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ON THE ORIGIN OF PLATFORMS
AN EVOLUTIONARY PERSPECTIVE

Dirk Auer, ***International Center for Law & Economics***
Geoffrey Manne, ***International Center for Law & Economics***

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ABSTRACT

Hardly a day goes by without news of some proposed intervention by competition authorities into the digital economy. In recent years, enforcers in both the United States and Europe have initiated dozens of competition cases against Silicon Valley's tech giants. Legislators around the globe have also passed sweeping regulations that fundamentally alter the way that large online platform markets function. These antitrust and regulatory initiatives are part of a global push ostensibly to "open up" digital markets. This paper uses the lens of evolutionary theory to shed new light on these initiatives. It suggests that current policy debates insufficiently consider whether the purported imperfections of digital platform markets might be "features" rather than "bugs." The paper focuses on two characteristics that drive a significant share of contemporary competition enforcement—namely, the "openness" of platforms (or, more precisely, the purported lack thereof) and the degree to which they are "propertized." In that respect, this paper identifies a sharp divergence between the online platforms that authorities want and those that emerge organically. The paper questions what forces might be driving this discrepancy and discusses their implications for contemporary policy-making discussions.

METADATA

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AUTHOR CONTACT INFORMATION

Dirk Auer, director of competition policy at the International Center for Law & Economics, adjunct professor at the University of Liège, icle@laweconcenter.org

Geoffrey Manne, president and founder of the International Center for Law & Economics, distinguished fellow at Northwestern University, Center on Law, Business, and Economics, icle@laweconcenter.org

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Introduction

Policymakers around the world are in the middle of unprecedented efforts to regulate digital platforms. These efforts extend far beyond the boundaries of traditional competition enforcement and eschew traditional antitrust principles—such as the consumer welfare standard—in favor of fully fledged market design.[1] But although there has been much discussion of the purported benefits of redesigning and restructuring large tech platforms, a more fundamental question appears to have flown under the radar: Why are today's dominant platforms structured the way they are in the first place? This question is the digital platform equivalent of Chesterton's Fence, yet so far it appears to have eluded policymakers. Indeed, efforts to intervene in these platforms are premised on the implicit assumption that they are designed, at least in certain respects, to reap anticompetitive rewards at the expense of users and complementors. But, of course, every large platform started out as a small platform without market power, and not all (if any) subsequent design and organizational decisions were aimed at exploiting economic power. Thus, the question remains, and it remains unanswered.

Our paper attempts to fill this void in the policy discussions surrounding tech regulation. In a nutshell, we argue that the most noteworthy and (in many cases) most criticized design features of today's successful tech platforms are the result of evolutionary market forces, including preferences on both the demand and the supply sides of the industry. More specifically, the extremely decentralized platform designs that policymakers are seeking to foist upon consumers and developers appear to have been previously rejected by the market. In other words, contrary to what is often assumed, no level of (de)centralization is superior across the board; everything is about balance and tradeoffs. Contemporary policymakers are thus wrong to categorically overlook or dismiss the potential benefits of comparatively closed and "propertized" platform business models, although the opposite would also be true (i.e., policymakers would be wrong to assume decentralization has no benefits).

A fictional professor famously said, "Your scientists were so preoccupied with whether or not they *could*, they didn't stop to think if they *should*."[2] Film-savvy readers will no doubt recognize the quote from Dr. Ian Malcolm, the "chaotician" from Stephen Spielberg's *Jurassic Park*, who lambasts industrialist John Hammond's ill-considered decision to clone dinosaurs. *Jurassic Park* might be a work of science fiction, but the sentiment identifies a very real problem in public policy: Policymakers' reach often exceeds their grasp.[3] Just like a fictional island filled with dinosaurs, markets are complex, evolving systems that are often difficult or impossible for outside

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[1] *See infra*, notes 5–26 and accompanying text.

[2] JURASSIC PARK (Universal City Studios 1993), *available at* Food for Thought, *Jurassic Park (1993)—Lunch Scene*, YOUTUBE (Nov. 25, 2011), https://www.youtube.com/watch?v=g1GfN8Yk_70, at 1:59.

[3] It's less titillating to quote Robert Browning than *Jurassic Park*, but the corollary to this sentiment—in *favor* of unfettered imagination exercised by artists—was, of course, most famously expressed in Browning's poem, "Andrea del Sarto": "Ah, but a man's reach should exceed his grasp, / Or what's a heaven for?" Robert Browning, *Andrea del Sarto*, *in* ROBERT BROWNING, MEN AND WOMEN: IN A BALCONY, DRAMATIS PERSONAE (1st ed. 1855). In the policy realm, this observation was labeled the Nirvana Fallacy by Harold Demsetz. *See* Harold Demsetz, *Information and Efficiency: Another Viewpoint*, 12 J.L. & ECON. 1, 1–2 (1969).

observers to decipher. Given this complexity, it is critical that policymakers strive to understand markets before they interfere with them.

This knowledge problem is perhaps nowhere clearer than in digital markets, where firms are constantly looking to survive (and thrive) by introducing new services that might disrupt rivals and by adapting their existing offerings to retain and attract users. Despite this complexity, policymakers around the globe have moved toward adopting sweeping regulations that would transform competition in online markets, or they have already passed such regulations into law.[4] The question is whether today's decision makers have a firm grasp on these online ecosystems, or whether—as was the case for Jurassic Park's scientists—there are subtleties of these markets that, with catastrophic effect, escape their understanding.

Hardly a day goes by without news of some proposed intervention by competition authorities into the digital economy. In recent years, authorities in both the United States and Europe have initiated dozens of competition cases against Silicon Valley's tech giants. In the United States, the Federal Trade Commission, the US Department of Justice, and dozens of state attorneys general have launched high-profile cases against Google,[5] Meta,[6] and Amazon.[7] On the other side of the Atlantic, the European Commission has adopted three major competition decisions against Google[8] and one major decision against Apple,[9] and it opened investigations into Amazon's Marketplace,[10] Apple's payment system,[11] and Facebook's Libra cryptocurrency.[12]

These interventions are part of a much broader push to bring the tech sector to heel. In October 2020, the US House Judiciary Committee issued a long-awaited report concerning competition issues in digital markets.[13] As expected, the committee recommended the adoption of regulations to "open up" digital markets, just as the Bell Labs, RCA, and IBM consent decrees

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[4] *See* Lazar Radic, Geoffrey Manne & Dirk Auer, *Regulate for What? A Closer Look at the Rationale and Goals of Digital Competition Regulations* (Int'l Ctr. for L. & Econ., White Paper No. 2024-05-15, Aug. 19, 2024).

[5] *See, e.g.*, Complaint, United States v. Google, LLC, No. 1:20-cv-03010 (D.D.C. 2020); Complaint, State of Colorado, et al. v. Google, LLC, No. 1:2020-cv-03715 (D.D.C. 2020); Complaint, State of Texas, et al., v. Google, LLC, No. 1:21-cv-06841 (S.D.N.Y 2021).

[6] *See* Complaint for Injunctive Relief, Federal Trade Commission v. Facebook, Inc., No. 1:20-cv-03590 (D.D.C. 2020), https://www.ftc.gov/system/files/documents/cases/ecf_75-1_ftc_v_facebook_public_redacted_fac.pdf. *See also* Complaint, New York et al. v. Facebook, Inc. (2020), https://ag.ny.gov/sites/default/files/facebook_complaint_12.9.2020.pdf.

[7] *See* Complaint, People of the State of California v. Amazon, Inc. (2022), https://oag.ca.gov/system/files/attachments/press-docs/2022-09-14%20Redacted-California%20v.%20Amazon%20Complaint.pdf.

[8] *See* Case AT.39740, Google Search (Shopping), 2017 E.R.C. I-379. *See also* Case AT.40099, Google Android, 2018 E.R.C. *See also* European Commission Press Release IP/19/1770, Antitrust: Commission Fines Google 1.49 Billion for Abusive Practices in Online Advertising (Mar. 20, 2019).

[9] *See* Case AT.40437, Apple—App Store Practices (Music Streaming) (Mar. 4, 2024), https://ec.europa.eu/competition/antitrust/cases1/202419/AT_40437_10026012_3547_4.pdf.

[10] *See* European Commission Press Release IP/20/2077, Antitrust: Commission Sends Statement of Objections to Amazon for the Use of Non-public Independent Seller Data and Opens Second Investigation into Its E-Commerce Business Practices (Nov. 10, 2020). The case was subsequently settled. *See* European Commission Press Release IP/22/7777, Antitrust: Commission Accepts Commitments by Amazon Barring It from Using Marketplace Seller Data, and Ensuring Equal Access to Buy Box and Prime (Dec. 20, 2022).

[11] *See* European Commission Press Release IP/20/1075, Antitrust: Commission Opens Investigation into Apple Practices Regarding Apple Pay (June 16, 2020). The case was subsequently settled. *See* European Commission Press Release IP/24/3706, Commission Accepts Commitments by Apple Opening Access to "Tap and Go" Technology on iPhones (July 11, 2024).

[12] *See* Lydia Beyoud & Aoife White, *Facebook's Libra Currency Gets European Union Antitrust Scrutiny*, BLOOMBERG, Aug. 20, 2019.

[13] *See* MAJORITY STAFF OF H.R. SUBCOMM. ON ANTITRUST, COMMERCIAL, AND ADMINISTRATIVE LAW & H.R. COMM. ON THE JUDICIARY, 117TH CONG., INVESTIGATION OF COMPETITION IN DIGITAL MARKETS (Comm. Print 117-8, 2020).

had for the semiconductor industry in the 1950s.[14] A year later, in October 2021, Senators Amy Klobuchar (D-MN) and Chuck Grassley (R-IA) introduced the American Innovation and Choice Online Act (AICOA), which seeks to boost competition in online markets.[15] Along similar lines, Senator Richard Blumenthal (D-CT) put forward the Open App Markets Act, which would, among other things, require the owners of app stores to open their platforms to rival payment systems.[16] At the time of this writing, it seems unlikely that any of these bills will be passed into law.

The European Union (EU) has also been extremely active on this front. In September 2022, it passed into law the Digital Markets Act (DMA), which imposes significant limits on the behavior of so-called gatekeeper platforms.[17] Along similar lines, the United Kingdom passed the Digital Markets, Competition and Consumers Act (DMCC), which imposes far-reaching obligations on firms with so-called Strategic Market Status.[18]

Finally, Australia has also been at the forefront of this movement. Following a "digital platforms inquiry" concluded in 2019,[19] the Australian Competition and Consumer Commission proposed a draft code of conduct in 2020 to address an alleged bargaining power imbalance between Australian news media businesses and major digital platforms such as Google and Facebook.[20] The government subsequently adopted the code in 2021.[21] It has since undertaken a "digital platform services inquiry" and released several reports on the topic.[22] Similar initiatives are ongoing (or have been passed into law) in Germany, France, and South Korea, among many other jurisdictions.[23]

It is hard to overstate the extent to which these initiatives mark a paradigmatic shift in the regulation of online markets. These antitrust cases and regulations rely heavily on novel theories of harm and contemplate remedies that, in some form or another, effectively impose various openness and neutrality obligations on dominant platforms. For instance, the (defunct) Klobuchar-Grassley legislation would have prevented so-called covered platforms from preferencing their own products and services over those of rivals.[24] It would also have forced these firms to grant

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[14] *See id.* at 7 ("When confronted by powerful monopolies over the past century—be it the railroad tycoons and oil barons or Ma Bell and Microsoft—Congress has acted to ensure that no dominant firm captures and holds undue control over our economy or our democracy. We face similar challenges today. Congress—not the courts, agencies, or private companies—enacted the antitrust laws, and Congress must lead the path forward to modernize them for the economy of today, as well as tomorrow. Our laws must be updated to ensure that our economy remains vibrant and open in the digital age.").

[15] American Innovation and Choice Online Act, S. 2992, 117th Cong. (2022).

[16] Open App Markets Act, S. 2710, 117th Cong. (2021).

[17] *See* Commission Regulation 2022/1925 of the European Parliament and of the Council of 14 September 2022 on Contestable and Fair Markets in the Digital Sector. *See also* Amending Council Directives 2019/1937 and 2020/1828 (Digital Markets Act), 2022 O.J. (L 265).

[18] Digital Markets, Competition and Consumers Act 2024.

[19] *See* AUSTRALIAN COMPETITION & CONSUMER COMM'N, DIGITAL PLATFORMS INQUIRY: FINAL REPORT (July 26, 2019).

[20] *See* AUSTRALIAN COMPETITION & CONSUMER COMM'N, DRAFT NEWS MEDIA BARGAINING CODE (July 31, 2020).

[21] News Media and Digital Platforms Mandatory Bargaining Code Act 2021.

[22] *See Digital Platforms Services Inquiry 2020–25*, AUSTRALIAN COMPETITION & CONSUMER COMM'N, https://www.accc.gov.au/inquiries-and-consultations/digital-platform-services-inquiry-2020-25.

[23] Radic, Manne & Auer, *supra* note 4.

[24] American Innovation and Choice Online Act, S. 2992, 117th Cong. (2022).

rivals access to their platforms.[25] The European DMA includes similar provisions but goes a step further by imposing far-reaching interoperability provisions on regulated firms.[26]

There are clear parallels between these regulatory initiatives and the common-carrier regulations historically applied to perceived natural monopolies, such as railroads, electricity grids, and telecommunications networks. These initiatives similarly would turn the tech sphere into a heavily regulated industry, with far more government oversight than is currently the case. As a result, the "permissionless innovation" that has spurred the rapid rise of the tech industry may become the exception rather than the norm.[27]

Although ongoing efforts to regulate the tech sector have attracted much attention in academic circles,[28] a fundamental question has all too often eluded these discussions: What goal are authorities trying to achieve? At first blush, the answer might appear to be extremely simple. Authorities want to "bring more competition" to digital markets.[29] Furthermore, they believe that this competition will not arise spontaneously owing to the underlying characteristics of digital markets, such as network effects, economies of scale, and tipping.[30] But while it may have some intuitive appeal, this answer misses the forest for the trees.

Framing tech regulation as merely an effort to increase competition in digital industries obfuscates a fundamental feature of these ongoing efforts. Countless levers could be pulled to increase competition in these markets. For many policymakers and commentators, competition enforcement (whether in the form of antitrust or market regulation) is the most obvious. But policymakers could also look at potential obstacles to startup funding. They could focus on regulatory barriers to market entry, such as privacy regulations and other rules that hinder new platforms from thriving.[31] Platform regulation is far from the only policy tool that policymakers could use to promote competition in digital markets. So why do policymakers so deliberately favor this one?

We can safely infer that, in seeking to restore competition, policymakers are not agnostic as to *how* this should take place; they are not simply calling balls and strikes (which has been the paradigm of antitrust and competition enforcement for decades). Instead, today's policymakers seek to fundamentally alter the way in which digital platform markets operate and, ultimately, to

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[25] *Id.*

[26] *See* Commission Regulation 2022/1925, *supra* note 17.

[27] *See* ADAM THIERER, PERMISSIONLESS INNOVATION: THE CONTINUING CASE FOR COMPREHENSIVE TECHNOLOGICAL FREEDOM vii (2016) (Defining *permissionless innovation* as "the notion that experimentation with new technologies and business models should generally be permitted by default.").

[28] *See, e.g.*, STIGLER CTR FOR THE STUDY OF THE ECONOMY AND THE STATE, STIGLER COMMITTEE ON DIGITAL PLATFORMS: FINAL REPORT 28 (2019); JACQUES CRÉMER, YVES-ALEXANDRE DE MONTJOYE & HEIKE SCHWEITZER, COMPETITION POLICY FOR THE DIGITAL ERA: FINAL REPORT (2019); DIGITAL COMPETITION EXPERT PANEL, UNLOCKING DIGITAL COMPETITION 17 (2019).

