluded year dummies as they correlated too highly with other explanatory variables. Table 1 shows the results.

We fail to reject Hypothesis 1. 25 of the business categories are associated with a statistically significant effect on a firm's propensity to use a mobile platform. Nine of these 25 have negative coefficients — *Biotechnology*, *Content and publishing*, *Energy*, *Hardware*, *Healthcare*, *Information technology*, *Manufacturing*, *Music and audio*, and *Professional services* — implying that firms associated with these categories are less likely than the average firm to utilize mobile platforms. That *Information technology* and *Music and audio* are in this list could be surprising until one considers the details shown in Appendix Table 1: *Information technology* includes such areas of products as *Cloud data services*, *Cloud management*, *Data center*, and *Network security* that are important areas of business, and that do not lend themselves to reliance on mobile platforms. *Music and audio* also includes areas of business — *Independent music*, *Music education*, and *Musical instruments* — that are not obviously advantaged by using mobile platforms.

**Table 1. Propensities to be associated with one or more mobile platforms**

<b>Business Category and Other Variables</b>	<b>Coefficient</b>	<b>Robust Std. Err.</b>
Administrative services	-0.5170	0.3590
Advertising	4.6540 ***	0.2750
Agriculture and farming	-0.4320	0.5430
Apps	11.3000 ***	0.2500
Artificial intelligence	0.0723	0.2890
Biotechnology	-0.7190 *	0.3040
Clothing and apparel	0.1680	0.2700
Commerce and shopping	0.5320 ***	0.1080
Community and lifestyle	0.3690 *	0.1720
Consumer electronics	1.3190 ***	0.1450
Consumer goods	0.1300	0.3460
Content and publishing	-0.2380	0.1440
Data and Analytics	-0.1970	0.1500
Design	-0.1550	0.1450
Education	0.1740	0.1890
Energy	-0.8400 *	0.3920
Events	0.2610	0.2350
Financial services	0.0259	0.2130
Food and beverage	0.7260 **	0.2800
Gaming	1.0780 ***	0.2400
Government and military	0.3600	0.4670
Hardware	-2.5310 ***	0.0920
Healthcare	-2.4170 ***	0.0997
Information technology	-0.5950 ***	0.0908
Internet services	-0.0949	0.0811
Lending and investments	0.2350	0.3920
Manufacturing	-1.0760 ***	0.2180
Media and entertainment	0.7060 ***	0.1290
Messaging and telecommunications	1.5960 ***	0.2640
Mobile	11.7900 ***	0.2260
Music and audio	-0.5820 **	0.2220
Natural resources	0.1470	0.5450
Navigation and mapping	0.7970 **	0.3030
Payments	1.7170 ***	0.3170
Platforms	1.9420 ***	0.2420
Privacy and security	-0.3310	0.1740
Professional services	-0.4160	0.2460
Real estate	-0.0283	0.2370
Sales and marketing	-0.0805	0.1640
Science and engineering	-0.3270	0.2100
Software	0.8880 ***	0.0847
Sports	0.5030 **	0.1650
Sustainability	0.2010	0.3970
Transportation	-0.0032	0.2030
Travel and tourism	0.5130 *	0.2340
Video	-0.0582	0.1620
Unemployment	-0.1770	0.0909
Smart phone shipments	0.0001 *	0.0040
Entrepreneurship	0.0000 *	0.0004
Constant	-3.8310	2.2900

Number of observations = 145,186, Pseudo R-square = 0.9346, Wald chi2(49) = 7018.06, Log pseudolikelihood = -3609

Eight business categories indicate statistically and economically significant indicators of businesses using mobile platforms.<sup>4</sup> These are *Advertising*, *Apps*, *Consumer electronics*, *Gaming*, *Messaging and telecommunications*, *Mobile*, *Payments*, and *Platforms*, with the coefficients for *Apps* and *Mobile* being more than twice the third largest coefficient, *Advertising*. Categories that are statistically but not economically significant are *Commerce and shopping*, *Community and lifestyle*, *Food and beverage*, *Media and entertainment*, *Navigation and mapping*, *Software*, *Sports*, and *Travel and tourism*. These eight categories tend to be associated with businesses that use mobile platforms, but many business models within these categories do not necessarily rely on such platforms.

There are a number of reasons why a firm may utilize a mobile platform. Digitization of business operations accompanied by mobility of employees, suppliers, or customers could make it profitable to use mobile platforms. On the other hand, products that are customized for customers or that require large screens or computing power would make mobile devices unattractive. There can be other reasons for why a category is more or less likely to be associated with businesses using a mobile platform. On the one hand, there may be a bandwagon effect at the level of categories where business success in one category induces other firms to join that category.

Future research should delve deeper into competing explanations. One way to examine whether the former explanation is the right one is through a longitudinal analysis of business performance and foundings in different categories, both among mobile platform businesses and others. To test the latter explanation needs a detailed understanding as well as additional data on the characteristics of businesses in different categories.

<sup>4</sup> We designate coefficients greater than one as indicating economic significance. This is admittedly an arbitrary choice, but it aids in discussion.

At this point, our research has identified 16 of 47 business categories that imply positive and statistically significant use of mobile platforms, with half of these also being economically significant. About 6 percent of the startups in our dataset are associated with one or more of these 16 categories, while only 2 percent are associated with one or more of the eight categories that are both economically and statistically significant.

## **V. Competition and Differentiation in Platforms**

### *A. Discussion and Hypotheses*

An extensive literature has noted that rival firms often differentiate products and serve different product niches. In strategic management, Hawley (1968) noted that diversity in organizational forms reflects the diversity of the operating environments. Levinthal (1997) visualized organizations as walking on a rugged landscape with many possible peaks, and posited that the specific peak in which a firm orients is based on where on the landscape it began. Indeed, anecdotal evidence reveals that often, firms have each selected a niche, with some emerging as leaders within their niches. For example, Samsung's Galaxy and Apple's iPhone are sometimes considered to compete in the market for smartphones, but their products are different both in terms of features and price points, potentially targeting different market segments, but perhaps with some overlap. (Benenson, Gassmann, & Reinfelder, 2013)

In economics, Hotelling (1929) was the first to develop a theoretical model of product differentiation. Characterizing differences in buyers' preferences as distances to be overcome to purchase a firm's product, he described a situation in which two rival firms would choose to produce homogeneous products. The firms' differentiation choices affected prices and sales: The more similar the firms' products were, the more prices approached underlying marginal costs. But also, the

closer a firm's product was to its rival's product, the more market share it would secure. In Hotelling's model, the market share feature dominated the effect of lower prices in determining profits. d'Aspremont, Gabszewicz, and Thisse (1979) develop a variation on the Hotelling model by assuming the cost of covering distance is nonlinear. In their model, rival duopolies choose to be differentiated.

Because of network effects, differentiation from a developer perspective might result from phone devices attracting different types of mobile phone users. Shaw et al. (2016) found that iPhone users were more than twice as likely to be female, more likely to view their phone as status objects, had lower levels of honesty and humility, had higher levels of emotionality, and were more likely to be extroverted than their Android counterparts. It is possible that these differences reflect differences in preferences for phone features and apps. There may be other explanations, too. One way to resolve these competing explanations is to gather data on anticipated user demographics (from businesses before launch, to avoid endogeneity issues) as well as demands on smartphone functionality from different mobile platform businesses and examine whether they statistically mediate the relationship between belonging to certain categories and the choice of platform.

It is possible that business categories affect businesses' platform preferences. Some might be homogeneous in their needs, leaving little room for platform differentiation and yielding results similar to Hotelling's. Other businesses might have different platform preferences and resemble Hotelling's linear costs of transport. Such situations would also lead to platforms being very similar. Yet other business categories might have different platform preferences that are better represented by d'Aspremont, Gabszewicz, and Thisse, resulting in platform differentiation.

