

ECONOMICS OF THE INTERNET AND MOBILE COMPUTING[‡]

Mobile Computing: The Next Platform Rivalry[†]

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All modern information and communications technology (ICT) industries use the platform organization. A platform is a reconfigurable base of compatible components on which firms and users build applications. Applications share the general purpose components, thereby exploiting increasing returns at an industrywide level (Bresnahan and Trajtenberg 1995).

Platforms sometimes compete for developers, who create applications which make the platform valuable for users. We consider such competition in mobile computing. Different mobile platforms are supplied by firms such as Microsoft, Google, Apple, Nokia, and Research in Motion, who employ different approaches. The approaches vary in the use of *hierarchy*, which frames a seemingly simple question: why doesn't one form of platform governance emerge as superior, dominating most markets in which platforms play an essential role?

This essay will stress the reasons for differentiation and proposes a new argument. A platform's hierarchy can help at one moment but then get in the way at a later time. Hierarchical organization helps coordinate supply and the invention of complements, avoids postinvention holdup through contracting and other forms of

commitment, and helps balance the interests of users and developers. However, hierarchy comes with drawbacks as well. It can limit the scope of developer innovation, reduce the breadth of experimentation, and make a platform inflexible in response to new market circumstances in a sense we will describe.

I. Options for Platform Governance

Industry figures describe governance as "open" and "proprietary" to different degrees. We eschew these labels. We stress the hierarchy of the platform.

At one extreme is an entirely hierarchical platform. Not just a theoretical ideal, this was used by IBM at the beginning of its period of dominance and by many telephone companies through the period of providing voice services and into the early period of data service provision. In this structure all general purpose components are provided by the platform leader, and all but one firm are customers.

Slightly weaker coordination arises with explicit contracts among suppliers of a platform's general components. This is the governance structure of the Windows platform since 1995. While Windows PCs involve supply of general purpose components by firms other than Microsoft, those firms, such as manufacturers of PCs, contract with a dominant firm which controls the platform. The Windows structure also uses contracts with software developers who build applications.¹

A related form of governance employs implicit contracts between platform sponsors

¹ The platform mixes vertical integration and contracts. Vertical integration is present: Microsoft makes Office, for example. Hundreds of firms also work under the contractual obligations and restrictions of software development kits (SDKs) and related developer support systems.

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and applications developers. This is the form most studied in the two-sided market literature (Rysman 2009). The platform sponsor sets contract features, and these induce supply of applications products. The most studied problem is the pricing of applications products, but a few papers (Tirole and Weyl 2010) also take up invention of new applications in response to the reward terms set by the platform sponsor.

This is the structure of Apple's mobile platform. The firm is vertically integrated into all the general purpose technical components (iPhone, iPad, iOS operating system, and so on) and controls the only distribution channel for apps and content, the iTunes store.² For an application, game, or content developer, access to the distribution channel raises the value of invention. That gives Apple negotiating leverage, for example, requiring specific conduct of developers.

There can be a dominant platform but nonhierarchical organization through *divided technical leadership*. This was observed at the beginning of the PC industry. A number of different firms supplied platform technologies, and no firm could block the widespread distribution of platform improvements, not even IBM in the days of the "IBM PC" (Bresnahan and Greenstein 1999).

In mobile platforms we observe a limited form of divided technical leadership, in which one firm continues to be the platform sponsor but cannot fully control influential applications developers. Consider the tensions between Apple and Google over the use of Maps in the iPhone. Apple could contract for use of Map, but Google and Apple could not reach agreement on how to contract for all aspects, particularly at intermediate stages of invention involving recombination of multiple inputs. Google had a direct connection to customers, reducing Apple's negotiating leverage.

Why does this matter? For the private returns to a platform sponsor, divided technical leadership may interfere with creating and capturing value from improvements. From a social returns perspective, divided technical leadership may

lead to future competition for the market in control of the platform.

Now consider a nonhierarchical platform. In every important historical example, such a platform lacks a profit-oriented platform sponsor. There can still be a governance structure. On the nonhierarchical WWW platform, the Internet Engineering Task Force (IETF) and World Wide Web Consortium (W3C) play this role. These organizations exert little control over suppliers. All participants have access to platform information, and firms use the technology as they please. The result is, as a Microsoft employee put it with a mixture of envy and fear, "a platform that nobody controls and anybody can enhance." This is as far from a hierarchical governance design as feasible.³

II. Governance Goals

We principally focus on two aspects of performance, coordination and exploration.