[29] Makena Kelly, *Amy Kloubuchar Leads Her Final Assault on Big Tech's Power*, THE VERGE (Jan. 27, 2022). ("Allowing more competition gives them more choice so that they can protect their kids."). *See also* Margrethe Vestager, Commissioner, Eur. Comm'n, Competition in a Digital Age, speech at the European Internet Forum: Competition in a Digital Age (Mar. 17, 2021).

[30] *See* sources cited *supra* note 28.

[31] *See* Rebecca Janßen, Reinhold Kesler, Michael E. Kummer & Joel Waldfogel, *GDPR and the Lost Generation of Innovative Apps* (Nat'l Bureau of Econ. Rsch., Working Paper No. 30028, 2022) ("Comparing long-run equilibria with and without GDPR, we find that GDPR reduces consumer surplus and aggregate app usage by about a third. Whatever the privacy benefits of GDPR, they come at substantial costs in foregone innovation."); Jian Jia, Ginger Zhe Jin & Liad Wagman, *The Short-Run Effects of the General Data Protection Regulation on Technology Venture Investment*, 41 MKTG. SCI. 593, 661 (2021) ("Our findings indicate negative post-GDPR effects after its 2018 rollout on European ventures relative to their counterparts in the United States and the rest of the world . . . . The negative effects manifest in the number of and amounts raised in financing deals, and are particularly pronounced for newer, data-related, and business-to-consumer ventures.").

bring them more in line with their own idiosyncratic preferences——for example, by making them more open or more diverse in terms of the business models they employ or by ensuring that they do not disrupt traditional media industries. This effort is less an exercise in the correction of transient monopoly power than it is one of full-fledged market design.

Consider the following example. There is a vast difference between the antitrust litigation launched against Microsoft on both sides of the Atlantic in the 1990s and early 2000s, on the one hand, and legislation such as the DMA, DMCC, and the (defunct) AICOA bill, on the other. The Microsoft antitrust cases, among other things, asked whether tying Microsoft software to its operating system (OS) prevented rivals from competing, *given the specific facts of the case*. In answering this question, litigation required the intervention of many economic experts, as well as the production of corroborating evidence. It also permitted the introduction of exculpatory evidence and arguments by Microsoft that its conduct did not have anticompetitive effect. Digital markets regulation goes much further. Indeed, legislation such as the DMA and the DMCC largely does away with the kinds of factual investigations that underpinned the Microsoft litigation. Such legislation creates an environment where policymakers no longer need rely on expert investigation, whether for the adoption of new rules or their implementation. In short, they replace (or would have replaced, in the case of AICOA) antitrust law's effects-based, case-by-case analysis and circumscribed application with an outright prohibition of certain business practices that policymakers do not like.

This sort of market design is not without risks. It rests on the assumption that central planners have some important piece of information that market participants either ignore or are incapable of acting on collectively.[32] That markets often fail to achieve the idealized benchmark of perfect competition is beyond doubt.[33] But market design also assumes that governments can do better. Proponents of market design thus presume that the world they seek to create is attainable and that intervention would constitute an improvement upon the status quo.[34] Both are questionable assumptions.

Against this backdrop, this paper uses the lens of evolutionary theory to shed new light on these initiatives. It suggests that current policy discussions insufficiently consider whether the purported imperfections of digital platform markets might be features rather than bugs. This paper focuses on two characteristics that drive a significant share of contemporary competition enforcement, as well as proposed digital market regulations: namely, the openness of platforms (or, more precisely, the lack thereof) and the degree to which they are propertized. In practice, policymakers influence these parameters with enforcement activities that seek to make platforms more interoperable and neutral and that attempt to reduce the rents they earn.

Section I lays out the evolutionary economic framework that underpins the paper. Section II argues that there is a divergence between the online platforms that authorities want and those that emerge organically. Put differently, the exceedingly open and shared platform model that

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[32] *See* Friedrich A. Hayek, *The Use of Knowledge in Society*, 35 AM. ECON. REV. 519 (1945).

[33] Whether this reflects a problem is another question—one that transaction costs economics has strongly challenged, but which most policymakers (and many scholars) fail to ask. *See* Alan J. Meese, *Market Failure and Non-standard Contracting: How the Ghost of Perfect Competition Still Haunts Antitrust,* 1 J. COMPETITION L. & ECON. 21, 83 (2005) ("[Pre–Chicago School] scholars considering questions of market failure did so on the assumption that markets were perfectly competitive. This assumption was not a statement about the actual state of the world, but instead a component of a theoretical model designed to guide scientific research. This methodological habit prevented these scholars from recognizing that various non-standard contracts could overcome market failure. In the absence of a beneficial explanation for these agreements, scholars naturally treated these departures from perfect competition as manifestations of market power.").

[34] *See* Demsetz, *supra* note 3.

authorities are currently seeking to promote has mostly failed in the marketplace. Section III analyzes the forces that might drive this discrepancy. It explores three potential causes: (a) that closed and propertized platforms systematically exclude more open and weakly propertized rivals; (b) that the former are easier to monetize and thus attract more investment; and (c) that consumers prefer the former. From the outset, it is important to recognize that the question is one of marginal preferences, as it is clear that there is no single optimal platform design (be it across space or time). Instead, firms need to balance the constantly evolving risks and opportunities that accrue from centralization or decentralization. Ultimately, the analysis suggests that the first of these three conjectures is insufficient to explain the success of relatively closed and propertized platforms. With that in mind, section IV lays out an alternative policy approach that assumes consumer preferences and heightened incentives to innovate are driving the emergence of closed and propertized platforms (at least relative to policymakers' ideal). The paper argues that several regulations and antitrust provisions currently raise transaction costs in online platform markets, potentially driving consolidation in the sector. By loosening some of these rules, authorities could facilitate the emergence of rivals as well as coordination among them.

I. Some Evolutionary Economics

It is useful to situate this paper within the broader literature on evolutionary economics, as well as to unpack some of the concepts that underpin its analysis of competition in digital markets. With that in mind, this section explains that evolutionary economics—like the natural science from which the discipline is derived—rests on three important assumptions about how competition unfolds: (a) the ubiquity of change in markets, (b) the fact that firms (and consumers, for that matter) are heterogeneous, and (c) the corollary that markets select those firms that are most fit for their environment. The section then focuses on certain salient traits where platforms exhibit significant variety, namely the extent to which they can be deemed open, propertized, and centralized. As we explain, it is platforms' heterogeneity regarding these traits that underpins the paper's analysis of online platform markets.

A. Evolutionary economics: A primer

Evolutionary economics is almost as old as modern economics itself. As early as 1898, Thorstein Veblen lamented that the economic literature of the day failed to adequately capture the *process* by which both economic agents and their environment change over time, and how they mutually shape each other:[35]

> The economic life history of the individual is a cumulative process of adaptation of means to ends that cumulatively change as the process goes on, both the agent and his environment being at any point the outcome of the past process. His methods of life to-day are enforced upon him by his habits of life carried over from yesterday and by the circumstances left as the mechanical residue of the life of yesterday.[36]

The field gained increased prominence in the 1940s and 1950s with seminal works from Joseph Schumpeter and Armen Alchian.[37] Both authors independently drew attention to several important

[35] Thorstein Veblen, *Why Is Economics Not an Evolutionary Science?*, 12 Q. J. ECON., 373 (1898).

[36] *Id*. at 391.

[37] Armen A. Alchian, *Uncertainty, Evolution, and Economic Theory*, 58 J. POL. ECON., 211 (1950); JOSEPH A. SCHUMPETER, CAPITALISM, SOCIALISM AND DEMOCRACY (Routledge 1976).

factors that have become central to the evolutionary analysis of economic phenomena and that arguably were overlooked by other economists at the time. These include the importance of change and uncertainty, how firms adapt to it, and the role of luck.[38] As Joseph Schumpeter put it:

> The essential point to grasp is that in dealing with capitalism we are dealing with an evolutionary process . . . . Capitalism, then, is by nature a form of economic change and not only never is but never can be stationary.[39]

Alchian argued further that economics was too focused on actors' rationality and their intentions. Instead, he surmised that it does not matter whether individual firms attempt to maximize their profits, because the competitive process ultimately selects those that do the best job in this respect.[40] To say these early works were influential would be an understatement. Their influence is plain to see in many other fields of economic research, notably in the management and business literature, where such works as Clayton Christensen's "innovator's dilemma" and David Teece's "dynamic capabilities" framework focus heavily on how firms adapt to changing economic conditions.[41]

Although the literature on evolutionary economics has come a long way since the works of Veblen, Schumpeter, and Alchian, its core axioms have remained substantially the same.[42] A first key proposition is that competition is a continuously evolving process—that is, that change is ubiquitous.[43] In that regard, it is not only the environment in which firms and consumers operate

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[38] *See* Alchian; SCHUMPETER, *supra* note 37.

[39] SCHUMPETER, *supra* note 37, at 72. *See also* RICHARD R. NELSON & SIDNEY G. WINTER, AN EVOLUTIONARY THEORY OF ECONOMIC CHANGE, ix (Harvard University Press 1985) ("Our greatest intellectual debts are to Joseph Schumpeter and Herbert Simon. Schumpeter pointed out the right problem—how to understand economic change—and his vision encompassed many of the important elements of the answer.").

[40] Alchian, *supra* note 37, at 211 ("This phenomenon—environmental adoption—is then fused with a type of individual motivated behavior based on the pervasiveness of uncertainty and incomplete information. Adaptive, imitative, and trial-and-error behavior in the pursuit of 'positive profits' is utilized rather than its sharp contrast, the pursuit of 'maximized profits.' A final section discusses some implications and conjectures."). *See also* Brian C. Albrecht, Joshua R. Hendrickson & Alexander William Salter, *Evolution, Uncertainty, and the Asymptotic Efficiency of Policy*, 192 PUB. CHOICE, 169 (2022).

[41] *See, e.g.*, CLAYTON M. CHRISTENSEN, THE INNOVATOR'S DILEMMA: WHEN NEW TECHNOLOGIES CAUSE GREAT FIRMS TO FAIL (2015). *See also* David J. Teece, Gary Pisano & Amy Shuen, *Dynamic Capabilities and Strategic Management*, 18 STRATEGIC MGMT. J. 509, 509 (1997) ("If correct, the framework suggests that private wealth creation in regimes of rapid technological change depends in large measure on honing internal technological, organizational, and managerial processes inside the firm. In short, identifying new opportunities and organizing effectively and efficiently to embrace them are generally more fundamental to private wealth creation than is strategizing, if by strategizing one means engaging in business conduct that keeps competitors off balance, raises rival's costs, and excludes new entrants.").

[42] *See, e.g.*, Richard R. Nelson, *A Perspective on the Evolution of Evolutionary Economics*, 29 INDUSTR. & CORP. CHANGE 1101 (2020).

[43] *See, e.g.,* Gerald P. O'Driscoll Jr., *Competition as a Process: A Law and Economics Perspective*, *in* ECONOMICS AS A PROCESS: ESSAYS IN NEW INSTITUTIONAL ECONOMICS 154 (Richard N. Langlois, ed. 1986) ("There is also a more profound way in which the traditional static theory of competition ignores the role of institutions. This can best be explained in the course of developing the alternative tradition or approach to the theory of competition. This tradition characterizes competition as a process in time rather than a timeless state of affairs. The process consists in economic agents discovering the very data (*e.g.*, costs) that are assumed given to them in the theory of perfect competition."). *See also* Friedrich A. Hayek, *Competition as a Discovery Procedure*, 5 Q.J. AUSTRIAN ECON. 9, 15 (2002) ("We are accustomed to calling the order brought about by competition an equilibrium—a none-too-felicitous expression, since a true equilibrium presupposes that the relevant facts have already been discovered and that the process of competition has thus come to an end. The concept of order, which I prefer to that of equilibrium, at least in discussions of economic policy, has the advantage of allowing us to speak meaningfully about the fact that order can be realized to a greater or lesser degree, and that order can also be preserved as things change. Whereas an equilibrium never really exists, one can nonetheless justifiably claim that the kind of order of which the 'equilibrium' of theory represents a

that changes, but the economic actors themselves who adapt to changing environments. As Richard Nelson and Sidney Winter put it:

> Evolutionary theory is useful in analyzing a wide range of phenomena associated with economic change stemming either from shifts in product demand or factor supply conditions, or from innovation on the part of firms. The specific models we build focus in tum on different aspects of economic change—the response of firms and the industry to changed market conditions, economic growth, and competition through innovation.[44]

A second central assumption of the evolutionary economics literature is that firms are heterogeneous in their capabilities, knowledge, resources, and so forth.[45] The result is that some of them may be better suited to their competitive environment than others, ultimately giving them an edge when it comes to surviving what Schumpeter called the "gales of creative destruction."[46] For instance, Richard Nelson writes:

> From the beginnings, a central aspect of evolutionary economics has been explicit recognition of the diversity of behaviors among economic actors operating in the same or very similar environmental contexts . . . . facts that seemed to require a theory of firm and industry behavior that recognized and explained differences among firms in their capabilities and behaviors much more easily than did the then standard neoclassical theory.[47]

One important aspect of this variety—and particularly salient in the case of tech markets—is that firms often have different capabilities when it comes to innovating or adapting to a changing environment. As Metcalfe summarizes:

> What is at issue here is the capability of the firm as a creative institution: the strategies it follows; the perceived opportunities to which it reacts; the resources it can allocate to innovation; and its ability to integrate its invention, production and marketing activities into the creation of innovations. On all of these aspects there is a rich literature spanning management science and economics (Nelson, 1992) and it is clear that innovation provides fertile ground for the study of diversity in behaviour.[48]

These two observations lead to a third, and crucial, finding: As in the field of biological evolutionary science, change and variety are the engines that lead market forces to select winning firms.[49] In other words, some firms have traits that enable them to survive environmental changes

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sort of ideal type is realized to a great extent."). Readers should note that evolutionary economics is a loose framing that may cover many different ideas; Ulrich Witt, *What Is Specific about Evolutionary Economics?*, *in* RETHINKING ECONOMIC EVOLUTION: ESSAYS ON ECONOMIC CHANGE AND ITS THEORY 41 (Ulrich Witt, ed. 2016) ("There is still no agreement about the specific features associated with the label 'evolutionary' in economic analysis, not to speak of a commonly accepted paradigmatic 'hard core' like, *e.g.*, the equilibrium optimization framework in canonical economic theory.").

[44] NELSON & WINTER, *supra* note 39, at 3.

[45] *See, e.g.*, Jan Fagerberg, *Schumpeter and the Revival of Evolutionary Economics: An Appraisal of the Literature*, 13 J. EVOLUTIONARY ECON. 125, 152 (2003) ("The problem, of course, is how to allow for sufficient change, or creation of novelty, within such an environment. Although evolutionary theorists have approached this question in different ways, their suggestions have always been based on the assumption of heterogeneous agents.").

[46] SCHUMPETER, *supra* note 37.

[47] Nelson, *supra* note 42, at 1104.

[48] J .Stanley Metcalfe, *Evolutionary Economics and Technology Policy*, 104 ECON. J. 931, 934 (1994).

[49] *See* Witt, *supra* note 43, at 551 ("Supported by attempts at extending the Darwinian theory universally beyond the domain of evolutionary biology (Dawkins 1983), three principles of evolution have now become increasingly popular as a heuristic for evolutionary theorizing: blind variation, selection, and retention (Campbell 1965).").