It is also possible that platforms collude and divide the market. For example, we found in Section IV that the category *Community and lifestyle*, and the category *Travel and tourism*, prefer to use mobile platforms, but the preferences are not

economically significant. So rather than compete for businesses in these categories — where demand might be considered “thin” — platform providers might divide the markets, with one serving the needs of *Community and lifestyle* and the other serving the needs of *Travel and tourism*. In this case we would find that some of the categories we identified in Section IV would tend to select one type of platform and other categories would select the other platform.

A key difference between platforms and more traditional brick-and-mortar businesses is that adaptation and selection forces operate at the level of an entire ecosystem rather than an individual firm. (Shapiro and Varian, 1998) The specific market within which the iOS platform competes, for example, is determined not only by Apple but also by all the app developers and supporting businesses. Nonetheless, we expect some forces that characterize differentiation among traditional brick-and-mortar companies to operate in the digital context as well.

These analyses lead to our next hypotheses:

*Hypothesis 2: The iOS and Android platforms are largely viewed as substitutes for businesses associated with categories for which platforms are important.*

*Hypothesis 3: The iOS and Android platforms differentiate for business categories for which platforms are relatively unimportant, so businesses associated with those categories tend to prefer one platform over another.*

As we explain next, we test these hypotheses using a multinomial model. We reject Hypothesis 2 for one or more of the 16 business categories that prefer to use a mobile app if we find that businesses associated with that category have a propensity to use one platform over the other. We reject Hypothesis 3 for a business category not in the 16 if we find that businesses associated with the category have a propensity to use one platform over another.

### B. Primary Analysis and Results

We test our hypotheses using (2) to predict whether being associated with specific categories affects the choice of platform arrangement, i.e.,

$$\mathbf{y}_m = \boldsymbol{\beta}_0 + \mathbf{c}\boldsymbol{\beta}_c + \mathbf{Z}\boldsymbol{\beta}_Z + \boldsymbol{\varepsilon} \quad (2)$$

where  $\mathbf{y}_m$  is an  $n \times J$  vector of values  $\log\left(\frac{p_{i,j}}{p_{i,J}}\right)$ ,  $p_{i,j}$  is the probability of the  $i$ th firm being associated with platform arrangement  $j = 1, 2, \dots, J$ ,  $\mathbf{c}$  is an  $n \times \bar{c}$  vector of business category dummies,  $\mathbf{Z}$  is an  $n \times \bar{z}$  vector of exogenous variables often associated with predicting business startups,  $\boldsymbol{\beta}_Z$  and  $\boldsymbol{\beta}_c$  are respectively  $\bar{z} \times J$  and  $\bar{c} \times J$  vectors of estimated coefficients,  $\boldsymbol{\beta}_0$  is an  $n \times J$  vector of estimated constants, and  $\boldsymbol{\varepsilon}$  is an  $n \times J$  vector of error terms.  $j = J$  is the baseline platform arrangement. The possible platform arrangements are iOS only, Android only, and both iOS and Android.

An underlying motivation for our analysis is to understand and characterize the extent to which iOS and Android have separate ecosystems. If all businesses associated with iOS were also associated with Android and vice-versa, it could indicate that the systems compete as homogenous or complementary products because startups are attracted to both platforms equally — or nearly equally. Our analysis not only helps to understand whether the two ecosystems are separate, but in cases where businesses were not on both platforms, our analyses indicate which categories were likely to be on iOS only and which were likely to be on Android only.

Because we wanted three comparisons — how being on iOS only compares with being on both, how being on Android only compares to being on both, and how being on Android only compares with being on iOS only — we ran our model twice: once using a firm being on both as the baseline and a second time using iOS-only as the baseline. Table 2 provides our results. The categories *Mobile*, *Platforms*,

and *Software* were omitted because they were too highly correlated with other covariates.

We fail to reject Hypotheses 2 and 3 for a number of categories, namely finding that businesses largely view the platforms as substitutes or complements, but some businesses that are largely ambivalent or negative about using platforms find them as differentiated. A number of business categories for which we found statistically significant preferences for using platforms did not result in preferences for particular platform arrangements. These included *Advertising*, *Community and lifestyle*, *Consumer electronics*, *Media and entertainment*, *Navigation and mapping*, *Payments*, and *Travel and tourism*. These appear to be reasonable results: For example, many electronic services depend on advertising as a major source of revenue, so we would expect advertising services to be present on both platforms.

Some — but not all — business categories that did not have a statistically significant relationship with being on any platform nonetheless resulted in platform preferences. For example, *Clothing and apparel* had no significant relationship with platforms in general, and yet businesses associated with it had a statistically significant preference for iOS relative to being on both platforms. This did not translate into a preference for iOS over Android: The coefficient for Android versus iOS is negative, but not statistically significant.



**Table 2. Propensities to be associated with particular platform arrangements**

Business Category and other Variables	iOS v. Both		Android v. Both		Android v. iOS	
	Coeff.	Robust St. Err.	Coeff.	Robust St. Err.	Coeff.	Robust St. Err.
Administrative services	0.4756	0.8631	1.2765	1.2156	0.8009	1.0042
Advertising	0.0446	0.2361	0.2088	0.4148	0.1642	0.4023
Agriculture and farming	-0.0011	0.8905	-14.6895 ***	0.7937	-14.6884 ***	0.5904
Apps	-0.2060 ***	0.0791	-0.2662 *	0.1416	-0.0601	0.1350
Artificial intelligence	-1.0742 **	0.4336	0.3749	0.6744	1.4491 **	0.6709
Biotechnology	0.1115	0.7959	-15.6234 ***	0.7601	-15.7349 ***	0.6108
Clothing and apparel	1.2510 ***	0.4398	0.5022	0.8879	-0.7488	0.8210
Commerce and shopping	0.3367 **	0.1434	-0.1580	0.2811	-0.4947 *	0.2668
Community and lifestyle	0.0895	0.2233	0.0283	0.4060	-0.0612	0.3931
Consumer electronics	0.3123	0.2289	0.4957	0.3542	0.1834	0.3350
Consumer goods	-0.4383	0.4165	-0.1075	0.5974	0.3308	0.5599
Content and publishing	0.5280 ***	0.1916	0.8098 **	0.3484	0.2818	0.3249
Data and analytics	-0.0502	0.2158	-0.4686	0.3871	-0.4183	0.3650
Design	-0.4451 ***	0.1563	-0.5919 *	0.3028	-0.1468	0.2997
Education	0.2512	0.2057	-0.5777	0.4508	-0.8289 *	0.4344
Energy	0.2581	1.2426	-13.1590 ***	1.0583	-13.4171 ***	1.1983
Events	0.2540	0.2765	-0.4766	0.6601	-0.7305	0.6381
Financial services	-0.2748	0.3165	0.4346	0.4725	0.7093	0.4565
Food and beverage	-0.1976	0.2581	-1.7876 *	1.0343	-1.5901	1.0274
Gaming	0.2253	0.1449	-0.6368 **	0.3221	-0.8621 ***	0.3101
Government and military	0.1459	0.7310	-0.2374	1.2825	-0.3833	1.1911
Hardware	-0.1780	0.1682	0.0626	0.2912	0.2405	0.2821
Healthcare	0.1276	0.2207	-0.0124	0.4235	-0.1400	0.4037
Information technology	0.3887 ***	0.1251	-0.0663	0.2268	-0.4550 **	0.2119
Internet Services	0.1401	0.1053	0.1679	0.1861	0.0278	0.1762
Lending and investments	-0.0676	0.5214	-1.2192	1.1695	-1.1516	1.1952
Manufacturing	0.6537	0.5774	1.5013 **	0.6177	0.8476 *	0.4625
Media and entertainment	-0.0605	0.1456	-0.3838	0.2889	-0.3233	0.2742
Messaging and telecommunications	-0.3601 *	0.2154	0.2344	0.3460	0.5944 *	0.3235
Music and audio	0.4449 *	0.2338	0.0453	0.4750	-0.3997	0.4455
Natural resources	16.1881 ***	0.8982	0.8127	1.0780	-15.3755 ***	1.1948
Navigation and mapping	0.3064	0.2649	0.1838	0.4559	-0.1226	0.4213
Payments	-0.2956	0.3811	-0.3660	0.5920	-0.0703	0.5856
Privacy and security	-0.0951	0.3642	0.8800 **	0.4484	0.9751 **	0.3837
Professional services	-0.3826	0.2926	-1.2736 *	0.7692	-0.8910	0.7652
Real estate	-0.8698 **	0.3862	0.1267	0.4910	0.9965 *	0.5304
Sales and marketing	-0.2803	0.1823	-0.2788	0.3237	0.0015	0.3176
Science and engineering	-0.1258	0.2891	0.3381	0.4308	0.4638	0.4115
Sports	0.0509	0.2085	-0.8218 *	0.4901	-0.8727 *	0.4784
Sustainability	0.2027	0.5183	-15.0569 ***	0.5040	-15.2596 ***	0.3627
Transportation	-0.2106	0.2842	-0.7928	0.6337	-0.5822	0.6245
Travel and tourism	-0.1155	0.2451	-0.3890	0.5643	-0.2735	0.5558
Video	0.1391	0.2047	-0.4141	0.4204	-0.5532	0.3986
Smartphone shipments	0.0001	0.0001	-0.0001	0.0001	-0.0002 ***	0.0001
Entrepreneurship	5.38E-06	4.60E-06	0.0000 **	0.0000	0.0000 ***	0.0000
Unemployment	0.0692	0.1172	-0.3635 **	0.2016	-0.4327 **	0.1900
Constant	-2.4169	2.9648	8.3191	5.1407	10.7360 **	4.8468