Since both applications and platform (general purpose) components are needed, a platform industry has a need for *coordination* of supply. Coordination of invention is also useful for a new platform with new applications and/or many new general purpose components, and often for later improvements.

Incomplete information about the best technologies and/or most important markets calls for *exploration*. Exploration aims to find improved technologies, "business models," and volumes of demand to support both platform and applications. For new platform industries this usually takes place in a highly contingent market-oriented setting, involving multiple potential directions.

At an industrywide level a single platform cannot simultaneously achieve both maximal coordination and exploration. Exploration calls for a wide range of initiatives, diverse in technology, cost, and services. Coordination, by its very nature, calls for some narrowing of that range. The need for coordination makes wide exploration hard to achieve, and vice versa, and that defines a tradeoff.

² Even this is a mixed control structure. Apple contracts with a large variety of mobile service providers, such as AT&T or Verizon, in much the same way as Microsoft contracts with PC manufacturers. So some general purpose components are coordinated by contract.

³ There is some variance within the structure of open source groups in policies for participation and for the decision rights. We leave a full discussion of this variance to aficionados of open source.

Two mainstream economic approaches resolve the tradeoff, but they are not perfect. One solution fixes the design of platform components and leaves all the exploration to applications. The other solution has competition between platforms, each one coordinating platform components with applications, in a (potentially differentiated) standards race. Neither of these works well if there is a single established platform with inertia around a less than optimal technology.

The tradeoffs between coordination and exploration emerge in two types of market settings, greenfield and renewal markets. Greenfield markets involve no strong established platform. These are rare in ICT industries. The question of renewal of exploration, coordination, and market selection arises more frequently. Renewal becomes possible when new technology, information, and learning alter the potential value of different choices.

Renewal subgoals include backward compatibility and breakthroughs. Achieving backward compatibility is costly, technically challenging in many contexts, and technically restrictive of frontier aspirations. Achieving breakthroughs is also challenging, requiring new combinations of pioneering operations and pioneering designs. Achieving compatibility and breakthroughs at the frontier can and do come into direct conflict.

That conflict creates tradeoffs, which begins to explain why differentiation plays a role. For example, a need for renewal can increase the value of platforms that support breakthroughs through exploration, but at other times coordination of compatibility may be valuable.

III. Benefits and Costs of Hierarchy

More hierarchical systems increase the degree of coordination, while less hierarchical systems increase the extent of exploration. A hierarchical platform will typically involve intertemporal contracts and commitments, and thus cannot change quickly; changing market needs for coordination versus exploration will often best be addressed through differentiated platform competition.

Hierarchy and contracting can help with coordination. This is a familiar argument: hierarchical platforms can coordinate the supply of complements (e.g., applications and general

purpose components), raising the returns to services in which users employ both. Intertemporal contracts and commitment support coordination by providing ex ante incentives to invest in invention and ensuring that there will not be ex post opportunistic problems. When there are thousands of applications developers and a single provider of general purpose components, it is easy to see the point of the “two-sided markets” literature, that hierarchical control can provide efficient incentives for such difficult coordination problems as platform balancing.

Why doesn't hierarchical governance always dominate? As already noted, a renewal opportunity can catalyze a new race to establish a new platform (and platform sponsor). This may be socially optimal, and at the same time problematic from the private perspective of the existing dominant firm.

Why problematic? To the familiar list, we add a few that are idiosyncratic to platforms. There is an element of inertia around a successful platform. Inertia is great for incumbents as long as it lasts, but the build-up of technological and market opportunity that happens outside a given platform means that a renewal opportunity, when it finally arrives, will have radical efforts by competitors and can entail the need for radical response.

Second, a hierarchical governance structure itself can create difficulties if there are elements of commitment. Coordination of innovation and product design is costly; a profit maximizing platform sponsor will face limits on how many designs it will support. These limits are sharper if applications developers will sink costs only into platform designs to which the platform sponsor is committed, or if progress has assumed a routine pattern, as it did during the era when Moore's Law in microprocessors paced complementary innovation in PCs.

Coordinating on only a few options—or even one—is not problematic when the direction of technical progress is largely known or routinized. However, renewal requires guesses about which technologies will best serve future customers (e.g., in markets that will open after the renewal), raising risks of coordinating on providing a service with limited demand. The incumbent platform sponsor has an incentive to “experiment” with compatible extensions to the existing general purpose components. This may prove too narrow a range of experiments.

