# The Lexicon of Network Economics in Evolving Markets: An Applied Guide

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## Abstract

What are the defining approaches, insights, and canonical examples in new economics of networks and platforms in fact moving markets? This essay identifies many of the key concepts in the new economics of networks using intuitive illustrations. It highlights the array of distinctly different economic frameworks that arise under ostensibly the same rubric. The extension of the new economics of networks and platforms to a broad class of issues highlights the tight links between the analysis of competition and the analysis of different governance regimes for platforms. Understanding those links is of first-order importance to this agenda.

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## *1. An Introduction to the Lexicon*

Economics rarely improves with reference to etymology, but an exception should be made for the economics of networks. Many valid but distinct definitions of "network economics" compete for attention. That causes confusion in academic writing and in public discourse. This essay seeks to clear up this confusion by defining the approaches, insights and canonical examples in the new economics of networking and platforms. In so doing the essay also stresses the analysis of the governance of platforms. Understanding the links between platform competition and governance is of first-order importance to this agenda.

There are many symptoms of this confusion in policy analysis. Consider this infamous example. The late Senator Ted Stevens inarticulately referred to the Internet as a "series of tubes." It earned him ridicule from many online commentators. Especially to many online youngsters it was unthinkable that the ranking Senator on the committee for regulating Internet commerce conflated the physical network – local area networks, backbone lines, access lines – with its applications – email, web surfing, and electronic commerce.[2]

To be fair to Senator Stevens, however, this conflation arose for rather understandable reasons. Stevens borrowed from common public discourse, which intermingles four distinct economic meanings for the term "network" without making due distinction. Said another way, Stevens used a habit of mind common in monopoly provision of local electricity and telephony. It came into conflict with another and newer habit of mind, one that lives online. Only recently have these twains begun to meet.

To appreciate the conflation, take each definition separately. Consider first the most traditional meaning of networks, the one that arises in regulatory economics for utilities. Three decades ago economic canon stated that the biggest networks in the industrialized world – the telephone, electrical, and gas pipeline networks – shared similar economic determinants. Operators of the networks incurred high fixed costs from large capital expenditures. Delivering services to homes and businesses fostered monopoly provision, ostensibly to save on the

[2] The excerpt about the series of tubes first came to the attention of Ryan Singel, when it appeared in this rambling soliloquy by Stevens: "They want to deliver vast amounts of information over the internet. And again, the internet is not something you just dump something on. It's not a truck. It's a series of tubes. And if you don't understand those tubes can be filled and if they are filled, when you put your message in, it gets in line and its going to be delayed by anyone that puts into that tube enormous amounts of material, enormous amounts of material." For a longer explanation, see Ryan Singel, *Wired* magazine blog *27B Stroke 6* "Your own Personal Internet," http://www.wired.com/threatlevel/2006/06/your_own_person/. Accessed September, 2011. As is well known, many commentators began commenting on Singel's article, and, thereafter, ridicule of the phrase exploded across the Web.

redundant costs of providing access. This was such an accepted idea that undergraduate textbooks characterized the canon without controversy, labeling it a "natural monopoly."

The economics profession largely reserved its disagreeableness for policy debates about introducing competitive elements into these networks. Local, state and federal regulators intervened in the operations of most utilities, implementing mandates governing various aspects of quality and pricing to end users. Regulators also implemented interconnection agreements between networks, and between competitors and network operators with vertical control over key facilities. Vigorous academic debates considered the myriad approaches to such mandates. Since these were considered to be open ended questions, textbooks characterized the fissures of these debates rather than resolving them.

Change came to the canon in several different guises, and initially did not appear to represent a large departure. One change came in the guise of new network engineering. Computing network engineers began to hypothesize that industry wide scale economies could arise from sharing expensive immobile or rare resources. In the 1970s experiments with "inter-networking" between computing systems – what we today call the Internet – began to bear fruit. These experiments eliminated redundancies, permitting data shared in one location to travel to many users in distinct locations.[3]

Among the many accomplishments of these networking experiments, these data systems also fostered new applications built around transferring files, and built around new modes of communication. To make a (very) long story short, today we recognize these applications in a variety of forms, as electronic mail, text messaging, Web browsing, peer-to-peer, media-streaming, and cloud computing. The economics of data-sharing plays a variety of different roles in all of these services. More to the point, in common speech many engineers will call the economics of data sharing the economics of networking, and without hesitance.

Another meaning for network arose at about the same time, motivated by the confluence of some unlikely market bedfellows. The markets for personal computers, the VCR, high-fidelity stereo systems, and costumer premise telephone equipment all began to grow in the 1970s and 80s, and all seemed to share similar economic traits. In each case users employed a system of components. The components were complements in demand, but the same firm did not necessarily supply the entire system or the package purchased by the user. Instead, (speaking loosely) multiple firms used similar technical standards to make their components work together, with users choosing among many options.

[3] Creating a technology that eliminated such redundancies was one of several key motivations for DARPA to fund the initial experiments that led to the Internet, as it was for the NSF to continue sponsoring its development. For example, there is considerable military value in keeping data stored in a safe place, but accessible by commanders in dangerous locations. See, e.g., Abbate (1999).

These situations supported another meaning for network, where "networks" refer to a group of suppliers whose economic fortunes are linked to one another, both as complements (to supply a service) and as competitors (for the same demand). This meaning stuck in common discourse. It is still quite common today for analysts to refer to a network of suppliers, where these suppliers provide complementary and competing components.

Motivated by similar and related examples, a fourth and additional meaning of network emerged among academic economists around the same time, and has persisted to the present. This meaning stressed the role of network effects. A network effect arises when the value to an individual from using a service rises with increasing participation by others. One source of network effect is a demand-side positive externality, as when a new product or service becomes more valuable as the number of users grow, and adoption of one user is independent of another. These externalities were hypothesized to be common in communications services, with the failure of AT&T's video phone service in the 1970s initially being the most cited example in academic discourse.[4]

Many other examples eventually took center stage in the large literature on network effects, well beyond the video phone. The modern Internet appears to be chock full of them. For example, instant messaging networks invariably require users to all employ the same software to communicate, exhibiting characteristics of network effects, because the value of the software to existing users grows with each new adopter. For many of the same reasons, it is common to assert, somewhat casually, that Skype, the popular modern video phone service, illustrates a network effect. Similar observations are also made about modern social networking sites, such as Facebook and LinkedIn.[5]

Why does confusion arise in common discourse, therefore? Simply stated, many of the markets in which network effects arise are also the markets in which the other meanings of network also arise. A non-expert could be excused for not being able to keep these meanings straight, for giving up altogether, or, at least not knowing where to start.