Number of observations = 3377, Wald chi2(49) = 6129, Pseudo R-square = 0.0345, Log pseudolikelihood = -2861

Tables 3 and 4 map the preferences shown in Tables 1 and 2. Table 3 illustrates platform preferences for all business categories that demonstrate a preference. The rows show three possible preferred platform arrangements: iOS only, both iOS and Android, and Android only. The columns also show these arrangements, but as arrangements that are disfavored relative to the arrangements in the rows. For example, Table 3 shows that businesses associated with *Clothing and apparel* prefer iOS only to being on both, but not to Android only, and that businesses associated with *Education* prefer iOS only to Android only, but not to being on both platforms. The categories *Commerce and shopping*, *Information technology*, and *Natural resources* have businesses that prefer iOS only to being on Android only or to being on both. The category *Content and publishing* is associated with businesses that prefer to specialize regarding their platforms: Businesses in this category tend to prefer being on iOS or Android to being on both. In contrast, businesses associated with *Apps* or *Design* tend to prefer being on both platforms.

Table 4 shows the business categories that are not associated with statistically significant preferences between platform arrangements. The first column has categories that were found to have statistically significant preferences to use a platform but have no measurable preferences for a particular platform arrangement. Column two contains categories that exhibit no statistically significant preferences for using a platform nor for any particular platform arrangement. The third column contains categories that have a negative, statistically significant probability of using a platform and have no platform preferences.

**Table 3. Platform preferences for business categories that have statistically significant preferences**

		...to this platform arrangement		
		iOS only	On both platforms	Android only
Prefers this platform arrangement...	iOS only		Clothing and apparel <sup>+</sup> Music and audio <sup>++</sup>	Education <sup>+</sup>
			Commerce and shopping Information technology <sup>++</sup> <b>Natural resources<sup>+</sup></b>	
			Content and publishing <sup>++</sup>	Agriculture and farming <sup>+</sup> <b>Biotech<sup>++</sup></b> <b>Energy<sup>++</sup></b> Gaming Sports Sustainability <sup>+</sup>
	On both platforms	Apps Design <sup>+</sup>		Apps Design <sup>+</sup>
		<b>Artificial Intelligence<sup>+</sup></b> Messaging and telecommunications Real estate <sup>+</sup>		<b>Food and beverage</b> <b>Professional Services<sup>++</sup></b>
	Android only		Content and publishing <sup>++</sup>	
		<b>Manufacturing<sup>++</sup></b> Privacy and Security <sup>++</sup>		

Notes: All categories mentioned are statistically significant at least at the 10% level in the multinomial analyses. “+” indicates categories that are not statistically significant in the logit model that relates categories to preferences to use any mobile platform. “++” denotes categories that have a negative and statistically significant relationship preference against using mobile platforms in the logit model. **Bold** indicates categories whose coefficients that we consider to be economically significant, meaning that their coefficients in the multinomial analyses are greater than one in at least one instance.

Examining Tables 3 and 4 reveals patterns indicating the nature of competition between platforms. Recognizing that three of the categories that were both economically and statistically significant in preferring to use platforms could not be analyzed for platform arrangement preferences, seven of these 13 categories that could be analyzed have no platform preferences, implying that iOS and Android appear homogenous to businesses associated with these categories. Three of these

seven categories — *Advertising*, *Consumer electronics*, and *Payments* — are also economically significant.

**Table 4. Business categories not associated with platform preferences**

<b>Business categories</b>		
<b>Significantly prefer using mobile platforms to not using them, but no platform preference</b>	<b>Indifferent to using a mobile platform and no platform preference</b>	<b>Negative tendency to use a mobile platform and no platform preference</b>
Advertising Community and lifestyle Consumer electronics Media and entertainment Navigation and mapping Payments Travel and tourism	Data analytics Consumer goods Events Financial services Government and military Internet services Lending and investments Sales and marketing Science and engineering Transportation Video	Hardware Healthcare

More business categories have preferences for iOS than for Android. Only *Manufacturing* and *Privacy and security* have strict preferences for Android, whereas *Commerce and shopping*, *Information technology*, and *Natural resources* have strict preferences for iOS. By “strict preference”, we mean that the businesses associated with the category tend to prefer one arrangement — in these cases Android only or iOS only — over all other arrangements. 10 categories are associated with weak preferences for iOS, compared with only four for Android. By weak preferences, we mean that the arrangement is preferred to one other arrangement, but not to all other arrangements. Furthermore, iOS is disfavored in seven categories, but Android is disfavored in fourteen. These results imply that a wider variety of businesses perceive iOS to be better suited for their products than they do Android.

Furthermore, Android tends to be preferred in business categories that do not have strong preferences for using mobile platforms. Of the six that have strong or weak preferences for Android, three — *Content and publishing*, *Manufacturing*, and *Privacy and security* — have negative preferences for being on any platform, and another two — *Artificial intelligence* and *Real estate* — are largely indifferent to platform use. In contrast, of the thirteen that have at least weak preferences for iOS, three — *Content and publishing*, *Gaming*, and *Sports* — have statistically significant preferences for using a platform.

Given these results, we conclude that iOS and Android are largely viewed as substitutes by businesses that tend to use mobile platforms and are differentiated primarily for businesses that do not have a strong desire to be on a platform. This is consistent with several platform business strategies. One possible strategy is competing in homogenous products, with only incidental differentiation. Another strategy is that of expanding markets: Each platform would be expending resources to expand the types of businesses that would find platforms useful. But because these business types would be considered marginal users — i.e., users that are largely indifferent to using platforms and so are not very profitable for platform providers — each platform is expanding in its own direction. Once a new market segment is developed, then it would be likely for the other platform to attempt to enter it.

