Uncovering The Role of Hubs
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Uncovering the Role of Hubs: A Network Science Perspective on Platform Competition

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Abstract. This paper offers a novel legal framework to evaluate competition among digital platforms. Drawing on network science, it contests two prominent approaches in antitrust law; namely, that network effects either lead to a winner-takes-all situation, or conversely safeguard against platform market power abuses. It coins the term "hub-plucking" to highlight a critical dynamic of platform competition that has surprisingly gone unnoticed: the competition between platforms over highly connected "hubs." Hub-plucking enables rivaling platforms, including new entrants, to instantly acquire market share by seizing hubs. Since many platforms of interest exhibit hubs, hub-plucking is applicable to a variety of industries and is thus crucial for competitive analysis. The paper demonstrates the viability of hub-plucking as a major restraint on platform market power. It analyzes the relative advantages of fledgling platforms over dominant ones in acquiring hubs, and provides empirical examples of industries where hub-plucking was successfully implemented to dethrone platform incumbents. Serving as a proof-of-concept for showcasing network science's enormous potential for advancing antitrust law, the paper last entertains two proposals for expanding antitrust's arsenal of potential interventions in the platform context.

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Introduction

"You know, there's about 5,000 broadcasters on Twitch who really-really matter, and our goal is to grow that body of people, and we do that by reaching out and talking to them directly, and we go do that by building a platform that they are interested in joining in the first place, and then when they join, they bring their entire fanbase with us. And so every time we get a YouTube director start broadcasting on Twitch, we win."

Emmett Shear, Twitch co-founder and CEO[1]

This paper challenges antitrust law's conventional wisdom on how network effects impact competitive dynamics. Drawing on network science, it pioneers a new line of thinking on the dynamics shaping platform competition. Specifically, it identifies a contradiction in the two dominant narratives in antitrust law on how network effects impact platform competition, debunks them both, and lays out a new roadmap for antitrust priorities in the digital era.

Digital platforms like Facebook, YouTube and Uber are networks characterized by *"network effects"*: the more participants they have, the more useful they become. This feature has led to a dominant view in antitrust law, which was famously narrated in the landmark 1990's Middleware case against Microsoft and shall thus be referred to as the *"Microsoft Narrative,"*[2] that markets characterized by network effects tend toward a winner-takes-all situation where a single platform rises to dominate the market. The claim is that when a market leader gains enough lead in platform participation, a domino effect is triggered, whereby the leader's relative advantage in network benefit becomes sufficiently powerful to attract new platform participants and to lock-in existing ones at the expense of rivaling platforms. This propels the leader's growth, and by the corollary erects a tremendous self-augmenting *"network effects entry barrier"* that relentlessly diminishes the ability of rivaling platforms to compete. Unless checked, this escalating dynamic may even lead the entire

[1] Emmett Shear – How to Find (and Serve) Your Most Important Users, YOUTUBE (July 1, 2015), https://www.youtube.com/watch?v=Auoq6fZleIU [https://perma.cc/7XZL-TTSW], at 17:20 ("**Emmett Shear**").

[2] While the Microsoft Narrative is often associated with the Middleware case, *United States v. Microsoft Corp.*, 253 F.3d 34 (D.C. Cir. 2001) ("**Microsoft-Middleware, Circuit**"), the claim that network effects raise a formidable entry barrier was raised for the first time in the *"Licensing Case"*, an earlier case waged against Microsoft. *See United States v. Microsoft Corp.*, Civ. Action No. 94-1564, 159 F.R.D. 318, at 333-334 (D.D.C. Feb. 14, 1995); *United States v. Microsoft Corp.*, 56 F.3d 1448, at 1452-1454 (D.C. Cir. June 16, 1995); William J. Kolasky, *Network Effects: A Contrarian View*, 7 GEO. MASON L. REV. 577, 581 (1999); Andrew I. Gavil & Harry First, THE MICROSOFT ANTITRUST CASES: COMPETITION POLICY FOR THE TWENTY-FIRST CENTURY 36-60 (2014) ("**Gavil & First**").

market to 'tip' to the market leader, transforming the market leader into an entrenched incumbent that can abuse its market power with impunity.[3]

Against this view, a second narrative claims that network effects are not a curse but a blessing, because they constitute the ultimate safeguard against platform incumbents' market power abuses. If dominant networks abuse their dominance, they risk triggering a vicious cycle of *"negative feedback effects"* which would cause an increasing number of participants to leave the platform, thus jeopardizing the platform's overall integrity.[4] While this contrasting narrative has existed in the antitrust literature for quite some time,[5] it has been recently fully endorsed by the U.S. Supreme Court in its *Ohio v. American Express Co.*[6] decision and shall thus be referred to as the *"Amex Narrative."*

While much of antitrust law is locked in a tug of war between these two sharply contrasting narratives, it lacks a foundational account for how to decide between them. When is a dominant position entrenched and when is it vulnerable, and how does one determine in specific cases which it is?[7] Legal sources tend to vehemently endorse one narrative over the other without attempting to reconcile the two.[8]

This indeterminacy is deeply troubling, because these two narratives lead in diametrically polar normative directions with sharp practical consequences. If network effects indeed constitute an insurmountable entry barrier that entirely insulates platform incumbents from competitive pressure, then extensive legal intervention is justified. Indeed, this view has gained considerable traction in

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[3] For manifestations of the Microsoft Narrative in the antitrust case-law and literature, *see infra* notes 8, 20, 24-25, 32-33, 35-36, 52, 57, 60, 78, 87.

[4] Herbert Hovenkamp, *Platforms and the Rule of Reason: The American Express Case*, 2019 COLUM. BUS. L. REV. ("**Hovenkamp-Amex**").

[5] David S. Evans & Richard Schmalensee, *Markets with Two-Sided Platforms*, 1 ISSUES IN COMPETITION L. & POL'Y 667, 674-675 (2008) ("**Evans & Schmalensee**"); David S. Evans & Michael Noel, *Defining Antitrust Markets When Firms Operate Two-Sided Markets*, 2005 COLOM BUS. REV. 667, 680-681.

[6] *Ohio et al., v. American Express Co.*, 138 S. Ct. 2274, 2280 (2018) ("**Amex**").

[7] *See* Joshua White et al., *European Union: Two-Sided Markets, Platforms and Network Effects*, *in* E-COMMERCE COMPETITION ENFORCEMENT GUIDE, Global Competition Review (GCR), at 86 (2019) (noting that network effects can lead to either tipping or *"death spirals"* and therefore *"significantly complicate competition analysis"*).

[8] *See,* e.g., *Fed. Trade Comm'n v. Facebook Inc.*, No. CV 20-3590 (JEB), 2022 WL 103308 (D.D.C. Jan. 11, 2022) ("**FTC v. Facebook**"). The decision completely reflects the Microsoft Narrative, referring to the network effects entry barrier as a *"well-established barrier to entry"* and including numerous statements demonstrating how this barrier entrenches Facebook's position. At the same time, the decision ignores *Amex* completely; STIGLER COMM. ON DIGITAL PLATFORMS, FINAL REPORT, CHICAGO BOOTH: STIGLER CENTER FOR THE STUDY OF THE ECON. AND THE STATE, at 16, 39 and 75 (2019) ("**Stigler Report**"). This report employs powerful rhetoric endorsing the Microsoft Narrative, for example that *"a major cause of this lack of competition is the presence of very sizable network externalities"* and that *"[i]f network effects are strong, however, the market will tip in favor of one competitor"*. However, the report neither cites *Amex* nor refers in any of its 336 pages to negative feedback effects.

recent years, largely due to the meteoric rise and growing market dominance of several notable platforms, namely Google, Amazon, Facebook, Apple and Microsoft ("**GAFAM**"), and has already led to notable tightening of antitrust enforcement.[9] If, however, market power of dominant networks is curtailed by negative feedback effects, as postulated by the Amex Narrative, then the market will ultimately self-correct, meaning that further legal intervention would prove unnecessary or even harmful. Platforms, after all, offer immense network benefits to their participants, and excessive intervention risks costing the public valuable services.[10] Moreover, considering the immense resources often required to litigate big-tech cases,[11] unwarranted antitrust intervention would be incredibly wasteful.

Drawing on network science, this paper offers a framework that resolves this indeterminacy. The paper identifies a general feature of networks that is central to their resilience, allowing to determine whether a dominant network is safely entrenched or vulnerable to unravelling. It offers a tool for antitrust law that could be applied on a case-by-case basis, allowing the law to outgrow its oversimplified dichotomy of the Microsoft and Amex narratives.

Network science calls into question a hidden assumption within the usual analysis of network effects, according to which each platform participant is similarly valuable. The paper explains that many (if not most) real-world platforms are *"scale-free networks"* that exhibit *"hubs,"* a few highly connected participants that coexist with a large number of significantly less connected ones.[12] It is the presence of such hubs and their portability to competing platforms that is determinative of a dominant platform's robustness. Put simply, when hubs are present in the incumbent's platform, rivaling firms can target them to breach the network effects entry barrier. For convenience, this paper coins the term *"hub-plucking"* to describe the competitive strategy of capturing platform hubs.

Second, this paper argues that the Amex Narrative overstates the risk of negative feedback effects. Drawing from network science's analysis of *"cascading failures,"* the paper explains that the presumption that negative feedback effects will necessarily propagate across the entirety of platform participants is far from a given. Instead, negative feedback effects rely on many variables,

[9] This includes both the frequent imposition of hefty fines, at times in the billions of dollars, as well as the reinvigorated pursuit of structural breakups, the most drastic of tools available in the antitrust arsenal. *See infra* notes 86-89.
[10] Michal S. Gal & Nicolas Petit, *Radical Restorative Remedies for Digital Markets*, 36(2) BERKELEY TECH. L. J. 617, 621 (2021) ("**Gal & Petit**").
[11] William H. Page & John E. Lopatka, THE MICROSOFT CASE: ANTITRUST, HIGH TECHNOLOGY, AND CONSUMER WELFARE, 5, 13-14 (2007) ("**Page & Lopatka**").
[12] Albert-László Barabási, NETWORK SCIENCE 145 (2016) ("**Barabási**").

including the platform's network topology,[13] the breakdown threshold of each individual platform participant, and the nature of the propagation process.[14]

To be clear, this paper does not claim that the Microsoft and Amex narratives are categorically meritless. There is no dispute that both the network effects entry barrier and the risk of negative feedback effects constitute existing phenomena of competitive significance. Rather, this paper questions their argumentative validity and contends that in many cases the intensity of the competitive dynamics they describe constitute a wild and unfounded exaggeration. The competitive reality usually resides between the narratives, and the wisdom therefore lies in employing the appropriate tools, namely the methodologies of network science, to decide between them according to the factual intricacies of individual cases.

The last part of this paper will explain how antitrust doctrine should be adjusted to overcome the narratives' shortcomings. Then, to further showcase the enormous potential of network science for antitrust law, this paper will provide a glimpse into more visionary applications of network science by entertaining two proposals for revolutionizing antitrust's arsenal of potential interventions in the platform context. The discussion on these proposals is not intended to be exhaustive, but rather to invite exploration and set the stage for future research.

The structure of this paper is as follows. Part II will present the Microsoft and Amex narratives, and explain how these narratives conflict. Part III will introduce the reader to the world of network science, elucidating this field's terminology, and explaining how certain mechanisms shape network topologies which in turn determine the networks' resilience to failures. Part IV constitutes the core of the paper, arguing that the narratives paint an oversimplistic view of competitive reality. Utilizing the insights of network science, Part IV claims that platforms often exhibit hubs, and that in such cases the Microsoft Narrative overestimates the formidability of the network effects entry barrier due to the rivals' ability to pursue a hub-plucking strategy. In addition, Part IV claims that the Amex Narrative overstates the risk of negative feedback effects by failing to analyze precisely how a price increase toward a specific platform participant will affect the remainder of the platform's participants and consequently its integrity. Last, Part V will briefly explore other visionary applications of network science to antitrust law, setting the stage for future research.

[13] The term topology refers to the arrangement of nodes and links in the network, that is, the network architecture.
[14] Barabási, *supra* note 12, at 286, 292.

I. A Tale of Two Narratives

A. The Network Effects Phenomenon

Network effects describe a phenomenon where the value of a network for its participants increases as the number of participants grows. A quintessential example is a telephone network; each subscriber's benefit from the network depends on the number of other subscribers on the network to whom she can call or from whom she can receive calls.[15]

Since each subscriber in the telephone network desires to link directly to other same-sided subscribers, a telephone network is said to exhibit *"direct"* network effects. In recent years, however, a substantial portion of the debate on the competitive implications that derive from network externalities took place within the context of two-sided (and multi-sided) platforms.[16] Two-sided platforms constitute intermediaries between two distinct groups (or 'sides') of transaction partners. *"Indirect"* network effects exist between those two groups since the value that participants on each side of the platform derive from it, increases with the number of participants on the platform's other side.[17] An illustrative example is found in a heterosexual dating app, whose value for women increases with the number of men who use the app and whose value for men increases with the number of women who use it.[18] Two-sided platforms maximize profits by maintaining an optimal mixture of participation and revenue from both sides.[19]

B. The Microsoft Narrative

The Microsoft Narrative claims that network effects tend toward a winner-takes-all situation where a single firm eventually dominates the market. According to this claim, the importance of network connectivity to platforms' services incentivizes participants to connect to the largest network. When a market leader gains enough lead in platform participation, a domino effect is triggered, whereby the leader's relative advantage in network benefit becomes

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[15] Howard A. Shelanski & J. Gregory Sidak, *Antitrust Divestiture in Network Industries*, 68 U. CHI. L. REV. 1, 7-8 (2001) ("**Shelanski & Sidak**"); Herbert Hovenkamp, FEDERAL ANTITRUST POLICY: THE LAW OF COMPETITION AND ITS PRACTICE 388, 411 (6th ed., 2020) ("**Hovenkamp-FAP**").
[16] Erik Hovenkamp, *Platform Antitrust*, 44 JOURNAL OF CORPORATION LAW 713, 714-715 (2019) ("**Erik Hovenkamp**").
[17] *Id.* at 720; Jean-Charles Rochet & Jean Tirole, *Two-Sided Markets: An Overview*, MIT PRESS, 1, 2-4 (2004); J. Gregory Sidak & Robert D. Willig, *Two-Sided Market Definition Competitive Effects for Credit Cards after United States v. American Express*, 1 CRITERION J. ON INNOVATION 1301, at 1301 (2016); Hovenkamp-Amex, *supra* note 4, at 37.
[18] Herbert Hovenkamp, *Antitrust and Platform Monopoly*, 130 YALE L. J. 1952, at 1996-1997 (2021) ("**Hovenkamp, Platform Monopoly**").
[19] Hovenkamp-Amex, *supra* note 4, at 37-38.

sufficiently powerful to attract new platform participants and to lock-in existing ones at the expense of rivaling platforms. This escalating dynamic confer benefits to the first firm to gain an early lead in market penetration, propelling its growth, and by the corollary erects a tremendous self-augmenting *"network effects entry barrier"* that relentlessly diminishes the ability of rivaling platforms to compete. To enter the market, rivals must offer a sufficiently better product or reduced price to compensate participants for incurring loss in network benefit. When the network effects become powerful enough to effectively deny such compensation, the network is said to have 'tipped' to the incumbent.[20]

These dynamics may also manifest in two-sided (and multi-sided) platforms. At the market entry stage, the need for the two-sided platform operator to attract both sides to realize indirect network externalities is often described as a chicken-and-egg problem, since there has to be enough participants—a critical mass—on one side before the intermediary can attract the other side as well.[21] This problem may understandably become intractable for new market entrants, when most potential participants (on either side) are locked-in to the incumbent's platform. Consider heterosexual dating apps again. To attract men an entrant must have women on the platform, and to attract women such entrant must have men. The entrant will undoubtedly face an uphill battle bootstrapping its app if all men and women are already using an incumbent's app.

While this paper presents the Microsoft and Amex narratives as two viable conceptions competing for preeminence, it is important to recognize that the Microsoft Narrative is by far the more popular of the two. Fueled by the competitive fear which stemmed from the meteoric rise of behemoth platforms such as GAFAM, the antitrust world has been captivated by the ability to seamlessly apply the Microsoft Narrative to the context of every platform that exhibits network effects, regardless of industry. Indeed, ever since the Microsoft Narrative made its case-law debut in the Microsoft antitrust cases,[22] it has dominated virtually every antitrust decision which dealt with platform

[20] Michael L. Katz & Carl Shapiro, *Systems Competition and Network Effects*, 8(2) J. OF ECON. PERSP. 93, at 105-108 (1994) ("**Katz & Shapiro**"); Daniel Rubinfeld, *Antitrust Enforcement in Dynamic Network Industries*, 43 ANTITRUST BULL. 859, at 862 (1998); Gavil & First, *supra* note 2, at 31-32; Kenneth A. Bamberger & Orly Lobel, *Platform Market Power*, 32 BERKELEY TECH. L.J. 1051, at 1068-1069 (2017); Hovenkamp-FAP, *supra* note 15, at 411; Shelanski & Sidak, *supra* note 15, at 8-9.
[21] Microsoft-Middleware, Circuit, *supra* note 2, at 55, 60; Shelanski & Sidak, *supra* note 15, at 59; Erik Hovenkamp, *supra* note 16, at 720.
[22] See *supra* note 2.

competition[23] and has featured extensively in scholarly literature,[24] institutional reports,[25] and even political manifestos.[26]

To understand the Microsoft Narrative's allure, consider the Microsoft Middleware case, in which the DOJ and several states challenged Microsoft's actions to maintain its monopoly in the operating systems ("**OSs**") market.[27] OSs constitute two-sided platforms that exhibit indirect network effects between users and application developers.[28] In analyzing the network effects entry barrier, which the courts named the *"applications barrier to entry"*,[29] the D.C. Circuit explained that *"[i]n markets characterized by network effects, one product or standard tends towards dominance . . . Once a product or standard achieves wide acceptance, it becomes more or less entrenched. Competition in such industries is 'for the field' rather than 'within the field."*[30] This elegant formulation of the Microsoft Narrative's is encompassing, simple and powerful. It is applicable to any platform context, does not require the decisionmaker to engage in complex fact-finding, and most importantly yields an unequivocal result. Indeed, to establish market dominance, all that the decisionmaker is required do is to follow this formulation's simple recipe, that is to inquire whether the market is characterized by network effects or not, and whether there is *"wide acceptance"* (i.e. substantial market share) or not. Usually, both questions are answered almost automatically, and assuming that the answer is affirmative, then voilá, the platform unequivocally possesses monopoly power.