[4] AT&T's service in the early 1970s was a large scale and widely publicized failure, and generated almost no adoption. Examining the failure at the time, economist Jeffrey Rohlfs asserted that the value of the communication network was rising in participation. From this Rohlfs inferred that it had to clear a "minimal size" to create enough value to users to overcome the user-costs of adoption. A full recounting is in Rohlfs (2001).

[5] Within academic studies and in business development, social networking refers to services that explicitly build on the social relationships among friends, often using the social graph of weak and strong ties to shape the design of services. The phrase "social networking" avoids the aforementioned confusion by always modifying "networks" with the phrase "social" in front. Until recently, the academic literature about social networking analyzes technology adoption in quite a different way than the economics literature on network effects, differing in their treatment of causality and heterogeneity in network effects. For attempts to bridge these gaps, see, e.g., Jackson and Rogers (2007) or Tucker (2008).

Indeed, the confusion is most pronounced in the area in which Senator Stevens made his statement, the modern commercial Internet. In the Internet today a network of suppliers – i.e., in the sense of complementary and competing component providers – make a system available to users. Some of this activity uses components from telephone firms, including their network trunk lines (which are easily compared to pipe), and parts of these operations must conform to regulatory mandates about interconnection. Many of the commercial Internet's most widely used applications operate on this network – electronic mail, instant messaging and social networking – and have been adopted by users who communicate with others, giving rise to a network effect.

This essay aims to go further and argues that a deeper problem causes the confusion, and the fault lies with the new economics of networks and platforms. The new literature builds on a number of examples where standards and interoperability play an important role. However, network effects also play a prominent role in analysis of payment networks, such as credit and debit card transactions, as well as in the analysis of liquidity within financial exchanges and trading networks, such as EBay. It is quite common to assert that the presence of network effects in all these situations leads to similar economic analysis. In fact, the latter examples have rather different governance arrangements, and the applications of concepts differ as a result.

This essay seeks to directly address this confusion by examining the lexicon of networking in the analysis of standards and interoperability. That will highlight the distinct issues that arise at the earliest moments of a platform and during an upgrade to an existing platform. It stresses the governance arrangements for participants in such platforms. That will also generate implications for the limitations of these insights.

The next section discusses the role of multisided platforms. The subsequent section discusses the sponsorship of platforms and the role of sponsors. Section four examines the importance of coordination and learning, which introduces some policy tradeoffs. Section five continues the focus on factors essential to analyze network evolution. Section six reviews experimentation in platforms, and it explains a few conceptual shortcuts typically used by market participants. The last section summarizes the large policy themes of the essay.

## *2. Multisided Platforms*

A good place to start is with *platforms.* A platform in computing is a reconfigurable base of compatible components on which users build applications. Platforms serve an important economic function, as intermediary between groups with different interests.[6]

[6] There are a variety of perspectives and approaches for analyzing the economics of platforms, each stressing different aspects, each stressing strategic, economic or policy insights. See, e.g., Bresnahan and Greenstein (1999),

For many decades within computing, platforms were most readily identified with their technical standards, i.e., engineering specifications for compatible hardware and software.[7] There are many famous platforms in history, such as the IBM System 360/370, the PC, and the DEC minicomputer. There are many today, such as the Oracle database community, the iPod/iTunes platform, the Facebook service, Android platforms, and so on.

Economic analysis labels a platform *multisided* when it possesses different features designed to meet the diverse needs of groups of participants, where each group has a different identity. The identity may be as developer, user, advertiser, and intellectual-property holder. Participants with distinct identities have different motives for participating in activities related to the platform. Thus, the modern economics of platforms associates an important economic function with accommodating so many participants, serving as an intermediary between participants.

A classic historical example of a platform sponsor in an information market was a local metropolitan newspaper. Readers are attracted by news or entertainment but find most advertising unpleasant. Advertisers pay newspapers for the rights to insert their ads, and newspapers subsidize readership to attract the readers, who advertisers want to reach, usually charging far less for a reader than the average cost of the newspaper.[8] Notice that this classic example often does not address questions about how the newspaper came to be a provider in the first place (how it out-competed others, for example), which is a limitation that arises again and again.

In many contexts a multisided platform facilitates interoperability, enabling component parts of a system to operate successfully together. One canonical example of a platform involving interoperability is a grocery store scanner and bar-code network.[9] This network is comprised of a diverse group of participants – equipment makers of scanners and registers, goods manufacturers who embed bar codes on their packages, software firms who enable firms

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Shapiro and Varian (1999), Spulber (1999), Cusamano and Gawer (2002), Evans, Hagiu and Schmalensee (2006), Farrell and Klemperer (2007), Gawer and Henderson (2007), or Gawer (2009).

[7] Bresnahan and Greenstein (1999).

[8] While that standard case seems straightforward, it is worth noting the importance of the assumption that users find displeasure in ads. If, on the other hand, users desire to see classified ads, then the optimal economic subsidy can change. One arrangement is to give away the newspaper for free (in a free weekly, say), while charging for listing a classified ad. Another arrangement is to charge nothing to list an ad (in a man-woman matching network), but charge for access to the entire set of ads.

[9] See Brown (1997) and Basker (2011).

to keep inventory, and grocery retailers and checkers who operate the equipment and manage inventory.[10]

A common economic function for interoperability is to support mix-and-match possibilities for users of systems of components. A modern example is the interoperability built around IEEE standard 802.11, aka Wi-Fi. All computing and antennae equipment makers and all hot-spots services employ the same interoperability standards, designed by IEEE committee 802.11, so all components work with one another, often seamlessly, though they come from many sources.[11] Thus, users can mix different handsets (laptops, smartphones) with different antennae from different manufacturers, which also facilitate choices over a variety of distinct locations for hot-spots. The Institute for Electrical and Electronics Engineers (IEEE) possesses no legal right to compel any market participant to use its designs, but participants voluntarily do so for a variety of reasons, a topic that arises again below.