(in this case, by profitably serving consumers) while others falter.[50] As Stanley Metcalfe puts it, "the distinctive feature of any evolutionary model is the role which variety in behaviour plays in driving a selection process."[51] To be more precise, firms may *vary* or *mutate* for endogenous reasons (for instance, because their engineers have different capabilities); they may *adapt* to exogenous alterations to the environment (in response to the entry of new competitors, for example); and the market will *select* some of these mutations and adaptations.[52] Although consumer demand plays an important part in this selection process, this does not mean that markets always select the optimal technology.

> The pertinent requirement—positive profits through relative efficiency—is weaker than "maximized profits," with which, unfortunately, it has been confused. Positive profits accrue to those who are better than their actual competitors, even if the participants are ignorant, intelligent, skillful, etc. The crucial element is one's aggregate position relative to actual competitors, not some hypothetically perfect competitors. As in a race, the award goes to the relatively fastest, even if all the competitors loaf.[53]

Furthermore, products (and especially platforms) themselves continually evolve in response to technological and market changes, not least by incorporating aspects of exogenous innovations through copying, acquisition, as well as trial and error. Often these become the basis for further innovation:

> [A]ssimilation can take various forms and impact various levels of integration, such as the incorporation of capabilities into a new distribution platform, licensing of complementary capabilities, and in some cases, acquisitions of entire companies with complementary products or technology assets. Not only are the pervasive forces of technological assimilation essential to the viability of many innovative products and industries, they often provide the basis for commercial feasibility of future innovations that build on prior innovations.[54]

In this sense, the process of innovation can often be conceived of as the "combining of technological components in a novel manner."[55] Thus, "the innovation lifecycle involves a selective assimilation of novel technologies into broader capabilities, which consequently gives

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[50] Metcalfe, *supra* note 48, at 936.

[51] *Id.*

[52] KURT DOPFER, THE EVOLUTIONARY FOUNDATIONS OF ECONOMICS 15 (Cambridge University Press 2005) ("[T]he distribution of variety that is the reality and that is the prerequisite for evolutionary change. Mutation or variation is change in variety. While variation contradicts the law of uniformity at a particular time, mutation contradicts its universal application over time. Newton stated the law of endogenous continuity, Darwin that of endogenous discontinuity. Adaptation means that entities relate to each other in a specific, informationally non-arbitrary way. This contradicts the classical law for an isolated informant agency, which holds that relations among bodies are determined by invariant physical parameters of mass and force. Selection means that not all relations can exist, and it introduces an instance that determines the future existence and future non-existence of an actualized entity.").

[53] Alchian, *supra* note 37, at 213. Outside the field of evolutionary economics, scholars have debated the extent to which path dependency and randomness play a role in the selection of winning firms and technologies. For instance, scholars have argued that network effects, rather than superior quality, explained the victory of the QWERTY keyboard layout over the DVORAK alternative. *See, e.g.*, Paul A. David, *Clio and the Economics of QWERTY*, 75 AM. ECON. REV. 332 (1985). *See also* Joseph Farrell & Garth Saloner, *Standardization, Compatibility, and Innovation*, 16 RAND J. ECON. 70 (1985). *Contra* Stan J. Liebowitz & Stephen E. Margolis, *The Fable of the Keys*, 33 J.L. & ECON., 1 (1990).

[54] Marco Iansiti & Gregory L. Richards, *Creative Construction: Assimilation, Specialization, and the Technology Life Cycle*, *in* COMPETITION POLICY AND PATENT LAW UNDER UNCERTAINTY: REGULATING INNOVATION 166–67 (Geoffrey A. Manne & Joshua D. Wright, eds. 2011).

[55] Lee Fleming & Olav Sorenson, *Science as a Map in Technological Search,* 25 STRAT. MGMT. J., 910 (2004).

rise to conditions that enable further innovation to occur, typically in increasingly specialized applications."[56]

These evolutionary economic insights appear particularly salient in technology markets, where change is—almost by definition—continuous. For instance, David Teece observes that "businesses must react in real time to changes in technology, regulation, and competition. The most alert and agile leadership teams are out in front driving innovation and change. . . . Unfortunately, mainstream economists are slow in coming to understand this new order."[57] In that respect, evolutionary scholars argue that competing firms iteratively explore different development paths to successfully commercialize new technologies.[58] A dominant design eventually emerges, causing many firms to either adapt or exit the market. Successful firms then compete within the parameters of that paradigm—until a new one appears.[59]

Yet even before any paradigm shift takes place, innovative markets will often be characterized by adaptation and exit. Although this process is often evolutionarily important and beneficial, absent the evolutionary perspective it may be mistaken as mere consolidation or even anticompetitive exclusion:

> The assimilation of technology is critical in driving the creation and evolution of broad based platforms . . . . These, in turn, enable more economic specialization, which fuels a thriving ecosystem of niche competitors. eBay's acquisition of online payment services provider PayPal in 2002 is a prime example. It illustrates how the assimilation of technology into a broader platform can enhance the long-term sustainability of niche applications, which is beneficial to a large ecosystem of customers and organizations.[60]

As we explain in the following section, these evolutionary insights—particularly the notion that firms are heterogeneous and that markets successively select platform designs that are well adapted to their environment at that point in time—have important ramifications for contemporary competition policy discussions pertaining to digital markets.

B. Heterogeneous platforms: Some terminology

The evolutionary insights of the previous section suggest that technology markets are constantly changing, and that competing firms develop different technological and commercial solutions to vie for consumer adoption. Time reveals which of these solutions are fit for purpose—as the market selects winners and losers on the basis of, among other factors, consumer preferences and firms' profitability.

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[56] Iansiti & Richards, *supra* note 54, at 170.

[57] David J. Teece, *Next-Generation Competition: New Concepts for Understanding How Innovation Shapes Competition and Policy in the Digital Economy*, 9 J.L. ECON. & POL'Y, 97 (2012).

[58] Richard R. Nelson & Sidney G. Winter, *Evolutionary Theorizing in Economics*, 16 J. ECON. PERSP. 23, 35 (2002) ("When a technology is new, there is uncertainty both about how the technology can improve and about what the customers really want. Both kinds of uncertainty make it hard to say which paths of development would be successful in meeting the needs better. Different inventors and firms lay their bets in different ways. New innovators and firms keep entering the industry, trying new things, and innovators and companies that have tried and failed go broke and leave. With time and accumulated efforts, one pathway or a set of pathways turns out to be effective, and the products of the new technology begin to attract a significant market. A 'dominant design' gradually emerges. Firms whose products exemplify that dominant design do well, and firms that are producing something else either have to switch over, which is not easy to do, or they fail.").

[59] *Id.*

[60] Iansiti & Richards, *supra* note 54, at 186.

The rest of this paper focuses on two important—and interrelated—traits that tend to differentiate platforms operating in the digital economy. The first concerns their "openness," and the second the extent to which they are highly "propertized." These two parameters ultimately influence how centralized or decentralized a platform will be. As these concepts are invoked throughout the paper, it is useful to unpack them.

Although there is no universally accepted definition, a platform's *openness* can be defined as the extent to which its operator makes it easy (or difficult) for other economic agents to use the platform, develop complementary products and services around it, and commercialize those products and services.[61] As Kevin Boudreau observes, openness depends on (a) whether the platform operator gives access to independent developers of complementary components and (b) the extent to which the operator controls the development of the platform, including strategic decisions.[62] For example, open platforms may license (sometimes freely) their source code to third parties, supply application programming interfaces (APIs) that third parties can use to develop compatible software, and enable original equipment manufacturers (OEMs) to preinstall the platform's software on the devices that they sell.[63] These parameters influence the platform operator's ability to enter into complementary markets.[64] Accordingly, the operator of a relatively open platform would, other things being equal, find it harder to foreclose its trading partners from the platform.[65]

For obvious reasons, a platform's openness is related to a second important concept: the degree to which it is propertized. *Propertization* is the extent to which access to the platform's infrastructure is subjected to formal or informal property rights and the extent to which those rights are vigorously enforced by the operator. On one end of the spectrum, platforms such as Linux rely on open-source software that is shared freely with the entire ecosystem. At the other end, platforms such as the Windows and MacOS operating systems rely on proprietary software that outside firms can access only via a license agreement, if at all.

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[61] *See, e.g.,* Kevin Boudreau, *Open Platform Strategies and Innovation: Granting Access vs. Devolving Control*, 56 MGMT. SCI. 1849, 1851 (2010) ("Broadly speaking, openness relates to the easing of restrictions on the use, development, and commercialization of a technology.").

[62] *Id.* at 1852.

[63] Joel West, *How Open Is Open Enough? Melding Proprietary and Open Source Platform Strategies*, 32 RSCH. POL'Y, 1259, 1264 (2003). *See also* Thomas R. Eisenmann, Geoffrey Parker & Marshall Van Alstyne, *Opening Platforms: How, When and Why*, *in* PLATFORMS, MARKETS AND INNOVATION, 131–132 (Annabelle Gawer ed., 2009) ("A platform is 'open' to the extent that: 1) no restrictions are placed on participation in its development, commercialization or use; or 2) any restrictions—for example, requirements to conform with technical standards or pay licensing fees—are reasonable and non-discriminatory, that is, they are applied uniformly to all potential platform participants. . . . [P]latform-mediated networks encompass several distinct roles, including: 1) demand-side platform users, commonly called 'end users'; 2) supply-side platform users, who offer complements employed by demand-side users in tandem with the core platform; 3) platform providers, who serve as users' primary point of contact with the platform; and 4) platform sponsors, who exercise property rights and are responsible for determining who may participate in a platform-mediated network and for developing its technology.").

[64] *See also* Annabelle Gawer & Rebecca Henderson, *Platform Owner Entry and Innovation in Complementary Markets: Evidence from Intel*, 16 J ECON. & MGMT. STRATEGY 1 (2007).

[65] Boudreau, *supra* note 61, at 1853 ("By giving up some measure of control over the platform, a platform owner might credibly commit to not abusing its partners—thereby restoring an incentive to invest in complementary innovation. Whether this strategy works in practice is unclear . . . ."). *See also* Jonathan M. Barnett, *The Host's Dilemma: Strategic Forfeiture in Platform Markets for Informational Foods*, 124 HARV. L. REV. 1861, 1868 (2010) ("In both the smartphone and open source software markets, controlled generosity follows from economic self-interest: implicit or explicit consortia of commercial firms open up access in order to commit against host opportunism and to induce adoption of a platform technology that promotes those firms' sale of complementary goods and services.").

Although propertization hinges to some degree on the intellectual property (IP) rights upon which the platform operator can rely, this factor is not always decisive. Open-source software usually benefits from the same IP protection as proprietary software, but its inventors commit to license it freely. Similarly, firms that own so-called standard-essential patents (SEPs) are often compelled to irrevocably limit their right to license those SEPs on terms that they see fit. Conversely, open-source platforms, such as Android, may rely on several business strategies to ultimately ensure that their creators earn a return on their investments, even though access to the platform is nominally free. In short, IP protection is an important part of determining whether a platform is strongly or weakly propertized, but it is not dispositive.

A platform's level of propertization is also related to the notion of appropriability. *Appropriability* is the extent to which an inventor captures the social benefits of its innovation.[66] Put differently, inventions create important social spillovers, and it is widely recognized that inventors generally do not fully capture the social benefits of their innovations.[67] The correlation between appropriability and propertization is far from perfect.[68] Strongly enforced intellectual property can sometimes lead to weak appropriability. This could be the case, for example, if a groundbreaking patent is easy to invent around. Conversely, firms with nominally weak IP protection can nevertheless create a regime of relatively strong appropriability.[69] Other things being equal, however, it is a reasonable heuristic that higher levels of propertization tend to be associated with stronger appropriability.

The complicated relationship between propertization and appropriability is perhaps best understood when one recognizes that platforms generally face a tradeoff between too much or too little propertization. In other words, it is necessary to find a sweet spot between both to maximize profits (and with that, inventors' returns on their innovations). As Jonathan Barnett writes:

> The [platform] therefore faces a basic trade-off. On the one hand, it must forfeit control over a portion of the platform in order to elicit user adoption. On the other hand, it must exert control over some other portion of the platform, or some set of complementary goods or services, in order to accrue revenues to cover development and maintenance costs (and, in the case of a for-profit entity, in order to capture any remaining profits).[70]

Taken together, these two concepts lead to a third one that is used much more loosely throughout the paper: the extent to which platforms are centralized or decentralized. The National Institute of Standards and Technology defines a *centralized network* as one in which "participants

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[66] David J. Teece, *Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy*, 15 RSCH. POL'Y 285 (1986) ("A regime of appropriability refers to the environmental factors, excluding firm and market structure, that govern an innovator's ability to capture the profits generated by an innovation"). *See also* Dirk Auer, *Appropriability and the European Commission's Android Investigation*, 23 COLUM. J. EUR. L. 647 (2017).

[67] Nobel laureate William Nordhaus finds, even in the presence of patents to facilitate the appropriability of the value of innovation by inventors, that "only a miniscule fraction of the social returns from technological advances over the 1948–2001 period was captured by producers, indicating that most of the benefits of technological change are passed on to consumers rather than captured by producers." *See* William D. Nordhaus, *Schumpeterian Profits in the American Economy: Theory and Measurement* 1 (Nat'l Bureau of Econ. Rsch., Working Paper No. 10433, 2004).

[68] *See, e.g.*, Edwin Mansfield, *Patents and Innovation: An Empirical Study*, 32 MGMT. SCI. 173, 175 (1986); Richard C. Levin, Alvin K. Klevorick, Richard R. Nelson, Sidney G. Winter, Richard Gilbert & Zvi Griliches, *Appropriating the Returns from Industrial Research and Development*, 1987 BROOKINGS PAPERS ON ECON. ACTIVITY 787, 797 (1987); Najib Harabi, *Appropriability of Technical Innovations: An Empirical Analysis*, 24 RSCH. POL'Y 981 (1995).

[69] *See* Auer, *supra* note 66, at 647.

[70] Barnett, *supra* note 65, at 1890.

must communicate with a *central authority* to communicate with one another," adding that "since all participants must go through a single centralized source, the loss of that source would prevent all participants from communicating."[71] Given this, it stands to reason that closed and highly propertized platforms will generally entail more centralized control by a central authority. Regardless, and unless stated otherwise, the notion of centralization is used as a shorthand for closed and propertized platforms throughout this paper.

II. An Evolutionary Question

Given that digital markets could have taken a vast number of shapes, why have they systematically gravitated toward those very characteristics that authorities condemn? For instance, if market tipping and consumer lock-in are so problematic, why is it that new corners of the digital economy continue to emerge via closed platforms, as opposed to collaborative ones? If more decentralized platforms are indeed beneficial for society—as the regulations discussed in the "Introduction" tend to assume—then it is those platforms that should succeed, because they purportedly produce greater gains from trade. And if consumers and platforms cannot realize those gains by themselves, then we should see intermediaries step into the breach—that is, arbitrage. This does not seem to be happening in the digital economy. The naive answer is to say that this is precisely the problem; the harder answer is to offer an account of *why*.

To draw another parallel with evolution, note that in the late 18th century, botanists discovered an orchid with an unusually long spur (see figure 1).[72] This feature made the orchid's nectar incredibly hard for pollinators to reach. Rational observers at the time could be forgiven for thinking that this plant's existence made little sense, that its design was suboptimal. And yet, decades later, Darwin conjectured that the plant could be explained by an as-yet-undiscovered species of moth with a proboscis long enough to reach the orchid's nectar.[73] Decades after his death, the discovery of the *Xanthopan morganii* moth proved Darwin right.[74]

Returning to the digital economy, we thus need to ask *why* the platform business models that authorities desire are not the ones that emerge organically. Unfortunately, this complex question is mostly overlooked by policymakers and commentators alike.