Enamored by this allure, antitrust decisionmakers have uncritically applied the Microsoft Narrative's gospel to countless wildly different platforms,[31] and in so doing have adopted powerful rhetoric that singles out the network effects entry barrier as the primary competition-killer. Consider *Realcomp II v. FTC*, a

[23] *See e.g.* the decisions referred to in *supra note* 8 and *infra* notes 32-33, 35-36, 52, 57, 60, 78, 87.
[24] *See supra* note 20. *See also* Adi Eyal, *Monopolization via Voluntary Network Effects*, 76 ANTITRUST L.J. 799, 800-802 (2010); Lina M. Khan, *Amazon's Antitrust Paradox*, 126 YALE L.J. 710, 785 (2017).
[25] OECD, *Rethinking Antitrust Tools for Multi-Sided* Platforms, at 73 (2018); Stigler Report, *supra* note 8, at 29; Digital Competition Expert Panel, *Unlocking Digital Competition*, at 4, 35 (2019) ("**Unlocking Digital Competition**"); Competition and Markets Authority, *Online Platforms and Digital Advertising*, at 73 (2020).
[26] Elizabeth Warren, *Break Up Big Tech* (2020), https://2020.elizabethwarren.com/toolkit/break-up-big-tech [https://perma.cc/C8UU-XFLY] ("**Warren**").
[27] Complaint, *United States v. Microsoft Corp.*, Civ. Action No. 98-1232 (D.D.C., May 18, 1998); Complaint, *New York v. Microsoft Corp.*, 87 F. Supp.2d 30 (D.D.C. 2000) (No. 98-1233); Plaintiff States' First Amended Complaint, *New York v. Microsoft Corp.*, 87 F. Supp.2d 30 (D.D.C. 2000) (No. 98-1233); Page & Lopatka, *supra* note 11, at 30-31; Gavil & First, *supra* note 2, at 60-61.
[28] Page & Lopatka, *supra* note 11, at 25.
[29] *United States. v. Microsoft Corp.*, 84 F.Supp.2d 9, ¶31 (D.D.C. 1999); Microsoft-Middleware, Circuit, *supra* note 2, at 55.
[30] Microsoft-Middleware, Circuit, *supra* note 2, at, 49; *See also United States v. Microsoft Corp.*, 87 F.Supp.2d 30, 36 (D.D.C. 2000) ("**Microsoft-Middleware, Conclusions of Law**").
[31] Such industries include OSs, app stores, search engines, social media, MLSs, and ride-hailing. *See supra* notes 2, 8, and *infra* notes 32-33, 35-36, 52, 57, 60, 78, 87.

case which dealt with a Multiple Listing Service ("**MLS**"), essentially a two-sided platform that intermediates between real-estate brokers representing buyers and sellers.[32] In that case, the FTC's Chief Administrative Law Judge ("**ALJ**") determined that network effects conferred to the Realcomp MLS *"substantial market power"*,[33] because they made successful entry by a rival MLS *"improbable"*.[34] These findings were subsequently adopted in their entirety by both the FTC and the Sixth Circuit, who uncritically echoed the ALJ's analysis of network effects.[35]

Likewise, when the E.U. imposed on Google a EUR 4.3 billion fine for engaging in anticompetitive practices that concerned Android mobile devices,[36] the Commission established Google's dominance in the Licensable Smart Mobile OSs market, by citing a study from an independent consultancy, concluding that *"indirect network effects create 'black oceans' which make competition with Android 'impossible.'"*[37] Similarly, to establish Google's dominance in the Android App Stores market, the Commission contented itself with quoting Deutsche Telekom's statement that *"the commercialisation [of an app store] seems close to impossible due to significant network effects as well as developer and customer lock-in"*.[38] Following that, the Commission explained that the combination of Google's first-mover advantage and indirect network effects resulted in an entry barrier that made it, this time in Amazon's words, *"extremely difficult to establish a meaningful market segment share"* for a new entrant.[39]

To be sure, there are fierce objectors to the Microsoft Narrative. The main criticism leveled against the narrative is that Schumpeterian competition[40] might overcome the network effects entry barrier to displace an incumbent's dominance through disruptive innovation.[41] Proponents of this criticism claim that the entrenched monopoly power which stems from the network effects entry barrier is a blessing rather than a curse, because it incentivizes rivals to

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[32] *Realcomp II, Ltd. v. F.T.C.*, 635 F.3d 815, at 819-820 (6th Cir. 2011) ("**Realcomp-Circuit**").
[33] Realcomp II Ltd., Docket No. 9320 (FTC, Off. of Admin. L. Judges, Dec. 10, 2007), 85, 97.
[34] The ALJ further explained that brokers on both the selling and buying sides of the incumbent have *"little or no unilateral incentive"* to switch to an alternative MLS in response to an increase in MLS fees, *"because there would be few, if any"* brokers to cooperate with on the alternative MLS. *Id.* at 43.
[35] Realcomp II Ltd., Docket No. 9320, at 12, 35 (FTC Oct. 30, 2009); Realcomp-Circuit, *supra* note 32, at 828-829.
[36] Case AT.40099 Google, Commission Decision, ¶ 2 (July 18, 2018).
[37] *Id.* ¶ 469(6).
[38] *Id.* ¶ 629.
[39] *Id.* ¶ 638.
[40] *See* Joseph Schumpeter, CAPITALISM, SOCIALISM & DEMOCRACY 81-86 (George Allen & Unwin, 2003) (1943); Mark Dodgson & David Gann, INNOVATION: A VERY SHORT INTRODUCTION, 20-22 (2010).
[41] Stan J. Leibowitz & Stephen E. Margolis, WINNERS, LOSERS & MICROSOFT: COMPETITION AND ANTITRUST IN HIGH TECHNOLOGY, 15 (2001); Shelanski & Sidak, *supra* note 15, at 10-11; Page & Lopatka, *supra* note 11, at 103.

innovate in order to capture monopolistic rents, thus fueling the Schumpeterian competitive process.[42] To substantiate the viability of this conjecture, they point to empirical evidence which they believe demonstrates the rapid substitution of incumbents in the digital sector.[43]

The merit of this criticism, however, is debatable. The empirical experience is riddled with counterexamples of entrenched platforms with persistent market dominance.[44] Incentives notwithstanding, as the network effects entry barrier intensifies, more radical innovation is required to breach it,[45] and the emergence of a disruptive innovation can be agonizingly protracted.[46] Until then, the entrenched platform can inflict competitive harm,[47] and worthwhile innovations cannot proliferate effectively in the market.[48]

Furthermore, the Schumpeterian criticism fails to offer antitrust decisionmakers a practical standard for determining whether the network effects entry barrier is likely to be breached within the confines of individual cases. It merely asserts speculatively that somehow, at some unspecified time, the incumbent will be inevitably displaced.[49] Such speculation is no match to the 'technical' explanation of the Microsoft Narrative that such displacement is utterly improbable in the foreseeable future. Thus, Schumpeterian claims rarely fare well in the case-law.

For example, in the Middleware case, while the D.C. Circuit briefly acknowledged that the entrenchment which stems from the network effects

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[42] A vivid articulation of this normative argument is found in William Baxter's words, that in the digital sector *"[w]e'll have a series of companies leapfrogging one another . . . The worst thing we can do is weaken the incentives to be the successful frog."*. Russ Mitchell and Marianne Lavelle, *Road Runner v. Coyote: As Microsoft Case Shows, Markets Move Faster than Justice*, 123(23) US NEWS AND WORLD REPORT 58 (Dec. 15, 1997).

[43] Hovenkamp, Platform Monopoly, *supra* note 18, at 1969-1970, 1974; Page & Lopatka, *supra* note 11, at 94.

[44] Gal & Petit, *supra* note 10, at 628; Julian Birkinshaw, *How Incumbents Survive and Thrive*, HARV. BUS. REV. 37 (Feb. 2022), https://hbr.org/2022/01/how-incumbents-survive-and-thrive [https://perma.cc/8H74-Z72F].

[45] Ariel Ezrachi & Maurice E. Stuke, VIRTUAL COMPETITION: THE PROMISE AND PERILS OF THE ALGORITHM-DRIVEN ECONOMY 175 (2016).

[46] *Id.*; RICHARD J. GILBERT, INNOVATION MATTERS: COMPETITION POLICY FOR THE HIGH-TECHNOLOGY ECONOMY 15-16 (2020).

[47] Microsoft-Middleware, Conclusions of Law, *supra* note 30, at 36. In addition, monopolies may squash innovations which jeopardize their own businesses, thereby undermining the Schumpeterian process itself. *See* Tim Wu, THE MASTER SWITCH 104-107 (2010) ("**Tim Wu**").

[48] Katz & Shapiro, *supra* note 20, at 106; Shelanski & Sidak, *supra* note 15, at 9; Maria J. Gil-Moltó, *Economic Aspects of the Microsoft Case: Networks, Interoperability and Competition*, *in* MICROSOFT ON TRIAL 361 (Luca Rubini ed., 2010).

[49] Put differently, when the Schumpeterian criticism is leveled at the Microsoft Narrative, antitrust decisionmakers are faced with Hume's problem of induction. They are required to infer from the fact that the network effects entry barrier had been breached in the past, that it will also be breached—in a reasonable time—in the case at hand. David Hume, A TREATISE OF HUMAN NATURE (VOLUME 1) 61-65 (Oxford University Press, 2007).

entry barrier *"may be temporary, because innovation may alter the field altogether,"*[50] the court swiftly emphasized the lack of commentary consensus concerning the likelihood of this possibility and its antitrust implications, and ultimately held that the network effects entry barrier gave Microsoft power to stave off even superior new rivals.[51]

Likewise, in *LiveUniverse v. MySpace*,[52] the court held that MySpace enjoyed monopolistic power[53], preferring LiveUniverse's allegation that network effects entrenched MySpace's position[54] over MySpace's Schumpeterian claim that the industry was characterized by constant market entry and exit.[55] MySpace's monopoly power was not disputed on appeal.[56]

Further, when the E.U. Commission imposed on Microsoft a EUR ~500 million fine for certain dominance abuses,[57] it outright rejected Microsoft's Schumpeterian claims that network effects did not entrench its position.[58] The Commission explained that the threat of a technological revolution was *"unforeseeable and unspecified,"* and determined that Microsoft's Schumpeterian claims were *"invalid"*, since even if a dominant position may be temporary, this does not detract from the current market power of a dominant company.[59] The European General Court approved the Commission's analysis on network effects.[60]

C. The American Express Narrative

The Amex Narrative claims that network effects constitute the ultimate safeguard against platform incumbents' market power abuses, because any such abuse would risk triggering a vicious cycle of *"negative feedback effects"*, an exodus of participants that will result in the platform's collapse. [61] While the notion of

[50] Microsoft-Middleware, Circuit, *supra* note 2, at 49.
[51] *Id.* at 49-50, 56.
[52] *LiveUniverse, Inc. v. MySpace, Inc.*, 2007 WL 6865852 (C.D. Cal. 2007).
[53] *Id.* at *10.
[54] *Id.* at *7-8.
[55] The court acknowledged there was some merit to MySpace's claims, noting that MySpace itself usurped Friendster despite network effects, and that Facebook was gaining momentum. Yet it concluded that while the industry's fluidity begged the question how long MySpace could retain its market power, LiveUniverse's allegations about network effects were nonetheless sufficient. *Id.* at 9-10.
[56] *LiveUniverse, Inc. v. MySpace, Inc.*, 2007 WL 6865852, at *1 (9th Cir. 2008).
[57] Case COMP/C-3/37.792 Microsoft, Commission Decision (Mar. 24, 2004).
[58] *Id.* ¶¶ 448-459.
[59] *Id.* ¶¶ 468-469.
[60] Case T-201/04 *Microsoft Corp. v. Commission of the European Union*, ECLI:EU:T:2007:289 (Ct. of First Instance, Sep. 17, 2007), ¶¶ 562, 1062.
[61] Hovenkamp-Amex, *supra* note 4, at 38.

negative feedback effects has existed in the antitrust literature for some time,[62] its recent endorsement by the U.S. Supreme Court in *Ohio v. American Express Co.* has elevated it to an effective competing narrative to the Microsoft Narrative.

In *Amex*, the U.S. Supreme Court dismissed the government's claim that credit-card company American Express's inclusion of *"antisteering provisions"* in its contracts with merchants violated §1 of the Sherman Act.[63] The case was the first time in which the Court explicitly addressed the concept of two-sided platforms.[64] The Court found that Amex operated a two-sided platform that intermediated between cardholders and merchants, and characterized it as a special type of two-sided platform, a *"transaction platform"*[65] that notably exhibits *"more pronounced"* indirect network effects.[66]

One might expect the Court to continue its analysis by routinely addressing network effects in accordance with the Microsoft Narrative. Yet where the case-law hitherto saw a competitive hazard in the form of a formidable entry barrier, the *Amex* Court romanticized a safeguard against anticompetitive conduct. Indeed, even the key terms *'entry barrier,' 'lock-in'* or *'tipping'* are strikingly absent from the decision.

Instead, the Court laconically explained that *"[d]ue to indirect network effects, two-sided platforms cannot raise prices on one side without risking a feedback loop of declining demand"*[67] and that *"[i]ndirect network effects thus limit the platform's ability to raise overall prices and impose a check on its market power."*[68] Notably, this treatment of the competitive implications arising from network effects was entirely at odds with the fact-findings of the District Court, later iterated by the Second Circuit, which adhered to the Microsoft Narrative in determining that Amex possessed market power and that network effects posed a formidable entry barrier in the credit-card industry.[69]

While the Court formulated the Amex Narrative in the context of two-sided platforms, it can be easily extended to cover one-sided platforms as well.[70]

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[62] David S. Evans & Michael Noel, *Defining Antitrust Markets When Firms Operate Two-Sided Platforms*, 2005 COLUM. BUS. L. REV. 667, 695 (2005); Evans & Schmalensee, *supra* note 5, at 674-675, 688.
[63] Amex, *supra* note 6, at 2280; Hovenkamp-Amex, *supra* note 4, at 43.
[64] Hovenkamp-Amex, *supra* note 4, at 35; Geoffrey A. Manne, *In Defence of the Supreme Court's 'Single Market' Definition in Ohio v American Express*, 7 J. ANTITRUST ENFORCEMENT 104 (2019) ("**Manne**").
[65] Amex, *supra* note 6, at 2280.
[66] *Id.* at 2278, 2286.
[67] *Id.* at 2285.
[68] *Id.* at 2281 n.1.
[69] *United States v. American Express Co.*, 88 F.Supp.3d 143 , 151, 188-190 (E.D.N.Y. 2015); *United States v. American Express Co.*, 838 F.3d 179, 190-92, 201 (2d Cir. 2016).
[70] To illustrate, imagine a hypothetical one-sided platform with 10 users. User 1 is willing to participate in the platform if it can connect to one additional user, User 2 is willing to participate if it can connect to two additional users, and so on. The platform raises its price,

Consequently, the Amex Narrative is just as encompassing, simple, and powerful as the Microsoft Narrative is. Essentially, the Amex Narrative requires decisionmakers to solely decide whether the platform at issue exhibits network effects or not, and if it does, then voilá, there can be no market power abuse. As discussed, whether platforms exhibit network effects is decided almost automatically, and is entirely indifferent to the industry at issue, which means that the Amex Narrative can be quickly applied, just as the Microsoft Narrative has been applied, to any platform case.

Furthermore, contrary to the Microsoft Narrative, the Amex Narrative is indifferent to the platform's market share and can even be applied to situations where incumbents operate in a competitive vacuum. Conceptually, the Amex Narrative cuts in the same vein of contestability theory, which holds that when entry barriers are low, there is a constant threat that new competitors will enter the marketplace and challenge the incumbent. This continuous risk of contestability constrains the incumbent's ability to charge a monopoly price, because the instant the incumbent tries to charge more it faces *"hit-and-run"* entry by competitors.[71] The Amex Narrative's claim is essentially similar, but goes even further, because the risk of negative feedback effects does not depend on competitive pressure, but on the premise that the escalating drop in network value will gradually cause each platform participant to lose interest in continuing their participation.[72] Competitive pressure is not a necessary condition for this risk to materialize, although it can lower the threshold at which each platform participant decides to leave the platform, and is therefore a contributive factor.

In terms of influence over the U.S. antitrust discourse, if the Microsoft Narrative is the entrenched monopolist, then the Amex Narrative is the fledgling maverick. While *Amex* forms a Supreme Court decision and thus possesses the authoritative power to command lower U.S. courts to cite the Amex Narrative, it is far from a foregone conclusion that *Amex* effectively eliminated the U.S. case-law's fixation on the Microsoft Narrative.

For starters, *Amex* was decided only recently, and not enough time has transpired to fully assess its impact on the case-law. Furthermore, *Amex* has been heavily criticized,[73] and this may dissuade lesser courts from applying the Amex

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and subsequently User 1 ceases using the platform. User 10 can now only connect to nine users and therefore follows suit. This prompts User 9 to leave, and so on, until the platform collapses.

[71] Hovenkamp-FAP, *supra* note 15, at 42-43.