Exploration in nonhierarchical structures also contains an advantage over hierarchical structures: fewer contracts to encumber developers. This can have considerable appeal to developers who want to explore new ways to generate value. While new to platform economics, the idea that market supply can sometimes be better than hierarchy is familiar in the theory of the firm (Williamson 1975; Gibbons 2005). We say more below.

As illustration, consider what happened to Research in Motion (RIM) as a renewal opportunity emerged in smartphones. RIM made Blackberry, and it had become the dominant mobile platform for enterprise customers. Apple emerged with a platform that appealed to consumers. This was a renewal opportunity, with the overall market for smartphones about to grow significantly. Blackberry ultimately fell to the position of being a very small platform in a large market.

That outcome was not inevitable. In the short run, enterprise smartphones were highly differentiated from consumer smartphones, and the tip away from Blackberry was far enough in the future to permit taking up, rather than being swamped by, the new market conditions. Indeed, the firm offered new kinds of phones and services and opened an app store. Users showed interest.

The many differences between a consumer smartphone and an enterprise smartphone did frame a challenge for RIM.⁴ We do not want to diminish those challenges, but we want to stress that they were not technically insurmountable. RIM did not lack executive talent with experience in the market. No issues about costs of components or shortages of inputs played any significant role in market events. *De novo* entrants were able to take them up.

Governance did play a role. RIM had taken explicit and implicit contractual approaches to managing its partnerships with developers and other business partners. As part of a

competitive response, RIM had to move away from the commitments that had served it in the past in order to attract developers of the new, consumer oriented apps. RIM's reputation for, and commitment to, supporting enterprise technologies made the move to new consumer technologies hard for RIM and for its cluster of developers. Such a reputation is a recipe for diseconomies of scope between the old, enterprise business one, and the new consumer one; in the language of Bresnahan, Greenstein, and Henderson (2012), the reputation is a "necessarily shared asset."

This example also illustrates the general argument, that a renewed round of exploration of platform technologies by a wide variety of potential platform sponsors is undesirable to the existing platform sponsor. Renewal raises the possibility of removal, i.e., competition for the position of platform leader.

IV. Frictions

Which transaction costs are most related to platform governance? We focus on factors that developers regard as frictions.

Uncertainty about the value of new apps may limit the ability of established platform sponsors to contract efficiently over time. Initial platform design may involve technical decisions (the application programming interfaces, the SDKs), governance decisions (the boundaries between components and real-time support), and shared assets (e.g., maps, fields for data input-output). If those plans aim in the direction that turns out to have less value to developers, then commitment raises difficulties marching back to square one.

Further, intertemporal contracting cannot necessarily take care of a platform design and governance arrangement that has lost its optimality. One might think that suppliers of complements need to write intertemporal contracts in order to invest in innovation because, post investment, there could be many holdup problems, including double marginalization in pricing. If a contract protects platform sponsor, developers worry that leaders will add new frictions later.

Renewal opportunities arise when there is fundamental new information; thus, no contract can prevent multiple holdup episodes across multiple rounds of renewal. That interferes with valuable incentives for application developers at early stages.

⁴ The Blackberry was far away from the features of the Apple iPhone in a variety of features: from keyboard to touch keying; from small screen to big color; from minimizing bandwidth to allowing high bandwidth applications; from minimal web presence to high web support; from data-center to cloud-based support; from deep carrier cooperation to tension with carriers; from protected e-mail to data plan for surfing. See Steve Sinofsky, <http://blog.learningbyshipping.com/2013/10/03/disruption-and-woulda-coulda-shoulda/>.

When there are a very large number of applications, of which only a few may be very valuable, it may be in the platform leader's interest to take control over the value of successful inventions *ex post*. This gives potential app developers an Arrow problem. If they must contract with platform sponsor to enter, then they have disadvantaged themselves for the later stage at which their invention competes against the incumbent's imitation. This can impact developer incentives, especially when the platform leader has the ability to be a "strong second."

Hierarchy has another drawback that economics has long stressed in other contexts: platform sponsors are loath to cannibalize their own services and revenues, or contractually allow permit complementors to threaten them. As illustration, Apple has made it easy to support its music services and requires use of iTunes. Android encourages use of the Google search engine and Google Maps. Neither has precluded users from going to web pages through a browser, but apps use less data and load more quickly, so the defaults have powerful positions in user experience, and developers and carriers respond in kind.