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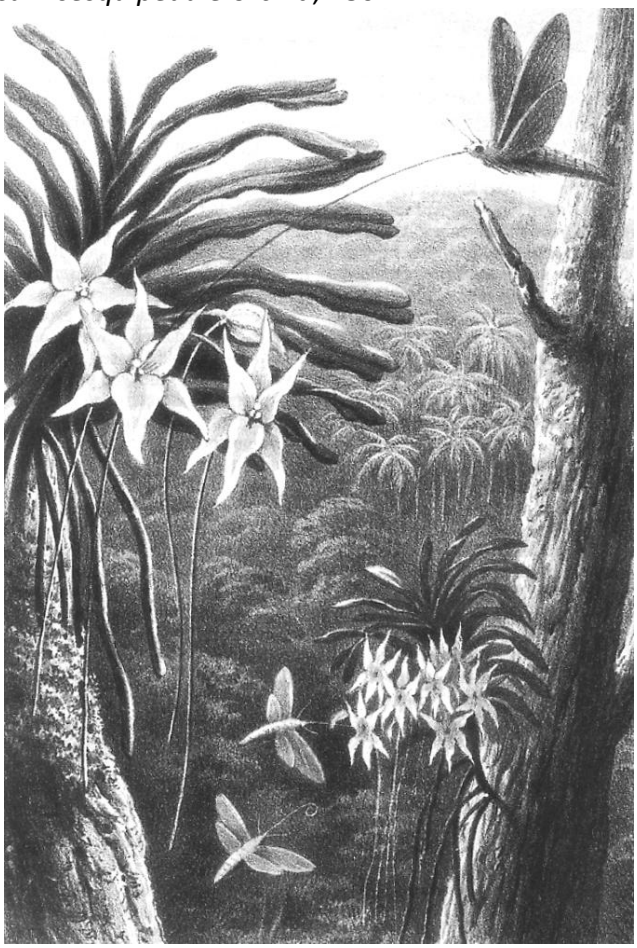
[71] Nat'l Inst. of Standards & Tech., *Centralized Network*, INFO. TECH. LABOR'Y COMPUT. SEC. RES. CTR., https://csrc.nist.gov/glossary/term/centralized_network (emphasis added).

[72] *See Angraecum sesquipedale*, iNATURALIST, https://www.inaturalist.org/taxa/366790-Angraecum-sesquipedale (last visited Oct. 15, 2024).

[73] *See* John van Wyhe, *Fertilisation of Orchids*, DARWIN ONLINE, http://darwin-online.org.uk/EditorialIntroductions/Freeman_FertilisationofOrchids.html (last visited Oct. 24, 2022).

[74] *See, e.g.,* Dave Hone*, Moth Tongues, Orchids and Darwin: The Predictive Power of Evolution*, THE GUARDIAN, Oct. 2, 2013.

FIGURE 1. Illustration of what would come to be discovered as the *Xanthopan morganii* moth eating from the *Angraecum sesquipedale* orchid, 1867

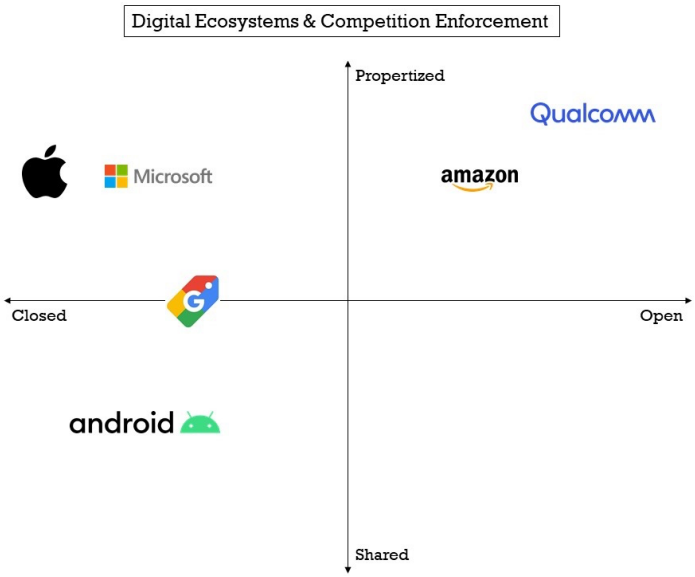


Source: Illustration by Thomas William Wood in Alfred R. Wallace, *Creation by Law,* 4 Q. J. SCI. 470 (1867).

A. Antitrust enforcement on a spectrum

This paper argues that the digital platforms that have been subject to recent competition cases and investigations can all be classified along the two main dimensions discussed in section I: the extent to which they are open (or closed) to "rivals" and the extent to which their assets are propertized (as opposed to shared). By applying this classification system, we see a platform landscape that looks something like figure 2 (note that the initial position of each platform is debatable, though the direction in which enforcers have attempted to steer these platforms is much clearer, as we shall explain).

FIGURE 2. Taxonomy of digital platform business models



In the top-left quadrant, Apple iOS and Microsoft Windows are both relatively closed and highly propertized platforms; Apple's iOS platforms are likely even more closed than Microsoft's Windows platform ever was. Both firms control who is allowed on their platform and how they can interact with users. Apple vets the apps that are available on its App Store and determines how payments can take place.[75] Microsoft famously insisted on licensing terms with the OEMs that assembled Windows-based desktop computers that required them to pay a fee to Microsoft for each PC they sold, regardless of the operating system that was ultimately installed on it, while also imposing certain default apps and, arguably, limiting the compatibility of Microsoft systems with servers running other operating systems.[76] Although Microsoft makes Windows available (by license) for OEMs to install on approved desktop devices, Apple's MacOS, iOS, and iPadOS are available only on devices designed and sold by Apple itself.

In the top-right quadrant, Amazon's retail platform and Qualcomm's broadband chips business are much more open, yet they remain highly propertized. Qualcomm's chips can be seen as a platform because Qualcomm must bring together (via technical standards) two important sets of users to succeed (in this case, so-called implementers and innovators).[77] Given its pivotal role

[75] *See App Review*, DEVELOPER APPLE, https://developer.apple.com/app-store/review/ (last visited Aug. 7, 2024).

[76] For a detailed discussion of Microsoft's practices, s*ee* Geoffrey A. Manne & Dirk Auer, *Antitrust Dystopia and Antitrust Nostalgia: Alarmist Theories of Harm in Digital Markets and Their Origins*, 28 GEO. MASON L. REV. 1281, 1363–96 (2021).

[77] *See, e.g.* Dirk Auer & Julian Morris, *Governing the Patent Commons*, 38 CARDOZO ARTS & ENT. L.J. 291, 317–18 (2020) ("[S]tandard developing organizations are multi-sided platforms (or two-sided markets) that seek to attract both innovators and implementers . . . . This dynamic surely plays an important role in the field of standard developing organizations. It potentially explains why SDOs have so far refused to impose 'socially desirable' pricing obligations on SEP holders, notably in the form of ex ante price commitments (because imposing such measures might cause some SEP holders to join rival SDOs with more inventor-friendly policies). More generally, the two-sided markets literature tells us that optimal SDO policies will tend to favor those agents that have the strongest outside options. This might, for instance, be the case for owners of strong IP portfolios, who may be in a position to bypass the standardization process altogether and vertically integrate if SDO policies do not meet their

within this standardization process, Qualcomm thus faces many of the same tradeoffs that makers of traditional platforms face. In that regard, almost anyone is free to implement Qualcomm's intellectual property, as long as they conclude a licensing agreement to do so. Likewise, for third-party merchants, there are very few limits on the goods that can be sold on Amazon's retail platform and at what prices,[78] but Amazon does, almost by definition, exert considerable control over the specific ways its platform can be monetized, and it controls many of the terms of sale, many of the important aspects of marketing and promotion, and much of the fulfillment services for goods sold through its platform.[79]

Finally, Google Search and Android sit in the bottom-left corner. Both services are relatively weakly propertized. The Android source code is shared freely through an open-source license, and Google's apps can be preloaded by OEMs free of charge. The only limit is that Google partially closes its platform, notably by requiring that its own apps (if they are preinstalled) receive favorable placement.[80] Likewise, Google's search engine is only partially "open." Although any website can be listed on the search engine, Google selects specialized results that are presented more prominently than organic search results (weather information, maps, etc.). There is also some amount of propertization—namely, that Google sells the best "real estate" via ad placement.

B. Enforcement and regulatory initiatives

Although the initial position of each platform on the spectrum described in section II.A is debatable (and relatively unimportant), it seems much clearer that, with respect to each of the platforms discussed, interventions by competition authorities have attempted (or are attempting) to move the respective platforms toward more openness and less propertization. This intervention is occurring despite the platforms' designs being the fruit of complex evolutionary dynamics that force them to achieve a delicate balance between centralization and decentralization, as well as the fact that, in the greater scheme of things, the platforms are already tremendously open (as the term *platform* implies). Figure 3 shows the movement of antitrust intervention that is taking place.

The Microsoft cases and the Apple investigation both sought to bring more openness and less propertization to those respective platforms. Microsoft was made to share proprietary data with third parties (less propertization) and to open its platform to rival media players and web browsers (more openness).[81] The same applies to Apple. Plaintiffs in private antitrust litigation brought in the United States[82] and government enforcement actions in Europe[83] sought to limit the fees that Apple can extract from downstream rivals (less propertization), as well as to ensure that it could not exclude rival mobile payments solutions from its platform (more openness).

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requirements."). *See also* Jean-Charles Rochet & Jean Tirole, *Two-Sided Markets: A Progress Report*, 37 RAND J. ECON. 645, 645 (2006).

[78] *See How to Start Selling on Amazon*, AMAZON, https://sell.amazon.com/sell.html (last visited Jul. 23, 2024).

[79] *See id.* For an insightful discussion of the characteristics that distinguish a (relatively open) platform from a (relatively closed) merchant, see Andrei Hagiu, *Merchant or Two-Sided Platform*, 6 REV. NETWORK ECON. 115 (2007).

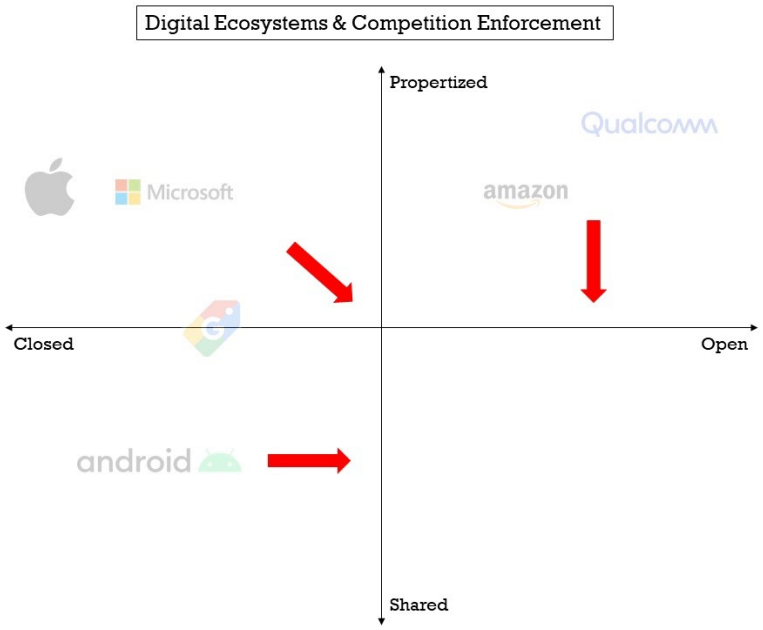
[80] For a discussion of the monetization of Android, *see, e.g.*, Auer, *supra* note 66.

[81] *See* Case COMP/C-3/37.792, Microsoft, O.J. (L 32) (May 24, 2004). *See also* Case COMP/39.530, Microsoft (Tying), O.J. (C 120) (Apr. 26, 2013).

[82] *See* Complaint, Epic Games, Inc. v. Apple Inc., No. 4:20-cv-05640-YGR, 493 F. Supp. 3d 817 (N.D. Cal. 2020).

[83] *See* Case AT.40437, Apple—App Store Practices (Music Streaming) (Mar. 4, 2024), https://ec.europa.eu/competition/antitrust/cases1/202419/AT_40437_10026012_3547_4.pdf. *See also* European Commission Press Release IP/24/3706, *supra* note 11.

FIGURE 3. Directional movement of antitrust intervention



The various cases that were brought by EU and US authorities against Qualcomm broadly sought to limit the extent to which it was monetizing its intellectual property.[84] The European Union's Amazon investigation centered on the ways that the company used data from third-party sellers (and, ultimately, the distribution of revenue between those sellers and Amazon).[85] In both cases, authorities ultimately tried to limit the extent to which firms could propertize their assets.

Finally, both of the EU's Google cases sought to bring more openness to the company's main platform. The Google Shopping decision sanctioned Google for purportedly placing its services more favorably than those of its rivals.[86] The separate Android decision sought to facilitate rival search engines' and browsers' access to the Android ecosystem. The same appears to be true of ongoing litigation brought by state attorneys general in the United States.[87]

Much of the same can be said of the numerous regulatory initiatives pertaining to digital markets. Indeed, draft regulations being contemplated across the globe mimic the features of the antitrust and competition interventions discussed previously. For instance, it is widely accepted that Europe's DMA effectively transposes and streamlines the enforcement of the theories' harm described herein.[88] Similarly, several scholars have argued that AICOA largely mimics European

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[84] *See* European Commission Press Release IP/18/421, Antitrust: Commission Fines Qualcomm €997 Million for Abuse of Dominant Market Position (Jan. 24, 2018); Federal Trade Commission v. Qualcomm Inc., 969 F.3d 974 (9th Cir. 2020).

[85] *See* European Commission Press Release IP/22/7777, *supra* note 10.

[86] *See* Case AT.39740, Google Search (Shopping), 2017 E.R.C. I-379. *See also* Case AT.40099 (Google Android), 2018 E.R.C.

[87] *See* Complaint, United States v. Google, LLC, No. 1:20-cv-03010 (D.D.C. 2020); Press Release, Dep't of Justice, Justice Department Sues Monopolist Google for Violating Antitrust Laws. *See also* Complaint, Colorado et al. v. Google, LLC, No. 1:2020-cv-03715 (D.D.C. 2020).

[88] *See, e.g.*, Giorgio Monti, *The Digital Markets Act: Institutional Design and Suggestions for Improvement* 3 (Tillburg L. & Econ. Ctr., Discussion Paper No. 2021-004, 2021) ("In sum, the DMA is more than an enhanced and simplified application of

competition policy.[89] Both pieces of legislation ultimately require (or would have, in the case of AICOA) firms to open up their platforms, most notably by forcing them to treat rival services as they would their own and to make their services more interoperable with those rivals.[90]

What is striking about these decisions and investigations is the extent to which authorities are pushing back against the very features that distinguish the platforms they are investigating. Closed (or relatively closed) platforms are forced to open up, and firms with highly propertized assets are made to share them (or, at the very least, monetize them less aggressively).

C. The empty quadrant

All of this would not be very interesting if it weren't for a final piece of the puzzle: the model of open and shared platforms that authorities apparently favor has traditionally struggled to gain traction with consumers. Indeed, there seem to be vanishingly few successful consumer-oriented products and services in this space.

There have been numerous attempts to introduce truly open consumer-oriented operating systems in both the mobile and desktop segments (see *infra* figure 4). Most have ended in failure. Ubuntu and other flavors of the Linux operating system remain fringe products. There have been attempts to create open-source search engines, but they have not met with success.[91] The picture is similar in the online retail space. Amazon appears to have beaten eBay, despite the latter being more open and less propertized. Indeed, Amazon has historically charged higher fees than eBay and offers sellers much less freedom in the ways in which they may sell their goods.[92]

This theme is repeated in the standardization space. There have been innumerable attempts to impose open, royalty-free standards. At least in the mobile internet industry, few, if any, of these efforts have taken off (instead, proprietary standards such as 5G and WiFi have been far more successful). That pattern is repeated in other highly standardized industries, such as digital-video formats. Most recently, the proprietary Dolby Vision format seems to be winning the war against the open HDR10+ format.[93]

Article 102 TFEU: while *the obligations may be criticised as being based on existing competition concerns*, they are forward-looking in trying to create a regulatory environment where gatekeeper power is contained and perhaps even reduced.") (emphasis added).