These situations appear to bear resemblance to the compatibility between bank cards and ATMs in various locations, which is another example that is often raised in the context of discussions about interoperability.[12] Note a key feature of the latter: interchange fees (between networks and ATMs) and usage fees (from banks) shape the costs of mixing and matching, and networks effectively remain incompatible without pricing arrangements. In short, universal compatibility is not necessarily an unalloyed benefit for all market participants. There is a trade-off between incompatibility (between networks) and the incentives to alter product attributes (for a network with higher fees). For example, the latter actually might benefit consumers, such as when it results in greater deployment.

The economic trade-offs in these situations are, therefore, not directly comparable. Interoperable designs, such as Wi-Fi, raise different issues than interoperability networks with ongoing operations and pricing for transactions, such as found in ATM networks. The governance and regulatory issues in such networks are, in fact, rather different, and the concepts used to describe payment networks do not carry over to the governance of interoperability designs.[13]

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[10] Another canonical example that arose with the grocery scanner and bar code has long since passed into history. This was the emergence of the platform that involved the VCR hardware, VCR rental store, and movie studio. As is well known, two distinct designs fought to be at the center of these platforms, the Betamax and VHS standards. The latter eventually succeeded, and it is widely believed that network effects had much to do with its success.

[11] Working together "seamlessly" should not be taken for granted. A design by itself is usually insufficient. For example, in Wi-Fi's case a private consortium, the Wi-fi alliance, performs conformance testing, and it is funded by private firms, such as Intel.

[12] See, e.g., Knittle and Stango (2008, 2009).

[13] Payment networks, such as debit cards, give rise to many related issues of this form. See, e.g., Rysman (2011) for analysis.

That is not fully apparent without understanding governance. Because platforms serve an important economic function as intermediary, it is worthwhile to understand the structure of platform governance that shapes the type of intermediary functions performed.

## 3. *Platform Governance*

In a platform oriented towards standards and interoperable designs a platform *sponsor* is the firm or organization who takes responsibility for managing the mediation between the various participants in a platform. It is quite easy to misunderstand platform sponsorship, and this confusion leads to misunderstanding about platform governance.

Many firms today aspire to take on the role of sponsor. In more modern times the role of sponsor has been affiliated with a firm that has taken technical leadership, and translated that into an economic role. The technical role normally involves a broad array of activities: sponsors design the platform, coordinate development, and upgrade the platform. Due to the resource requirements affiliated with such technical activity, as well as for other reasons discussed below, usually a large firm takes on this role, not a small firm, nor new entrant.

A modern example of a sponsored platform arises in the search-engine market married to keyword search based advertising. Today this business is dominated by Google, who is, in fact, one of those unusual entrants who succeeded at a young age (the firm was founded in 1998). It developed a very fast and relevant search technology. Google charges nothing for use of its search engine (far less than its average cost), but charges advertisers for the right to show their ads next to user searches. Advertisers bid for the right to show ads next to a user's keywords.

Google is far from the only firm today that seeks to play the role of platform sponsor. Firms such as Apple, Microsoft, Google, IBM, and Oracle have aspired to play this role by designing the computer hardware and/or software that mediates activities among many participants. Speaking more precisely, in a typical interoperability platform, a sponsor performs four functions:

- Designing a standard bundle of technical implementations that others used in their application;
- Operating processes to alter those standards and inform others about the alteration;
- Establishing targets and roadmaps to coordinate developer and user investment;
- Providing tools and alternative forms of assistance to others who want to build applications using their technical standards.

Agreement ends outside these four functions, however. Many managers and consultants today hold considerably different opinions about the best practices for managing

platforms. [14] Some of this disagreement is merely for public posturing, but some has consequential economic consequence. It is possible to do all four functions with a variety of different processes, and such processes might result in quite different behavior from business partners, and result in quite distinct products that better match user preferences. The choice over process is (often) a strategic choice for a platform leader.

Among the most important dimensions is whether to be open or proprietary. *Open platforms* make information available to any industry participant without discriminating about their identity, while *proprietary platforms* do not treat all component providers the same, typically favoring affiliated partners over the unaffiliated. In addition, open platforms place no restrictions on how the information may be used, while proprietary platform leaders may use a variety of incentives, tools, and contractual restrictions to guide, instruct, or restrict the activities of their partners.

This variance has been present for as long as firms have discussed platforms. The variance arises because platform leaders chose different processes for shaping the direction of innovative activity among affiliates, where information disclosure and reach-through play important roles.

To illustrate, Microsoft is the platform leader of the Windows Operating System. It also has a business interest in selling copies of Windows, invests heavily in supporting application developers, and it has an elaborate program for supporting partners. In the service of that interest it restricts access to information, giving direct partners more timely access than non-partners. It also has altered the design of its own products to achieve functionality previously provided by partners, later facing charges that it imitated its prior business partner using information gained during their business relationship. The company also has faced accusations about giving different partners different treatments, and its policies have changed over time partly in response.

Intel is also a platform leader of the microprocessor used most commonly in desktop and notebook personal computers, and its platform position contains many parallels. It has a business interest in selling those microprocessors, as well as selling a wide variety of other integrated circuits. It too has an elaborate program for supporting partners, and it too has distinct policies for how it shares information with partners. It too has altered its designs over time, and some of those have put prior business partners out of business. It too has faced considerable scrutiny from public oversight for its policies with partners.

As example of an open sponsor, consider the Internet Engineering Task Force (IETF), along with its parent, the Internet Architecture Board. It provides for the four functions above

[14] For a taste of this variety, see the quite different approaches in, e.g., Gawer and Cusumano (2002), Evans, Hagiu and Schmalensee (2006), and Gawer and Henderson (2007). Each takes a rather distinct approach to discussing negotiations between platform sponsor and business partners.

for the Internet. Yet, a large host of other firms are responsible for managing and operating the Internet. Though these firms may have representatives voice their interests at the IETF, decisions at the IETF do not correspond with one firm's commercial interests. All participants have the same privileges, and have equal access to information. In an important contrast with a sponsored platform, the IETF never exercises what lawyers call "reach-through rights", so any organization can do whatever they want with the information published by the IETF.