[72] *See supra* note 70.

[73] One of the main controversies surrounding *Amex* revolves around the Court's market definition analysis. *See* Hovenkamp-Amex, *supra* note 4, at 57-64, 81; Manne, *supra* note 64, at 110; Michael Katz and Jonathan Sallet, *Multisided Platforms and Antitrust Enforcement,* 127 YALE L. J. 2142, 2170 (2018); Aaron M. Panner, *Market Definition and Anticompetitive Effects in Ohio v. American Express,* 103 YALE L. J. F. 608, 621 (Jan. 18, 2021).

Narrative in future cases. Indeed, *Amex* conferred to the lower courts substantial doctrinal leeway to deviate from the Amex Narrative, for instance by narrowly defining credit-card networks as transaction platforms, a definition that clearly excludes many platforms.

The proliferation of the Amex Narrative may also be hindered by *Amex*'s particular economic context. In contrast to cases such as the Middleware case, the *Amex* decision ultimately dealt with a relatively minor platform that was not a market leader.[74] Likewise, *Amex* considered allegations of exploitative vertical restraints and not exclusionary monopolistic behavior. For now, the same seems true for the subsequent cases that follow *Amex*, which tend to likewise deal with relatively minor platforms, and which obediently cite the Amex Narrative, but do so primarily in the context of considering whether the respective platform's conduct is competitively harmful considering the 'net' effect on all its participants,[75] and not in the context of evaluating the feasibility of inter-platform competition. Exclusionary cases dealing with major platforms, by contrast, still seem to devoutly follow the Microsoft Narrative despite *Amex's* authoritative power.[76]

Outside of the U.S. case-law, the Amex Narrative's influence pales in comparison to the Microsoft Narrative's. In the antitrust literature, the Amex Narrative's risk of negative feedback effects is often mentioned in passing while the network effects entry barrier is being described in detail through the Microsoft Narrative's lens.[77] Likewise, the Microsoft Narrative still dominates the E.U. case-law, where no analogous case of Amex's caliber exists.

D. Antitrust Law's Inability to Reconcile the Narratives' Opposing Claims

The Microsoft and Amex narratives constitute opposing claims which are being sweepingly asserted at a high level of generality. Each narrative comprehensively claims that in any platform context, the same factual element—the presence of network effects—is bound to lead to opposite competitive outcomes. This contradiction bewilders antitrust law, as it cannot be that every dominant platform is simultaneously irreparably entrenched and utterly restrained. The narratives obviously fail to consider other factual intricacies which complicate network effects dynamics, thus resulting in an oversimplistic competitive analysis.

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[74] *Amex*, *supra* note 6, at 2282.
[75] *See e.g. U.S. Airways, Inc. v. Sabre Holdings Corp.*, 938 F.3d 43, 56 (2d Cir.2019); *United States v. Sabre Corp.*, 452 F.Supp.3d 97, 136 (D. Del. 2020); *Competitive Enter. Inst. V. Fed. Commc'n Comm'n*, 970 F.3d 372, 383-384 (D.C. Cir. 2020); *In re Nat'l Collegiate Athletic Ass'n Athletic Grant-In-Aid Cap Antitrust Litig.*, No. 14-MD-02541 CW, 2018 WL 4241981, at *4 (N.D. Cal. 2018); Viamedia, Inc. v. Comcast Corp., No. 16 C 5486, 2022 WL 742488, at *8 (N.D. Ill. Mar. 11, 2022).
[76] *See, e.g.*, FTC v. Facebook, *supra* note 8; SC Innovations-Decision, *infra* note 78.
[77] *See, e.g.*, Hovenkamp-Amex, *supra* note 4, at 38.

Unfortunately, current antitrust law is ill-equipped to discuss these narratives critically and, as a result, lacks the proper means for developing intelligible principles for deciding between them, both in the confines of individual cases and certainly across the board. Indeed, as it frustratingly stands, it seems that in any case where one can invoke the Microsoft Narrative to argue that a platform is entrenched and therefore possesses immense market power, one may equally invoke the Amex Narrative to counter that its power is restrained, and vice versa.

SC Innovations v. Uber provides a vivid example for this indeterminacy. In that case, Sidecar, a defunct ride-hailing company, claimed that it was driven out of business by Uber's alleged anticompetitive practices in the ride-hailing market.[78] Notably, Sidecar successfully relied on both the Microsoft and Amex narratives in making its different claims. First, Sidecar employed the Microsoft Narrative to establish Uber's market power,[79] to which Uber predictably responded with the Amex Narrative defense.[80] Holding for Sidecar, the court summarily dismissed Uber's Amex Narrative defense, concluding that *"[Sidecar] has plausibly suggested a mechanism—the same network effects* addressed *in American Express—by which Uber can leverage its dominant market share to raise both passenger fares and commissions withheld from drivers without a rival increasing output to restore competitive equilibrium."*[81] Yet Sidecar also employed the threat of negative feedback effects to charge that Uber had waged a campaign of fraudulently hailing and canceling rides on Sidecar's platform, thereby successfully triggering a vicious downward spiral of drivers and riders leaving the platform.[82] One would expect the court to continue adhering to the Microsoft Narrative, and at the very least question the claim. After all, as both Sidecar and Uber constituted similar ride-hailing platforms, the Microsoft Narrative should have afforded substantial protection to Sidecar from negative feedback effects, making it less likely that negative feedback effects indeed led to Sidecar's downfall. But despite

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[78] *SC Innovations, Inc. v. Uber Tech., Inc.*, 2020 WL 2097611 (N.D. Cal., May 1, 2020) ("**SC Innovations-Decision**").

[79] *Id.* at 2; *SC Innovations, Inc. v. Uber Tech., Inc.*, Second Amended Complaint, Demand for Jury Trial, Case No. 3:18-cv-07440-JCS, ¶2 (N.D. Cal. 2020) ("**SC Innovations-Complaint**") (*"Uber exploited [the network effects entry barrier] with a 'winner takes all' strategy it has pursued since its inception of predatorily pricing below its costs . . . to capture the overwhelming power over the market while enjoying the protections afforded by [the network effects entry barrier]"*); *See also* SC Innovations-Decision, *supra* note 78, at 2.

[80] *SC Innovations, Inc. v. Uber Tech., Inc.*, Defendant's Motion to Dismiss Second Amended Complaint, Case No. 3:18-cv-07440-JCS (N.D. Cal., Feb. 18, 2020), at 6. (*"[Sidecar] (mistakenly) believes that [network effects] ease rather than heighten [Sidecar's] burden in pleading market power. But the reverse is true. As the Supreme Court has held, 'indirect network effects. . . limit the platform's ability to raise overall prices and impose a check on its market power'"*).

[81] SC Innovations-Decision, *supra* note 78, at 9.

[82] SC Innovations-Complaint, *supra* note 79, at 114-118.

the court's unwillingness to apply the Amex Narrative to Uber's platform, the court was surprisingly comfortable with applying this narrative to Sidecar's.

This inconsistency invites questions. First, why did the court completely ignore the Amex Narrative in Uber's context, considering its conclusion that the risk of negative feedback effects materialized against Sidecar? The court said borderline nothing in that regard. Second, why did the court completely ignore the Microsoft Narrative in Sidecar's context? This question is particularly puzzling considering the court's factual finding that Sidecar's platform was already *"established"*[83] when Uber attacked it. The court did not explicitly address this question, but its answer seems to rest on the disparity in the relative size of the platforms.[84] That is, the court hypothesizes that when a large platform and a small platform compete, the network effects entry barrier is bound to tip the competition to the large platform, while negative feedback effects will tear to shreds the smaller one. This hypothesis, however, rests on assumptions that are far from self-evident.[85] Furthermore, at the extreme this hypothesis breaks the causal link between Uber's alleged anti-competitive conduct and Sidecar's downfall, for if the disparity in platforms' relative size is sufficient to bring about a larger platform's triumph, then Uber would have defeated Sidecar regardless of any anti-competitive practices it engaged in.

In truth, it seems that the reason why the court preferred the Microsoft Narrative in Uber's context, and the Amex Narrative in Sidecar's context, stems more from the wisdom of hindsight than careful reasoning. Sidecar's downfall and Uber's triumph were *fait accompli*, leading the court to adopt in retrospect oversimplistic explanations as to how network effects affected competition. But the truth lies in the middle, and it is safer to assume that both narratives applied to each platform simultaneously. Evidently, antitrust law needs better analytical tools to address the intricacies of this competitive reality.

While *SC Innovation* exposes antitrust law's inability to reconcile the narratives' opposing claims, the indeterminacy extends far beyond this case, embroiling antitrust's decisionmaking across the entire digital sector. Indeed, the two narratives lead in completely opposite normative directions with sharp practical consequences. On the one hand, if we follow the path that the Microsoft Narrative lays before us, that is, we accept the claim that the network effects entry barrier is sufficiently powerful to insulate incumbents from competitive pressure, then this warrants extensive legal intervention in the

[83] SC Innovations-Decision, *supra* note 78, at 2, 8.
[84] *Id.* at 8.
[85] For example, despite network effects, the migration of participants from small platforms to large ones may be hampered by switching costs arising from a variety of competitive barriers, such as price or getting accustomed to an interface. One cannot simply assume that any disparity in the platforms' relative size, however minor, will enable network effects to overpower such barriers.

digital sector. This view has gained considerable traction in recent years, largely due to the meteoric rise and growing market dominance of GAFAM. Calls to ramp up antitrust enforcement in the platform context have already borne fruit and led to stricter merger control,[86] as well as to the imposition of hefty billions of dollars fines.[87] But the peak may yet to come, as there are growing calls that some platforms' market power has grown so immense, and the network effects entry barrier so robust, that nothing but the employment of break ups—the most drastic measure in the antitrust arsenal[88]—will suffice to address these platforms' dominance.[89]

Conversely, if we follow the Amex Narrative's path, that is, we accept the assertion that negative feedback effects effectively countervail platform market power, then the market will ultimately police itself, meaning that further antitrust and regulatory intervention would prove unnecessary or even harmful. Platforms after all offer immense network benefits to their participants, and over-intervention risks costing the public valuable services.[90] Moreover, considering the immense resources that are usually required to litigate high-tech cases,[91] unwarranted antitrust intervention would be incredibly wasteful.

There is thus a pressing need to critically evaluate the narratives' validity, and develop intelligible principles to decide which narrative prevails and which

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[86] US Dep't of Justice & Fed. Trade Comm., *Draft Merger Guidelines* (2023); Herbert Hovenkamp, *Distinguishing Harms from Benefits in the 2023 Merger Guidelines*, PROMARKET (2023), https://www.promarket.org/2023/08/31/herbert-hovenkamp-distinguishing-harms-from-benefits-in-the-2023-merger-guidelines/ [https://perma.cc/KCG3-WB95] (noting that the draft guidelines would apply a stricter standard to both horizontal and vertical mergers); Carl Shapiro, *Why Dropping Market Power from the Merger Guidelines Matters* (2023), https://www.promarket.org/2023/08/07/carl-shapiro-why-dropping-market-power-from-the-merger-guidelines-matters/ [https://perma.cc/6YL5-JZ9K].

[87] *See, e.g.*, *supra* notes 36, 57, 60; *See also* Case T-612/17 *Google LLC v. European Commission*, ECLI:EU:T:2021:763 (General Ct., Nov. 10 2021), at ¶702 (imposing a fine of roughly EUR 2.42 billion).

[88] Structural remedies are considered more stringent than behavioral ones. Richard A. *Epstein, Monopolization Follies: The Dangers of Structural Remedies Under Section 2 of the Sherman Act*, 76 ANTITRUST L. J. 205, 206 (2009); Philip J. Weiser, *Regulating Interoperability: Lessons from AT&T, Microsoft, and Beyond*, 76 ANTITRUST L. J. 271, 296 (2009).

[89] *Tim Wu Explains Why He Thinks Facebook Should Be Broken Up*, WIRED (7.5.2019), https://www.wired.com/story/tim-wu-explains-why-facebook-broken-up/ [https://perma.cc/7ZZV-LZPL]; Warren, *supra* note 26; Dan Milmo, *Lawsuit Aiming to Break Up Facebook Group Meta Can Go Ahead, US Court Rules*, GUARDIAN (Jan 12, 2022), https://www.theguardian.com/technology/2022/jan/12/lawsuit-aiming-to-break-up-facebook-group-meta-can-go-ahead-us-court-rules [https://perma.cc/C8CD-EENM]; William Skipworth, *Here's How Amazon Could be Broken Up After an FTC Lawsuit*, FORBES (July 27, 2023), https://www.forbes.com/sites/willskipworth/2023/07/27/heres-how-amazon-could-be-broken-up-after-an-ftc-lawsuit/?sh=118b63cf3ab2 [https://perma.cc/K3CF-A46X].

[90] Gal & Petit, *supra* note 10, at 621.

[91] Page & Lopatka, *supra* note 11, at 5, 14.

relents across different platform contexts. To achieve this, Part III will introduce the reader to network science, a novel cutting-edge methodology for analyzing the properties of networks. Embracing this methodology will equip antitrust law with insights currently outside its purview, but which are crucial to assessing the competitive implications of network effects. Specifically, part III lays the groundwork for debunking the Microsoft Narrative by unveiling that many platforms possess scale-free topologies, exhibiting hubs that pose a critical vulnerability to platforms robustness. It similarly paves the way for challenging the Amex Narrative, by underscoring the intricate and context-dependent nature of cascading failures propagation, precluding the narrative's oversimplified generalizations.

II. A Very Short Introduction to Network Science

A. Terminology and Key Network Characteristics

Network theory is a new academic field which studies complex systems. The field describes a wide range of systems in nature and society, ranging from social to technological, infrastructural, biological, and economical systems. While seemingly disparate, it is increasingly recognizable that real-world networks share common features, and that their topology and evolution are governed by similar organizing principles.[92] Since platforms likewise constitute complex networks, this field offers unique insights to their competitive analysis.[93]

Networks consist of *"nodes"* that interact with one another through *"links."* We denote the total number of nodes in the system with N, and the total number links in the system with L.[94] For example, we could diagram Facebook's network by representing users and business pages with nodes, and interactions between such users and businesses (befriending a user or liking a business page) with links.

Once we established the nodes and links of the network, we can employ network science to investigate the network's properties. For the purpose of this paper, we shall focus on two such properties, the *"average degree"*[95] and the *"degree distribution."*[96] To understand their meaning, we must first familiarize ourselves with a key property that each node has, that is a node's *"degree"*, representing the

[92] Barabási, *supra* note 12, at 23-24; Reka Albert & Albert-László Barabási, *Statistical Mechanics of Complex Networks*, 74 REV. OF MODERN PHYSICS 47, 47-48 (2002) ("**Statistical Mechanics**"); Albert-László Barabási et al., *Uncovering the Role of Elementary Processes in Network Evolution*, 3:2920 SCIEN. REP. 1, at 1 (2013).
[93] Barabási, *supra* note 12, at 24.
[94] *Id.* at 45.
[95] *Id.* 48-49.
[96] *Id.* at 49-51.

number of links that a node has to other nodes in the system.[97] In Facebook, the users' degree may represent the number of friends they have, in addition to the number of business pages they follow.[98] We denote by k the degree of the ith node in the network.[99] For example, in the illustration below, node number 1 in the network has 2 links, thus $k_1 = 2$.

The average degree, denoted by $\langle k \rangle$, captures the number of links that each node has on average, which for an undirected network is:[100]

$$\langle k \rangle = \frac{1}{N}\sum_{i=1}^{N} k_i = \frac{2L}{N}$$

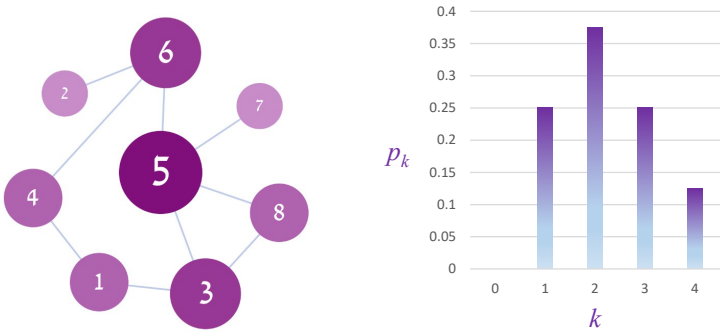
The degree distribution, denoted by p_k, provides the probability that a randomly selected node has degree k. For a network with N nodes, the probability that a node has exactly k links is given by the ratio between the number of nodes that have degree k and the total number of nodes, meaning that:[101]

$$\sum_{k=1}^{\infty} p_k = 1 \qquad\qquad p_k = \frac{N_k}{N}$$

To illustrate, Figure 1 details a network with 8 nodes and 9 links, detailing its average degree and degree distribution. This network has, for example, 3 nodes with 2 links, and so the chance of randomly selecting a node with two links is $p_3 = \frac{3}{8} = 0.375$.

Fig. 1

[97] *Id.* at 47.
[98] *Id.* at 29, 81.
[99] *Id.* at 47.
[100] *Id.* at 48. A network is *"undirected"* when there is no significance to the direction of the links in the network. For instance, in Facebook there is no direction to the friendship interaction between the users. If I am friends with Lauren, then Lauren is friends with me. By contrast, in the WWW, URLs point out from one webpage to the next in a directed manner. *Id.* at 45.
[101] *Id.* at 49.