Another strategy is product differentiation, at least along some platform features. This strategy overlaps with the expanding markets strategy but has a different purpose in that the differentiation strategy increases profitability by allowing for higher prices, but also invites entry as research has found that more firms can profitably enter differentiated markets than can profitably enter homogenous product markets.

A fourth strategy could be dividing markets (i.e., the firms agree to separately serve at least some market segments). Our results are consistent with research on

collusion that has found that firms are more likely to collude when the benefits of cheating on the collusive agreement are small, namely situations in which profit margins are thin in the markets subject to collusion. However, other data would appear inconsistent with the collusion theory: Statista (2021b, 2021c) shows the number of apps on both platforms steadily growing, except for a sharp drop in Google Play in early 2018. An exercise of market power generally results in output restrictions, so we would expect to see at least a softening of growth. Such a pattern isn't evident, but this is not conclusive evidence refuting the collusion theory.

We cannot discern which of these four strategies is being used without additional data and analysis.

### *C. Discussion for Further Analysis*

Beyond categories, it is also both interesting and important to examine whether businesses associated with mobile platforms differ from other businesses in performance as well as outcomes like exit through acquisitions, IPOs, and closure. A key feature of businesses based on mobile platforms is possible lower barriers to entry. For example, both Apple (2021) and Google (2021) offer step-by-step instructions for developers seeking to build apps on their platforms. In addition, Apple offers the Integrated Development Environment and Google offers the Android Studio, both of which enable developers to quickly build and launch apps on the respective platforms. The absence of setup and infrastructure costs associated with traditional brick-and-mortar businesses and the potential upside (given possible network effects) implies easier entry. Future research should delve deeper into this area.

## VI. Analysis of Category Factors

98 percent of the Crunchbase businesses that use a mobile platform belong to more than one Crunchbase business category, implying that categories may interact in their association with business preferences for using mobile platforms. We examine this issue using factor analysis, which reduces the dimensionality of data and identifies relationships between categories (Meyers, Glenn, & Guarino, 2013). Each factor, which is a latent dimension, is a linear combination of all variables in the data. However, the weight assigned to a particular variable reflects the extent to which it is correlated with that factor. When considering our earlier examples, we might believe that there is a latent underlying dimension connecting *Energy*, *Natural resources*, and *Sustainability*. If true, these variables would be weighted more heavily on that latent factor than others.

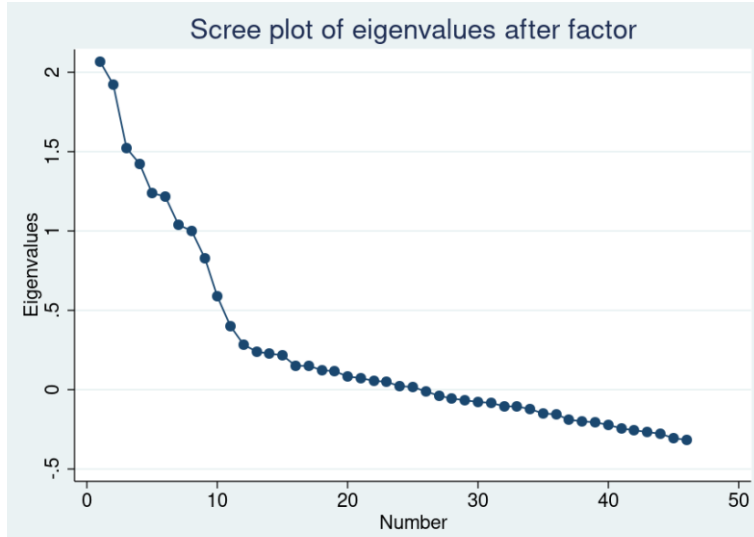
Our factor analysis produces as many factors as there are business categories. However, a few factors collectively account for most of the variance in the data. We reduce dimensionality by retaining for further analysis only those factors that account for most of the variance. In addition, we rotate factors to help us better identify which variable(s) each factor is strongly associated with.

In our specific context, a factor analysis with an orthogonal varimax rotation<sup>5</sup> results in the emergence of 10 factors that accounted for the bulk of variance (see scree plot in Figure 3). In addition, each of these 10 factors loads strongly on one or more variables.<sup>6</sup> Table 5 displays these 10 factors and indicates the variable/s each is strongly associated with.

<sup>5</sup> We also ran analyses with an oblique rotation for robustness. While the factor structure that emerged was similar, the logistic and multinomial regressions that followed did not converge.

<sup>6</sup> We define a factor as loading strongly on a variable if the correlation between the factor and that variable was at least 0.5.

**Figure 3. Scree Plot of Eigen Values**



**Table 5. Top ten factors and associated categories**

Factor	Associated categories
Factor 1	Energy, Natural Resources, Sustainability
Factor 2	Artificial Intelligence, Data and Analytics
Factor 3	Content and Publishing, Media and Entertainment
Factor 4	Biotechnology, Science and Engineering
Factor 5	Apps, Mobile, Platforms
Factor 6	Advertising, Sales and Marketing
Factor 7	Consumer Electronics, Hardware
Factor 8	Clothing and Apparel, Design
Factor 9	Financial Services, Lending and Investments
Factor 10	Information Technology

We use these 10 factors in the logistic regression (3) to predict the propensity to be associated with a mobile platform:

$$y_l = \beta_0 + cF\beta_F + Z\beta_Z + \varepsilon \quad (3)$$



Where  $\mathbf{y}_i$ ,  $p_i$ ,  $\mathbf{c}$ ,  $\mathbf{Z}$ ,  $\boldsymbol{\beta}_z$ ,  $\boldsymbol{\beta}_0$ , and  $\boldsymbol{\varepsilon}$  are defined as in (1),  $\mathbf{F}$  is an  $\bar{c} \times f$  vector of factors,  $f$  is the number of factors, and  $\boldsymbol{\beta}_F$  is an  $f \times 1$  vector of estimated coefficients. Table 6 displays the results.

**Table 6. Propensities to associate with a mobile platform predicted by factor scores**

Factor Scores and Variables	Coefficient	Robust Std. Err.
Scores for factor 1	-0.2640 ***	-0.0499
Scores for factor 2	-0.1320 ***	-0.0311
Scores for factor 3	0.5420 ***	-0.0218
Scores for factor 4	-0.5870 ***	-0.0565
Scores for factor 5	7.0480 ***	-0.0756
Scores for factor 6	0.5890 ***	-0.0297
Scores for factor 7	-0.1940 ***	-0.0298
Scores for factor 8	0.0311	-0.0305
Scores for factor 9	0.0078	-0.0252
Scores for factor 10	-0.4750 ***	-0.0313
Unemployment	-0.3100 ***	-0.0667
Smartphone shipments	-0.0002 ***	-0.00003
Entrepreneurship	-0.00002 ***	-0.000003
Constant	4.5280 **	-1.6830

Observations = 145,186, Degrees of freedom = 13, Wald chi-square = 9109, Pseudo R-square = 0.8935, Log pseudolikelihood = -5875

We also use the 10 factors in multinomial logistic regression (4) to analyze the propensity to be associated with iOS only, Android only, or both.

$$\mathbf{y}_m = \boldsymbol{\beta}_0 + \mathbf{cF}\boldsymbol{\beta}_F + \mathbf{Z}\boldsymbol{\beta}_z + \boldsymbol{\varepsilon} \quad (4)$$

where  $\mathbf{y}_m$ ,  $p_{i,j}$ ,  $\mathbf{Z}$ ,  $\boldsymbol{\beta}_z$ ,  $\boldsymbol{\beta}_0$ , and  $\boldsymbol{\varepsilon}$  are defined as in (2), and  $\mathbf{F}$  and  $\boldsymbol{\beta}_F$  are as defined in (3). Table 7 displays our results.