Consider Apache, which operated informally for several years before establishing the Apache Software Foundation (ASF) in 1999.[15] The ASF now has nearly 100 projects, and is a non-profit organization structured to ensure that these projects endure beyond the involvement of any single contributor. It too does not restrict the release of information, but it does restrict contributions to the code. The ASF bylaws[16] state that new members may be nominated by existing members and confirmed through the approval of a majority of existing members. Although it is not required in the bylaws, traditionally new members have shown a significant dedication to open-source software, especially by contributing to projects under the ASF umbrella. Generally members that have been in the organization since the early days are afforded some informal authority to help the current leadership choose the path the ASF takes. Currently there are 370 members of the ASF; however, there are less than 3,000 people who contribute code to the ASF projects. [17] Yet, the software remains quite popular, reportedly powering approximately two thirds of all servers on the Internet.[18]

There are also examples of hybrids between all these governance arrangements. Proprietary firms have attempted a range of approaches to sponsoring open source arrangements. These vary in their membership requirements, their arrangements for dispute resolution, their ownership arrangements for the output, and even the nitty-gritty for how information is released.[19]

Variance is especially evident at early moments in an industry's evolution, namely, before market events have revealed what type of organizational arrangements, business relationships, and designs will generate the most value. As illustration, consider the smartphone segment today. There are several prominent sponsored platforms from Apple, Microsoft (with a partnership with Nokia), RIM, HP, and Samsung. There is one open platform,

[15] http://www.apache.org/foundation/, Retrieved July 11, 2011.

[16] http://www.apache.org/foundation/bylaws.html, Retrieved July 11, 2011.

[17] For a deeper look at the interactions of these team members and the code development process, see Mockus, Fielding, and Herbsleb (2002).

[18] According to the July 2011 Netcraft Web Server survey

[19] See O'Mahoney and West (2008).

Android, sponsored by Google, with partnerships with Motorola (and, recently, potential ownership), HTC, Samsung and over two dozen other handset makers.

Despite the tendencies of crusaders to overstate their claims, there has been enough experience to suggest the variety will persist into the foreseeable future. Both open and proprietary platforms exist in many market segments where interoperability networks thrive, and in some segments they co-exist and compete for customers along certain margins. That said, there is no general economic theory for why an open platform emerges in one set of circumstances, a proprietary platform in another, and both in yet another.

Just to reiterate the etymological point, the difference between open and proprietary focuses on restrictions affiliated with information/transactions, not on pricing. Part of the confusion arises due to an artifact of the English language, which uses the word "free" for multiple purposes – (a) pricing at zero or without cost, versus (b) liberation or lacking restriction. Part of the confusion arises because lack of pricing and lack of restriction tend to appear together, even though it is possible for one to appear without the other, or for neither to appear.[20]

To illustrate, in multisided platforms it is quite common to observe platform providers making access costless to one participant (or even subsidizing it) in order to foster participation from a revenue-generating participant, even while the sponsor places restrictions on the behavior of the different participants. For example, Microsoft subsidized the production of software tools to help many large developers of applications for Windows95, and a wide array of marketing programs (and subsidies and discounts) also influenced what many developers and OEMs did as Windows95 was unveiled. Most of this aimed at developing an operating system and set of applications that users valued. Interestingly, Microsoft incurred many of these costs before making the majority of its revenues by charging users for the licenses to use the Operating System.

This confusion also infiltrates into discussion about the competition between open and proprietary platforms. Rarely do potential buyers face a stark choice between an unpriced system and a priced one. Many large enterprises, for example, maintain multiple platforms, investing in them at different rates, depending on a variety of market factors and commitments. The quality of the local labor market for technical talent plays a large role in successfully deploying open source software, as do the needs of the enterprise. The price of the software alone rarely determines the choice.

For rather different reasons a similar general observation applies to suppliers. For example, when software firms consider writing applications for different platforms, the price of platform rarely plays a large role in the design of the application, or in the decision to develop it

[20] Needless to say, some of this confusion *does not* arise in non-English speaking countries. For example, the word for open source in many Roman languages is typically *libre,* which emphasizes freedom or lack of restriction.

at all. Much more relevant are economics factors such as the size of the customer base, the costs of supporting upgrades, the quality of third-party support for technical issues, the restrictions and limitations that come with a specific firm's approach to managing a proprietary platform, and the quality of the governance of the platform.

Interoperability arrangements define an important different between open and proprietary platforms. Open platforms generally connect without restriction. In contrast, proprietary platform designers typically do not internalize all the benefits to users from mix and match networks, so they have rational reasons not to invest in universal compatibility. This incentive is most obviously manifest when a sponsor denies interconnection to other platforms, for example, due to concerns about the loss of some competitive advantage by inviting more competition. For example, that notion arises in analysis of Microsoft's refusal to allow Linux application developers to have access to the API's to its leading email program, *Exchange and Outlook*. While Linux users would benefit from such interoperability, it would cost Microsoft resources to design such features. Moreover, Microsoft viewed this popular application as motivator for purchasing its server operating system, and had little incentive to encourage purchase of an alternative.

The broader point is that competition between platforms takes place on multiple dimensions. It is misleading to focus solely on pricing as the only relevant difference between open and proprietary platforms, or, for that matter, between two proprietary platforms. Said another way, settings in which price competition may be the primary dimension of platform competition differs substantially from those in which prices do not play such a central role.

Another implication is salient. Because a considerable number of factors, such as platform governance and developer behavior, shape platform competition, it is quite difficult to provide a simple theory for what type of private ordering will most efficiently provide platforms. Moreover, self-interested economic actors will seek private orderings in their own interest,[21] but that does not imply unique equilibrium in every situation.

At present there is no general theory for understanding the identity of a dominant platform provider. That is, why does an open platform emerge in one situation, and a proprietary one in another? For that matter, why does a new firm's platform thrive in a new market instead of another proprietary platform, which has had success in yet another setting?

Of course, that does not stop self-interested stake holders from offering theories. There is a tendency among lawyers for dominant firms, for example, to argue that their platform is dominant because it is more efficient than any other, which is a sweeping economic theory for explaining any economic outcome after it has arisen. While such a theory certainly holds *some of the time*, it begs a harder question: is it the only explanation for all settings? The occasional

[21] Chiao, Lerner, Tirole (2007).

success of not-for-profit platforms suggests the weakness of placing the assertion in front of studying the institutional facts – any given situation depends too much on the specific histories of the institutions within that market.

Indeed, the remainder of the essay elaborates on that observation. It discusses how sponsors govern the platforms that form in light of what other firms do, and how private orderings among many firms govern the platforms that form in light of what a large incumbent firm does. That will illustrate that more than merely efficiency shapes platform emergence and competition, especially at early moments in a young network or young platform, before markets settle into routines that resemble an equilibrium operating.