[89] *See, e.g.*, Aurelien Portuese, *"Please, Help Yourself": Toward a Taxonomy of Self-Preferencing* 1 (Info. Tech. & Innovation Found., Oct. 25, 2021) ("The latest example of such weaponization of self-preferencing by antitrust populists is provided by Sens. Amy Klobuchar (D-MN) and Chuck Grassley (R-IA). They introduced legislation in October 2021 aimed at prohibiting the practice. However, the legislation would ban self-preferencing only for a handful of designated companies—the so-called 'covered platforms,' not the thousands of brick-and-mortar sellers that daily self-preference for the benefit of consumers. Mimicking the European Commission's Digital Markets Act prohibiting self-preferencing, [the] Senate and the House bills would degrade consumers' experience and undermine competition, since self-preferencing often benefits consumers and constitutes an integral part, rather than an abnormality, of the process of competition.").

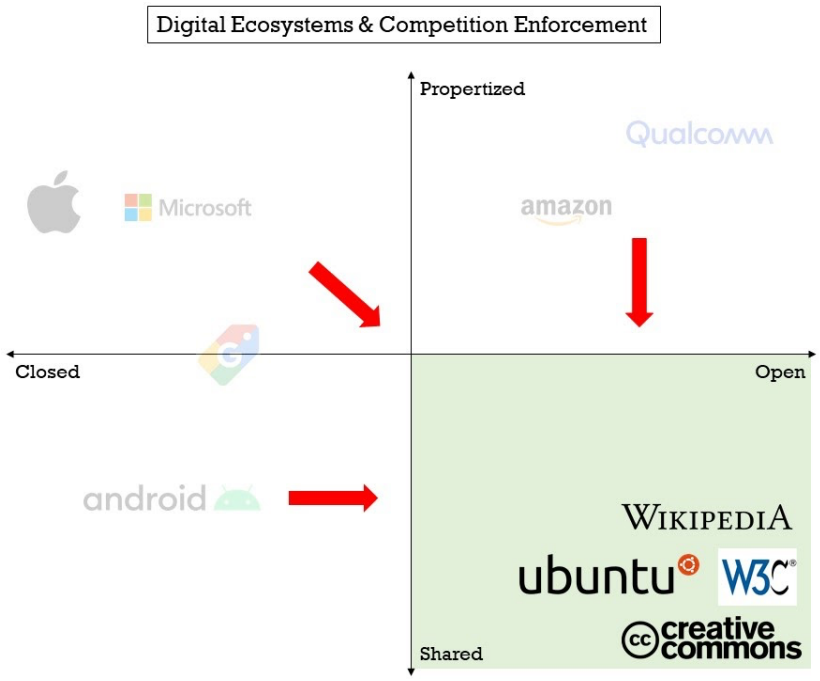
[90] Efforts to saddle platforms with "non-discrimination" constraints are tantamount to mandating openness. *See* Geoffrey A. Manne, "*Foreword: Against the Vertical Discrimination Presumption*," CONCURRENCES, May 2020, at 1, 2 ("The notion that platforms should be forced to allow complementors to compete on their own terms, free of constraints or competition from platforms is a species of the idea that platforms are most socially valuable when they are most 'open.' But mandating openness is not without costs, most importantly in terms of the effective operation of the platform and its own incentives for innovation.").

[91] *See, e.g.,* Klint Finley, *Your Own Private Google: The Quest for an Open Source Search Engine*, WIRED (July 12, 2021).

[92] *See* Brian Connolly, *Selling on Amazon vs. eBay in 2021: Which Is Better?*, JUNGLESCOUT (Jan. 12, 2021); Simon Slade, *A Comprehensive Comparison: Amazon vs. eBay: Which Platform Is Right for Your Online Business?*, SALEHOO (Aug. 14, 2024).

[93] *See, e.g.*, Dave Meikleham, *HDR10 vs Dolby Vision: Which HDR Format Is Better?*, TECHRADAR (Mar. 31, 2023).

FIGURE 4. Open and shared platforms



This is not to say that there haven't been any successful examples of open, royalty-free standards—internet protocols, blockchain, and Wikipedia all come to mind—or that we will not see more decentralized goods in the future. But, by and large, firms and consumers have not yet taken to the idea of *fully* open and shared platforms, or at least those platforms have not yet achieved widespread success in the marketplace (potentially owing to supply-side considerations such as the difficulty of managing open platforms or the potentially lower returns to innovation in weakly propertized ones).[94] And though some open projects have achieved tremendous scale, the consumer-facing side of these platforms is often dominated by intermediaries that opt for much more traditional business models (think of Coinbase in the blockchain space or Android's use of Linux).

III. An Evolutionary Explanation

Section II has posited a recurring reality: the digital platforms that competition authorities wish to bring into existence are fundamentally different from those that emerge organically. But why have authorities' ideal platforms, so far, failed to achieve truly meaningful success?

Three potential explanations come to mind. First, closed and propertized platforms might systematically—and perhaps anticompetitively—thwart their open and shared rivals. Second, shared platforms might fail to persist (or grow pervasive) because they are much harder to monetize (and there is thus less incentive to invest in them). This is essentially a supply-side

[94] On the importance of managers, *see, e.g.,* Nicolai J. Foss & Peter G. Klein, *Why Managers Still Matter*, 56 MIT SLOAN MGMT. REV. 73, 73 (2014) ("In today's knowledge-based economy, managerial authority is supposedly in decline. But there is still a strong need for someone to define and implement the organizational rules of the game.").

explanation. Finally, consumers might opt for *relatively* closed systems precisely because they prefer these platforms to marginally more open ones—that is, a demand-side explanation.

This section discusses these three hypotheses and examines several case studies to ascertain the most likely explanation. It concludes that today's most successful platforms are ultimately the fruit of market selection rather than random chance. In other words, the defining features of these platforms were instrumental in enabling them to thrive while many of their early rivals faltered.

A. Are existing platforms better adapted to their environment than policymakers' favored alternatives?

In evaluating the first conjecture, the key question is whether successful "closed" and "propertized" platforms overcame their rivals before or after they achieved some measure of market dominance. If success preceded dominance, then anticompetitive foreclosure alone cannot explain the proliferation of the closed and propertized model.[95]

As this section explains, many of today's dominant platforms often overcame open and shared rivals well before they achieved their current size. It is thus difficult to make the case that the early success of their business models was due to anticompetitive behavior. (This is not to say these business models cannot raise antitrust issues, but rather that anticompetitive behavior is not a good explanation for their emergence.)

Both the second and the third conjectures essentially ask whether closed and propertized platforms might be better adapted to their environment than open and shared rivals. It might come as a surprise to readers, but both these conjectures are almost systematically overlooked in antitrust policy discussions and rulings. And yet, if true, both would strongly cut against current efforts to regulate digital platforms and ramp up antitrust enforcement that targets them.

It is not unreasonable to surmise that highly propertized platforms would generally be easier to monetize than shared ones. For example, monetizing open-source platforms often requires relying on complementarities, which tend to be vulnerable to outside competition and free-riding.[96] There is thus a natural incentive for firms to invest and innovate in more propertized environments. In turn, competition enforcement that limits a platform's ability to propertize its assets may harm innovation.

Similarly, authorities should reflect on whether consumers really want the more competitive ecosystems that they are trying to design. The European Commission, for example, has a long track record of seeking to open digital platforms, notably by requiring that platform owners do not preinstall their own web browsers (the *Microsoft* decisions are perhaps the most salient example). And yet, even after those interventions, new firms have kept using the very business model that the commission reprimanded, rather than the pro-consumer model it sought to impose on the industry. For example, Apple tied the Safari browser to its iPhones; Google went to some length

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[95] It is generally agreed that anticompetitive foreclosure is possible only when a firm enjoys some degree of market power. Frank H. Easterbrook, *Limits of Antitrust*, 63 TEX. L. REV. 1, 20 (1984) ("Firms that lack power cannot injure competition no matter how hard they try. They may injure a few consumers, or a few rivals, or themselves . . . by selecting 'anticompetitive' tactics. When the firms lack market power, though, they cannot persist in deleterious practices. Rival firms will offer the consumers better deals. Rivals' better offers will stamp out bad practices faster than the judicial process can. For these and other reasons many lower courts have held that proof of market power is an indispensable first step in any case under the Rule of Reason. The Supreme Court has established a market power hurdle in tying cases, despite the nominally per se character of the tying offense, on the same ground offered here: if the defendant lacks market power, other firms can offer the customer a better deal, and there is no need for judicial intervention.").

[96] *See, e.g.*, Josh Lerner & Jean Tirole, *Some Simple Economics of Open Source*, 50 J. INDUS. ECON. 197 (2002).

to ensure that Google Chrome was preloaded on devices; and, for a significant period of time, Samsung phones came with Samsung Internet as the default.[97] Yet this model has not ostensibly steered consumers away from those platforms. Along similar lines, a sizable share of consumers opted for Apple's iPhone, which is even more centrally curated than Microsoft Windows ever was (and the same is true of Apple's MacOS). In other words, it is hard to claim that opening platforms is, in and of itself, good for consumers when the same people routinely opt for platforms with the very features that policymakers are trying to eliminate.

Finally, it is worth noting that the remedies imposed by competition authorities have been anything but successes. Windows XP N (the version of Windows that came without Windows Media Player) was an unmitigated flop, selling a paltry 1,787 copies to retailers and distributors in Europe.[98] Likewise, the internet browser "ballot box" imposed by the commission was so irrelevant to consumers that it took months for authorities to notice that Microsoft had removed it, in violation of the commission's decision.[99] One potential inference is that consumers do not value competition interventions that move ecosystems away from their chosen mix of openness and propertization.

There are many reasons consumers might prefer closed systems (at least, relative to the model favored by many policymakers), even when they must pay a premium for them. Take the example of app stores. Maintaining some control over the apps that can access the store enables platforms to easily weed out bad actors. Similarly, controlling the hardware resources that each app can use may greatly improve device performance. Indeed, it may be that a measure of control facilitates the very innovations consumers demand, and "authorities and courts should not underestimate the indispensable role control plays in achieving coordination and coherence in the context of systemic efficiencies. Without it, the attempted novelties and strategies might collapse under their own complexity."[100] Relatively centralized platforms can eliminate negative externalities that "bad" apps impose on rival apps and consumers.[101] This is especially true when consumers will tend to attribute dips in performance to the overall platform, rather than to a particular app.[102] At the same time, they can take advantage of positive externalities to improve the quality of the overall platform.

And it is surely the case that consumers prefer to make many of their decisions at the interplatform level rather than within each platform. In simple terms, users arguably make their most important decision when they choose between an Apple or an Android smartphone (or a Mac or a PC). In doing so, they can select their preferred app suite with one simple decision. They might thus purchase an iPhone because they like the secure App Store or choose an Android smartphone because they like the Google Chrome browser and Google Search. Absent false information at the time of the initial platform decision, this decision will effectively incorporate expectations about subsequent constraints.[103] Furthermore, forcing users to make too many within-platform choices may undermine a product's attractiveness. Indeed, it is difficult to create

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[97] *See* Matthew Miller, *Thanks, Samsung: Android's Best Mobile Browser Now Available to All*, ZDNET (Aug. 11, 2017).

[98] *Fact Sheet: Windows XP N Sales*, REGMEDIA (June 12, 2009), https://regmedia.co.uk/2009/06/12/microsoft_windows_xp_n_fact_sheet.pdf.

[99] *See* Case COMP/39.530, Microsoft (Tying), O.J. (C 120) (Apr. 26, 2013).

[100] Konstantinos Stylianou, *Systemic Efficiencies in Competition Law: Evidence from the ICT Industry*, 12 J. COMPETITION L. & ECON. 557 (2016).

[101] *See, e.g.*, Steven Sinofsky, *The App Store Debate: A Story of Ecosystems*, MEDIUM, June 21, 2020.

[102] *Id.*

[103] *See, e.g.*, Benjamin Klein, *Market Power in Aftermarkets,* 17 MANAGERIAL & DECISION ECON. 143 (1996).

a high-quality reputation if each user's experience is fundamentally different.[104] In short, contrary to what antitrust authorities appear to believe, closed platforms might give most users exactly what they desire.

All of this suggests that consumers and firms often, though not always, gravitate spontaneously toward both closed and highly propertized platforms, the opposite of what the European Commission and other competition authorities tend to favor. The reasons for this trend are still misunderstood and mostly ignored. Too often it is simply assumed that consumers benefit from more openness, and that shared and open platforms are the natural order of things. Instead, this paper suggests that what some regard as market failures may in fact be *features* that explain the rapid emergence of the digital economy. Ronald Coase expressed this idea best when he quipped that economists always find a monopoly explanation for things that they fail to understand. The digital economy might just be the latest in this unfortunate trend.[105]

B. Excessive decentralization: Case studies

The intuition of section III.A finds some support in the competition that has unfolded in the past and continues to unfold in several digital markets in the present. Indeed, the history of competition in digital markets shows that *overly* decentralized platforms often struggle to attract consumers and retain developers (just as overly *centralized* ones might, though that example is of less policy relevance since enforcers and lawmakers are not attempting to make platforms more closed and propertized). In evolutionary terms, *overly* decentralized platforms seem poorly adapted to environments where rapid changes and strategic decisions are required to meet evolving consumer and developer demand (though it must be noted that every platform contains both closed and open elements simultaneously[106]).

We substantiate our point with a series of case studies. In these examples, the type of platforms that contemporary competition policymakers are trying to create by fiat appear to have been rejected by the market in favor of relatively more centralized alternatives. This is the case for app store–based platforms that supplanted more open ecosystems (subsection 1); the Windows operating system prevailing over Linux (subsection 2); Amazon outcompeting eBay (subsection 3); and, more recently, certain segments of the generative artificial intelligence (AI) industry (though the picture is significantly more fluid there) (subsection 4).

1. Android, iOS, and Chromebook: The rise of the app stores

The Android, iOS, and the Chromebook ecosystems are good examples of relatively closed and tightly propertized platforms outcompeting what often have been more open and more weakly propertized rivals. All three of these platforms rely on different iterations of the app store model that has, in part, superseded the more open software distribution model of many previous platforms (such as Windows OS). Indeed, the rise of these closed ecosystems does not appear to stem from anticompetitive foreclosure but instead appears to be driven by the app store model's ability to stimulate the developer community and thus offer compelling services to consumers.

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[104] *See, e.g.*, Simon Hill, *What Is Android Fragmentation, and Can Google Ever Fix It?*, DIGITAL TRENDS, Oct. 31, 2018.

[105] *See* Ronald H. Coase, *Industrial Organization: A Proposal for Research*, *in* POLICY ISSUES AND RESEARCH OPPORTUNITIES IN INDUSTRIAL ORGANIZATION 67 (Victor R. Fuchs ed., 1972) ("[I]f an economist finds something—a business practice of one sort or another—that he does not understand, he looks for a monopoly explanation. And as in this field we are very ignorant, the number of ununderstandable practices tends to be very large, and the reliance on a monopoly explanation, frequent.").

[106] *See* Barnett, *supra* note 65.

At the time of this writing, iOS and Android (and their respective app stores) are the two largest mobile ecosystems by a significant margin.[107] Meanwhile, Google's Chromebook has gathered significant momentum, closing the gap on Windows and MacOS laptops.[108] Although, at first blush, Android and iOS (mobile ecosystems) might appear to have little in common with Chromebook (a laptop ecosystem), there are, in fact, important parallels among these platforms.