Nodes (*N*) 8 **Links (*L*)** 9 **Average Degree ($\langle k \rangle$)** 2.25

B. Random and Scale-Free Networks

Network science endeavors to construct models that reproduce the topologies of real networks.[102] One possibility is that networks' topologies spun at random, which may seem intuitively appropriate for some networks. One might hypothesize, for example, that social networks possess a random topology since individuals meet their acquaintances through random encounters.[103] This apparent randomness has been embraced by the "*random network model*" which constructs networks that are purely random. One way to construct a random network is to start with N nodes and connect every node pair with probability p.[104]

For this paper's purposes, the main thing to note concerning random networks is that there are no hubs in their topology. While there can be different realizations of random networks with the same parameters N and p, the fixation of p for connecting each node pair means that each node in the network is expected to possess almost the same number of links. Accordingly, the degree distribution of random networks is bell-curved with its peak around the average degree $\langle k \rangle$.[105]

In contrast, *"scale-free networks"* exhibit hubs. Their degree distribution is not bell-curved but follows a power law.[106] As a result, large scale-free networks

[102] *Id.* at 74.
[103] *Id.* at 81.
[104] *Id.* at 74-78; Statistical Mechanics, *supra* note 92, at 48.
[105] Barabási, *supra* note 12, at 78-81; Albert-László Barabási & Eric Bonabeau, *Scale Free Networks*, SCI. AM. 50, at 52-53 (2003) ("**Barabási & Bonabeau**").
[106] Barabási, *supra* note 12, at 115-120; Statistical Mechanics, *supra* note 92, at 71. The recent scientific interest in scale-free networks ensued following a series of seminal papers

exhibit numerous low-degree nodes coexisting with a few highly connected hubs, which have orders of magnitude more links than the most connected nodes in random networks.[107] This aligns with empirical observations that have shown that many real-world networks constitute scale-free networks and exhibit hubs.[108]

Figures 2a-b illustrate this difference, comparing two networks that have the same number of nodes ($N = 50$), links ($L = 96$), and average degree ($\langle k \rangle = 3.84$). Figure 2a depicts a random network, whereas Figure 2b depicts a scale-free one. As is apparent, in the random network, most nodes have a comparable degree in the vicinity of $\langle k \rangle$, that is, approximately 4 links. Conversely, in the scale-free network, most nodes have degree lower than $\langle k \rangle$, that is, between 2 and 3 links, but the number of hubs and their degree also increases. For convenience, the nodes' labels indicate their degree.

Fig. 2.

published by Barabási and colleagues at the University of Notre Dame who mapped the topology of the WWW. *See* Albert-László Barabási & Réka Albert, *Emergence of Scaling in Random Networks*, 286 SCIENCE 509 (1999) ("**Barabási & Albert**"); Albert-László Barabási et al., *Mean-Field Theory for Scale-Free Random Networks*, 272 PHYSICA A 173 (1999); Albert-László Barabási et al., *Error and Attack Tolerance of Complex Networks*, 406 NATURE 378 (2000).

[107] Barabási, *supra* note 12, at 121.

[108] *Id.* at 127-128.

Figure 2a

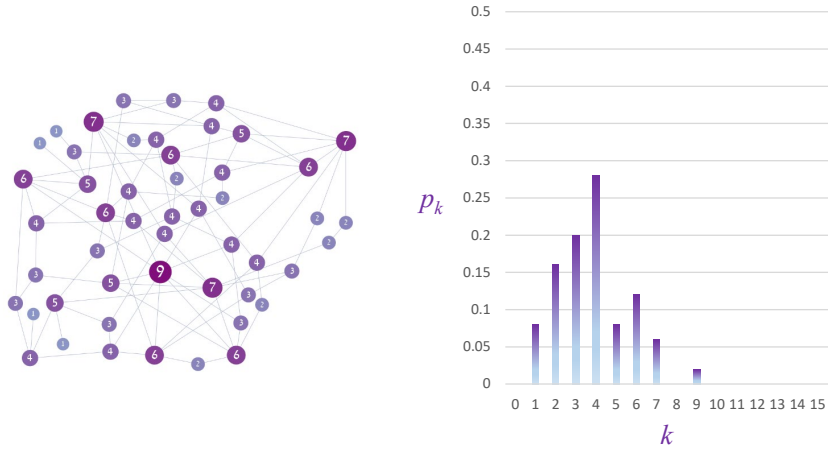
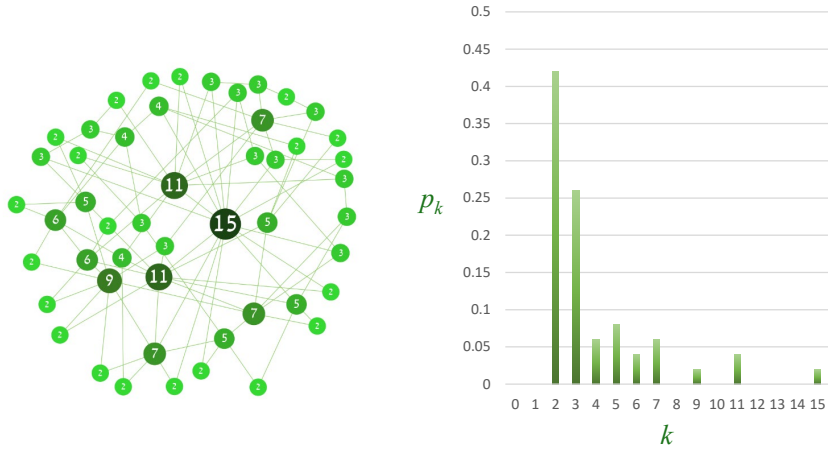


Figure 2b



Nodes (*N*) 50 **Links (*L*)** 96 **Average Degree ($\langle k \rangle$)** 3.84

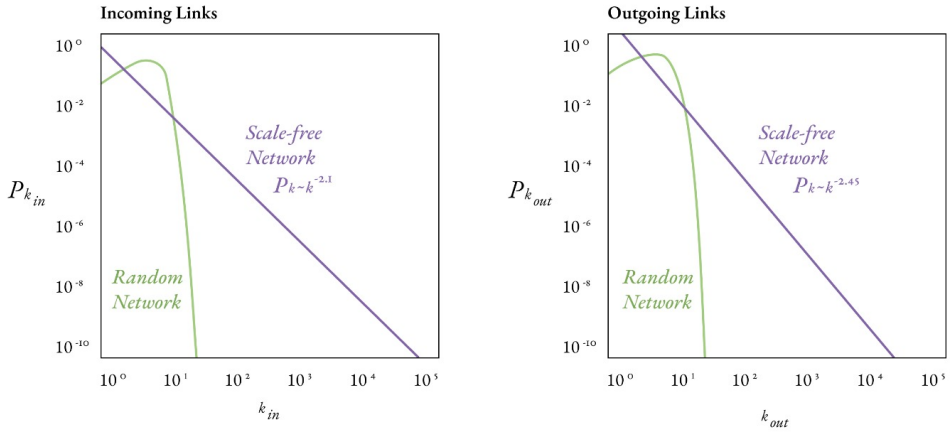
This difference will become even more pronounced as we increase the networks' size. For example, Figures 3a-b show the degree distribution of a sample of the WWW (in purple), as well as the degree distribution of a random network with the same N, L and $\langle k \rangle$ (in green).[109] Note that the scales are logarithmic. The WWW is directed and so Figure 3a shows incoming URLs and Figure 3b shows outgoing URLs. As apparent, the scale-free WWW exhibits

[109] This figure is a reproduction of the one found in Barabási, *supra* note 12, at 115, which in turn is based on Réka Albert et al., *Diameter of the World-Wide-Web*, 401 NATURE 130 (1999). For explanatory purposes, it also incorporates elements from Barabási, *supra* note 12, at 120.

hubs that are several orders of magnitude larger than the largest node in the comparable random network.

Fig. 3.

Figure 3a *Figure 3b*



C. The Formation Process of Hubs in Scale-Free Networks

The fact that real networks deviate substantially in their properties from random ones implies that pure chance cannot be the sole driving force behind the topology of real networks. When one considers this realization, together with the revelation that hubs and the related scale-free topology have been observed in many remarkably different real-world networks, this immediately begs the question: what are the mechanisms, aside from randomness, that bring about the emergence of hubs in scale-free networks?[110]

This question has been answered in 1999 through the seminal *"Barabási-Albert model"*,[111] a minimal proof-of-concept model that generates scale-free networks.[112] This model indicates that the combination of two simple mechanisms—which are absent from the random network model—are responsible for the scale-free topology.[113]

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[110] Barabási, *supra* note 12, at 99-100, 127-128 and 165-166.
[111] Barabási & Albert, *supra* note 106, at 510. For a technical explanation of the model, *see* Barabási, *supra* note 12, at 169-170.
[112] Barabási, *supra* note 12, at 192.
[113] *Id.* at 169-170.

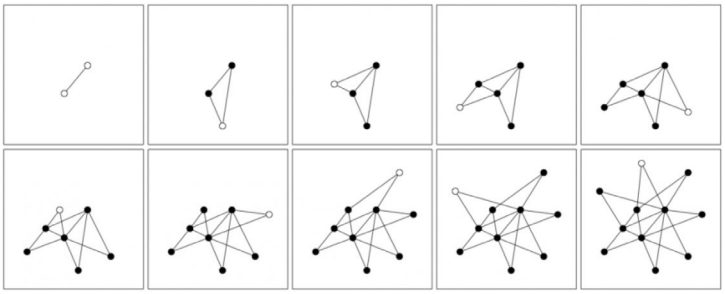
(1) *"Growth"*: the random network model assumes that the total number of nodes is fixed. Yet real-world networks are the result of a growth process that continuously increases the network's size through the addition of new nodes.[114] For example, since Mark Zuckerberg created the first Facebook Profile in 2004,[115] Facebook has grown to an astounding size through a continuous addition process of new profiles and pages to Facebook's network.

(2) *"Preferential Attachment"*: the random network model assumes that nodes link to one another through pure randomness. Yet, in real-networks nodes tend to link to more connected nodes.[116] In Facebook, users are far more likely to follow a celebrity such a Cristiano Ronaldo than some average user. Indeed, the most followed Facebook pages have millions of followers, much higher than the number of followers that the average page/user enjoys.[117]

To illustrate, Figure 4's sequence of images shows nine subsequent steps of the Barabási-Albert model. At each time step, a node with two links is added to the network. These links have an increased probability to connect to more connected nodes:[118]

[114] *Id.* at 166-167.
[115] Camelia Zoica, *First 10 People on Facebook: Who Created the First Facebook Accounts?*, HOT IN SOCIAL MEDIA (May 21, 2020), https://hotinsocialmedia.com/the-first-10-people-who-have-made-a-facebook-account/ [https://perma.cc/HB2M-DVJQ].
[116] Barabási, *supra* note 12, at 167-169.
[117] *Most Popular Facebook Fan Pages as of June 2022, Based on Number of Fans*, STATISTA (2022), https://www.statista.com/statistics/269304/international-brands-on-facebook-by-number-of-fans/ [https://perma.cc/DJB8-27SG].
[118] The Figure is taken from Barabási, *supra* note 12, at 169.

Fig. 4.



Because the preferential attachment increases the likelihood of each node to attract new links every time that node gains a new link, the model results in a *"rich-gets-richer phenomenon"* that provides older nodes with an advantage in acquiring new links. As the network evolves, the older-larger nodes will acquire links at the expense of smaller nodes, eventually becoming hubs. This situation notably aligns with the first-mover advantage that results from the network effects entry barrier.[119]

To be sure, there are other mechanisms besides Growth and Preferential Attachment which shape the topologies of real-world networks.[120] Other mechanisms that network science has discussed extensively include, *"fitness"*,[121] *"internal links addition"*[122] and *"node deletion"*.[123] While these mechanisms are expected to make the network either more or less homogeneous and by the corollary alter the size of the hubs, they typically do not entail the loss of the hub-generating scale-free topology.[124] This finding bolsters the expectation to find hubs in diverse network contexts, which together with the hitherto empirical evidence that networks tend to exhibit the scale-free property, indicates the wide applicability of this paper's contribution to the competitive analysis of many different platforms.

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[119] *Id.* at 170, 173-174.
[120] In real networks the growth rate of nodes does not depend on age alone. In the WWW, for example, Facebook became the largest social media hub even though other social media platforms preceded it. Spencer Weber Waller, *Antitrust and Social Networking*, 90 N.C. L. REV. 1771, 1801 (2012).
[121] The term *"fitness"* refers to the intrinsic ability of nodes to attract links, irrespective of their degree. Barabási, *supra* note 12, at 203-205
[122] *Id.* at 219-217.
[123] *Id.* at 219-220.
[124] A network is considered *"homogeneous"* when its nodes have comparable degrees. In scale-free networks, the more homogenous the network is, the smaller are its hubs. For how different mechanisms affect scale-free networks' homogeneity, *see Id.* at 215-223.

D. Network Robustness

1. Random Node Removal and Targeted Attacks

Network robustness is the subfield under network science exploring the impact of node failures on a network's integrity. The question of primary interest for this subfield is what percentage of nodes needs to be removed from a network to break it into tiny clusters.[125] We consider the impact of two alternative processes of node removal, both in the context of random networks and scale-free ones. Under *"random node removal"* we gradually remove randomly selected nodes from a network,[126] whereas *"targeted attacks"* focus on a network's hubs by first removing the highest-degree node, then the second highest-degree node, and so on.[127]

Random networks do not exhibit hubs, and so there is little difference between random node removal and targeted attacks.[128] For random networks, the critical threshold at which the network breaks is often found around the ~60% mark, depending on the network's density.[129] Conversely, scale-free networks demonstrate extraordinary resilience to random node removal, requiring one to remove almost the entirety of nodes to break a scale-free network.[130]

The reason for this enhanced robustness lies in the presence of hubs in scale-free networks' topologies. Random node removal is blind to nodes' degree, thus affecting with equal probability high-degree and small-degree nodes. However, in scale-free networks there are far more small-degree nodes than hubs, and therefore the random removal process will predominantly target small-degree nodes, with negligible chances to randomly select a hub. Since small-degree nodes are far less valuable to the network's integrity, their removal does little damage.[131]

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[125] *Id.* at 271-277. In strict mathematical terms, the condition for a network to become broken is for its largest remaining cluster—called the *"giant connected component"* ("**GCC**")—to become independent of the network size N. Put differently, the degree of network fragmentation can be measured over a continuum depending on the extent to which the size of the GCC depends on N. A network will be deemed more connected if the size of its GCC increases linearly with N ($GCC \sim N$) than if the size of its GCC increases logarithmically with N ($GCC \sim \log N$). My deepest thanks to Prof. Baruch Barzel for this explanation.
[126] *Id.* at 276.
[127] *Id.* at 284.
[128] *Id.* at 285.
[129] *Id.* at 280, 286; GUIDO CALDARELLI & MICHAEL CATANZARO, NETWORKS: A VERY SHORT INTRODUCTION 97-98 (2012).
[130] Barabási, *supra* note 12, at 280; Barabási & Bonabeau, *supra* note 105, at 56 (noting that simulations on the scale-free Internet network showed that as many as 80% of randomly selected Internet routers can fail and the remaining ones will still form a connected cluster).
[131] Barabási, *supra* note 12, at 281; Melanie Mitchell, COMPLEXITY: A GUIDED TOUR 245-246 (2009).

While hubs provide scale-free networks with enhanced robustness against random node removal, relying on them entails a serious drawback in the form of an Achilles' heel to targeted attacks. The removal of a single hub is unlikely to fragment a network, as the remaining hubs can nonetheless hold the network's integrity together. But the gradual removal of hubs can rapidly break the network asunder.[132] In fact, it turns out that the simultaneous removal of as little as 5-15% of all hubs can completely dismantle a scale-free network.[133] This threshold is remarkably low, not only in comparison to scale-free networks under random node removal, but also in comparison to comparable random networks.[134] This Achilles' heel is obviously non-existent in random networks that do not possess hubs.[135]

2. Cascading Failures

The hitherto analysis of random node removal and targeted attacks has assumed that nodes fail independently of each other, meaning that the removal of each node has no effect on the intactness of the remainder of nodes in the network. In real networks, however, the intactness of each node often depends on the intactness of its neighboring nodes, meaning that the removal of one node may induce the failure of the nodes connected to it.[136] This phenomenon is referred to as *"cascading failures"*.

The emergence of a cascading failure depends on many variables, from the topology of the network on which the cascade propagates, through the nature of the propagation process, to the breakdown threshold of each individual network component.[137] Modeling the precise process by which cascading failures occur in real networks is therefore context-specific and incredibly complex.[138] However, as a general rule cascading failures can only exacerbate the vulnerability of networks to independent node removal. Additionally, the presence of hubs typically constitutes the chink in the networks' armor also in the context of cascading failures.[139]

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[132] Barabási, *supra* note 12, at 284.
[133] *Id.* at 285; Barabási & Bonabeau, *supra* note 105, at 55-56.
[134] Barabási, *supra* note 12, at 283-284.
[135] *Id.* at 285.
[136] *Id.* at 286.
[137] *Id.* at 292.
[138] For example, in real-world networks the breakdown threshold for each node may vary, failed nodes might become healthy again, multiple nodes might fail (or become healthy) simultaneously, and so on.
[139] Consider the *"failure propagation model"* wherein the breakdown threshold at which each node fails depends on the percentage of its neighboring nodes that have already failed. Barabási, *supra* note 12, at 293-294. In this model, hub-targeting is both more likely to trigger a cascading failure and would hasten the network demise in less timesteps. We can also easily envision alternative breakdown thresholds that would make hub-targeting even more crucial, for example if nodes fail when their links to a critical number of hubs are severed.