A good place for understanding this point is to start with the motivations among participants in platforms. What costs and gains do they perceive?

## *4. Coordination and Learning*

The modern economics of network recognizes two broad classes of gains and costs to developing multisided platforms. One class of gains and costs stresses *coordination*. Another class stresses economies of *experimentation and learning*. Neither of these economic gains is inherently static in nature, and understanding a specific market typically requires analysis of sequences of actions or historical events. Both are quite salient for analysis of standards and interoperable designs in information services, where an advancing technical frontier in processing, storage, data transportation, and software design continually enable new opportunities to reconsider the design of information services.

Consider coordination. These explanations stress that successful multisided platforms require the participation of many firms. Their presence generates a coordination gain that all participants benefit from. That is, the platform serves as a focal point around which all participants make investments. The gains from coordination overcome limitations to its absence, where each participant acts independently of the other.

The grocery store scanner and bar code illustrates. There was a gain from coordinating around a set of technical standards, and no firm could realize that gain through a unilateral action. For example, packaged-food manufacturers, groceries, the makers of scanner equipment, and the makers of inventory management software benefited from adopting the same technical standard, one symbol instead of multiple symbols. From the outset coordination was a key goal. An inventive new scanner, by itself, was not particularly useful without cooperation from all the other firms, particularly those doing the packaging. With an industry wide design, each participant had discretion to specialize in its component part, and had (some) assurance that the effort might not go to waste due to acting alone.

It is clichéish to say, but coordination gains do not arise for free. Though all participants may benefit from participating in a whole greater than the sum of its parts, rivalry may prevent

firms from cooperating, as can lack of appropriate transfers between gainers and those in need of subsidies. Bargaining issues among heterogeneous participants without transfers may prevent emergence of a platform, even when society as a whole may benefit.

The bar code and grocery scanner again can illustrate how such issues arise. The scanner was a product innovation in a retailer, who compared it to a cash register, but the inventory management software was a process innovation. To an equipment maker it was a new product, an expansion of the product line. To the makers of packages it was nothing other than an additional feature of a package's design. Each participant's costs depended on the functionality of a distinct part of the entire platform, but none could benefit unless all did. The historical record makes clear that the agreements between all the participants were quite fragile, and the entire system remained unprofitable for grocers for many years after its initial rollout. In light of all the growth occurring later, it is remarkable to realize, but the lack of initial profitability placed in doubt whether the coalition would hold together. The determination and commitment of a few key managers and visionaries was all that stood between moving forward and falling apart.[22]

The importance of coordination becomes most visible when firms have failed to anticipate the need to coordinate. The classic illustration comes from the VCR market, which grew dramatically in the late 1970s and early 1980s, after firms had invested for more than a decade of investing in its technical development. The lack of coordination occurred because the commonly-accepted use-case for VCRs (which was common to all firms) had anticipated that home users would show reruns of TV shows and various versions of home movies. None of the key firms, such as Sony and JVC, had planned for the rental industry, as it actually emerged.[23] Video rental stores sprung up a few years after the hardware had begun to sell well, and without much influence from the hardware designers, so the feedbacks between rental distribution and hardware distribution occurred outside the control of the prominent firms. Sony had chosen to distribute Beta in a limited way in the first few years, a choice about distribution that ensured quality and high prices, but which had disastrous consequences once video rental stores appeared in droves. Though Beta had been more profitable than VHS, VHS had wider popularity at that moment.[24] When users bought hardware, they typically invested in only one format. Video stores carried titles, even in both formats, but favored more titles

[22] Brown (1997).

[23] Indeed, JVC and Sony were in a format war in the first place because an earlier attempt to enter the mass market, which Sony coordinated around one format design, had failed miserably, costing all the firms. The ex post negotiations to settle accounts embittered JVC's management, and their management refused to work with Sony during the next roll-out, which actually did generate positive sales. Sony was first mover in this success, while JVC entered later. As second entrant JVC chose a strategy that emphasized wide distribution and low margins, in contrast to Sony's strategy of limited distribution with high margins. See Cusumano and Rosenbloom (1987).

[24] Cusumano, Mylonadis, and Rosenbloom (1992).

with the format that reflected the most popular format with local customers. Little by little, feedback between demand for rentals and demand for hardware shaped the choice of hardware format. More VHS hardware generated more demand for VHS rentals, which generated more purchases of VHS hardware, and so on. It took a few years, but eventually VHS pushed out Beta altogether.

Both examples also highlight another feature, the inexorable upgrade and enhancement of the platform, either to add new functionality, or to enable new services, or to low expenses. Well-designed and wisely governed platforms confer a benefit to its participants, namely, smoother enhancements. In many settings, platforms become a focal point to facilitate experimentation and learning. The experience in bar codes nicely illustrates the typical issue: Even though the payoff to society from developing a platform may eventually be great, private firms have little incentive to experiment for another firm's benefit. After all, grocery stores adopting scanner machines do not care whether everybody else can benefit from the experimentation and learning at a later time. They care only about their own bottom line, and whether the experimentation helps it.

This second observation points to a common trade-off between competition and learning in platform development. On the one hand, if experience brings down costs, then costs may come down sooner with fewer platforms, as participants focus their limited resources and experiences on one platform or very few. On the other hand, fewer platforms raise the possibility of less competition, which potentially slows incentives to conduct experiments, generates insufficient variety to generate a compelling gain for users, or leads to higher prices.

The experiments with Wi-Fi's design illustrate that trade-off. The market for wireless LANs had grown little in the early 1990s, while the cost and price point were high, and while equipment from competing firms remained incompatible. Only a few intrepid buyers willingly bought the products offered by firms at that time. Early experiments in wireless LANs hit this wall like a textbook cliché. Only large scale manufacturing could bring costs down, but only a low priced standardized product could attract so many customers. The IEEE standard helped break through this barrier by facilitating coordination (at first). That generated cooperation from many participants (albeit, not all of them), and then firms began to experiment with different designs. Those experiments yielded a variety of cost savings, and new users.[25] Wireless cash registers, wireless campuses, and wireless warehousing all appear comparatively early in the minds of the designers. The technology's evolution changed the typical use case, as many industry participants learned from experience. At the outset nobody was thinking about what eventually did emerge as the mass market – the home mass market, hot-spots at cafés (or at McDonalds or Starbucks, for that matter), and Centrino (e.g., Wi-Fi integrated into laptops).