Unlike most previous software ecosystems,[109] all three of these platforms are built around a proprietary app store that, to varying degrees, regulates access to the underlying platforms and serves as a payment point where the platform owner can earn revenue and pass on some of those proceeds to developers.

This is most obviously the case for the "walled-garden" approach taken by iOS. Apple's App Store is the only way that app developers can reach users on the iPhone, and all in-app payments must be made via Apple's payment system.[110] In short, Apple's iOS is arguably the most closed and tightly propertized software platform of the past two decades—though, as we explain in section III.C, it is still significantly decentralized in the grand scheme of things.

Google's Android ecosystem shares many of these features, albeit to a lesser degree than iOS. Although users can bypass Google's core services (such as Google Play, Google Chrome, Google Search, and Google Pay), the Android platform is designed to steer users strongly toward them.[111] In simple terms, Android offers users a safe environment from which they may depart at their own risk, although they are certainly not encouraged to do so. For example, users can download Android apps from the open web and install rival app stores on their devices, thus allowing them to rely on rival in-app payment systems.[112]

Lastly, Google's Chromebook platform applied something akin to the Android and iOS app store model to the more open world of laptop computing. Although it was initially derided by many critics,[113] Google's Chromebook has gained significant traction over the past couple of

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[107] Ahmed Sherif, *Market Share of Mobile Operating Systems Worldwide from 2009 to 2024, by Quarter*, STATISTA (Sept. 23, 2024), https://www.statista.com/statistics/272698/global-market-share-held-by-mobile-operating-systems-since-2009/; *iOS vs Android Quarterly Market Share*, COUNTERPOINT (May 25, 2024), https://www.counterpointresearch.com/insights/global-smartphone-os-market-share/.

[108] Jonathan Greig, *Chromebooks Dominate Worldwide PC Market with 75% Annual Growth*, ZDNET, July 29, 2021. However, the second half of 2021 saw a marked decline in Chromebook sales. *PC and Tablets See Strong Sales in Q1 2022, Chromebook Sales Plummet 60% Globally*, GSMARENA (May 4, 2022), https://www.gsmarena.com/pc_and_tablets_see_strong_sales_performance_in_q1_2022_chromebook_sales_plummet_60_globally-news-54201.php. Chromebook sales then grew slightly in 2023. *Chromebook Shipments Up While Tablets Falter in Q2 2023*, CANALYS (Aug. 4, 2023), https://www.canalys.com/newsroom/global-tablet-market-share-Q2-2023.

[109] Note that Apple's was not the first app store. *See* Ernie Smith, *The Many App Stores Before the App Store*, VICE, June 28, 2021.

[110] This requirement is what prompted Epic Games' antitrust suits in the United States against both Apple and Google. *See, e.g.*, Dirk Auer, *Making Sense of the Google Android Decision*, Int'l Ctr. for L. & Econ., White Paper 2020-02-25 (2020).

[111] *See, e.g.,* Auer, *supra* note 66, at 655 ("Although these three theories of harm raise quite idiosyncratic issues, they appear to be part of a single plan. First, Google wants to 'nudge' Android users into using Google search and its related applications. Second, Google is battling rival forks in order to avoid fragmentation of the Android OS. These are two sides of the same coin: Google is trying to make as many people as possible use its applications and services. This strategy is accomplished by inducing a higher share of Android users to opt for Google's services, and ensuring that full-Android devices are as ubiquitous as possible."). *See also* Auer, *supra* note 110, at 26 ("Google steers the development of Android so as to ensure that a large number of devices run the 'standard' version of Android (notably via antifragmentation agreements with OEMs). However, unlike Apple, it cannot unilaterally coerce users of its ecosystem into adopting its own preferred version of Android.").

[112] Steve Larner, *How to Download Apps on Android Without Google Play*, ALPHR, Aug. 10, 2022).

[113] Tom Simonite, *Six Reasons Why Chromebooks Are a Bad Idea*, MIT TECHNOLOGY REVIEW, May 12, 2011.

years.[114] Between 2019 and 2021, sales of Chromebooks grew by 275 percent, compared with 62 percent for other notebooks, thus overtaking MacOS as the second most popular laptop operating system.[115] Since then, the sales have remained roughly stable.[116] Unlike traditional laptops, Google's Chromebooks are designed to run only a limited series of applications, mostly Google's cloud-based suite of productivity apps.[117] This design choice limits the options and functions available to consumers—especially compared to traditional alternatives such as Windows or MacOS. Indeed, Chromebook users must largely rely on Google Play and its proprietary payment system to run apps and make in-app purchases.[118] This sacrifice results in much lower costs, higher security, and arguably better performance for the price.[119]

Despite the superficial differences among these platforms, they appear to be part of a broader trend in which users opt for ecosystems built largely around a centrally controlled app store. Several rivals have tried to emulate Google and Apple's success. For instance, Microsoft added an app store to its Windows operating system with the 2011 release of Windows 8.[120] Microsoft's store has struggled, however, facing criticism that it is, paradoxically, both too open and too closed.[121] In an attempt to kick-start its ecosystem, Microsoft significantly reduced the barriers to placing apps on its store. Unfortunately, by many accounts, the result has mostly been to flood the store with poorly developed apps and buggy clones, rather than attracting additional high-quality apps.[122] Thus, though the relatively closed app store model appears to be gaining traction, successful implementation—notably by achieving a good balance between openness and closedness of said stores—can be challenging. Even ecosystems with large existing user bases, such as Microsoft's, may struggle to successfully shift toward this business model.

Although there are myriad reasons for the app store model's success, some of it appears to stem from the design choices on which these platforms rely. To use the terminology of this paper, several important aspects of these ecosystems are closed and propertized, though it does also appear important to avoid becoming overly centralized—as explained in section III.C, Apple's iOS remains the quintessential *platform*.

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[114] Ben Schoon, *Chromebooks Dominate the Global PC Market to 275% Growth, with HP Leading the Charge*, 9TO5GOOGLE, May 5, 2021.

[115] *Id. See also* Emil Protalinski, *Chromebooks Outsold Macs Worldwide in 2020, Cutting into Windows Market Share*, GEEKWIRE, Feb. 16, 2021.

[116] *Chromebook Shipments up While Tablets Falter in Q2 2023*, CANALYS, Aug. 4, 2023.

[117] *What Is a Chromebook?*, GOODWILL CMTY. FOUND. GLOB., https://edu.gcfglobal.org/en/chromebookbasics/what-is-a-chromebook/1 (last visited June 6, 2022) ("Unlike most computers, Chromebooks do not run Windows. Instead, they use Chrome OS, which is similar to the Google Chrome web browser. This means you can use a Chromebook to do just about anything you'd normally do online: read websites, check your email, watch online videos, and so on.").

[118] *Install and Use Android Apps on Your Chromebook*, GOOGLE PLAY HELP, https://support.google.com/googleplay/answer/7021273?hl=en (last visited Sept. 28, 2024); Mark Coppock, Tyler Lacoma & Michael Bizzaco, *How to Get Android Apps on a Chromebook*, DIGITAL TRENDS, Apr. 21, 2024, https://www.digitaltrends.com/computing/how-to-get-android-apps-on-a-chromebook.

[119] *See, e.g.*, *Top 10 Pros and Cons of Chromebooks*, CANALYS (Aug. 4, 2023), https://www.canalys.com/newsroom/global-tablet-market-share-Q2-2023; Daniel Thorp-Lancaster, *The Best Chromebooks for Every Budget*, WIRED, Mar. 5, 2022 ("If you spend all day in a web browser, work with Google apps, and do some occasional light photo editing, a solid Chromebook could be all you need.").

[120] Glenn Champan, *Microsoft to Open 'App Store' in February,* PHYS.ORG (Dec. 7, 2011), https://phys.org/news/2011-12-microsoft-app-february.html.

[121] Mark Hachman, *Big Changes to the Microsoft Store Could Make Windows Better, or a Lot Worse*, PCWORLD, May 24, 2022.

[122] Rich Woods, *The Microsoft Store Is Officially Open to All Win32 Apps*, XDA, May 24, 2022; Hachman, *supra* note 121; Sergiu Gatlan, *Emergency Windows 10 Updates Fix Microsoft Store App Issues*, BLEEPINGCOMPUTER, May 20, 2022.

Apple appears to have understood (or at least stumbled upon) these dynamics when it launched the iPhone. Much has been said about the role that Apple's superior hardware played in overcoming BlackBerry (arguably Apple's biggest rival when the first iPhone was launched). Apple did away with physical keyboards and instead relied on powerful hardware and touchscreens.[123] Apple managed to kick-start a vibrant ecosystem around its device, while BlackBerry failed to recognize the key role that third-party developers could play. As Michael Jacobides summarizes:

> This was Blackberry's failure. The company had become complacent about its remarkably loyal customers and didn't recognize the threat posed by rival ecosystems. Like many established firms before it, Blackberry blew the opportunity to become a nodal player and leverage the energies of its complementors, in the way that Apple does with its apps.[124]

Others have made similar points:

> [T]he plethora of apps available for Android devices and iPhones has made these more attractive to employees (and consumers) to carry. Together, these factors, along with the absence of the coolness factor, have contributed to the precipitous declines in RIM's fortune.[125]

But commentators often overlook a second part of the equation: Intuitively, one might think that this success was due to the combination of powerful hardware and providing developers with a marketplace to reach consumers. It is clear, however, that Apple took active steps to encourage developer adoption, to help developers monetize their apps, and to exclude bad players. This effort by Apple suggests the importance of limiting who can access the ecosystem, as well as rules that govern how revenue is distributed among the ecosystem's stakeholders:

> We find that firms that succeed are those that proactively manage the structure of their sectors and keep a set of suppliers working for them in hierarchical, closed supplier networks. IBM made the mistake of opening up its sector through a set of standards which ultimately led to its demise, whereas today's Apple has a carefully controlled set of suppliers and complementary players to support its value proposition.
>
> The solution is not to be vertically integrated but, rather, to control by managing differentiability—i.e., being the actor along the value chain who guarantees the product quality and shapes the experience—as well as manage the replaceability of other actors along the value chain.[126]

In this respect, some of Apple's decisions were particularly significant. Apple notably implemented a stringent review process for apps that sought access to its store, rejecting more than 1 million apps annually.[127] Apple also notoriously requires that developers rely on Apple Pay

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[123] Michael Simon, *How the iPhone Killed Blackberry (and Why It Didn't Have to Happen)*, MACWORLD, Jan. 4, 2022; Rene Ritchie, *How Apple Killed BlackBerry*, IMORE, Feb. 6, 2020 ("BlackBerry was selling keyboards to people who were thirsting for full-screen content."); John Brownlee, *It's Nuts How Far the Original iPhone Was Ahead of the Competition*, CULT OF MAC, July 22, 2015.

[124] Michael G. Jacobides, *Blackberry Forgot to Manage the Ecosystem*, HARV. BUS. REV., Aug. 19, 2013.

[125] Pradeep K. Chintagunta, *What Yoda Would Tell BlackBerry*, CHICAGO BOOTH REV., Feb. 18, 2013.

[126] Jacobides, *supra* note 124.

[127] *App Review Guidelines*, DEVELOPER APPLE, https://developer.apple.com/app-store/review/guidelines (last visited Sept. 28, 2024); Kate, *How to Pass an App Store Review: Practical Recommendations for Subscription App Owners*, QONVERSION: INFRASTRUCTURE BLOG (July 14, 2021), https://qonversion.io/blog/how-to-pass-app-store-review/; Sami Fathi, *Apple "Surprised" by Developer Frustration with Its App Review Process*, MACRUMORS (Mar. 22, 2014), https://www.macrumors

for in-app purchases.[128] These cautionary measures may seem excessive to some—and they have led to antitrust and regulatory scrutiny[129]—but they play a vital role in ensuring that the iPhone ecosystem is among the safest for its users.[130] The sheer scale of this task is huge. In 2021 alone, Apple blocked almost 1.5 billion fraudulent transactions and banned nearly 600,000 accounts.[131]

Proponents of tougher antitrust enforcement sometimes retort that competing app stores and in-app payment systems would perform these same functions, but this view ignores a key part of the equation. As things stand, Apple alone bears responsibility to create its reputation for quality and safety. By dispersing these reputational duties, increased competition would likely result in a collective action problem, where rival services fail to fully account for the effect of their behavior on the ecosystem. This is not just conjecture; issues of this sort have proven thorny for the Android platform, and scholars have argued that highly centralized ownership may, paradoxically, have helped the decentralized Bitcoin network overcome important collective action issues.[132]

In the case of the Android ecosystem, Google also had to contend with difficulties linked to the open-source software on which it relies (in addition to the issues discussed previously). Unlike Apple's iOS, anyone is free to distribute modified copies of the Android source code (a *fork*, in technical terms).[133] This situation gives rise to a critical problem for Google. If the market for forks proliferates, causing many different versions of Android to coexist, there is a risk that applications will not run smoothly on all Android devices. As one journalist writes:

.com/2021/03/22/apple-surprised-developer-concerns-app-review. One result is that the App Store now features fewer apps than Google's more open Play Store. *See* Sanja Zdraveska, *Apple App Store vs Google Play Store (2024 Comparison)*, CYBERCREW (Feb. 9, 2024), https://cybercrew.uk/software/app-store-vs-play-store.

[128] It was this policy that underpinned the antitrust case brought by Epic Games against Apple. *See* Epic Games Inc. v. Apple Inc., No. 21-16506 (9th Cir. 2023).

[129] *Id*. *See also* European Commission Press Release IP/22/2764*,* Antitrust: Commission Sends Statement of Objections to Apple over Practices Regarding Apple Pay (May 2, 2022). The case was subsequently settled. *See* European Commission Press Release IP/24/3706, Commission Accepts Commitments by Apple Opening Access to "Tap and Go" Technology on iPhones (July 11, 2024). Apple's App Store policy is also central to an ongoing DMA case brought by the European Commission. *See* European Commission Press Release IP/24/3433, Commission Sends Preliminary Findings to Apple and Opens Additional Non-compliance Investigation Against Apple under the Digital Markets Act (June 24, 2024).

[130] APPLE, BUILDING A TRUSTED ECOSYSTEM FOR MILLIONS OF APPS (June 2021). *See also* Brief of *Amici Curiae* International Center for Law & Economics and Scholars of Law and Economics in Support of Appellee/CrossAppellant at 20; Epic Games Inc. v. Apple Inc., 9th Cir. (2023) (No. 21-16506) ("Centralized app distribution and Apple's "walled garden" model (including IAP) increase interbrand competition because they are at the core of what differentiates Apple from Android. 1-ER148–49. They play into Apple's historical business model, which focuses on being user-friendly, reliable, safe, private, and secure. 1-ER86; *see also* 1-ER107 (recognizing that the safety and security of Apple's closed system is a 'competitive differentiator for its devices and operating system'). Even Epic's CEO, Tim Sweeney, recognized that Apple would lose its competitive advantage if it were to compromise its safety and security features. 1-ER48 n.250 (noting Epic's expert, Susan Athey, testified that 'privacy and security are competitive differentiators for Apple'))"; Smriti Tiwari, *13 Advantages and Disadvantages of Apple Pay*, HONEST PROS AND CONS, Nov. 22, 2020 ("Credit card hacks have recently been suffered by major stores including Target and Home Depot. By eliminating the use of credit information as part of the purchase, Apple Pay avoids that. With Apple Pay, a system account number is used to process the transfer, along with a transaction-specific dynamic authentication token. So Apple never exchanges the real credit or debit card numbers with retailers or transmits them with the order.").

[131] Press Release, Apple, App Store Stopped Nearly $1.5 Billion in Fraudulent Transactions in 2021 (June 1, 2022).