The results in Tables 6 and 7 provide the same conclusions as Tables 1 and 2 regarding our hypotheses. Comparing Tables 1 and 6, the following factors have the expected signs and statistical significance: Factor 1 (*Energy, Natural resources, and Sustainability*), Factor 3 (*Content and publishing, and Media and entertainment*), Factor 4 (*Biotechnology and Science and engineering*), Factor 5 (*Apps, Mobile, and Platforms*), Factor 6 (*Advertising, Sales and marketing*), Factor

7 (*Consumer electronics and Hardware*),<sup>7</sup> Factor 8 (*Clothing and apparel, and Design*), Factor 9 (*Financial services, and Lending and investments*), and Factor 10 (*Information technology*). The only outlier is Factor 2 (*Artificial intelligence and Data analytics*), whose primary components are not statistically significant in Table 1, but are in Table 6, probably because of the other categories that are small individually, but that influence Factor 2 in the aggregate.

**Table 7. Propensities to associate with particular mobile platforms predicted by factor scores**

Factor Scores and Variables	iOS vs. Both		Android vs. Both		Android vs. iOS	
	Coefficient	Robust Std. Err.	Coefficient	Robust Std. Err.	Coefficient	Robust Std. Err.
Scores for factor 1	0.1890	0.1780	-0.2830	0.1870	-0.4720 ***	0.1390
Scores for factor 2	-0.0794	0.0641	-0.0520	0.1250	0.0274	0.1210
Scores for factor 3	0.1420 ***	0.0382	-0.0267	0.0711	-0.1690 *	0.0670
Scores for factor 4	-0.2660 *	0.1340	0.0984	0.1580	0.3640 *	0.1680
Scores for factor 5	-0.1690 *	0.0690	-0.2500 *	0.1230	-0.0809	0.1170
Scores for factor 6	-0.0828	0.0484	-0.0495	0.0882	0.0334	0.0855
Scores for factor 7	0.0219	0.0449	0.1930 **	0.0662	0.1710 **	0.0609
Scores for factor 8	0.0354	0.0558	-0.1220	0.1210	-0.1570	0.1180
Scores for factor 9	-0.1640 *	0.0666	0.0524	0.0984	0.2160 *	0.0972
Scores for factor 10	0.0433	0.0499	0.1510	0.0795	0.1080	0.0728
Unemployment	0.0521	0.1150	-0.4280 *	0.1970	-0.4800 **	0.1860
Smartphone shipments	0.00007	0.00005	-0.0002	0.00009	-0.0002 **	0.00008
Entrepreneurship	0.000004	0.000005	-0.00002 *	0.000008	-0.00002 **	0.000007
Constant	-1.3250	2.9390	10.4400 *	5.0770	11.7600 *	4.7830

Observations = 3377, Degrees of Freedom = 26, Wald chi-square = 91, Pseudo R-square = 0.0143, Log pseudolikelihood = -2921

We now turn our attention to how factors are associated with platform preference. Our findings support the conclusion that businesses largely view the platforms as substitutes or complements. From Table 7 we see that half of the factors are associated with strong preferences: Factor 3 (*Content and publishing, and Media and entertainment*) is associated with statistically significant

<sup>7</sup> In Table 2, *Consumer electronics* is statistically significant and negative, whereas *Hardware* is statistically significant and positive. We expect *Hardware* to dominate as its coefficient in Table 2 is much larger than *Consumer electronics'* coefficient in absolute value.

preferences for iOS over Android and iOS only over being on both platforms, but the factor is not associated with a statistically significant use of platforms (Table 6). Factors 4 (*Biotechnology and Science and engineering*) and 9 (*Financial services, and Lending and investments*) are the opposite, being associated with a preference for Android over iOS and using both platforms over using iOS only. But Factor 4's primary categories capture less than 5 percent of the firms using mobile platforms and Factor 9 is not a statistically significant user of mobile platforms (Table 6). Factor 5 (*Apps, Mobile, and Platforms*) is associated with using both apps rather than any one alone and is associated with nearly all of the firms that use mobile platforms. The outlier is Factor 7 (*Consumer electronics and Hardware*), which is statistically significant, is associated with about 10 percent of the firms using mobile apps, and is associated with preferring Android alone over iOS alone or using both platforms.

Only one factor is associated with weaker preferences: Factor 1 (*Energy, Natural resources, and Sustainability*) prefers Android only over iOS only and represents only about 1 percent of the firms that use mobile platforms. The remaining factors have no statistically significant platform preferences.

None of the factors are economically significant in the same sense as we used for assessing the Table 2 results, namely that the coefficients would be greater than one in absolute value. The most economically significant are Factors 1 (*Energy, Natural resources, and Sustainability*) and 4 (*Biotechnology and Science and engineering*). Factor 1 is associated with a preference for iOS over Android, but firms categorizing as *Energy, Natural resources, or Sustainability* make up only about 1 percent of our firms using mobile platforms. Factor 4 is associated with a preference for Android over iOS, but firms identifying with *Biotechnology and Science and engineering* make up only about 4 percent of firms using mobile platforms. So we conclude that while these factors may be more economically

significant on average, they have little influence in the overall population of firms using mobile platforms.

Tables 8 and 9 further illustrate these conclusions. Table 8 is similar to Table 3 in its design, and Table 9 is similar to Table 4 in its design. Tables 8 and 9 illustrate the importance of considering how business category interactions are chief indicators of platform choice. We focus our discussion on categories that characterize more than 10 percent of the firms that use mobile platforms. These include categories driving Factor 2 (*Data analytics* 12 percent), Factor 3 (*Media and entertainment* 23 percent), Factor 5 (*Mobile* 78 percent, *Platforms* 18 percent), Factor 6 (*Sales and Marketing* 13 percent), Factor 7 (*Hardware* 12 percent), and Factor 10 (*Information technology* 18 percent).

For Factor 2, which has a statistically significant negative relationship with platform use (Table 6), *Artificial intelligence* by itself is associated with a strong preference away from iOS, but *Data analytics* is more important given that it has no statistically significant relationships with platform use when considered alone (Table 4) or once interactions are considered (Table 9). For Factor 3, *Content and publishing* is associated with a preference for being on both platforms when considered by itself (Table 3), while *Media and entertainment* has no preference across platforms (Table 4), but Factor 3 demonstrates a preference for iOS once category interactions are considered (Table 8).

Factor 5, which is associated with more businesses than any other factor, is associated with firms being on both platforms, whether considered as a factor (Table 8) or considering its individual primary categories (Table 3).<sup>8</sup> Factor 6 is associated with firms preferring to use platforms, but with no platform preference. Its category *Advertising* follows that same pattern, while its other leading category,

<sup>8</sup> Recall that *Mobile* and *Platform* were dropped from the multinomial for categories individually.

*Sales and Marketing*, has no preference for using platforms and no platform preference when one is used.

**Table 8. Platform preferences for business category factors that have statistically significant preferences**

		...to this platform arrangement		
		iOS only	On both platforms	Android only
Prefers this platform arrangement...	iOS only		Factor 3: Content & publishing, Media & entertainment	
	On both platforms	Factor 4: Biotechnology, Science and Engineering <sup>++</sup>		
		Factor 5: Apps, Mobile, Platforms		Factor 5: Apps, Mobile, Platforms
	Android only	Factor 1: Energy, Natural Resources, Sustainability <sup>++</sup>		
		Factor 4: Biotechnology, Science and Engineering <sup>++</sup>		
		Factor 7: Consumer electronics, Hardware <sup>++</sup>		

Notes: All categories mentioned are statistically significant at least at the 10% level in the multinomial analyses. All are statistically significant in the logit model that relates category factors to preferences to use any mobile platform. “++” denotes categories that have a negative and statistically significant relationship preference against using mobile platforms in the logit model.