What was the role for differentiated platform governance? Apple entered with a user-friendly platform, one that was backward compatible with its music services on iTunes. Hierarchy reserved many rights for Apple and pushed costs on to developers and content providers. Developers overtly complained on many websites about the control Apple retained. No developer can distribute iPhone or iPad apps without agreeing to revenue sharing with Apple. Apple has an approval process for all apps. From Apple's perspective, this is part of a platform-balancing strategy, tilting to the consumer/user with a platformwide promise of quality and safety. From a developer perspective, these are hierarchical frictions.

In contrast to first-mover Apple, Google entered with a very different platform strategy—platform differentiation at work in an entrant's strategy and in competition. The Android platform is, first off, governed in a nonhierarchical way. Google maintains neither control of information about Android nor control of distribution of apps. The lack of control of information has led to some coordination failures and fragmentation, as different hardware vendors have created different, sometimes

incompatible, devices.⁵ On the other hand, it has allowed a customization of hardware and software by complementors. Some of this has had tremendous market success (the Amazon Kindle, for example, is an Android device, and is so differentiated in software and distribution as almost to represent a second platform.) While most Android apps are distributed through a Google online store, the platform sponsor allows any application to sell anywhere, speeding time-to-market for developers. More importantly, it leaves Google committed to a strategy of not exploiting developers.

The elements of platform differentiation are several. Google first invested in Android and then purchased it in 2005 with both defensive and offensive motives related to Microsoft's and Apple's actions, releasing first designs more than a year after Apple's first iPhone release in June 2007. As it has turned out, events suggest both fast entry and the right choices over dimensions of platform differentiation were important. Delay would have provided a longer opportunity to Apple, with the potential to gain such positive feedback that potentially no second entrant could succeed against. Delay would also have reduced the likelihood for success in competition with new potential entrants, or with renewed mobile platforms from established firms such as Nokia, RIM, or Microsoft.

IV. Open Questions

The tradeoff between coordination and exploration in platform industries, especially renewed coordination or renewed exploration, turns on the platform governance structure. In the mobile computing arena, we have shown how use of a hierarchical governance structure impeded Blackberry's response to a renewal opportunity, and how a market governance structure provided valuable product differentiation for entrant Android competing against the hierarchical Apple governance structure. Those examples leave open the question of either socially



⁵ Some fragmentation is avoided through Google's use of a Compatibility Definition Document for smartphone services (geolocation, voice recognition, barcodes, etc.). It makes sure that all Android phones with a particular version of the OS can run all Android applications for that OS. This action puts Google in the role as "champion" for Android. See Shapiro and Varian (1998).

or privately optimal governance structures. The Blackberry example shows how hierarchical control can sow the seeds of later competitive destruction; but renewal opportunities are rare, and the resulting differentiated competition is not costless nor quick. The current platform race shows the potential benefits of differentiation in governance structures, but we would speculate that the incentives to differentiate along these lines need not align with those benefits.

REFERENCES

- Bresnahan, Timothy F., and Shane Greenstein.** 1999. "Technological Competition and the Structure of the Computer Industry." *Journal of Industrial Economics* 47 (1): 1–40.
- Bresnahan, Timothy, Shane Greenstein, and Rebecca M. Henderson.** 2012. "Schumpeterian Competition and Diseconomies of Scope: Illustrations from the Histories of Microsoft and IBM." In *The Rate and Direction of Inventive Activity Revisited*, edited by Josh Lerner and Scott Stern, 203–71. Chicago: University of Chicago Press.
- Bresnahan, Timothy F., and M. Trajtenberg.** 1995. "General Purpose Technologies: 'Engines of Growth'?" *Journal of Econometrics* 65 (1): 83–108.
- Gibbons, Robert.** 2005. "Incentives Between Firms (and Within)." *Management Science* 51 (1): 2–17.
- Rysman, Marc.** 2009. "The Economics of Two-Sided Markets." *Journal of Economic Perspectives* 23 (3): 125–43.
- Shapiro, Carl, and Hal R. Varian.** 1998. *Information Rules: A Strategic Guide to the Network Economy*. Boston: Harvard Business School Press.
- Slivka, Ben.** 1995. "The Web is the Next Platform." Microsoft internal memo, GX 1016. AQ 2
- Tirole, Jean, and Glen Weyl.** 2010. "Materialistic Genius and Market Power: Uncovering the Best Innovations." Institut d'Économie Industrielle Toulouse Working Paper 629.
- Williamson, Oliver E.** 1975. *Markets and Hierarchies: Analysis and Antitrust Implications*. New York: Free Press.

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