[132] *See, e.g.,* Jaron Lanier & Glen Weyl, *The Decentralized Mystique*, COINDESK, June 6, 2022 ("It was not technical decentralization that sustained Bitcoin, but rather the decision of a small number of people, who seem to have known each other (through cryptography conferences and online forums) and their roles, not to attack the system. What motivated this 'altruistic' behavior? We believe that two interrelated causes are likely: the potential of financial gain in the future if the system was seen as never failing and a vision of technical decentralization that the early leaders wanted to see tried at scale.").

[133] Auer, *supra* note 110.

> There's a fairly universal perception that Android fragmentation is a barrier to a consistent user experience, a security risk, and a challenge for app developers.[134]

In more economic terms, by giving each OEM the ability to tailor Android to meet its own needs, the open-source approach may give rise to a collective action problem, as differentiation means there is no longer a single version of Android for developers to target.[135] By modifying the standard Android, developers of forks potentially impose a negative externality on developers of apps and other forks. If left unchecked, this situation potentially could lead to deterioration of the ecosystem. Google has thus taken active steps to prevent such fragmentation from happening:

> First, it is crucial for Google to control the development costs of applications for the Android platform. One method is to prevent the fragmentation of the Android OS by refusing to support incompatible forks.[136]

What matters for the purposes of this paper is that the steps taken by Google to prevent fragmentation make its ecosystem relatively more closed than would otherwise be the case. Google essentially leverages its proprietary applications to limit the appearance of forks that stray too far from the Android community's recommendations.[137] Likewise, because Google cannot earn revenue directly from licensing its OS, it has taken steps to ensure its proprietary applications feature prominently on Android devices. The resulting monetary returns ensure that it maintains an incentive to improve the Android OS.[138] Again, this action marginally limits the extent to which rivals can enter the Android ecosystem.

Competition authorities (most notably the European Commission) and private plaintiffs have argued that Apple and Google's decisions to close their ecosystems are anticompetitive strategies to keep out rivals.[139] But there is a strong case to be made these firms are merely seeking to provide users and developers with a workable ecosystem. If true, then the successes of Apple and Google's platforms are at least partly due to decisions that make them marginally more centralized.

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[134] Simon Hill, *What Is Android Fragmentation, and Can Google Ever Fix It?*, DIGITAL TRENDS, Oct. 31, 2018. For more extensive survey of this issue, *see* Auer, *supra* note 110.

[135] Collective action problems are akin to those discussed by Elinor Ostrom in her Nobel Prize–winning work concerning the tragedy of the commons. *See* ELINOR OSTROM, GOVERNING THE COMMONS (Cambridge University Press 2015).

[136] Auer, *supra* note 66 at 652. *See also* Auer, *supra* note 110 at 27 ("The anti-fragmentation agreements concluded between Google and OEMs present a partial solution to this problem. In a nutshell, Google withholds the Google Play and Google Search apps from OEMs that distribute 'incompatible devices' (*i.e.*, devices that significantly depart from the 'standard version' of Android").

[137] Auer, *supra* note 66.

[138] Auer, *supra* note 110 at 25–26. ("Google must ensure that a large share of Android users opt for its own search services, rather than those of rivals. As things stand, the Android operating system would be largely unprofitable without this conversion of Android users to Google Search. This is probably why Google concluded a series of agreements with OEMs (so-called MADAs). These agreements effectively required OEMs to obtain Google's proprietary apps as a bundle (but for free), and to preinstall a number of them on new devices. Ultimately, these agreements increased Google's control over the app layer of Android smartphones.").

[139] *See, e.g.*, Commission Decision AT.40099, *Google Android*, slip op. (July 18, 2018); European Commission Press Release IP/22/2764, Antitrust: Commission Sends Statement of Objections to Apple over Practices Regarding Apple Pay (May 2, 2022); Autoriteit Consument & Markt, *Summary of Decision on Abuse of Dominant Position by Apple* (Aug. 24, 2021), https://www.acm.nl/sites/default/files/documents/summary-of-decision-on-abuse-of-dominant-position-by-apple.pdf; Complaint, Epic Games, Inc. v. Apple Inc., No. 4:20-cv-05640-YGR, 493 F. Supp. 3d 817 (N.D. Cal. 2020); Complaint, Epic Games, Inc. v. Google LLC, No. 3:20-cv-05671-JD (N.D. Cal. 2020).

This is where the Chromebook story is important. If closed ecosystems were merely a function of firms exercising their market power, rather than catering to consumer demand, one would expect those same ecosystems to fail in competitive markets where consumers can turn to more open and weakly propertized alternatives. The rise of the Chromebook cuts against this market-power narrative.

The Chromebook ecosystem clearly offers less choice to consumers than rival offerings, such as Windows or MacOS. It is significantly harder for Chromebook users to purchase software directly from developers, thus bypassing the ecosystem's app store. For a long time, it was impossible to "sideload" apps on the Chromebook without entering developer mode (this is now possible, but not straightforward).[140] Thus, most in-app purchases must be made via Google's own payment-processing service.[141]

And yet, as explained previously, none of this has prevented Chromebook from gaining market share. Perhaps even more importantly, if closing and propertizing an ecosystem were as bad for consumers as several policymakers suggest, then the Chromebook should not have gained traction. Consumers would be foolish to invest in such a device, and Google would be wrongheaded to persist with this strategy in the face of the better alternatives offered by rivals. In short, the rise of app store–centric ecosystems stands as proof that relatively centralized ecosystems are sometimes, though certainly not always, better for consumers, developers, and platform operators alike.

2. Windows vs. Linux

The rise of the app store is not the first time that a relatively closed and propertized platform has prevailed over more open rivals. Another excellent example is the competition that took place between Microsoft and Linux in the market for desktop operating systems from the 1990s onward.

Competition between these platforms presented consumers with the archetypal choice between two business models—one open and the other comparatively closed. Windows is a proprietary operating system that Microsoft mostly licenses to a handful of OEMs, who then preinstall the software on devices sold to consumers.[142] In contrast, Linux is an open-source operating system. Accordingly, any private or professional user can freely install it, distribute it, and modify it. To be more precise, Linux was initially licensed under the GNU General Public License, which allowed those freedoms amd also ensured that modified versions of the Linux OS (so-called forks) could not be licensed for money.[143] Moreover, unlike Windows, where commercial and development decisions were made by a centralized authority, decisions within the

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[140] Arjun Sha, *How to Sideload Android Apps on Chromebook Without Developer Mode*, BEEBOM, Nov. 2, 2021.

[141] Purnima Kochikar, *Allowing Developers to Apply for More Time to Comply with Play Payments Policy*, ANDROID DEVELOPERS (July 16, 2021); Sarah Perez, *Epic Games' Bandcamp Temporarily Wins Rights to Use Its Own Payments System on Google Play*, TECHCRUNCH, May 23, 2022.

[142] Sean Ross, *Apple vs. Microsoft Business Model: What's the Difference?*, INVESTOPEDIA, Jan. 26, 2022.

[143] *What Is Open Source?*, RED HAT (Oct. 24, 2019), https://www.redhat.com/en/topics/open-source/what-is-open-source; *Release Notes for Linux v0.12*, INTERNET OFFICE WAYBACK MACHINE (Aug. 19, 2007), https://web.archive.org/web/20070819045030/http://www.kernel.org/pub/linux/kernel/Historic/old-versions/RELNOTES-0.12.

Linux ecosystem were far more decentralized, relying on a mix of consensus-driven development, as well as the influence exerted by so-called benevolent dictators for life.[144]

When Linux launched in 1991, Microsoft's Windows OS was already the dominant force that it is today, with more than 70 percent market share, according to some accounts.[145] Given that Microsoft would later face antitrust cases on both sides of the Atlantic, it is plausible (though not certain) that anticompetitive strategy played some part in its ultimate success. (Linux never really took off in the desktop operating system space.)[146]

Despite the previous caveat, there are important reasons to believe that Linux failed mostly because of demand- and supply-side reasons. Maintaining an open operating system meant that Linux was significantly less user-friendly than Windows.[147] Likewise, the Linux model offered poor incentives for developers of complementary software, who had to contend with significant fragmentation. As Linux's founder candidly conjectured, "I still wish we were better at having a standardize [sic] desktop that goes across all the distributions. . . . It's not a kernel issue. It's more of a personal annoyance how the fragmentation of the different vendors have, I think, held the desktop back a bit."[148] Finally, at the platform level, developers faced more limited monetary returns than those that were available to firms like Microsoft.[149] In short, while Microsoft's competitive strategy certainly did not help Linux, the operating system had deeper problems that were likely the more important cause of its demise. And many of those factors were intrinsically linked to the decentralized path taken by Linux.

On the demand side, Linux was notoriously hard to learn for users who were not technically proficient—the vast majority of PC users were not software engineers or IT specialists. Because Linux's distribution was largely decentralized, there were at any given time multiple versions of Linux competing for consumer attention, each with its own idiosyncrasies and with widely varying levels of user friendliness. As one journalist put it, "There are too many choices available when it comes to desktop Linux and this is overwhelming to the new users to the extent that they just avoid using it."[150] Relatedly, Linux did not require a graphical user interface (GUI) to run.

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[144] Nathan Schneider, *Admins, Mods, and Benevolent Dictators for Life: The Implicit Feudalism of Online Communities*, 24 NEW MEDIA & SOC'Y 9 (2021). ("The Linux governance model centers around founder Linus Torvalds, who is popularly referred to as the project's 'benevolent dictator for life,' or BDFL . . . . But perhaps more influential than the Linux model has been its underlying software: Git, the version-control system that Torvalds developed in 2005 to manage the development of Linux, and which became a standard tool for free/open-source software projects."). *See also* Siobhán O'Mahony, *The Governance of Open Source Initiatives: What Does It Mean to Be Community Managed?*, 11 J. MGMT. & GOVERNANCE 139, 147 (2007). ("In the Apache, GNOME, Debian, and the Linux Standards Base communities, community-wide decisions are determined by community representatives, while code level decisions remain the meritocratic purview of local code owners.").

[145] Alphonse Eylenburg, *Operating Systems: Market Shares Since the 1970s* (2021), https://eylenburg.github.io/os_marketshare.htm.

[146] For a discussion of the antitrust cases, *see, e.g.,* Manne & Auer, *supra* note 76.

[147] *See, e.g.,* Joe Cabrera, Windows vs. Linux: A Comparative Study 11 (Apr. 27, 2009) (Proposal, Technical Writing, Blinn College) ("Linux on the other hand might seem a bit more daunting to average computer user[s] and sometimes even computer administrators. While many Linux distributions these days come with a GUI[,] either Gnome or KDE, an effective Linux server is best run using no GUI at all and simply relying on text-based commands. This places the user in a position that requires him to learn how to navigate and configure a Linux machine entirely using text-based commands.").

[148] Abhishek Prakash, *Fragmentation Is Why Linux Hasn't Succeeded on Desktop: Linus Torvalds*, IT'S FOSS, Oct. 29, 2020.

[149] *See, e.g.*, Linus Dahlander, *Appropriation and Appropriability in Open Source Software*, 9 INT'L J. INNOVATION MGMT. 259, 261 (2005) ("This, of course, raises a number of questions of how firms appropriate returns and protect knowledge, given that important inputs are located outside the boundaries of the firm in the public domain.").

[150] Prakash, *supra* note 148. *See also* Alan Pope as transcribed in Jason Evangelho, *Fragmentation Is GOOD: Why We Still Need New Linux Distros*, LINUX FOR EVERYONE, Jan. 27, 2022 ("Stop making other distros and only focus on Ubuntu. If you promote

Though GUIs sometimes came preinstalled with certain Linux distributions, users remained free to install a GUI that matched their personal preferences.[151] Each of these GUIs relied on particular features that users would have to learn (assuming they were not sufficiently technically proficient to use text commands in the Linux console), and each offered varying degrees of compatibility with the different versions of Linux that coexisted at any given time.

Perhaps even more fundamentally, because many different distributions of Linux had to run across wildly varying hardware configurations—essentially the sort of interoperability that many competition policy scholars would like to impose on Big Tech firms—Linux did not always run smoothly "out of the box."[152] This is not to say that Linux did not have many attractive features, but its decentralized structure precluded it from achieving the sort of consistent user experience that arguably is needed to appeal to a mass audience.

There were also significant problems on the supply side. Because fragmentation at the OS level made it difficult for developers to ensure that their programs ran smoothly across all versions of Linux, it was also difficult to effectively troubleshoot software before the software was released (as performance could vary from one distribution to another).[153] This problem made it more challenging to develop software for Linux and partly explains why many mainstream developers declined to offer Linux versions of their software, despite access to the platform being free. Likewise, the development of Linux itself generally lagged rival software platforms such as Windows or MacOS. For example, partly for philosophical reasons but mostly for monetary ones, Linux distributions often had to forgo the use of proprietary standards, as Linux did not generate the revenue necessary to pay the royalties associated with these inputs.

Despite its lofty ambitions and success on several fronts—such as performance, security, and influence on how software is developed to this day—Linux was simply too decentralized to garner mass-market appeal (at least, not without the sort of control that exists within the Linux-based Android platform). In fact, in hindsight, it is simply stunning that people within the Linux community thought that the OS was a good candidate for widespread adoption by lay users. Indeed, the idea that each user could tailor the OS to meet his or her needs is completely at odds with the revealed preferences of those consumers who jumped on the iPhone (it was easy to use, worked out of the box, and was almost impossible to "brick," and users could install and run all compatible apps at the touch of a single button). It appears Linux was always doomed to fail as a mass-market operating system.

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all these other distros, all these other niches, you paralyze the users with choice. . . . [G]ive them just one option, like there's one option for Windows and one option for macOS.").

[151] Rahul Kumar, *10 Best Linux Desktop Environments of 2022*, TECADMIN, Oct. 30, 2021; Ankush Das, *The Best Desktop Environments for Linux (We Tested Them So That You Don't Have To)*, IT'S FOSS, Aug. 24, 2021.

[152] Andres Guadamuz, *Why Has Not Linux Taken Over OS Market*, TECHNOLLAMA (Feb. 18, 2008), https://www.technollama.co.uk/why-has-not-linux-taken-over-os-market.

[153] Igor Ljubuncic, *Linux Fragmentation: The Sum of All Egos*, DEDOIMEDO (May 18, 2018), https://www.dedoimedo.com/computers/linux-fragmentation-sum-egos.html ("One thing that the open-source nature of Linux did allow is for the number of distributions to grow and proliferate. Any disagreement, be it technical or ideological, eventually becomes a fork in software code. Because, why not."). *See also* Jim Hillier, *Why Linux Will Never Be Mainstream*, DAVES COMPUTER TIPS (Mar. 9, 2022), https://davescomputertips.com/why-linux-will-never-be-mainstream ("When these developers invest in Windows they are developing a one-shoe-fits-all program that they know will be available to billions of users. On the other hand, developing for Linux, with its measly market penetration shared among over 600 distros with differing baselines, why would they bother? Well, they wouldn't and most don't, because it's simply not financially viable.").

3. eBay vs. Amazon

The potential benefits of more tightly controlling how consumers and professional users interact within a platform can also be seen in online marketplaces, where Amazon competes with eBay. Both firms launched within a couple of months of each other, but ultimately Amazon prevailed.[154] As we will argue, this success was, among many other factors, achieved by limiting the options available to the platform's users.