Factor 7 is led by two factors, *Consumer electronics* and *Hardware*, that have opposite propensities to be on a platform when analyzed individually. *Consumer electronics* is associated with a preference to use platforms, whereas *Hardware* is associated with a preference to not use platforms, but neither has a platform

preference. As a factor, however, there is a negative propensity to be on a platform, with a preference for Android over iOS and over being on both. Similarly, Factor 10 and its major category, *Information technology*, both have a preference to not use mobile platforms. As an individual category, *Information technology* prefers iOS over being on Android or both platforms. As a factor, it has no platform preference.

**Table 9. Business category factors not associated with platform preferences**

<b>Business categories</b>		
<b>Significantly prefer using mobile platforms to not using them, but no platform preference</b>	<b>Indifferent to using a mobile platform and no platform preference</b>	<b>Negative tendency to use a mobile platform and no platform preference</b>
Factor 6 ( <i>Advertising, Sales and marketing</i> )	Factor 8 ( <i>Clothing and apparel, and Design</i> )	Factor 2 ( <i>Artificial intelligence and Data analytics</i> )  Factor 10 ( <i>Information technology</i> )

## **VII. Summary**

We set out to study how various categories of businesses cluster on mobile platforms, along with differences between the two ecosystems in terms of types of companies spawned. Our results provided several key insights. First, it seems there are categories of businesses that tend to be associated with both the iOS and Android platforms, and there are other categories that tend to associate with either but not both, but most businesses do not seem to have preferences for using mobile platforms. Firms in particular categories can use these results to guide platform choice in an imitation strategy by following what other firms do, or in a

differentiation strategy by choosing a different platform strategy. There are both spaces in which the platforms compete as homogenous products, but there are also some in which users have clear and significant preferences.

That businesses in some business categories do not have strong preferences between the platforms does not mean that the firms are on both platforms. It simply means that firms associated with the categories view the platforms as substitutes when deciding on which platforms to build. Some businesses find that they have to adapt their software to each platform, and so may economize by being on only one platform. In such situations, the platform competition occurs before the business begins using a platform.

Our findings have implications for competition and antitrust policies. As we cited above, the EU concluded that iOS and Android were in separate markets. But we find that many types of businesses view the platforms as nearly perfect substitutes or important complements. Most platform differentiation is in business types that are only marginally interested in mobile platforms.

Regarding the case that Epic Games filed against Apple Inc., Epic argues that iOS and Android are separate markets when it comes to games. Our findings disagree. While game-related businesses favor iOS to Android, they also favor being on both platforms to being on Android only. They have no preference of iOS-only over both. And *Games* is not a leading category explaining variations in types across businesses. So while Epic might be sincere in its claim that it feels it needs to be on the iOS platform, that does not mean that iOS is a separate market from Android for the gaming industry. We cannot reject a hypothesis that a business associated with the gaming industry is just as likely to be on both platforms as on iOS only.

Our research also has implications for legislation in the US Congress and states. Many legislators are supporting laws that implicitly assume iOS and Android are not in competition with one another. Our research indicates this assumption is

incorrect, which implies such laws would harm businesses, markets, and consumers.

At least three directions seem ripe for future research. First, given that Crunchbase has data on funding rounds, that may in turn help us estimate the value created by mobile platform businesses. Given that a financing round also values a company, the valuations that angel investors, venture capitalists, and other external equity financiers assign a company may help us determine the value created — at least as assessed by equity financiers. It may also be productive to examine whether the financing decision is dependent on the category a mobile platform business belongs to. Trends in the flow of financing to specific categories may help us better understand how the variety of offerings from mobile platform ecosystems evolves over time. Categories may receive different levels of attention from external equity financiers over time.

Second, Apple and Google vary in how they foster their mobile platform ecosystems. While Apple is known to maintain tight quality controls over apps on its mobile platform, Google is known to offer greater freedom to app developers and to how apps are placed on its platform. It would be interesting to examine how these different businesses strategies impact ecosystem evolution, and to what extent the differences we observe between iOS and Android are attributable to these strategies of the platform owners.

Third, while we pointed out that some categories of businesses prefer different platforms, we are still unclear on the reasons behind these choices. Given that the iOS platform is associated with Apple's iPhone while the Android platform is associated with other smartphones, it may be that features of those smartphones drive decisions of which platform to associate with. On the other hand, it may be that the varying demographics of the two platforms are primarily responsible for these differences. Future research should thus delve deeper. One way is to obtain data on both demands on smartphone features from different mobile platform



businesses as well as anticipated demographics of user base. Another way is testing for possible mediation effects. Data on anticipated demographics of user base should be gathered before launch to avoid potential endogeneity issues.

Finally, it is important to note that both the iOS and Android platforms have undergone significant changes since 2007. For example, Apple only added in-app purchases in 2009 and launched the Swift programming language for app developers in 2014. Likewise, Google has redesigned the Google Play user interface several times and launched Google Play Instant in 2017, which allows users to try out an app without installing it first. Future research should consider the impacts of these fine-grained changes.



**Appendix Table 1. Crunchbase Business Categories, 2020**

Industry Group	Industries
Administrative Services	Archiving Service, Call Center, Collection Agency, College Recruiting, Courier Service, Debt Collections, Delivery, Document Preparation, Employee Benefits, Extermination Service, Facilities Support Services, Housekeeping Service, Human Resources, Knowledge Management, Office Administration, Packaging Services, Physical Security, Project Management, Staffing Agency, Trade Shows, Virtual Workforce
Advertising	Ad Exchange, Ad Network, Ad Retargeting, Ad Server, Ad Targeting, Advertising, Advertising Platforms, Affiliate Marketing, Local Advertising, Mobile Advertising, Outdoor Advertising, SEM, Social Media Advertising, Video Advertising
Agriculture and Farming	Agriculture, AgTech, Animal Feed, Aquaculture, Equestrian, Farming, Forestry, Horticulture, Hydroponics, Livestock
Apps	App Discovery, Apps, Consumer Applications, Enterprise Applications, Mobile Apps, Reading Apps, Web Apps
Artificial Intelligence	Artificial Intelligence, Intelligent Systems, Machine Learning, Natural Language Processing, Predictive Analytics
Biotechnology	Bioinformatics, Biometrics, Biopharma, Biotechnology, Genetics, Life Science, Neuroscience, Quantified Self
Clothing and Apparel	Fashion, Laundry and Dry-cleaning, Lingerie, Shoes
Commerce and Shopping	Auctions, Classifieds, Collectibles, Consumer Reviews, Coupons, E-Commerce, E-Commerce Platforms, Flash Sale, Gift, Gift Card, Gift Exchange, Gift Registry, Group Buying, Local Shopping, Made to Order, Marketplace, Online Auctions, Personalization, Point of Sale, Price Comparison, Rental, Retail, Retail Technology, Shopping, Shopping Mall, Social Shopping, Sporting Goods, Vending and Concessions, Virtual Goods, Wholesale

Source: Crunchbase <https://support.crunchbase.com/hc/en-us/articles/360043146954-What-Industries-are-included-in-Crunchbase->