[25] Hayes, et al (2011).

Does the presence of scale economies in the new economics of networks lead to any robust lessons? The answer depends on the comparison. If the scale economies are valuable (as they often can be), and sufficiently large (as they often can be), then there is a likely divergence between private and societal incentives to establish at least one platform. That is most likely when one platform is more valuable than none, and no private unilateral action by any market participant can generate a gain similar to one that requires coordination among many participants.

The realization of the coordination gain from the entry of a newly designed platform is analogous to a public good from which all the participants gain. Similarly, the gains and costs can be such that no industry participant may have an incentive to unilaterally supply it in the absence of transfers or subsidies. Relatedly, as with the provision of public goods, non-convexities play an essential role in the provision of interoperable designs and standards.[26]

The presence of non-convexities provides one reason why it is quite challenging to provide a general theory for why private orderings arise in specific settings, such as occurred in bar codes or in the development of Wi-Fi. In specific situations the analysis tends to stress specific details at early moments. These may be the sequence of the arrival of new opportunities (and whether these were anticipated or not), the presence (or absence) of charismatic leaders, the factors shaping bargaining among coalitions of firms, and other features of the legal setting. Any reasonably complete applied analysis involves combinations of these factors.

That does not imply that analysts throw up their hands in frustration due to lack of general theorems. Rather, several key concepts have emerged in the new economics of networks to analyze why platforms and platform competition can take a variety of different paths. That is the topic of the next section.

## *5. Analysis of Platform Evolution*

Consider the addition of value to existing platforms. There is one key question: can an existing platform add value without limit? If so, then existing platforms tend to deter entry of new platforms. Here is the reasoning. If an existing platform can add value without limit, then it takes advantage of an economy of scale. The existing platform has expended the sunk costs of setting up a platform while any new entrant would have to expend new costs. Hence, there is a natural tendency for existing platforms to expand their scope to add new functionality. Due to this expansion by existing platforms, new platforms that fail to leapfrog functional norms of existing platforms face considerable challenges attracting new users. Such tendencies are especially pronounced if the existing installed base of users values the interoperability of a new

[26] Starrett (1988).

platform with their existing installations.[27] Hence, established platform markets tend to be characterized by concentration.

This conclusion is in the spirit of Sutton's analysis of industries with "endogenous sunk costs."[28] This perspective tends to relegate pricing and the other facets of strategic behavior to the background as details, placing emphasis on the bounds on the number of entrant platforms. This approach stresses that markets have limited room for platforms that continually grow their value, and it stresses that users and vendors adjust their behavior in anticipation of this tendency.

Notice that this is a statement about the number of platforms, not about the number of firms. It is possible for multiple firms to exist within the bounds of one platform. The result will depend on the governance of the platform, whether information is accessible without limit, whether the market is large enough to cover the fixed costs of many component makers, and so on.

There are limits in practice. Users often prefer new functionality to be added in a way that preserves the value of existing investments, namely, for it to remain backward compatible with the investments of the existing installed base. That typically involves advancing the technical functionality embedded in a platform, but preserving features used by the installed base. That limitation on adding functionality has consequences for the number of firms. For example, in the 1970s mainframes could add functionality, but could not reduce the role of centralized management, while minicomputers and PCs could reduce the role of centralized management in spite of serious functionality limitations. Many administrative users were willing to sacrifice one to have access to another.[29]

That observation illustrates a broader point about differentiation between platforms. Some differentiation is straightforward. For example, when platforms differentiate horizontally (e.g., they vary in color or geographic location), then additional issues determine the margins on which platforms compete (more below). When platforms compete vertically for all users (e.g., one is faster than another), then it is possible for one platform to dominate with superior features. If the superior feature comes at a high cost, it is possible for platforms to specialize, one in low cost low quality and the other in high cost high quality. For example, today mobile devices have started to differentiate vertically, based on their use of expensive bandwidth. Historically, the mainframe and the minicomputer and the PC platforms differentiated in this sense, and co-existed for much of the 1980s, each platform satisfying a different user base's willingness to trade-off processing capacity for independent operation. The broad point is

[27] Shapiro and Varian (1999).

[28] Sutton (1992).

[29] Bresnahan and Greenstein (1999).

straightforward: Where differentiation of platforms provides value to users, multiple platforms can survive and thrive.

Theories of platform competition suggest more subtlety to this differentiation, based on how platforms attract different constituencies. For example, in many cities of the United States two distinct platforms compete for real estate transaction listings. One works with agents and uses the Multiple-Listing-Service (MLS). The other works with owners of homes who put their houses directly up for sale, using an on-line platform. One study of such platform competition in Madison, Wisconsin, (Hendel, Nevo and Ortalo-Magne, 2009) found that these two platforms attracted sufficient attention to be liquid enough for buyers and sellers with distinct preferences. Thus, the platforms competed for some of the same listings, but also tended to differentiate in terms of homes of different sizes and the probability of a fast sale.

Many studies of platform consider the role of multi-homing. Multi-homing arises when participants actively maintain viable economic relationships with multiple platforms. The history of bar codes and scanners can illustrate how (lack of) multi-homing matters to market outcomes. Before anybody had invested in scanners, multiple large vendors of packaged food faced calls from multiple retailers, asking them to embed symbols on their packages to enable advances using computing technology in inventory management and point-of-sale software. Nobody on the manufacturing side of these discussions wanted to see multiple symbols on packages, with each symbol satisfying another user. The surface area on a typical package was too precious. That strong resistance to any multi-homing among bar codes was an important factor in the decision to use one code for early experiments.[30]

There are also examples of multi-homing fostering a competitive outcome. The canonical example is the Internet data-exchange point in the transport layer of the Internet. When the National Science Foundation privatized the Internet its planners thought the United States would not realize economy-wide gains without several data-exchange points for multiple data carriers that facilitated multi-homing throughout the network. This was one of several factors that contributed to growing a “mesh” of backbone firms in the US commercial network instead of a large dominant monopoly provider of backbone services.[31]

Handset platform competition today has considerable multi-homing in it too, as many household maintain different platforms on different devices and application developers maintain the same applications on different (and differentiated) platforms. Such multi-homing clearly matters to competitive outcomes. Many industry observers do believe this market can profitably sustain more than one platform, but, at this point, virtually nobody believes it can

[30] Grocers also did not want multiple symbols because the scanners were expensive, and the checkout counters could not easily support more than one.