III. The Narratives Through the Lenses of Network Science

A. Transcending the Narratives' Binary-Simplistic Nature

Having established a foundation in network science, we can now unravel the Gordian Knot which stems from the narratives' sweeping claims concerning how network effects impact competition. It is easy to notice some striking conceptual similarities between the narratives and network science. For example, the Microsoft Narrative's claim that the importance of network connectivity incentivizes participants to connect to the largest network, thus bringing about the self-augmenting network effects entry barrier and risk of tipping,[140] is fully aligned with networks science's preferential attachment mechanism and the associated rich-gets-richer phenomenon.[141] And the elusive concept of negative feedback effects that underpins the Amex Narrative,[142] is akin to network science's concept of cascading failures.[143]

Yet there is a fundamental difference between the narratives' and network science's grasp of network effects. The narratives discuss network effects in a binary *'if-then'* language that is highly ambiguous. Recall for instance the Middleware case's formulation of the Microsoft Narrative that *"[i]n markets characterized by network effects, one product or standard tends towards dominance . . . Once a product or standard achieves wide acceptance, it becomes more or less entrenched."*[144] This claim essentially progresses with a binary decision tree: either the market is characterized by network effects or not; either there is wide acceptance or not; and if both conditions are met then, voilà, there is necessarily entrenchment (and dominance). This formulation notably fails to either limit the claim's scope or to provide any meaningful guidance on how to apply its loose terms to specific circumstances. One is left wondering, among other things, whether this claim holds true across all platforms characterized by network effects, what exactly constitutes wide acceptance, or how to discern between different degrees of entrenchment. In contrast, network science views underlying network properties as a matter of discoverable magnitude. To determine how entrenched a platform is, network science delves into its underlying topology, factoring in many variables including the platform's network size, its density, whether it has hubs, the breakdown thresholds of its various participants, and so on.

Similarly, recall the formulation of the Amex Narrative that *"[d]ue to indirect network effects, two-sided platforms cannot raise prices on one side without risking a*

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[140] *See supra* I.B.
[141] *See supra* II.C.
[142] *See supra* I.C.
[143] *See supra* II.D.2.
[144] Microsoft-Middleware, Circuit, *supra* note 2, at 49.

feedback loop of declining demand."[145] and that *"[i]ndirect network effects thus limit the* platform's *ability to raise overall prices and impose a check on its market power."*[146] This formulation likewise progresses with a binary decision tree, employing loose terms to essentially claim that when there are indirect network effects, there cannot be supra-competitive prices. But again, this formulation obscures fundamental issues for determining the claim's scope, including the exact point at which the price raise would suffice to trigger a negative feedback loop (given the counterbalancing lock-in of existing participants), whether this point always resides above the supra-competitive threshold, and whether every negative feedback loop automatically entails the collapse of the entire platform. As we have seen, network science enables us to answer these questions to a far better extent, because the different variables that bring about a cascading failure, including the breakdown threshold for each platform participant, the network topology, and the propagation process, could all be modeled. Thus, with sufficient data, we could assess the exact necessary conditions to bring about a cascading failure of a certain size.

In the coming sections, this paper will level two generalized criticisms against the Microsoft and Amex narratives. The paper will show that the presence of hubs demonstrably weakens the Microsoft Narrative's assertion regarding the formidability of the network effects entry barrier, and the Amex Narrative vastly exaggerates the risk of negative feedback effects. However, these generalized criticisms should not overshadow the essential principle that the competitive impact of network effects must be thoroughly analyzed on a case-by-case basis. While shared mechanisms shape the structure of diverse networks, they nonetheless retain their unique properties.

The emerging complexity may seem overwhelming, yet dealing with factual complexities is standard practice in antitrust law. In nearly every antitrust case, expert economists are called upon to explain the vast array of technical economic intricacies involved.[147] It would be unimaginable not to rely on such economic expertise. As network science forms the best tool to address the intricacies of networks, it is equally essential to leverage the specialized knowledge of network scientists to scientifically resolve the intricacies that platform cases present.

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[145] *Amex*, *supra* note 6, at 2285.
[146] *Id.* at 2281 n.1.
[147] John L. Solow & Daniel Fletcher, *Doing Good Economics in the Courtroom: Thoughts on Daubert and Expert Testimony in Antitrust*, 31 J. CORP. L. 489, 489-91 (2006).

B. The Microsoft Narrative Overestimates the Network Effects Entry Barrier

1. Employing Hub-Plucking to Breach the Network Effects Entry Barrier

The Microsoft Narrative assumes a homogeneous view of network effects, positing that all platform participants uniformly contribute to a platform's network externalities, thus making them equally valuable to its network integrity. The conception is that in a platform with a huge number of equivalent participants, the unilateral defection of a single participant will pale in comparison to the many remaining participants and will not be significant enough to induce further defections.

This conception may be valid for platforms exhibiting random topologies, where all nodes have a comparable number of connections.[148] However, this conception is demonstrably incompatible with platforms exhibiting scale-free topologies, since such platforms' hubs are considerably more important for their network integrity than low-degree nodes. Indeed, the topologies of networks dramatically impact their robustness, and the withdrawal of but a small percentage of hubs in scale-free networks can inflict critical damage to their integrity. Yet the Microsoft Narrative remains strikingly oblivious to hubs' presence in platforms' networks.

To illustrate, let us compare Uber and Facebook. Uber demonstrably deviates from a scale-free topology, adopting a distinct *"hub-and-spoke"* architecture, wherein Uber itself acts as a central sole hub surrounded by a multitude of low-degree nodes representing countless riders and drivers. Each participant directly connects with Uber through the downloaded app, their sole link to the hub. Further representing the rides that occur between drivers and riders with links would grant them a limited, comparable, increase in transient connections.[149] Given Uber's hub-and-spoke topology, and assuming high market share, the Microsoft Narrative correctly captures how the network effects entry barrier entrenches its market position. With no hubs, there is no vulnerability to exploit in the network effects entry barrier, and so rivals will

[148] However, this requires to some additional assumptions. For example, just as fitness (*see supra* note 121), captures the intrinsic ability of nodes to attract links irrespective of their links, one can imagine an extreme scenario where nodes' importance to a network's integrity stems not from their degree, but from an internal property whereby their removal immediately triggers the removal of their neighboring nodes.

[149] This is because both riders and drivers can only make so many rides within a certain time frame, do not choose with whom to ride in accordance with preferential attachment, and cannot accumulate links in the long run since every link that is formed between a driver and rider during a ride vanishes once the ride ends.

find it exceedingly difficult to lure drivers and riders to switch to their platforms.[150]

But the situation seems starkly different with Facebook. The number of Facebook users is estimated at roughly 3 billion as of 2023,[151] with each of them estimated having on average 338 Facebook-friends based on extrapolating data in 2013.[152] Had Facebook's network included only these users, then fragmenting it would have required the removal of roughly 60% of these users, a borderline unobtainable objective. Had that been the case, the Microsoft Narrative would have hold true for Facebook. But Facebook's network does not include only comparable-degree users, but also possesses high-degree hubs that are far more susceptible to attacks. The number of followers of renowned footballer Cristiano Ronaldo, for example, stands at a whopping 170 million at the date of writing![153]

These hubs constitute an acute vulnerability in the network effects entry barrier, which rivals may exploit by pursuing a *"hub-plucking"* strategy to seize Facebook's hubs. Such hub-plucking has far-reaching efficacious potential for undermining large scale-free platforms such as Facebook.[154]

First, Hub-plucking 5-15% of Facebook's hubs offers a significantly more scalable approach than removing 60% of its less connected participants (the fragmentation threshold that would have existed had Facebook had a random topology).[155] In fact, a rival may only need to hub-pluck a smaller percentage of hubs, as dismantling Facebook's entire platform is not essential for competing with it. All that the rival needs do is to hub-pluck a sufficient percentage of hubs

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[150] A hub-and-spoke network is extremely robust to random node removal, as only the removal of its central hub can fragment it into isolated components. Barabási, *supra* note 12, at 297.

[151] *Number of Monthly Active Facebook Users Worldwide as of 4th Quarter 2023*, STATISTA (Oct. 27, 2022), https://www.statista.com/statistics/264810/number-of-monthly-active-facebook-users-worldwide/ [https://perma.cc/59G5-5JB6].

[152] Aaron Smith, *What People Like and Dislike about Facebook*, PEW RESEARCH CENTER (Feb. 3, 2014), https://www.pewresearch.org/fact-tank/2014/02/03/what-people-like-dislike-about-facebook/ [https://perma.cc/W3EF-S6MM].

[153] Crisitano Ronaldo's Official Facebook Page, FACEBOOK, https://www.facebook.com/Cristiano [https://perma.cc/H3RE-MVJE].

[154] Hub-plucking encompasses both the *removal* of hubs from the attacked platform and their concomitant *integration* into the attacking platform. Yet one could envision scenarios where firms would only remove other platforms' hubs, without integrating them into their own platforms. For example, even without a social media platform of its own, Google could induce hubs on Facebook to cease activities on Facebook, thereby harming Facebook's competitiveness in overlapping markets. Alternatively, a market entrant might incentivize hubs to abandon Facebook, undermining it before launching its own platform. For our purposes, however, we can disregard the distinction between removing and integrating hubs.

[155] Of course, if Facebook has a scale-free topology, it is necessary to remove almost the entirety of its participants to fragment its network, thus making the hub-plucking strategy even more efficacious.

for obtaining the critical-mass of participants needed to maintain its own platform.

Second, hub-plucking seems far more likely to trigger a cascading failure, compared to targeting low-degree platform participants. While removing a low-degree Facebook user only directly concerns its limited number of neighbors, hub-plucking a hub impacts orders of magnitude more nodes. Additionally, some platform participants may be less resilient to hub-plucking compared to low-degree node removal. Facebook users would probably not be fazed if a handful of casual connections stopped using the platform, but their platform engagement would likely plummet if hubs representing their interests were hub-plucked. Indeed, Ronaldo has probably grown into Facebook's largest hub largely because of his successful soccer career, which almost certainly gives him higher fitness[156] than most Facebook participants. This high fitness, reflecting the strong interest of Ronaldo's followers in his activities, likely increases the chance that his followers would quit Facebook if he were hub-plucked. To be sure, to truly assess how cascading failures would propagate on Facebook following a hub removal there is need of extensive empirical inquiry. Nevertheless, at least intuitively, a cascading failure seems far more imminent under hub-plucking than low-degree node removal.

2. Many Platforms Constitute Scale-Free Networks

Network science suggests that growth and preferential attachment lead to the emergence of scale-free networks across a wide range of platforms. This shared topology may seem counterintuitive given the diverse characteristics of these platforms, including services offered, revenue models, network size and connectivity, and competitive environments. While the generalizable nature of growth and preferential attachment may overcome such heterogeneity to potentially shape the topologies of platforms across diverse domains,[157] whether these platforms exhibit scale-free properties in real-world observations remains a critical empirical question. Despite scarce empirical data on platform networks, several indications suggest that the scale-free topology may indeed be ubiquitous in this context as well.

First, it is repeatedly claimed in the network science literature that the scale-free phenomenon is universal,[158] and that empirical findings demonstrate that many if not most real-world networks are scale-free.[159] There is no good reason

[156] *See supra* note 121.
[157] Barabási, *supra* note 12, at 166.
[158] *Id.* at 127-128, 130.
[159] Anna D. Broido & Aaron Clauset, *Scale-Free Networks are Rare*, 10 NATURE COMMUNICATIONS 1, 2 (2019) ("**Broido & Clauset**").

to believe that this claim, if true in general, will prove predominantly untrue in the platform context.

To be fair, there is some limited controversy surrounding this claim which mainly arises from certain complications on the question of when to classify a network as scale-free. The determination of whether a network is considered scale-free hinges on whether its degree distribution follows a power-law.[160] However as the topology of real-world networks is shaped by a myriad of mechanisms beyond growth and preferential attachment,[161] power-law degree distribution is unlikely to appear in pure form in actual networks.[162] Adding to the ambiguity, there is no universally agreed-upon definition of scale-free,[163] nor a clear threshold for allowable deviations from the pure power-law degree distribution.[164] This lack of precision and consensus inevitably leads to subjective judgments in classifying networks as scale-free, casting some shadow on the claim of scale-free network prevalence.

This controversy, however, is of little relevance for this paper's purposes. First, while classifying networks as scale-free can be tricky, the prevailing view in the network science literature is that the scale-free topology is empirically ubiquitous.[165] Furthermore, our focus is not really on the ubiquity of scale-free networks, but rather on the ubiquity of hubs in platforms of antitrust concern. This point is beyond dispute, as even those who question the ubiquity of scale-free networks do not seriously dispute the ubiquity of hubs in real-world networks.

Second, the limited empirical data that is available corroborates the presence of hubs in the platform context. Two notable examples are Twitter (now X) which has been found to be scale-free,[166] and Facebook which has been found to exhibit hubs.[167]

Third, even though many platforms have yet to be rigorously examined by network scientists, we can reasonably expect to find hubs in them based on other studies. For example, one might recall Sherwin Rosen's canonical paper *"The Economics of Superstars"* in which numerous industries *"wherein relatively small numbers of people earn enormous amounts of money and dominate* the *activities in*

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[160] Petter Holme, *Rare and Everywhere: Perspectives on Scale-Free Networks*, 10 NATURE COMM. 1, 2 (2019) ("**Holme**").
[161] See *supra* II.C.
[162] Barabási, *supra* note 12, at 144; Holme, *supra* note 160, at 1.
[163] *Id.* at 2.
[164] Broido & Clauset, *supra* note 159, at 2.
[165] My deep thanks to Prof. Barzel for this input.
[166] Barabási, *supra* note 12, at 129; Sofía Aparicio et al., *A Model for Scale-Free Networks: Application to Twitter*, 17 ENTROPY 5848, 5853 (2015), https://www.mdpi.com/1099-4300/17/8/5848 [https://perma.cc/YX99-NJ2Q].
[167] Barabási, *supra* note 12, at 129; Johan Ugander et al., *The Anatomy of the Facebook Social Graph*, 1 (2011).

which they engage" have been identified. Rosen listed films, television, and music to be among such industries.[168] Likewise, and more recently, Tim Wu wrote that *"the entertainment industry is the classic, indeed definitive, example of what economists call a 'hit-driven' industry. In such a context, a few hits will outperform the rest, sometimes by several orders of magnitude"*.[169] Clearly, such studies indicate that hubs should be expected in content streaming platforms which form the entertainment industry's current manifestation.

Of course, not all platforms are scale-free.[170] As discussed, if either growth or preferential attachment is absent from the platform's formation process, the emergence of the scale-free topology will not occur. Likewise, the scale-free topology may be lost under extreme conditions due to other topology-shaping mechanisms.[171] In the previous section we noted that Uber is probably not scale-free, but rather exhibits a hub-and-spoke topology. It is easy to imagine other examples beyond ride-hailing for platforms that feature such hub-and-spoke topologies. A prominent example is found in dating apps, where there are no hubs because men and women date at a comparable rate. On such platforms where hubs are absent, hub-plucking is impossible, and the network effects entry barrier is at full strength.

3. The Rival's Relative Advantages for Successfully Pursuing Hub-Plucking

Even if conceptually hub-plucking offers an efficacious strategy to breach the network effects entry barrier in scale-free platforms, the skeptic may wonder whether, in practical terms, a rival with a fledgling platform harbors a realistic hope of successfully implementing this strategy. After all, the entrenched platform, shielded by network effects and presumably wielding superior resources, will fiercely defend its hubs to thwart any hub-plucking attempt. This begs the question: What are the relative advantages that the rival holds over the incumbent in winning over hubs? Although further research is required on this question, in this section we shall take a preliminary look on two such possible advantages, that may facilitate the rival's success in its hub-plucking mission.