**Appendix Table 1. Crunchbase Business Categories (cont.)**

Community and Lifestyle	Adult, Baby, Cannabis, Children, Communities, Dating, Elderly, Family, Funerals, Humanitarian, Leisure, LGBT, Lifestyle, Men's, Online Forums, Parenting, Pet, Private Social Networking, Professional Networking, Q&A, Religion, Retirement, Sex Industry, Sex Tech, Social, Social Entrepreneurship, Teenagers, Virtual World, Wedding, Women's, Young Adults
Consumer Electronics	Computer, Consumer Electronics, Drones, Electronics, Google Glass, Mobile Devices, Nintendo, Playstation, Roku, Smart Home, Wearables, Windows Phone, Xbox
Consumer Goods	Beauty, Comics, Consumer Goods, Cosmetics, DIY, Drones, Eyewear, Fast-Moving Consumer Goods, Flowers, Furniture, Green Consumer Goods, Handmade, Jewelry, Lingerie, Shoes, Tobacco, Toys
Content and Publishing	Blogging Platforms, Content Delivery Network, Content Discovery, Content Syndication, Creative Agency, DRM, EBooks, Journalism, News, Photo Editing, Photo Sharing, Photography, Printing, Publishing, Social Bookmarking, Video Editing, Video Streaming
Data and Analytics	A/B Testing, Analytics, Application Performance Management, Artificial Intelligence, Big Data, Bioinformatics, Biometrics, Business Intelligence, Consumer Research, Data Integration, Data Mining, Data Visualization, Database, Facial Recognition, Geospatial, Image Recognition, Intelligent Systems, Location Based Services, Machine Learning, Market Research, Natural Language Processing, Predictive Analytics, Product Research, Quantified Self, Speech Recognition, Test and Measurement, Text Analytics, Usability Testing
Design	CAD, Consumer Research, Data Visualization, Fashion, Graphic Design, Human Computer Interaction, Industrial Design, Interior Design, Market Research, Mechanical Design, Product Design, Product Research, Usability Testing, UX Design, Web Design
Education	Alumni, Charter Schools, College Recruiting, Continuing Education, Corporate Training, E-Learning, EdTech, Education, Edutainment, Higher Education, Language Learning, MOOC, Music Education, Personal Development, Primary Education, Secondary Education, Skill Assessment, STEM Education, Textbook, Training, Tutoring, Vocational Education

**Appendix Table 1. Crunchbase Business Categories (cont.)**

Energy	Battery, Biofuel, Biomass Energy, Clean Energy, Electrical Distribution, Energy, Energy Efficiency, Energy Management, Energy Storage, Fossil Fuels, Fuel, Fuel Cell, Oil and Gas, Power Grid, Renewable Energy, Solar, Wind Energy
Events	Concerts, Event Management, Event Promotion, Events, Nightclubs, Nightlife, Reservations, Ticketing, Wedding
Financial Services	Accounting, Angel Investment, Asset Management, Auto Insurance, Banking, Bitcoin, Commercial Insurance, Commercial Lending, Consumer Lending, Credit, Credit Bureau, Credit Cards, Crowdfunding, Cryptocurrency, Debit Cards, Debt Collections, Finance, Financial Exchanges, Financial Services, FinTech, Fraud Detection, Funding Platform, Gift Card, Health Insurance, Hedge Funds, Impact Investing, Incubators, Insurance, InsurTech, Leasing, Lending, Life Insurance, Micro Lending, Mobile Payments, Payments, Personal Finance, Prediction Markets, Property Insurance, Real Estate Investment, Stock Exchanges, Trading Platform, Transaction Processing, Venture Capital, Virtual Currency, Wealth Management
Food and Beverage	Bakery, Brewing, Cannabis, Catering, Coffee, Confectionery, Cooking, Craft Beer, Dietary Supplements, Distillery, Farmers Market, Food and Beverage, Food Delivery, Food Processing, Food Trucks, Fruit, Grocery, Nutrition, Organic Food, Recipes, Restaurants, Seafood, Snack Food, Tea, Tobacco, Wine And Spirits, Winery
Gaming	Casual Games, Console Games, Contests, Fantasy Sports, Gambling, Gamification, Gaming, MMO Games, Online Games, PC Games, Serious Games, Video Games
Government and Military	CivicTech, Government, GovTech, Law Enforcement, Military, National Security, Politics, Public Safety, Social Assistance

**Appendix Table 1. Crunchbase Business Categories (cont.)**

Hardware	3D Technology, Application Specific Integrated Circuit (ASIC), Augmented Reality, Cloud Infrastructure, Communication Hardware, Communications Infrastructure, Computer, Computer Vision, Consumer Electronics, Data Center, Data Center Automation, Data Storage, Drone Management, Drones, DSP, Electronic Design Automation (EDA), Electronics, Embedded Systems, Field-Programmable Gate Array (FPGA), Flash Storage, Google Glass, GPS, GPU, Hardware, Industrial Design, Laser, Lighting, Mechanical Design, Mobile Devices, Network Hardware, NFC, Nintendo, Optical Communication, Playstation, Private Cloud, Retail Technology, RFID, RISC, Robotics, Roku, Satellite Communication, Semiconductor, Sensor, Sex Tech, Telecommunications, Video Conferencing, Virtual Reality, Virtualization, Wearables, Windows Phone, Wireless, Xbox
Health Care	Alternative Medicine, Assisted Living, Assistive Technology, Biopharma, Cannabis, Child Care, Clinical Trials, Cosmetic Surgery, Dental, Diabetes, Dietary Supplements, Elder Care, Electronic Health Record (EHR), Emergency Medicine, Employee Benefits, Fertility, First Aid, Funerals, Genetics, Health Care, Health Diagnostics, Home Health Care, Hospital, Medical, Medical Device, mHealth, Nursing and Residential Care, Nutraceutical, Nutrition, Outpatient Care, Personal Health, Pharmaceutical, Psychology, Rehabilitation, Therapeutics, Veterinary, Wellness
Information Technology	Business Information Systems, CivicTech, Cloud Data Services, Cloud Management, Cloud Security, CMS, Contact Management, CRM, Cyber Security, Data Center, Data Center Automation, Data Integration, Data Mining, Data Visualization, Document Management, E-Signature, Email, GovTech, Identity Management, Information and Communications Technology (ICT), Information Services, Information Technology, Intrusion Detection, IT Infrastructure, IT Management, Management Information Systems, Messaging, Military, Network Security, Penetration Testing, Private Cloud, Reputation, Sales Automation, Scheduling, Social CRM, Spam Filtering, Technical Support, Unified Communications, Video Chat, Video Conferencing, Virtualization, VoIP

**Appendix Table 1. Crunchbase Business Categories (cont.)**

Internet Services	Cloud Computing, Cloud Data Services, Cloud Infrastructure, Cloud Management, Cloud Storage, Darknet, Domain Registrar, E-Commerce Platforms, Ediscovery, Email, Internet, Internet of Things, ISP, Location Based Services, Messaging, Music Streaming, Online Forums, Online Portals, Private Cloud, Product Search, Search Engine, SEM, Semantic Search, Semantic Web, SEO, SMS, Social Media, Social Media Management, Social Network, Unified Communications, Vertical Search, Video Chat, Video Conferencing, Visual Search, VoIP, Web Browsers, Web Hosting
Lending and Investments	Angel Investment, Banking, Commercial Lending, Consumer Lending, Credit, Credit Cards, Financial Exchanges, Funding Platform, Hedge Funds, Impact Investing, Incubators, Micro Lending, Stock Exchanges, Trading Platform, Venture Capital
Manufacturing	3D Printing, Advanced Materials, Foundries, Industrial, Industrial Automation, Industrial Engineering, Industrial Manufacturing, Machinery Manufacturing, Manufacturing, Paper Manufacturing, Plastics and Rubber Manufacturing, Textiles, Wood Processing
Media and Entertainment	Advice, Animation, Art, Audio, Audiobooks, Blogging Platforms, Broadcasting, Celebrity, Concerts, Content, Content Creators, Content Discovery, Content Syndication, Creative Agency, Digital Entertainment, Digital Media, DRM, EBooks, Edutainment, Event Management, Event Promotion, Events, Film, Film Distribution, Film Production, Guides, In-Flight Entertainment, Independent Music, Internet Radio, Journalism, Media and Entertainment, Motion Capture, Music, Music Education, Music Label, Music Streaming, Music Venues, Musical Instruments, News, Nightclubs, Nightlife, Performing Arts, Photo Editing, Photo Sharing, Photography, Podcast, Printing, Publishing, Reservations, Social Media, Social News, Theatre, Ticketing, TV, TV Production, Video, Video Editing, Video on Demand, Video Streaming, Virtual World
Messaging and Telecommunications	Email, Meeting Software, Messaging, SMS, Unified Communications, Video Chat, Video Conferencing, VoIP, Wired Telecommunications
Mobile	Android, Google Glass, iOS, mHealth, Mobile, Mobile Apps, Mobile Devices, Mobile Payments, Windows Phone, Wireless