[31] Greenstein (2010).

viably sustain the half dozen – e.g., Apple iPhone, Google Android, RIM Blackberry, Microsoft Windows, and others from HP and Samsung – that presently vie for commercial success.

Challenges with multi-homing also can play an important role in competitive conduct before participants settle on one platform exclusively in settings where the network effect arises from liquidity. Consider the "Battle of the Bund," which took place in the 1990s. The Frankfurt-based exchange Deutsche Terminboerse (DTB, the ancestor of Eurex) managed to challenge the London International Financial Futures and Options Exchange's (LIFFE's) dominance of the market for the Bund future, one of the most traded futures in the world.[32] This fight can be viewed through the lens of platform competition, as a fight for participants (i.e., firms who exchanged the Bund). Some traders multi-homed while many did not, and there was sufficient multi-homing to keep open the questions about which exchange would get participation from the most firms. The electronic format of DTB provided traders with a cost advantage and the ability to attract orders from virtually anywhere in the world. That increased its liquidity, and with LIFFE's sluggish reaction, it led to the eventual complete reversal of market share, away from LIFFE, the early leader.

There is an important limitation to the lessons from this example about exchanges: The competition between exchanges took place within the context of a much larger set of reasons for participating in these exchanges at all. Not surprising, therefore, both exchanges continued to operate after the battle for the Bund ended. Multi-homing did not arise in a vacuum; This battle for one futures market was for but one of many services offered by both exchanges.

Compare that with the battle between two auctions with similar targets for participation, however. Brown and Morgan (2009) chronicled the battle between trading sites operated by EBay and Yahoo. The (il)liquidity of participation by buyers and sellers altered the price of trade-able goods, which fed back into choices over further participation. In that setting the auction site with less participation, namely, Yahoo's auction, was at a distinct disadvantage, and eventually it led to the decline and final demise of the platform.

Finally, consider the entry of converters. A converter provides a technical bridge between two otherwise incompatible platforms. The invention and availability of converters can have a large impact because it can change the scale of platform size very quickly, bringing users and firms into contact with one another who previously had been separated by networks lacking interoperability.

Converters can have a large impact on network formation. For example, the development of a converter in 1987 allowed all the leading data networks in the United States to exchange email. That invention – called a "gateway" by contemporaries – was a key step in developing the national Internet. The converter enabled all the participants to exchange email

[32] Cantillon and Yin (2011).

with each other, and not multi-home on multiple internetworking protocols. That permitted the NSF to invest in TCP/IP without concerns about imposing additional multi-homing costs on its users. The gateway also fostered growth in the applications, raising the value of electronic mail, which, in turn, raised the value of the infrastructure supporting that application.

Converters also can play a role in platform competition. For example, in 1997 the 56k modem war reached a standstill after a year of platform competition between two incompatible designs of modems. Due to the confusion, mass market users refused to adopt, despite the benefits. Suppliers came together, hoping to find a way forward to encourage adoption. They negotiated a solution, a new design that acted as a converter between all existing designs. This hybrid became the standard thereafter, and all subsequent improvements were built on top of it.[33]

What is the main message from examining additions of value, differentiation, multi-homing and converters? There are multiple pathways for society to develop platforms. These pathways include private orderings inside for-profit and not-for-profit industry-wide organizations, or through numerous evolutionary paths.[34] Those paths depend on the motives of the participants, the strategies of platform sponsors, and how the platform sponsors meet the needs of participants.

Though different paths can have distinct consequences for the private interests of firms, different paths may yield nearly equivalent outcomes from a public standpoint. For many an applied issue, this is often the key question, and it cannot be analyzed in general. It requires deep detail of the governance of platforms, the motives for participating, and explanations for why choices turned out as they did. Analyzing the economic trade-offs requires considerable detail about the paths taken and not taken.

## *6. Analyzing Experimentation*

Most upgrades involve considerable experimentation. Experimentation arises at early moments in the development of an industry or technology, when there is considerable doubt about the economic viability of any platform or its optimal design or even the preferred use-case.[35] Uncertainty of this sort arises frequently in new markets for information services, and might even be characterized as endemic.

[33] Augereau, Greenstein, and Rysman (2006).

[34] Farrell and Simcoe (2011).

[35] David (1986) coined the phrase “blind giants” to capture the notion that the most influential actors at an early moment may be the most unable to discern the best action. David writes about the many dimensions in which policy will be blind, necessarily, when its impact can be greatest.

The uncertainty becomes magnified because one market structure does not fit all situations. There may be more than one potential way to configure a platform before user preferences are fully revealed. Complicating analysis further, at an early moment the primary market actors may be pursuing a variety of strategic approaches, each strategy conditioned on a different perspective about user preferences and their motivation for participating in the platform.

Moreover, while individual actors in an economy may differ in the payoff to different configurations for platforms, from a policy maker's perspective different configurations for achieving (essentially) the same (large scale) outcome may be (nearly) equivalent. For example, in some circumstances it may be worthwhile for one sponsor to integrate and coordinate all activities, internalizing the scale economy. In another situation, it may be in a sponsor's interest to allow a large third-party industry to develop, customizing a platform to a wide variety of circumstances, achieving scale in the supply of the infrastructure. And in another circumstance some firms may find it worthwhile to develop an industry-wide standard, one that all firms use in their interoperable products, which they differentiate from one another with distinct brands, designs, or distribution.

One approach to analysis in these situations stresses conceptual shortcuts. Such short cuts look for symptoms of a healthy situation – namely, behavior that correlates with desirable market-wide outcomes, such as improvement in products, lower prices, new capabilities, or other innovations that lead to productivity improvements. If such symptoms are present, then action is not required. If symptoms are absent, then selective action might be considered.

What are the patterns of healthy commercial behavior indicative of an innovative situation? Symptoms of a healthy situation include the presence of many economic experiments in the market, many entrepreneurial entrants, vigorous standards competition, and the absence of unilateral bargaining between suppliers.[36]

A related symptom is the presence of absence of a virtuous cycle, which is a symptom many managers and Wall Street analysts use the midst of an uncertain setting. A virtuous cycle arises when one participant's action raises the value of participation for another, who then decides to participate, which then raises the value for another, and so on, as would occur if a platform successfully acts to coordinate the investments of multiple participants.