One of the rival's advantages is that hubs might not get along with one another. There are quite a few intuitive examples of this, from various industries. For example, the Spotify-exclusive *"The Joe Rogan Experience"* ranks

[168] Sherwin Rosen, *The Economics of Superstars*, 71 AM. ECON. ASS'N 845, 845 (1981).
[169] Tim Wu, *supra* note 47, at 220-221.
[170] Barabási, *supra* note 12, at 130-131.
[171] *Id.* at 130-131.

among the most listened-to podcasts in the US and globally.[172] But after Robert Mellon, who was a guest on the podcast in December 2021, compared the response of the US government to the Covid-19 pandemic to the rise of Nazi Germany,[173] and following several controversial statements by Joe Rogan himself concerning the pandemic,[174] Neil Young threatened to pull his music from Spotify if the company did not drop Rogan.[175] Spotify refused, and John Young carried out his threat, followed by other prominent musicians.[176]

Network science notably offers us tools to grasp the extent to which hubs get along with each other in a specific network. One such tool lies in the concept of *"degree correlations"* which captures the extent to which nodes link to other nodes of similar or dissimilar degree.[177] If the networks' hubs tend to link to each other and avoid linking to small-degree nodes then the network is said to be *"assortative."*[178] Conversely, if the hubs avoid each other, linking to low-degree nodes, then the network is said to be *"disassortative"*.[179] It can be reasonably hypothesized that high assortativity indicates interdependence among hubs, where the success of one hub relies on the activities of other hubs. This suggests that assortativity could be a valuable metric for estimating the chances of success for hub-plucking strategies when targeting specific platforms. For

[172] Todd Spangler, *Joe Rogan Had the Most Popular Podcast on Spotify in 2022*, VARIETY (Nov. 30, 2022), https://variety.com/2022/digital/news/joe-rogan-spotify-top-podcast-2022-1235444743/ [https://perma.cc/J49X-CH6C].
[173] Timothy Bella, *A Vaccine Scientist's Discredited Claims Have Bolstered a Movement of Misinformation*, WASHINGTON POST (Jan. 24, 2022), https://www.washingtonpost.com/health/2022/01/24/robert-malone-vaccine-misinformation-rogan-mandates/ [https://perma.cc/6UHE-SB7V].
[174] Todd Spangler, *Joe Rogan Anti-Vax Comments About Young People Create New Headache for Spotify*, VARIETY (Apr. 27, 2021), https://variety.com/2021/digital/news/joe-rogan-anti-vaccine-podcast-spotify-1234961803/; William Earl, *Joe Rogan Announces He Has Covid*, VARIETY (Sept. 1, 2021), https://variety.com/2021/digital/news/joe-rogan-covid-12350 54176/ [https://perma.cc/XQV7-U7S8].
[175] Sian Cain, *Neil Young Demands Spotify Remove His Music Over Joe Rogan Vaccine Misinformation*, GUARDIAN (Jan. 25, 2022), https://www.theguardian.com/music/2022/jan/25/neil -young-demands-spotify-remove-his-music-over-joe-rogan-vaccine-misinformation [https://perma.cc/B2GS-X3WE].
[176] Maya Yang & Ben Beaumont-Thomas, *Spotify Removes Neil Young Music in Feud Over Joe Rogan's False Covid Claims*, GUARDIAN (Jan. 27, 2022), https://www.theguardian.com/technology/2022/jan/26/spotify-neil-young-joe-rogan-covid-misinformation [https://perma.cc/DG8E-JR3U]; Mary Biekert, *Here's a List of Artists Who are Boycotting Spotify Because of Joe Rogan*, TIME (Feb. 2, 2022), https://time.com/6144634/artists-boycott-spotify-joe-rogan/ [https://perma.cc/GMM5-5A8C].
[177] Barabási, *supra* note 12, at 237.
[178] In a perfectly assortative network each node links only to nodes with the same degree. *Id.* at 236-237.
[179] *Id.* at 237.

example, Facebook's observed assortativity[180] casts a shadow over the effectiveness of hub-plucking strategies against its hubs, as the mutual reliance between intertwined hubs discourages their defection. Furthermore, assortativity not only affects the likelihood of successful hub-plucking, but also the damage inflicted to the network integrity of a platform. In assortative networks, hub-plucking inflicts less damage because the hubs form a core group, hence many of them are redundant. Hub-plucking is more damaging in disassortative networks, as in such networks the hubs connect to many small-degree nodes, which fall of the network once a hub is plucked.[181]

A related tool lies in the concept of *"communities,"* which in network science terminology means that the network contains groups of nodes that have a higher likelihood of connecting to each other than to nodes from other communities.[182] One could hypothesize that focusing on hubs within a specific community would simplify hub-plucking implementation. The cohesive nature of communities, with their higher internal connectivity, makes targeted action within these smaller groups significantly more feasible than attempting to identify and remove hubs across a vast platform.[183] Platform differentiation offers a promising approach for such targeted action. This is exemplified in the rise of conservative Twitter clones, such as Parler and Truth Social, and their considerable success in attracting high-profile platform participants from Twitter.[184]

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[180] Christo Wilson et al., *Beyond Social Graphs: User Interactions on Social Networks and Their Implications*, 6 ASS'N COMPUTER MACHINERY TRANSACTIONS WEB 1, 9 (2012).
[181] Barabási, *supra* note 12, at 257.
[182] More strictly, a community is a *"locally dense connected subgraph"*, wherein each node in the community is reachable through other nodes of the same community. We can distinguish between three types of communities. In a *"clique"*, each of the community's nodes is directly connected to all other nodes in the community. In a *"strong community"*, each of the communities' nodes have more links within the community than to the rest of the network. In a *"weak community"*, the total number of internal links within the community exceeds the total number of external links to the remainder of nodes in the network. Every clique is a strong community, and every strong community is a weak community, but the reverse is generally not true. *Id.* at 322, 325-327.
[183] Interestingly, this hypothesis runs counter to the hypothesis that hub-plucking would be more difficult in assortative networks, because the tendency of platform participants to form communities can induce assortative correlations. *See Id.* at 250.
[184] Adam Smith, *Parler: What is the app that MPs and right-wing celebrities are joining?*, INDEPENDENT (June 24, 2020), https://www.independent.co.uk/tech/parler-app-mps-right-wing-twitter-katie-hopkins-a9579241.html [https://perma.cc/4PW2-RAYH]; Jon Jackson, *Kristie Alley, Tito Ortiz and More Celebrities Who Made the Move to Parler*, NEWSWEEK (Nov. 12, 2020), https://www.newsweek.com/kirstie-alley-tito-ortiz-more-celebrities-who-made-move-parler-1547008 [https://perma.cc/8JAB-HUVF]; Brooke Singman, *Trump's TRUTH Social to Begin Welcoming Americans Who Pre-Ordered the App Monday*, FOX BUSINESS (Feb. 20, 2020) https://www.foxbusiness.com/politics/trumps-truth-social-to-begin-welcoming-americans-who-pre-ordered-the-app-monday [https://perma.cc/GSM5-B4U7]; Stuart A. Thompson and Matthew Goldstein, *Truth Social's Influence Grows Despite Its Business Problems*, NEW YORK TIMES (Nov. 7, 2022), https://www.nytimes.com/2022/11/01/technology/truth-

A second relative advantage for the rival lies in seizing the initiative. While the incumbent is compelled to consistently defend all its hubs, the rival takes the offensive, allowing for a focus on hubs susceptible to hub-plucking.[185] This advantage is nontrivial, as the need to safeguard all hubs compels the incumbent to disperse its resources, posing a challenge in countering financial incentives extended by rivals. Furthermore, as the incumbent is tasked with protecting an increasing number of hubs, its ability to accommodate the idiosyncratic and potentially conflicting needs among different hubs becomes constrained. This contrasts with the rival's capability in concentrating on hubs with more homogeneous preferences, enabling the rival to differentiate its platform and tailor its services for better alignment with the specific needs of those hubs.

Consider the competition between YouTube, the titan of video-sharing, and Twitch, a live-streaming platform with a specific focus on video game live-streaming. In the early 2010s, as part of its utter dominance in the realm of video-sharing, YouTube claimed a staggering 95% share of video game viewing.[186] It may sound fantastic, but during those years, some of the largest hubs on the entire YouTube platform were individuals who recorded themselves playing video games, commonly referred to as *Let's Play* videos. Especially known is Felix Kjellberg, whose YouTube channel *"PewDiePie"*, which Kjellberg started in 2010, became YouTube's most-subscribed channel in August 2013, and reigned as YouTube's most-viewed channel from December 2014 to February 2017.[187] But beyond PewDiePie, many other prominent channels featured Let's Play videos, such that in 2014 it was reported that four of the ten most-subscribed YouTube channels were Let's Play channels.[188]

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social-conservative-social-app.html [https://perma.cc/7QG6-78XE]; Amanda Hoover, *Truth Social is Rising as the Anti-Mastodon*, WIRED (Nov. 23, 2022), https://www.wired.com/story/truth-social-trump-mastodon/ [https://perma.cc/S7BG-J8GC].

[185] CARL VON CLAUSEWITZ, ON WAR 163 (Michael Howard & Peter Paret trans., Oxford University Press, 2007).

[186] Brad Johnsmeyer et al., *Gamers on YouTube: Evolving Video Consumption* (2013), https://www.thinkwithgoogle.com/marketing-strategies/app-and-mobile/youtube-marketing-to-gamers/#:~:text=How%20automation%20is%20changing%20marketing&text=The%20rapid%20growth%20of%20game,doubled%20over%20the%20year%20before/ [https://perma.cc/D6L3-ZMFC].

[187] Christopher Zoia, *This Guy Makes Millions Playing Video Games on YouTube*, ATLANTIC (Mar. 14, 2014), https://www.theatlantic.com/business/archive/2014/03/this-guy-makes-millions-playing-video-games-on-youtube/284402/ [https://perma.cc/S9J5-VACV].

[188] *Id.*; Harrison Jacobs, *The 20 Most Popular YouTubers in the World*, BUSINESS INSIDER (Nov. 10, 2014), https://www.businessinsider.com/top-20-most-popular-youtube-stars-2014-11#10-stampylonghead-11 [https://perma.cc/N7FR-42SQ]; Samuel Gibbs, *Twitch: What is it, and Why Has Google Bought it for $1bn*, GUARDIAN (July 25, 2014), https://www.theguardian.com/technology/2014/jul/25/twitch-google-gaming-video-site [https://perma.cc/49S7-FJ7T] ("**Samuel Gibbs**").

However, despite gaming's centrality to YouTube, the advent of live-streaming allowed Twitch to dethrone YouTube in the video game live-streaming segment and surge to market dominance by 2014.[189] In doing so, Twitch hub-plucked YouTube.[190] In two telling interviews, Twitch co-founder Emmett Shear described that when he contemplated where the strategic value was for Twitch, he realized that *"there were about 200 at the time, people streaming video games who mattered, who had some kind of following or audience, and my realization was wow I could talk to all 200 of these people. Like there's nothing stopping me from going one by one and figuring out what they need and winning them over."*[191] Twitch thus approached many of these streamers *"asking them if they use twitch, why not, what else do you use, what can we do to make you switch."*[192] This allowed Twitch to identify and address the streamers' needs to win them over – *"we started building stuff they wanted, and we'd go back to them and say 'hey, that thing you said you wanted, we built it!', it turns out that's a really powerful sales technique, they really liked that."*[193]

Of course, the rival's advantage of initiative does not nullify the countervailing advantages of the incumbent, who will act resolutely to eradicate the rival's competitive threat. So is the case of the YouTube-Twitch competition, where the growing prominence of gaming prompted Google to

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[189] James Cook, *Twitch Founder: We Turned a 'Terrible Idea' Into a Billion-Dollar Company*, BUSINESS INSIDER (Oct. 20, 2014), https://www.businessinsider.com/the-story-of-video-game-streaming-site-twitch-2014-10 [https://perma.cc/QDW4-8T47]; Paul Tassi, *Why Google Buying Twitch is an Unsettling Thought*, FORBES (May 19, 2014), https://www.forbes.com/sites/insertcoin/2014/05/19/why-google-buying-twitch-is-an-unsettling-thought/?sh=2cb285ab280e [https://perma.cc/54LV-HU75]; Darren Geeter, *Twitch Created a Business Around Watching Video Games: Here's How Amazon Has Changed the Service Since Buying it in 2014*, CNBC, at 00:17 (Feb. 26, 2019), https://www.cnbc.com/2019/02/26/history-of-twitch-gaming-livestreaming-and-youtube.html [https://perma.cc/3NCN-UUL6]; Dot Esports Staff, *Twitch Dominated Streaming in 2013, and Here are the Numbers to Prove it*, DOT ESPORTS (Jan. 16, 2014), https://dotesports.com/culture/news/twitch-growth-esports-streaming-mlg-youtube-2013-90.

[190] Stuart Dredge, *Google Launches YouTube Gaming to Challenge Amazon-Owned Twitch*, GUARDIAN (Aug. 26, 2015), https://www.theguardian.com/technology/2015/aug/26/youtube-gaming-live-website-apps [https://perma.cc/SLQ7-DNNL] ("**Stuart Dredge**").

[191] *Creators or Viewers First? – (Twitch) Emmett Shear & (CNBC) Ryan Browne – Slush 2022*, YOUTUBE (Nov. 22, 2022), https://www.youtube.com/watch?v=9d12kjw_oC4 [https://perma.cc/BU8Y-W8EZ], at 05:45 ("**Creators or Viewers First?**"); *See also Founding Story of Twitch with Kevin Lin*, YOUTUBE (Apr. 19, 2020), https://www.youtube.com/watch?v=2i5L-2jZL3Y [https://perma.cc/UK8X-X83V], at 02:25 (*"[W]e started reaching out to creators on other platforms, YouTube creators that weren't doing live, and that was really a big change for us actually spending the time to talk and talk with and interview and really get to know our core customer who is a creator, and learning from them what were the tools they needed to have that we needed to build in order to make them successful"*).

[192] Emmet Shear, *supra* note 1, at 06:30.

[193] Creators or Viewers First?, *supra* note 191, at 07:38.

initially pursue the acquisition of Twitch for USD 1 billion,[194] and after this attempt failed,[195] to establish YouTube Gaming in order to take Twitch head-on.[196] But YouTube Gaming initially trudged, and transforming it into a success story demanded substantial efforts from Google. It was initially launched as a standalone platform in 2015. However, separating it from YouTube's main platform proved to be a disastrous misstep,[197] leading to its shutdown in 2018 and integration as a tab into YouTube's main platform.[198] Clearly, YouTube is unable to provide a competitive response of this nature to every competitive threat from a niche rival. Integrating dedicated tabs into a general-interest platform is cumbersome, and the viability of employing this solution will diminish as niche threats to the general-interest platform increase.

Furthermore, while launching a dedicated gaming-platform allowed YouTube to experiment with gaming content without affecting its main platform,[199] this decision incurred significant costs in terms of resources and, more detrimentally, resulted in the waste of valuable time. Indeed, by the time YouTube Gaming gained momentum, Twitch's platform had grown substantively, solidifying itself behind its own network effects entry barrier. It was also acquired by Amazon,[200] thereby equalizing the depth of the competing platforms' war chests.

In the upcoming section, we will list various industries characterized by network effects, where competition manifests through hub-plucking. However, it can already be noted that the competition in video game live-streaming serves as a quintessential example of such an industry.[201] In this market, platforms

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[194] Todd Spangler, *YouTube to Acquire Videogame-Streaming Service Twitch for $1 Billion: Sources*, VARIETY (May 18, 2014), https://variety.com/2014/digital/news/youtube-to-acquire-videogame-streaming-service-twitch-for-1-billion-sources-1201185204/ [https://perma.cc/JXY3-KHHR]; Samuel Gibbs, *supra* note 188.

[195] Ryan Mac, *Amazon Pounces on Twitch After Google Balks due to Antitrust Concerns*, FORBES (Aug. 25, 2014), https://www.forbes.com/sites/ryanmac/2014/08/25/amazon-pounces-on-twitch-after-google-balks-due-to-antitrust-concerns/ [https://perma.cc/5XBL-9V6S].

[196] Stuart Dredge, *supra* note 190.

[197] Sarah Perez, *YouTube to Shut Down Standalone Gaming App, as Gaming Gets a New Home on YouTube*, TECHCRUNCH (Sept. 18, 2018), https://techcrunch.com/2018/09/18/youtube-to-shut-down-standalone-gaming-app-as-gaming-gets-a-new-home-on-youtube/amp/ [https://perma.cc/T6T7-8MU2] ("**Sarah Perez**").

[198] Patricia Hernandez, *YouTube Launches New Gaming Destination, Admits that the Separate App Was a Bust*, VERGE, (Sept. 18, 2018), https://www.theverge.com/2018/9/18/17871176/youtube-gaming-app-creator-on-the-rise [https://perma.cc/JBL3-6F5T].

[199] Sarah Perez, *supra* note 197.

[200] Eugene Kim, *Amazon Buys Twitch for $970 Million in Cash*, BUSINESS INSIDER (Aug. 25, 2014), https://www.businessinsider.com/amazon-buys-twitch-2014-8 [https://perma.cc/3KEZ-UFYL]; Emmett Shear, *A Letter from the CEO*, Twitch the Official Blog (Aug. 2, 2014), https://web.archive.org/web/20140825205617/http://blog.twitch.tv/ [https://perma.cc/TKV3-5SN9].

[201] Emmett Shear, *supra* note 1, at 17:20 (detailing Twitch's employment of hub-plucking to acquire market share).

actively pursue exclusivity agreements with prominent streamers, resulting in a constant shuffle of streamers between platforms.[202] For example, on August 1, 2021, Twitch experienced a significant loss when its most popular streamer at the time, Richard Tyler Belvins (known online as *"Ninja"*), transitioned to Microsoft's Mixer platform.[203] On November 2019, Jeremy Wang (known online as *"Disguised Toast"*), who was the second most-watched streamer on Twitch at the time, signed an exclusive deal with Facebook Gaming,[204] before returning to Twitch in November 2021.[205] On December 2019, Twitch signed three major streamers to exclusive contracts through multi-year deals,[206] but by September 2021 two of them left Twitch to sign exclusivity agreements with YouTube Gaming.[207] Also in September 2021, major Spanish streamer Raúl Álvarez Genes (known online as *"AuronPlay"*), who had roughly 30 million YouTube subscribers as opposed to 10 million Twitch followers at the time, left YouTube to stream exclusively on Twitch (later becoming the second most-followed Twitch Channel).[208] Between May and July 2022, however, three other

[202] Ben Gilbert & Kevin Webb, *Amazon's Wildly Popular Video Game Streaming Service, Twitch, is No Longer the Biggest Game in Town: These are All the Stars Who Have Signed Exclusivity Deals with the Competition*, BUSINESS INSIDER (Jan. 14, 2020).

[203] Tramel Raggs, *Fortnite Star Ninja Leaves Twitch to Stream on Microsoft's Mixer*, WASHINGTON POST (Aug. 1, 2019), https://www.washingtonpost.com/sports/2019/08/01/fortnite-star-ninja-leaves-twitch-stream-microsofts-mixer/ [https://perma.cc/PR53-AHVV]. Mixer ultimately struggled to scale its operations and shut down in July 2022. As part of the closure, Microsoft partnered with Facebook to migrate Mixer's viewers and streamers to Facebook Gaming. Tom Warren, *Microsoft is Shutting Down Mixer and Partnering with Facebook Gaming*, VERGE (June 20, 2022), https://www.theverge.com/2020/6/22/21299032/microsoft-mixer-closing-facebook-gaming-partnership-xcloud-features [https://perma.cc/YL7V-TNGQ]. Belvins, however, ultimately returned to Twitch, signing a multiyear exclusive deal with the service. Natalie Jarvey, *Superstar Gamer Tyler "Ninja" Belvins Return to Twitch (Exclusive)*, HOLLYWOOD REP. (Sep 10, 2022), https://www.hollywoodreporter.com/news/general-news/superstar-gamer-tyler-ninja-blevins-returns-to-twitch-exclusive-4057872/ [https://perma.cc/TB7K-ZPHB].

[204] Trent Murray, *Streamer Disguised Toast Signs Exclusive Deal with Facebook Gaming*, ESPORTS OBSERVER (Nov. 22, 2019), https://archive.esportsobserver.com/disguised-toast-facebook-gaming/ [https://perma.cc/DDY5-ZMW5].