**Appendix Table 1. Crunchbase Business Categories (cont.)**

Music and Audio	Audio, Audiobooks, Independent Music, Internet Radio, Music, Music Education, Music Label, Music Streaming, Musical Instruments, Podcast
Natural Resources	Biofuel, Biomass Energy, Fossil Fuels, Mineral, Mining, Mining Technology, Natural Resources, Oil and Gas, Precious Metals, Solar, Timber, Water, Wind Energy
Navigation and Mapping	Geospatial, GPS, Indoor Positioning, Location Based Services, Mapping Services, Navigation
Other	Alumni, Association, B2B, B2C, Blockchain, Charity, Collaboration, Collaborative Consumption, Commercial, Consumer, Crowdsourcing, Customer Service, Desktop Apps, Emerging Markets, Enterprise, Ethereum, Franchise, Freemium, Generation Y, Generation Z, Homeless Shelter, Infrastructure, Knowledge Management, LGBT Millennials, Non Profit, Peer to Peer, Professional Services, Project Management, Real Time, Retirement, Service Industry, Sharing Economy, Small and Medium Businesses, Social Bookmarking, Social Impact, Subscription Service, Technical Support, Underserved Children, Universities
Payments	Billing, Bitcoin, Credit Cards, Cryptocurrency, Debit Cards, Fraud Detection, Mobile Payments, Payments, Transaction Processing, Virtual Currency
Platforms	Android, Facebook, Google, Google Glass, iOS, Linux, macOS, Nintendo, Operating Systems, Playstation, Roku, Tizen, Twitter, WebOS, Windows, Windows Phone, Xbox
Privacy and Security	Cloud Security, Corrections Facilities, Cyber Security, DRM, E-Signature, Fraud Detection, Homeland Security, Identity Management, Intrusion Detection, Law Enforcement, Network Security, Penetration Testing, Physical Security, Privacy, Security
Professional Services	Accounting, Business Development, Career Planning, Compliance, Consulting, Customer Service, Employment, Environmental Consulting, Field Support, Freelance, Intellectual Property, Innovation Management, Legal, Legal Tech, Management Consulting, Outsourcing, Professional Networking, Quality Assurance, Recruiting, Risk Management, Social Recruiting, Translation Service
Real Estate	Architecture, Building Maintenance, Building Material, Commercial Real Estate, Construction, Coworking, Facility Management, Fast-Moving Consumer Goods, Green Building, Home and Garden, Home Decor, Home Improvement, Home Renovation, Home Services, Interior Design, Janitorial Service, Landscaping, Property Development, Property Management, Real Estate, Real Estate Investment, Rental Property, Residential, Self-Storage, Smart Building, Smart Cities, Smart Home, Timeshare, Vacation Rental



**Appendix Table 1. Crunchbase Business Categories (cont.)**

Sales and Marketing	Advertising, Affiliate Marketing, App Discovery, App Marketing, Brand Marketing, Cause Marketing, Content Marketing, CRM, Digital Marketing, Digital Signage, Direct Marketing, Direct Sales, Email Marketing, Lead Generation, Lead Management, Local, Local Advertising, Local Business, Loyalty Programs, Marketing, Marketing Automation, Mobile Advertising, Multi-level Marketing, Outdoor Advertising, Personal Branding, Public Relations, Sales, Sales Automation, SEM, SEO, Social CRM, Social Media Advertising, Social Media Management, Social Media Marketing, Sponsorship, Video Advertising
Science and Engineering	Advanced Materials, Aerospace, Artificial Intelligence, Bioinformatics, Biometrics, Biopharma, Biotechnology, Chemical, Chemical Engineering, Civil Engineering, Embedded Systems, Environmental Engineering, Human Computer Interaction, Industrial Automation, Industrial Engineering, Intelligent Systems, Laser, Life Science, Marine Technology, Mechanical Engineering, Nanotechnology, Neuroscience, Nuclear, Quantum Computing, Robotics, Semiconductor, Software Engineering, STEM Education
Software	3D Technology, Android, App Discovery, Application Performance Management, Apps, Artificial Intelligence, Augmented Reality, Billing, Bitcoin, Browser Extensions, CAD, Cloud Computing, Cloud Management, CMS, Computer Vision, Consumer Applications, Consumer Software, Contact Management, CRM, Cryptocurrency, Data Center Automation, Data Integration, Data Storage, Data Visualization, Database, Developer APIs, Developer Platform, Developer Tools, Document Management, Drone Management, E-Learning, EdTech, Electronic Design Automation (EDA), Embedded Software, Embedded Systems, Enterprise Applications, Enterprise Resource Planning (ERP), Enterprise Software, Facial Recognition, File Sharing, IaaS, Image Recognition, iOS, Linux, Machine Learning, macOS, Marketing Automation, Meeting Software, Mobile Apps, Mobile Payments, MOOC, Natural Language Processing, Open Source, Operating Systems, PaaS, Predictive Analytics, Presentation Software, Presentations, Private Cloud, Productivity Tools, QR Codes, Reading Apps, Retail Technology, Robotics, SaaS, Sales Automation, Scheduling, Sex Tech, Simulation, SNS, Social CRM, Software, Software Engineering, Speech Recognition, Task Management, Text Analytics, Transaction Processing, Video Conferencing, Virtual Assistant, Virtual Currency, Virtual Desktop, Virtual Goods, Virtual Reality, Virtual World, Virtualization, Web Apps, Web Browsers, Web Development

**Appendix Table 1. Crunchbase Business Categories (cont.)**

Sports	American Football, Baseball, Basketball, Boating, Cricket, Cycling, Diving, eSports, Fantasy Sports, Fitness, Golf, Hockey, Hunting, Outdoors, Racing, Recreation, Rugby, Sailing, Skiing, Soccer, Sporting Goods, Sports, Surfing, Swimming, Table Tennis, Tennis, Ultimate Frisbee, Volley Ball
Sustainability	Biofuel, Biomass Energy, Clean Energy, CleanTech, Energy Efficiency, Environmental Engineering, Green Building, Green Consumer Goods, GreenTech, Natural Resources, Organic, Pollution Control, Recycling, Renewable Energy, Solar, Sustainability, Waste Management, Water Purification, Wind Energy
Transportation	Air Transportation, Automotive, Autonomous Vehicles, Car Sharing, Courier Service, Delivery Service, Electric Vehicle, Ferry Service, Fleet Management, Food Delivery, Freight Service, Last Mile Transportation, Limousine Service, Logistics, Marine Transportation, Parking, Ports and Harbors, Procurement, Public Transportation, Railroad, Recreational Vehicles, Ride Sharing, Same Day Delivery, Shipping, Shipping Broker, Space Travel, Supply Chain Management, Taxi Service, Transportation, Warehousing, Water Transportation
Travel and Tourism	Adventure Travel, Amusement Park and Arcade, Business Travel, Casino, Hospitality, Hotel, Museums and Historical Sites, Parks, Resorts, Timeshare, Tour Operator, Tourism, Travel, Travel Accommodations, Travel Agency, Vacation Rental
Video	Animation, Broadcasting, Film, Film Distribution, Film Production, Motion Capture, TV, TV Production, Video, Video Editing, Video on Demand, Video Streaming

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