Virtuous cycles get attention because they are self-reinforcing. The cycle could not be present without participation by all potential participants and positive feedback between participants with different identities. The absence of virtuous cycles is often a signal of decline (and sometimes goes by the label "vicious cycle" or "death spiral.")

[36] Greenstein (2009).

The canonical virtuous cycle is the early PC market in the IBM platform. The entry of the IBM hardware platform came into competition with the Apple platforms and CP/M platforms, which already had hardware, software and peripheral suppliers. IBM attracted many application developers with an open system design (i.e., unrestricted information about the design), as well as the promise that IBM's system would be attractive to business users.[37] That attracted further entry by developers and peripheral markets, and so on. The platform grew for many years thereafter, long after IBM lost control over managing the upgrades.

A similar virtual cycle describes the entry of application developers for smartphones after the introduction of the iPhone in 2007. The introduction attracted users and developers, which jump-started a new category of applications. This has not finished growing new value, as evidenced by, for example, the recent airline program for code-based ticketing on iPhones and Androids, and Starbucks program to enable reward-card programs on iPhones and Androids using QR codes.[38]

In spite of the importance of multiple participants, Wall Street analysts tend to sharply focus on the growth rates of key participants in the virtuous cycle, such as developers. This is not fixation on one participant for its own sake, but, rather, fixation on one type of participant whose activity generates reaction from others, and, not trivially, can be observed and counted. In other words, the growth of developer participation not only produces value (through the production of applications), but also acts as a measured symptom of whether the virtuous cycle continues to be self-reinforcing or not.

For related reasons platform sponsors pay attention to developers, typically giving larger developers more technical and marketing support than smaller ones. That relationship receives considerable scrutiny by policy makers, and with good reason. The rules and contracts governing that relationship can shape multi-homing costs, which can shape the competitive conditions facing new platform entrants, and other competing platforms more broadly. For example, consider Apple's restrictive provisions in its contracts with developers. Apple

[37] Greenstein (2010).

[38] QR codes recently evolved from their industrial use to become the predominant code design for consumer oriented coupons on smart phones. The new platform has taken on new functionality and a very new set of participants, albeit it also built on a combination of existing and new equipment. For example, after considering many options, and after observing the successful use of QR codes on smartphones in other contexts, Starbucks adopted QR codes for the electronic version its payment card for frequent buyers. Starbucks simultaneously installed readers throughout its many outlets.

assertions that it owns all the customer-specific information are designed to make it more costly for developers to move between multiple platforms, such as Android, that is, to limit multi-homing.

Not surprisingly, these are precisely the contract provisions undergoing the most scrutiny by public actors. Which platform rules most affect platform competition? Once again, this is an important open question, and no general answer can suffice. Successful analysis requires considerable detail of platform governance, the motives for participating in platforms, and the multiple dimensions on which platforms compete.

## 7. Limits and boundaries

The new economics of networks stresses the importance of participation by a diverse set of economic actors, namely, participation by users, application developers, or advertisers. This approach also stresses the economic role of the platform as intermediary between participants with varied interests.

This approach began by focusing on commercial information services, such as video telephony and instant messaging, and new services that embed interoperability standards, such as bar codes and Wi-Fi. These were settings in which innovations embedded within the platforms enabled the markets went through dramatic and fundamental changes. Hence, prior research places importance on a number of costs and benefits affiliated with coordinating on a platform. It also stresses concepts that help understand the evolution of platforms upgrades and platform competition.

The new economics of networks and platforms has been extended in ways that facilitate applying the core insights to new settings, focusing in market settings where network effects arise, such as home-video recording equipment, operating system software, modems, wireless local area network equipment, and grocery scanner equipment. Such diverse settings – far outside of the area of computing and communications – such as real estate platform competition, financial exchange competition, on-line auctions, and the build-outs of payment network – have received attention. In these new settings the micro-foundations for network effects arise from increasing liquidity of market matching due to increased participation.

Those extensions are motivated by the resemblance of the economics of mix-and-match networks and trading among market participants. In both a network effect arises because the value of participation rise as the number of participants increases. The value of a mix-and-match network rises for users as more components become available. The liquidity behind trading rises with participation by more traders.

In contrast, the focus on innovation and upgrades diminishes in these extensions. That also suggests the limitations to the extensions. There are tight links between the analysis of competition and the analysis of different governance regimes for platforms. Understanding

those links is of first-order importance to understanding the micro-mechanisms of innovation. For example, participation in a platform depends on a myriad of governance decisions, such as: the nuances of how open/proprietary principles operate in practice; the margins of differentiation between distinct platforms, as perceived by users; the tendency for users and vendors to multi-home; and whether firms invested around the use-case that experimentation in the market place revealed as most valuable.

This review illustrated these limitations. Though the concepts of network effect can be extended across many different types of examples, analysis of the private orderings for coordinating between platforms did differ across settings. For example, key notions of open/proprietary in compatibility networks do not easily extend to financial exchanges, or to credit/debit card networks, and competition in those arenas cannot be analyzed in the absence of understanding that governance. Interconnection disputes in a traditional utility network also do not necessarily extend to other settings where interconnection plays a role, such as in payment systems, or communications among instant messaging, for that matter.

Related limitations arise in analyzing government actors, who can play very different roles in shaping outcomes. When governments hold the statutory authority that interferes with private activities (e.g., switching from analog to digital TV over spectrum), their intervention is required for the private market to move forward. In such situations learning and experimentation may be expensive and urgent and private firms may not undertake it without assurances from government actors. When governments hold statutory authority over interconnection of third parties who compete with their offerings (e.g., FCC designs of plugs to enable private equipment markets that interoperated with the telephone network), then their intervention can shape entry conditions. Government action can facilitate entry and experimentation (or harm it with poorly designed policies). When governments hold statutory authority to intervene in the vertical relationships between firms, the intervention could change vertical restraints that enable or prevent multi-homing or the entry of converters, and otherwise speed up or slow down the introduction of new services or new platforms. In all such cases the analysis, once again, crucially depends on details of the governance of existing platforms.

The variety of forms that governance can take should suggest a circumspect analytical approach is likely to be more fruitful for understanding platform competition in practice than any single sweeping theory. The new economics of networks does not presume that monopoly necessarily arises in every instance, nor necessarily for profit-oriented governance of the platform, so it allows for a variety of structures for supplying platforms. That suggests there is considerable room for new insights, but also need for caution when using intuition, lest hasty conclusion are drawn from on setting and applied in an inappropriate and distinctly different setting.

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