[205] Leonardo Biazzi, *Disguised Toast returns to Twitch*, DOT ESPORTS (Nov. 24, 2021), https://dotesports.com/streaming/news/disguised-toast-returns-to-twitch [https://perma.cc/9NQ9-QUNH].

[206] Gene Park, Twitch Signs Three Major Streamers to Exclusive Contracts, Washington Post (Dec. 10, 2019), https://www.washingtonpost.com/video-games/2019/12/10/twitch-signs-three-major-streamers-exclusive-contracts/ [https://perma.cc/CH3V-R6SP].

[207] Nicole Carpenter, *Twitch Departures Continue as TimTheTatman Leaves for YouTube*, POLYGON (Sept. 1, 2021), https://www.polygon.com/22652550/timthetatman-leaves-twitch-for-youtube-exclusive [https://perma.cc/DD3Y-9GD4].

[208] Carlos Ferrer-Bonsoms Cruz, *AuronPlay Leaves YouTube Permanently and It is a Clear Sign that Twitch is Now the Trend and Will Be the Future of 'Streaming'*, BUSINESS INSIDER (From Spanish; Sept. 3, 2021), https://www.businessinsider.es/auronplay-deja-youtube-apuesta-tendencia-futuro-twitch-925525 [https://perma.cc/XRK5-FAFT]; Social Blade, *Twitch Stats Summary Profile for AuronPlay* (retrieved on Dec. 4, 2022), https://socialblade.com/twitch/user/auronplay [https://perma.cc/UE6Y-M5H5].

major streamers reportedly left Twitch to sign exclusivity agreements with YouTube.[209]

4. Hub-Plucking Empirically

Despite the firm theoretical foundation of hub-plucking as a mechanism for inter-platform competition, its practical significance could be contested by proponents of antitrust intervention due to the scarcity of empirical data substantiating its real-world occurrence. While conclusive data is unavailable, initial findings suggest hub-plucking plays a pivotal role in shaping inter-platform competition dynamics.

In the previous subsection, we already mentioned the competition in video game live streaming, but there are many more examples. For instance, on April 9, 2022, when Elon Musk maneuvered to acquire Twitter, he addressed the low activity of celebrities on the platform, asking *"Is Twitter dying?"*,[210] thus highlighting the importance of Twitter's top accounts to the platform's integrity.[211] The Washington Post subsequently reported that celebrities in fact switched from Twitter to other platforms, such as Instagram and TikTok.[212] The Washington Post's explained that the switching occurred because Twitter's competitors added certain technological features to their platforms, such as *"slicker video tools and more-robust safety features that give users more ways of blocking out unwanted interactions"*, that were important for the celebrities' capability to engage with their followers. The Washington Post also noted financial incentives, quoting a veteran celebrity social media consultant who claimed that while Twitter is hard for celebrities to monetize, *"[i]nstagram, YouTube and TikTok get you paid."*.[213]

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[209] Petrana Radulovic, *Popular Streamer Sykkuno Moves to YouTube in Exclusive Deal*, POLYGON (May 2, 2022), https://www.polygon.com/23053800/sykkuno-youtube-deal-streamer-twitch-valkyrae [https://perma.cc/95PJ-TQ3E]; Ana Diaz, *Popular Streamer LilyPichu Takes Exclusive Deal with YouTube*, POLYGON (July 7, 2022), https://www.polygon.com/23198801/lilypichu-offlintetv-exclusive-deal-youtube-twitch-streamer [https://perma.cc/ET2S-3ATA]; Nicole Carpenter, *Streamer, Former Fortnite Pro Myth Moving to YouTube in Exclusive Deal*, POLYGON (July 11, 2022), https://www.polygon.com/23204360/myth-fortnite-pro-youtube-twitch-exclusive-deal [https://perma.cc/56W8-RB79].

[210] Elon Musk (@elonmusk), TWITTER (Apr. 9, 2022), https://twitter.com/elonmusk/status/1512785529712123906 [https://perma.cc/JF4J-D7YR]; *See also* BEN MEZRICH, BREAKING TWITTER: ELON MUSK AND THE MOST CONTROVERSIAL CORPORATE TAKEOVER IN HISTORY 83-84 (Grand Central 1st Ed., 2023) ("**Ben Mezrich**").

[211] *See also* Ben Mezrich, *supra* note 210, at 17 (noting Twitter rise to prominence with an assist from celebrity Tweeters); NICK BOLTON, HATCHING TWITTER: A TRUE STORY OF MONEY, POWER, FRIENDSHIP, AND BETRAYAL 278 (2013) (ebook) (noting Twitter itself refers to celebrities as "Very Important Tweeters" (VITs)).

[212] Taylor Lorenz et al, *How Twitter Lost the Celebs*, THE WASHINGTON POST (May 12, 2022), https://www.washingtonpost.com/technology/2022/05/12/twitter-celebrities-musk/ [https://perma.cc/MFS6-76DW].

[213] *Id.*

Another example is found in the console video games industry. Gaming consoles constitute two-sided platforms that intermediate between game developers and gamers, thus exhibiting indirect network effects.[214] For this reason, the video game industry is often cited as a canonical example of a 'tippy' market,[215] though in reality it has historically been oligopolistic.[216] The latest iteration of this oligopoly—Microsoft, Sony, and Nintendo—has dominated the making of gaming consoles for over two decades, with over 90% of worldwide console sales.[217] The competition between these console manufacturers on gamers is fierce, because gamers rarely purchase more than a single same-generation console.[218] Historically, manufacturers primarily attracted gamers by introducing better console technology, but since the differences in hardware capabilities between the manufacturers' consoles grew increasingly marginal,[219] this strategy has become less viable.[220] Consequently, manufacturers today mainly attempt to outcompete each other by pursuing a strong library of console-exclusive prominent titles, so that the variety and quality of games on their respective consoles will become superior to that of their competitors.[221] There are two methods to achieve this. First, console manufacturers can

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[214] Myriam Davidovici-Nora & Marc Bourreau, *Two-Sided Markets in the Video Games Industry*, 173-174(3) RÉSEAUX 97, (Liz Carey-Libbrecht trans. 2012), IV, IX-X, and XII-XIII, https://doi.org/10.3917/res.173.0097 [https://perma.cc/9RJC-C3Y3] ("**Davidovici-Nora & Bourreau**"); Clayton Alexander, *Game Over? How Video Game Console Makers Are Speeding Toward an Antitrust Violation*, 4 BUS. ENTREPRENEURSHIP & TAX L. REV. 151, 153 (2020) ("**Clayton Alexander**").

[215] Kenneth S. Corts & Mara Lederman, *Software Exclusivity and the Scope of Indirect Network Effects in the U.S. Home Video Game Market*, 27 INT'L J. INDUS. ORG. 121, 122 (2009), https://www.sciencedirect.com/science/article/abs/pii/S0167718708000891 [https://perma.cc/AKW2-4KR5].

[216] Davidovici-Nora & Bourreau, *supra* note 214, at X.

[217] *Id.* at X .

[218] *Id.* at XI.

[219] Clayton Alexander, *supra* note 214, at 152.

[220] Historically, console manufacturers *inter alia* competed with one another on the hardware capabilities of their respective consoles. For instance, in the late 1980s, Sega succeeded in challenging Nintendo's dominance in the industry, by *inter alia* introducing the 16-bit Sega Genesis console that was technologically superior to Nintendo's competing console, the 8-bit Nintendo Entertainment System (NES). To emphasize the Genesis's technological advantages, Sega emblazoned the '16-bit' on the Genesis's case, and spearheaded a marketing campaign with the slogan *"Genesis does what Nintendon't"*. Steven L. Kent, THE ULTIMATE HISTORY OF VIDEO GAMES: FROM PONG TO POKÉMON AND BEYOND—THE STORY BEHIND THE CRAZE THAT TOUCHED OUR LIVES AND CHANGED THE WORLD 404-405, 434 (2001) ("**Kent, Vol 1**"). However, in recent years the differences in technological capabilities between consoles have grown increasingly marginal, and thus the competitive focus today lies primarily in the offered game selection. Clayton Alexander, *supra* note 214, at 152.

[221] Davidovici-Nora & Bourreau, *supra* note 214, at XIX-XX. Another reason for ensuring quality games is that the manufacturers often use the royalties paid by third-party developers to subsidize the consoles for the gamers. Thus, the games must sell to compensate for the subsidization. *Id.* at XVI, XIX.

internally develop games and refuse to port them to competing consoles.[222] Nintendo is the main manufacturer to pursue this strategy, having developed some of the most successful game franchises of all time, most notably *"Mario"* and *"Legends of Zelda,"* and keeping them strictly unavailable on non-Nintendo consoles.[223] Alternatively, manufacturers can contract for exclusivity with or even permanently acquire third-party developers. Our interest lies in this second method, because there are strong indications that the inter-manufacturer competition over third-party developers is relentless.

For starters, in recent years there is a trend of manufacturers acquiring third-party developers to exclusively produce titles for their respective consoles.[224] This trend is expected to continue, as is vividly indicated by Sony Interactive Entertainment's CEO and president Jim Ryan that *"in terms of future M&A activity . . . we're not at all finished with our strategy of trying to grow PlayStation inorganically"*.[225] Other statements by manufacturers further demonstrate the high value that they place on third-party support for their consoles' success.[226]

Moreover, there are examples of console manufacturers hub-plucking third-party developers. For instance, prominent third-party developer SquareSoft, creator of the renowned *"Final Fantasy"* franchise, developed games exclusively for Nintendo for roughly a decade, but later broke with Nintendo to develop games exclusively for Sony.[227] The relationship between Microsoft, Sony and third-party developer Bungie provides another example, and one that

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[222] *Id.* at X.

[223] STEVEN L. KENT, THE ULTIMATE HISTORY OF VIDEO GAMES, VOLUME 2: NINTENDO, SONY, MICROSOFT, AND THE BILLION-DOLLAR BATTLE TO SHAPE MODERN GAMING 143, 249-250 (2021) ("**Kent, Vol 2**").

[224] Clayton Alexander, *supra* note 214, at 152; Brianna Reeves, *Sony Spent $329 Million of Third-Party Publishing Partnerships for PS5*, SCREEN RANT (Feb. 17, 2021), https://screenrant.com/playstation-exclusives-third-party-329-milllion-spending-sony/ [https://perma.cc/YQP7-HPQ]; Paul Tassi, *Xbox is Grabbing Headlines and Studios, But PlayStation is Still Extremely Strong*, FORBES (Apr. 11, 2021), https://www.forbes.com/sites/paultassi/2021/04/11/xbox-is-grabbing-headlines-and-studios-but-playstation-is-still-extremely-strong/?sh=8f79bdd47f3d [https://perma.cc/22JZ-HHCV] (noting Microsoft's acquisition of Bethesda/ZeniMax for USD 7.5 billion, giving it exclusive rights to prominent franchises such as *"Fallout"* and *"Elder Scrolls"*.).

[225] *PlayStations's CEO Jim Ryan Full Q&A from Sony IR Day*, YOUTUBE (May 26, 2022), https://www.youtube.com/watch?v=aRZG38M5ca4 [https://perma.cc/33J3-EKP2], at 17:40.

[226] Ollie Barder, *Nintendo is Well Aware of the Importance of Third-Party Support for the Switch*, FORBES (Jan. 19, 2017), https://www.forbes.com/sites/olliebarder/2017/01/19/nintendo-is-well-aware-of-the-importance-of-third-party-support-for-the-switch/?sh=386c0003220b [https://perma.cc/P4DN-A77Y] ; Christopher Dring, *PlayStation's Jim Ryan: Our Games Could Suffer If They Went Straight into PS Plus*, GAMESINDUSTRY.BIZ (Mar. 29, 2022), https://www.gamesindustry.biz/articles/2022-03-28-playstations-jim-ryan-our-games-could-suffer-if-we-put-them-straight-into-ps-plus [https://perma.cc/MNC9-K3VH].

[227] Kent, Vol 1, *supra* note 220, at 541-542; Kent, Vol 2, *supra* note 223, at 261.

demonstrates that third-party developers may switch allegiances even following a merger with a manufacturer. Bungie is the creator of the critically acclaimed *"Halo"* franchise which became the flagship title for the Xbox consoles.[228] It was acquired by Microsoft in 2000 and released three best-selling games, turning Halo into a franchise worth billions of dollars. In 2007, however, Bungie split from Microsoft, with Microsoft retaining the intellectual property rights in Halo for itself.[229] Bungie moved forward to develop the extremely successful *"Destiny"* franchise, and was eventually acquired by Sony for USD 3.6 billion in 2022.[230]

Last, console manufacturers are also incentivized to combat the exclusivity obligations of third-party developers toward other manufacturers.[231] For example, in 1990 Sega succeeded in convincing third-party developer Acclaim to license some of Acclaim's games for use on the Genesis console, even though Acclaim was at the time subject to exclusivity obligations toward Nintendo.[232] Likewise, in 2006 Microsoft succeeded to convince third-party developer Square-Enix[233] to port *"Final Fantasy XI"* to Xbox 360, even though Final Fantasy games were PlayStation exclusives since 1997.[234]

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[228] Indeed, when the X-Box was launched, the gaming industry referred to it as the "Halo delivery system" to reflect the belief that the only reason people were purchasing X-Boxes was to play Halo. Kent, Vol 2, *supra* note 223, at 143.

[229] Paul Tassi, *Does Microsoft Need to Give 'Halo' To Someone Besides 343?*, FORBES (Apr. 22, 2022), https://www.forbes.com/sites/paultassi/2022/04/24/does-microsoft-need-to-giv e-halo-to-someone-besides-343/?sh=2230e97bdff3 [https://perma.cc/8B47-CPYX].

[230] At first glance, Sony's goal in acquiring Bungie was not exclusivity, as both Sony and Bungie (reportedly following an FTC probe) have emphasized that Bungie would remain an "*interplatform studio*". But statements by Sony indicate that Bungie is expected to assist Sony's internal gaming division in the development of games, and one could suspect that Sony intends to keep these Bungie-assisted games exclusive for itself, especially given the high merger price. *See* Rebekah Valentine, *FTC Probing Sony's Bungie Acquisition As Gaming Merger Oversight Gets More Aggressive*, IGN (May 5, 2022), https://www.ign.com/articles/ftc-probing-sony-bungie-acquisition-oversight-aggressive [https://perma.cc/manage/create?folder=22751-215112-231928-231929]; Jim Ryan, President & CEO of Sony Interactive Entertainment, *Bungie is Joining PlayStation: Legendary Developer to Join PlayStation as Independent, Multi-Platform Studio and Publisher*, PLAYSTATION.BLOG (2022), https://blog.playstation.com/2022/01/31/bungie-is-joining-playstation/ [https://perma.cc/4EHV-EXJN]; Paul Tassi, *So What Changes with Sony's Acquisition of Bungie Finalized? Nothing Allegedly*, FORBES (2022), https://www.forbes.com/ sites/paultassi/2022/07/16/so-what-changes-with-sonys-acquisition-of-bungie-finalized-nothing-allegedly/?sh=1ecf8dfc5e14 [https://perma.cc/KLS4-XBV5]; Shubhankar Parijat, *"Bungie Will Support the Development of Future PlayStation Live Service Titles" - Jim Ryan*, GAMINGBOLT (1.31.2022), https://gamingbolt.com/bungie-will-support-the-development-of-future-playstation-live-service-titles-jim-ryan [https://perma.cc/MVU6-J77Z].

[231] Kent, Vol 2, *supra* note 223, at 404.

[232] Kent, Vol 1, *supra* note 220, at 440.

[233] Square Soft and Enix Corporation merged in 2003. Kent, Vol 2, *supra* note 223, at 261.

[234] *Id.* at 261.

Of course, future research may reveal industries where platforms exhibit hubs, but inter-platform competition is not characterized by widespread hub-plucking. Given the inherent potential of hub-plucking, such a revelation would necessitate antitrust law investigating why platforms choose not to actively pursue this practice. While the possibility exists that network effects would prove sufficiently powerful to also lock-in the hubs, if other barriers such as financial imbalances are preventing hub-plucking, then antitrust law's fixation on network effects as the sole entry barrier is barking at the wrong tree. The exact barrier that prevents hub-plucking must be ascertained, and the antitrust response tailored precisely to address this specific barrier.

C. The Amex Narrative Overstates the Risk of Negative Feedback Effects

Just as the Microsoft Narrative asserts that all platform participants are equally valuable for maintaining platform integrity, so does the Amex Narrative. The Supreme Court's explanation for negative feedback effects rests on a succinct premise that *"[r]aising the price on side A risks losing participation on that side, which decreases the value of the platform to side B. If participants on side B leave due to this loss in value, then the platform has even less value to side A—risking a feedback loop of declining demand."*[235] This premise paints an overly simplistic picture of two equally important sides, comprised of homogeneous participants. Indeed, even the intricate dynamics of the *Amex* decision itself glaringly expose the inherent flaws of this simplistic claim.

First, this claim is completely unaware of the potential presence of hubs, and the viability of hub-plucking. A large merchant such as Walmart abandoning Amex would inflict far greater harm to its platform than the defection of small merchants or individual cardholders. This disparity stems not only from large merchants currently serving many more cardholders than small merchants, but also from the differential value cardholders place on access to them. While purchasing at large merchants is anticipated, the same expectation does not extend to most small merchants. Despite this, Amex fails to provide any details concerning the network topology of Amex's platform, such as the number of large merchants and their relative sizes compared to small merchants.

The Amex Narrative also ignores the possibility that different platform participants will have different breakdown thresholds. One is left wondering, for example, whether it takes the same number of cardholders leaving to induce both large and small merchants to leave? Is this number uniform for all merchants across different industries? How many merchants must leave for a cardholder to leave? And so on. Answering such questions is extremely complex,

[235] Amex, *supra* note 6, at 2281. This argument rests almost verbatim on David S. Evans & Richard Schmalensee, *Markets with Two-Sided Platforms*, in 1 ISSUES IN COMPETITION L. AND POL'Y 667, 675, 688 (2008).

as the breakdown threshold of platform participants may be multidimensional. For example, some cardholders may only stay on the platform if they can use their card at X large merchants of a certain type, Y large merchants of another type and Z small merchants. Moreover, it is necessary to analyze the interplay between this multidimensional connectivity and the pricing points that would trigger the departure of different platform participants under various connectivity scenarios.

The Amex Narrative does nothing of this, and therefore its fundamental argument is utterly devoid of substance. There is absolutely no way to predict the size of the cascading failure that would be triggered by a specific price increase, in the absence of any information regarding the relevant platform's network topology and the breakdown thresholds of the platform participants in terms of connectivity and pricing. This does not mean that the Amex Narrative is completely wrong, as the risk of negative feedback effects may obviously materialize under certain conditions. For example, it can be easily assumed that raising the daily cardholder fee to USD 10,000 would trigger a cascading failure that would lead to the collapse of Amex's entire platform. But the *Amex* Court's sweeping reasoning does not do nearly enough to specify these conditions. Indeed, a strong indication that the Amex Narrative overstates the risk of negative feedback effects is found in the fact that although credit card platforms frequently adjust pricing and see both merchants and cardholders migrate to competing services, credit-card platforms rarely collapse.[236]

IV. Evolving Antitrust Through Network Science

Given the oversimplified thinking underlying the Microsoft and Amex Narratives, a refinement of antitrust doctrine is necessary to properly address platform cases characterized by network effects. As discussed previously, the applicability of both narratives hinges solely on just two key questions: does the platform exhibit network effects, and does it hold a dominant market share. The Microsoft Narrative demands an affirmative answer to both queries, whereas the Amex Narrative only requires an affirmative answer to the first one.[237]

However, network science necessitates expanding the inquiry by posing further questions. To determine the extent to which the Microsoft Narrative is applicable to a specific platform, that is, the robustness of the network effects

[236] Indeed, network science has empirically studied the frequency and magnitude of cascading failures in many different contexts. For example, power blackouts, information spreading on social media, earthquakes, flight delays, the disappearance of species in biological ecosystems, and component shortages in supply changes. These studies suggest that the *"magnitude distribution"* of cascading failures follows a power-law, meaning that most cascades are barely noticeable, and only few impacts entire systems. Barabási, *supra* note 12, at 288-291.

[237] *See supra* II.2 and II.3.

entry barrier, courts and antitrust agencies must additionally inquire whether the platform exhibits hubs, the likelihood of successfully implementing a hub-plucking strategy, and whether such hub-plucking is expected to induce additional platform participants to migrate from the platform. A platform like Uber, with a topology devoid of hubs, aligns more closely with the Microsoft Narrative,[238] whereas YouTube, with hubs susceptible to hub-plucking, stands distantly from it.[239]

Likewise, in determining the applicability of the Amex Narrative to a specific platform, that is, the extent of the risk of negative feedback effects, antitrust decisionmakers must inquire about the platform's network topology, and the breakdown thresholds of each platform participant. This involves considering both the participants' required connectivity and their willingness to pay for it.[240]

In addressing these inquiries, the expertise of a network scientist is indispensable. The network scientist must adeptly construct a model predicting the expected network dynamics on the platform, carefully accounting for realistic competitive conditions.

While the importance of incorporating these newfound questions into the antitrust doctrine is indisputable, this constitutes but a single and relatively ready-to-use application of network science for antitrust law among a multitude of potential applications. Embracing network science, however, has immense potential to propel the boundaries of antitrust law even further, towards more visionary frontiers.

One particularly intriguing possibility lies in utilizing network science's insights to revolutionize antitrust's arsenal of interventions in the platform context. Typically, antitrust intervention is considered when a platform has already achieved dominance, meaning that its underlying network is fully developed and possesses an enormous size. However, at this advanced stage the ability to administer an effective remedy is often both limited and costly.[241] Antitrust enforcement in the fast-moving and highly complicated digital sector tends to be slow and cumbersome,[242] allowing full-fledged platforms to protract and counter effective intervention. Fines need to be exceedingly high to influence the behavior of the largest platforms and have thus far failed to effectively impact market conditions.[243] Structural breakups pose the risk of

[238] *See supra* IV.2.a.
[239] *See supra* IV.2.c.
[240] *See supra* IV.3.
[241] Gal & Petit, *supra* note 10, at 619-620.
[242] *Id.* at 629; Richard Posner, ANTITRUST LAW, at 102; Unlocking Digital Competition, *supra* note 25, at 6 and 58; Microsoft-Middleware, Circuit, *supra* note 2, at 49; Gavil & First, *supra* note 2, at 246.
[243] Unlocking Digital Competition, *supra* note 25, at 58; Gal & Petit, *supra* note 10, at 620, 633.

significant value loss for platform participants, making them a weapon of last resort that may prove more harmful than effective.[244]

This highlights that legal intervention should arrive at an earlier stage. Previous sections demonstrated that platforms' topologies influence the viability of free-market inter-platform competition. We have also seen that these topologies are shaped by certain mechanisms such as growth and preferential attachment, which operate when networks are formed. Consequently, antitrust law might become more impactful if it would shift its focus from *ex-post* remedies to *ex-ante* regulations which target these mechanisms when platforms' networks are forming. Further research is required to develop this concept, perhaps the final frontier of antitrust regulation. However, to somewhat elucidate how such topology-shaping regulations might look like, consider the following stylized scenario.

Let us imagine a hypothetical world in which an enhanced version of Uber—the *"uber-Uber"*—is the exclusive provider of ride-hailing services, and briefly consider how we could instill competition into ride-hailing within such scenario. As previously noted, the Microsoft Narrative applies in full force to Uber's platform, as its topology has no hubs vulnerable to hub-plucking.[245] This suggests the breaking of uber-Uber into several competing platforms as a sensible approach to foster ride-hailing competition in such a world. One way to pursue this breakup is to emulate the AT&T breakup of 1982,[246] splitting uber-Uber geographically.[247] Yet this approach has its limitations. First, a ride-hailing monopoly in one geographic market could be leveraged to monopolize other geographical markets.[248] Furthermore, as the AT&T breakup quintessentially exemplifies, the primary issue with splitting a large platform into distinct geographical components lies in the potential for reconsolidation.[249]

An alternative approach could involve artificially inserting hubs to uber-Uber's network. Currently, ride-hailing platforms permit only individual drivers and riders to connect directly to their platforms. Consider a scenario, however, where we mandate ride-hailing platforms *not* to connect directly to

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[244] Hovenkamp, Platform Monopoly, *supra* note 18, at 2010; Crémer et al., *Competition Policy for the Digital Era* (2019) (final report submitted to the European Commission), at 67, https://op.europa.eu/en/publication-detail/-/publication/21dc175c-7b76-11e9-9f05-01aa75ed71a1/language-en [https://perma.cc/ZNF2-2D74]; Page & Lopatka, *supra* note 11, at 204-206; Herbert Hovenkamp, *Antitrust Remedies for Big Tech*, REG. REV. (1.18.2021), https://www.theregreview.org/2021/01/18/hovenkamp-antitrust-remedies-big-tech/ [https://perma.cc/X8EZ-EZX7].

[245] *See supra* IV.2.a.

[246] *United States v. American Tel. & Tel. Co.*, 552 F. Supp. 131, 200-201 (D.D.C. 1982).

[247] The dissolution of AT&T included the creation of seven separate regional operating companies. Tim Wu, *supra* note 47, at 194.

[248] *See* SC Innovations-Decision, *supra* note 78, at 2.

[249] Tim Wu, *supra* note 47, at 239-240, 248-249.

drivers and riders, but rather through intermediaries that cluster them, such as labor unions, consumer associations and business clients. This proposal is not an entirely outlandish. There is scholarly work arguing that Uber forms an entrenched labor-monopsony exploiting drivers,[250] and that consequently drivers should be allowed to unionize to counter Uber's market power.[251] Here we essentially entertain the same idea, though for a different purpose. The drivers/riders are allowed to collectively bargain not for the sake of their own empowerment, but rather to insert hub-vulnerability into uber-Uber's platform, thereby lowering the network effects entry barrier for market entrants and facilitating inter-platform competition.

Interestingly, the primary legal obstacle preventing drivers from unionizing is antitrust law.[252] Unions, after all, are essentially price-fixing cartels,[253] the epitome of illegality under antitrust law. While antitrust law acknowledges a labor exemption that immunizes both unionization and certain union activities from antitrust condemnation,[254] this exemption is exogenous to antitrust law, and embodies a normative value, worker welfare, that seemingly collide directly with competitive considerations.[255] It may thus seem intuitive to conclude that from a purely endogenous antitrust perspective, one must fiercely object to driver unionization as normatively undesirable.

But as this uber-Uber scenario highlights, jumping to this conclusion thoughtlessly misses the policy crossroad that network effects dynamics present to antitrust law. On the one hand, if driver unionization is deemed legal, then

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[250] Marshall Steinbaum, *Monopsony and the Business Model of Gig Economy Platforms*, ¶15-21 (June 5, 2019) (a note submitted for the OECD's "Roundtable on Competition Issues in Labour Markets"), https://one.oecd.org/document/DAF/COMP/WD(2019)66/en/pdf [https://perma.cc/3BVA-T7LK?type=standard].

[251] Eric A. Posner, HOW ANTITRUST FAILED WORKERS 150, 157-159 (2021) ("**Eric Posner**"); Brishen Rogers, *Employment Rights in the Platform Economy: Getting Back to Basics*, 10 HARV. L. & POL'Y REV. 479, 484, 518 (2016); Seth D. Harris & Alan Krueger, *A Proposal for Modernizing Labor Laws for Twenty- First- Century Work: The "Independent Worker",* BROOKINGS INST. 15 (2015) ("**Harris & Krueger**").

[252] Harris & Krueger, *supra* note 251, at 16; Eric Posner, *supra* note 251, at 158.

[253] Eric Posner, *supra* note 251, at 158.

[254] The labor exemption stems from language in the Clayton and Norris-LaGuardia Acts. *United States v. Hutcheson*, 312 U.S. 219, 235 (1941); *See also* Susan Schwochau, *The Labor Exemptions to Antitrust Law: An Overview*, 21(4) J. LABOR RES. 535, 536 (2000); Eric Posner, *supra* note 251, at 196 n.32.

[255] Marina Lao, *Worker in the Gig Economy: The for Extending the Antitrust Labor Exemption*, 51 U.C.D. L. REV. 1542, 1565-1566 (2018). The courts have attempted to reconcile the tension between the competing goals of antitrust law and the labor exemption by holding that the exemption covers *"employees"* exclusively and does not extend to *"independent contractors"*, thus limiting the exemption's applicability to employer-employee relationships. But the exemption's applicability in the ride-sharing context remains controversial, as there is great ambiguity as to whether ride-sharing drivers constitute employees or contractors. *See Columbia River Packers Ass'n v. Hinton*, 315 U.S. 143 (1942), at 145-147; Eric Posner, *supra* note 251, at 158; Harris & Krueger, *supra* note 251, at 15-16.

indeed antitrust law consents to some price-fixing arrangements in the uber-Uber's platform, but it also promotes inter-platform competition. On the other hand, if antitrust law prohibits driver unionization, then it essentially stabilizes an entrenched monopoly that could have been considerably weakened. While antitrust law currently endorses the latter alternative, when one considers the inherent instability of numerous price-fixing unions coordinating thousands of drivers, it is far from clear that—in the long run—succumbing to a single entrenched monopoly is preferable.

Another possibility for revolutionizing antitrust's arsenal involves the strategic use of temporary shutdowns for nodes and links. Gal and Petit have entertained the idea of temporarily shutting down entire platforms to compel their participants to migrate to competing services,[256] thereby restoring opportunities for competitors to build an installed base and promoting competitive entry.[257] The underlying thought is that this radical measure could stimulate competition by exposing users to competing services, and by enabling competitors to reach the necessary size to compete effectively.[258]

Unfortunately, as Gal and Petit themselves note, shutting down entire platforms—even temporarily—is an extreme measure.[259] Obviously, there are evident constitutional challenges involved. But even from an endogenous antitrust perspective, this measure essentially removes a firm from a market, thereby diminishing competitive pressure and undermining antitrust policy's pursuit of consumer welfare in the short-run.[260] Gal and Petit entertain the notion a temporary reduction in rivalry might advance long-term antitrust goals.[261] However, they also emphasize that *"[a]ny shutdown in digital markets should thus be carefully calibrated with attention to consumer's interests"*,[262] preluding to their list of limiting principles that should be followed to avoid consumer harm.[263]

We can thus entertain a milder version of Gal and Petit's idea, namely the temporary shutdown of hubs on certain platforms. For instance, envision mandating Cristiano Ronaldo not to engage on Facebook. It is not unreasonable to think that such a measure would yield pro-competitive effects. First, we should expect the activity of Ronaldo on the non-restricted platforms (e.g. Twitter, TikTok etc.) to increase, at least relatively to Facebook, in a manner that should promote inter-platform competition. Moreover, the reduced activity of Ronaldo on Facebook might even allow other nodes on Facebook to

[256] Gal & Petit, *supra* note 10, at 663.
[257] *Id.* at 622, 663.
[258] *Id.* at 663.
[259] *Id.* at 622.
[260] *Id.* at 664-65.
[261] *Id.* at 664.
[262] *Id.* at 665-66.
[263] *Id.* at 666-68.

grow, enjoying Facebook's size and currently unmatched ability to reach audiences. Consequently, the pool of hubs that social-media platforms could compete for, at least in the short-run, might grow. And importantly, this measure, while not to be trifled with, is considerably less socially costly than Gal and Petit's shutdown of entire services.[264] No business is being totally prohibited from operating in the market, even temporarily, thus mitigating both the constitutional concerns and the conflict with short-term antitrust goals.

Granted, the discussion surrounding both the artificial insertion of hubs and the temporary shutdown of hubs proposals leaves open a multitude of important questions that must be addressed before implementation. For instance, with artificial-hub-insertion we would probably want to address the risk of one intermediary beating the other intermediaries and conquering the entire platform. Another challenge may arise from disparities in market power between intermediaries on one side of the platform and those on the other, potentially tilting the quality of service between the sides of the platform. Likewise, with the hub-temporary-shutdowns, a host of questions arise concerning the number of hubs that will be impacted and the duration of the shutdowns. To be clear, the discussion on each of these proposals is not meant to be exhaustive, and this paper does not necessarily advocate for adopting either of them. Rather, the aim is to intrigue the imagination towards new directions of thought, setting the stage for future and exciting research.

Conclusion

H. L. Menken once famously stated that *"for every complex problem there is an answer that is clear, simple and wrong."* This paper has demonstrated that the conflicting Microsoft and Amex narratives embody such simplistic answers. These narratives are fraught with assumptions that are far from self-evident and remain entirely oblivious to factual intricacies crucial for competitive analysis. Presently, antitrust law is acutely ill-equipped to discuss these narratives critically. This is deeply troubling, as they lead to opposite normative extremes, with the Microsoft Narrative demanding extensive legal intervention, while the Amex Narrative preaches conservative inaction. Addressing this conundrum is thus of the utmost importance, necessitating an evolution in antitrust thinking.

Driven by the desire to transcend the narratives' oversimplistic thinking, this paper posits that antitrust law should be equipped with the cutting-edge tools of network science, unlocking access to previously unattainable insights. Wielding these tools, this paper unveiled that many platforms likely constitute scale-free networks, and that such platforms are susceptible to hub-plucking,

[264] In fact, the temporary shutdown of certain platforms' hubs is in line with Gal and Petit's second limiting principle that *"the shutdown need not apply to all users of the incumbent firm". See Id.* at 666.

meaning that the network effects entry barrier is far less formidable than the Microsoft Narrative unreservedly claims. Likewise, this paper has demonstrated that the Amex Narrative likely exaggerates the risk of negative feedback effects, because it fails to consider the network topology of the platforms, and the breakdown thresholds of platform participants. While these insights hold general validity, this paper stresses the competitive implications of network effects are ultimately a factual matter that must thoroughly assessed—using the correct tools—on a case-by-case basis. Looking forward, I wholeheartedly believe that network scientists play a vital role in every antitrust case involving network effects, offering expert opinions, and developing analytical tools to deciphering the network intricacies of platform competition.

Beyond unveiling valuable insights, this paper is intended as a proof-of-concept showcasing network science's transformative potential for revolutionizing antitrust law. While this paper focused on scrutinizing antitrust's conceptions of market power, embracing network science has the potential to send ripples through the entire antitrust enterprise, from recalibrating merger control, through redefining bans on anti-competitive conduct, to crafting novel remedies. This paper provided a glimpse into how insights from network science could further be applied into antitrust law, when it briefly discussed two proposals for expanding antitrust's arsenal of interventions in the platform context. Yet this is only the beginning, and one could easily conceive many additional applications. For example, considering the hubs' capacity to compromise platforms' integrity, one may wonder whether hubs wield market power over either platform operators or low-degree platform participants. This prompts crucial considerations regarding the measurement of such market power, for which network science offers us valuable metrics, such as the hub's degree, as well as closeness and betweenness centrality.[265] Additionally, one may question whether specialized prohibitions should be imposed on hubs, such as banning them from demanding platform operators to remove low-degree platform participants.

Indeed, the possibilities for network science to elevate antitrust law are boundless, setting the stage for exciting future research agenda.

[265] For a simple explanation regarding such metrics, *See* Andrew Disney, *Social Network Analysis 101: Centrality Measures Explained*, CAMBRIDGE INTELLIGENCE (Jan. 2, 2020), https://cambridge-intelligence.com/keylines-faqs-social-network-analysis/ [https://perma.cc/ZH49-7Y5Q].