Amazon was not always the sector's runaway leader. In fact, contrary to how things later transpired, it was eBay that initially took the lead. By the end of 2007, eBay's sales volume was almost seven times larger than Amazon's.[155] But by 2008, it had started to become clear that Amazon was on the way up. As Brad Stone wrote for the *New York Times*, "The balance of power in e-commerce seems to be shifting faster than anyone expected. Just three years ago, eBay had 30 percent more traffic than Amazon. Today, its total of 84.5 million active users is barely ahead of the 81 million active customer accounts that Amazon reported in June. Amazon has exceeded eBay in other measures as well."[156] The rest is history. Amazon ultimately eclipsed eBay. At the time of writing, Amazon's annual revenue is roughly 50 times greater than eBay's, and its market capitalization is more than 10 times higher.[157]

The reasons for Amazon's success over eBay are, of course, multiple. The platforms had distinct backgrounds that may have affected their competitive strengths and strategic outlook. After all, eBay started life as a marketplace for collectibles (notably, Pez dispensers) and other used items, while Amazon initially sold only books. In other words, Amazon started as a pure reseller and only later became a marketplace, while eBay was always the latter.[158] Likewise, Amazon's decision to move into cloud computing, as well as the launches of Amazon Prime and the Kindle, were likely instrumental in achieving the company's current market position.

Although it may or may not have been a deciding factor, Amazon's relatively tight control over the platform was likely also part of the equation. This is perhaps best illustrated by the following anecdote: Amazon is so good at maintaining a consistent user experience that several consumers believe they are buying from Amazon even when they are not (roughly 60 percent of sales[159] on the platform are made by third-party sellers).[160] As a *New York Times* piece summarizes:

> "Ebay could have closed the door to Amazon back when Amazon was mostly just a platform to sell books and music," said Scott Devitt, an analyst at Stifel, Nicolaus & Company, the investment bank. "But what eBay did in those days was to take a very hands-off approach and let the marketplace control itself. And that ended up being the downfall of the business relative to others that have succeeded."
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> . . .

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[154] Suzanne Wells, *The Beginnings of eBay*, LIVEABOUT, Jan. 14, 2019.

[155] Scot Wingo, *Amazon vs. eBay: The Giants of E-Commerce Duke It Out*, SEEKING ALPHA, Feb. 5, 2009.

[156] Brad Stone, *Amid the Gloom, an E-Commerce War*, NEW YORK TIMES, Oct. 12, 2008.

[157] *Compare Stocks*, BARCHART, https://www.barchart.com/my/compare-stocks (last visited Oct. 15, 2024).

[158] Andrei Hagiu & Julian Wright, *Do You Really Want to Be an eBay?*, HARV. BUS. REV., Mar. 2013.

[159] Daniela Coppola, *Share of Paid Units Sold by Third-party Sellers on Amazon Platform from 2nd Quarter 2007 to 2nd Quarter 2024*, STATISTA (Aug. 6, 2024), https://www.statista.com/statistics/259782/third-party-seller-share-of-amazon-platform.

[160] Benj Edwards, *How to Tell If You're Buying from a Third-Party Seller on Amazon*, HOW-TO GEEK, Nov. 3, 2020; *Consumer Survey Supports OnBuy's Fair Approach to eCommerce*, ONBUY.COM (Apr. 6, 2022), https://www.onbuy.com/gb/news/consumer-survey-supports-onbuys-fair-approach-to-ecommerce~a702 ("Nearly two-thirds (64%) of consumers expressed a desire to support independent retailers in 2022, yet 90% of them believe the only way to do so is to buy from them directly.").

> Ebay has known for years that some Web buyers were looking for a different experience. Surveys suggested that auction participants were alienated by untrustworthy sellers and hidden shipping fees, and increasingly preferred the certainty of instantly buying items at a fixed price.[161]

Maybe because of its background as a pure reseller, Amazon played a much more active role in determining who could access its platform and how they could interact with other users. In the terminology of this paper, Amazon was the more closed and tightly propertized of the two platforms.

One of the biggest differences between the platforms is that Amazon handles the fulfillment of many, though not all, third-party sales (effectively limiting and controlling the shipping options available to resellers and consumers). This design choice likely gave it a critical edge over more open rivals, such as eBay, because it guaranteed a more reliable and consistent consumer experience. As Jeff Bezos summarizes:

> It was only by focusing on supporting sellers and giving them the best tools we could invent that we were able to succeed and eventually surpass eBay.
>
> One such tool is Fulfillment by Amazon, which enables our third-party sellers to stow their inventory in our fulfillment centers, and we take on all logistics, customer service, and product returns.
>
> By dramatically simplifying all of those challenging aspects of the selling experience in a cost-effective way, we have helped many thousands of sellers grow their businesses on Amazon.[162]

And it is not just fulfillment where Amazon is the more centralized platform. Amazon also exerts much tighter control over many other aspects of the shopping experience. It notably has a particularly consumer-favorable return policy, while eBay's is largely left up to sellers:

> Another reason Amazon is often seen as the go-to for online shoppers is the ease with which products can be returned. Their A–Z Guarantee ensures that shoppers can receive a full refund if they are dissatisfied with the quality of their purchase, or its delivery time.
>
> In contrast, eBay's policy is much more complicated when it comes to returning items and receiving full refunds. Not to mention, sellers can even tick eBay's "No Returns" box, leaving buyers with no recourse if they are unhappy with the product.[163]

Likewise, Amazon is said to have played a much more active role (at least during the company's early years) in deciding which third-party retailers could access its platform:

> Integrating small merchants into its operations also allows Amazon to learn more about whom it can trust to sell on its site. Compared with eBay, the company says it exerts a far greater measure of control over its marketplace, calling certain vendors "featured sellers" and vetting others in product categories that are sensitive to fraud.

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[161] Stone, *supra* note 156.

[162] Ina Steiner, *Amazon CEO Jeff Bezos on How Amazon Surpassed eBay*, ECOMMERCE BYTES (July 29, 2020) https://www.ecommercebytes.com/C/abblog/blog.pl?/comments///1596031523.html.

[163] Brian Connolly, *Selling on Amazon vs eBay in 2024: Which Is Better?*, JUNGLESCOUT, Apr. 10, 2024. Amazon also does not allow resellers to use auction formats, while eBay gives them the choice. *See* Simon Slade, *Crucial Differences Between Amazon and eBay*, SALEHOO, https://www.salehoo.com/educate/selling-on-amazon/crucial-differences-between-amazon-and-ebay (last visited Feb. 8, 2021).

> "At the end of the day, we believe it's good for all of our sellers to make sure we are protecting the consumer experience first," Bezos said. "Our first and foremost goal is to earn trust with consumers. If there are no consumers buying, nothing else matters."[164]

The result of these policies is that it remains much easier to sell products on eBay than on Amazon. Indeed, while the former only requires that sellers complete three simple steps, the latter imposes more complicated steps that include precisely listing the types of products being sold, determining whether other rivals already sell it, formatting the product page according to Amazon's template, and so on.[165]

In short, Amazon runs a much tighter ship than eBay, which has arguably enabled it to thrive. Of course, there are certain niche segments where eBay's more open platform gives it a competitive edge (the market for used athletic shoes springs to mind).[166] And none of this is to say that centralization is always better. After all, Amazon is a platform with more third-party than first-party sales. It could obviously have been more closed, though this characteristic would undoubtedly have thwarted its growth.

But it would be equally misguided to claim that decentralization is always better for consumers. Under certain circumstances, it may be valuable to limit which users may interact with a platform, as well as the ways in which they can do so. Amazon's success is a testament to this lesson. Competition policymakers would be wrong to ignore it and blindly attribute the closed aspects of Amazon's platform to monopolization.

4. Open and closed platforms in generative AI

The emergence of generative AI technology provides yet another example of intense competition among services that exhibit significant differences in terms of openness, propertization, and centralization. The industry is still in its formative years, and no firm appears to have successfully discovered a winning paradigm in the same way that web 2.0's most successful firms managed to do.[167] It is thus too early to confidently predict which of the industry's competing firms will ultimately be the most successful ones. Nevertheless, differing product design philosophies (especially pertaining to openness, propertization, and decentralization) clearly will play a key role in determining which (types of) services are most successful with different user groups. Indeed, as a piece in *Forbes* surmised:

> If you're considering how your organization can use this revolutionary technology, one of the choices that have to be made is whether to go with open-source or closed-source (proprietary) tools, models and algorithms. Why is this decision important? Well, each option offers advantages

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[164] Stone, *supra* note 156.

[165] *How to Start Selling on Amazon*, AMAZON, https://sell.amazon.com/sell (last visited June 7, 2022); *How to Sell*, EBAY, https://www.ebay.com/sellercenter/selling/how-to-sell (last visited June 7, 2022).

[166] Gilles De Roo, *eBay: Sneaker Authentication Can Rejuvenate Growth*, SEEKING ALPHA, Nov. 30, 2020; Tonya Garcia, *EBay Steps Up Its Sneaker Game as Resale Business Expected to Hit $30 Billion*, MARKETWATCH, Oct. 13, 2020; Shoshy Ciment, *eBay Is Adding a New Fee to Sneaker Sales After Eliminating Them in 2019*, FOOTWEAR NEWS, Dec. 28, 2021.

[167] It is still unclear how generative AI firms will manage to offer highly profitable services. *See, e.g.*, João da Silva, *Technology Shares Drop in US and Asia as AI Stocks Slide*, BBC, July 25, 2024 ("'Investors are now becoming more concerned about all this expenditure with AI without the revenue benefit,' said Jun Bei Liu, Portfolio Manager at Tribeca Investment Partners. 'I don't think this will mark the start of the disbelief in AI . . . it just simply means investors will focus more on returns in this space than just buying the whole sector,' she added."). For example, while OpenAI's revenue has more than doubled to reach $3.4 billion annually, it is still only a fraction of the revenue generated by the largest web 2.0 platforms. *See, e.g.,* Laura Bratton, *OpenAI's Revenue Is Skyrocketing*, QUARTZ, June 13, 2024.

> and disadvantages when it comes to customization, scalability, support and security. In this article, we'll explore the key differences as well as the pros and cons of each approach, as well as explain the factors that need to be considered when deciding which is right for your organization.[168]

At the time of this writing, numerous generative AI services are vying for consumers' and business users' attention. Not only are these services put to extremely heterogeneous purposes—including AI chatbots, image- and video-generation tools, automated coding, and more[169]—but they also feature vastly different design paradigms. Indeed, as Thibault Schrepel and Jason Potts observe in their empirical assessment of the competitive landscape, the various AI services often have radically different design philosophies, ranging from fully open-source initiatives to closed and highly propertized systems.[170]

Against this backdrop, it appears increasingly likely that the field of generative AI is about to become the next major industry where open and closed services compete for users' attention. We use the term *services* rather than *platforms* because it is not yet clear whether and to what extent all of these generative AI services will (or will not) take the form of multisided platforms that bring together distinct groups of users with indirect network effects. At the time of this writing, for example, OpenAI is structured primarily as a standard online service that earns most of its revenue from licensing or subscriptions.[171] OpenAI did, however, introduce the so-called GPT Store in January 2024.[172] If successful, the GPT Store would effectively turn this relatively closed online *service* into a more open online *platform*, providing further evidence that the optimal balance between open and closed systems is inherently dynamic—that is, firms must continuously adapt to evolving user preferences and developer capabilities.

Guessing where the AI industry will go in the coming years is beyond the scope of this paper, and we offer no firm conclusions as to which types of generative AI services (closed vs. open, strongly vs. weakly propertized, etc.) will ultimately prove most successful. We can, however, comment on some of the emerging trends in this space and draw some tentative conclusions pertaining to the optimal balance between open and closed systems in the generative AI industry.

To start, it is not entirely surprising that OpenAI's ChatGPT, one of the earliest leaders in this space, is—despite the reference to "open" in the company's name—relatively closed and propertized. According to Schrepel and Potts, the GPT-4 foundation model that underpins the ChatGPT service is in the bottom half of AI foundational models when it comes to openness.[173] The service has a closed governance model with proprietary APIs, and—unlike Meta's Llama 3.1

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[168] Bernard Marr, *Navigating the Generative AI Divide: Open-Source vs. Closed-Source Solutions*, FORBES, Apr. 22, 2024. *See also* Thibault Schrepel & Alex Sandy Pentland, *Competition Between AI Foundation Models: Dynamics and Policy Recommendations* 6 (Mass. Inst. of Tech., MIT Connection Science Working Paper 1-2023, June 28, 2023) ("Foundation models are currently being developed and offered under different conditions, from closed source to open-source.").

[169] *See, e.g.*, *26 Generative AI Tools: The Power Game Is On!*, RAPIDOPS (Mar. 2023), https://www.rapidops.com/blog/generative-ai-tools/.

[170] Thibault Schrepel & Jason Potts, *Measuring the Openness of AI Foundation Models: Competition and Policy Implications* 20–21 (Sciences Po Digital, Governance and Sovereignty Chair, Working Paper, May 14. 2024).

[171] *See, e.g.*, Nicole Willing, *How Does OpenAI Make Money? Revenue Streams Beyond ChatGPT*, TECHOPEDIA, Apr. 11, 2024.

[172] *Introducing the GPT Store*, OPENAI (Jan. 10, 2024), https://openai.com/index/introducing-the-gpt-store/.

[173] Schrepel & Potts, *supra* note 170, at 20.

model[174]—there is no possibility for developers to fork the software.[175] In other words, OpenAI's ChatGPT and the GPT-4 model that underpins it largely fall in the closed and propertized categorization of this paper (though that could change in the future).

At the time of this writing, ChatGPT is largely regarded as the most successful generative AI service.[176] It is also the service that likely did the most to bring generative AI technology into the public eye.[177] That it also happens to be on the centralized end of the spectrum is not surprising. As we have explained throughout this paper, closed systems tend to present some advantages that make them particularly well adapted to the formative years of an emerging industry. Indeed, they are usually conducive to more straightforward monetization strategies, and it is generally easier to design a consistent and reliable user experience in a closed system, where a single firm controls all of the service's parameters.[178]

In simple terms, ChatGPT's ease of use may partly explain why it has proven so successful with novice users.[179] The size of the GPT-4 foundation model that underpins ChatGPT might also explain its closed design. Indeed, research shows that models with more parameters tend to be more closed than smaller counterparts. It is, however, unclear whether that correlation will still hold after the release of Meta's Llama 3.1, which the company claims is the largest-ever open-source AI model.[180] But as the market evolves and median consumers begin to demand more varied and bespoke tasks from their generative AI services, relatively open systems might become more compelling to a broader audience (although this is, again, far from certain).

A second important observation is that the optimal level of openness for different generative AI services also varies, and it will likely continue to evolve along with, for example, the sophistication of each service's intended user base. Mass-market services such as ChatGPT, Google's Gemini, and Anthropic's Claude have initially tended to be on the closed end of the spectrum,[181] but this could be changing. Indeed, users' increasingly sophisticated demands might

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[174] *See, e.g.*, Mark Zuckerberg, *Open Source AI Is the Path Forward*, META, July 23, 2024 ("Today we're taking the next steps towards open source AI becoming the industry standard. We're releasing Llama 3.1 405B, the first frontier-level open source AI model, as well as new and improved Llama 3.1 70B and 8B models. In addition to having significantly better cost/performance relative to closed models, the fact that the 405B model is open will make it the best choice for fine-tuning and distilling smaller models.").

[175] *See, e.g.*, Funmi Somoye, *ChatGPT Isn't Open Source, But These AI Tools Are*, PC GUIDE, Apr. 10, 2024.

[176] Philip Wegner, *The Leading Generative AI Companies*, IOT ANALYTICS, Dec. 14, 2023; Chris Westfall, *New Research Shows ChatGPT Reigns Supreme In AI Tool Sector*, FORBES, Nov. 16, 2023; Sujan Sarkar, *AI Industry Analysis: 50 Most Visited AI Tools and Their 24B+ Traffic Behavior*, WRITERBUDDY (2023), https://writerbuddy.ai/blog/ai-industry-analysis.

[177] *See, e.g.*, Amber Jackson, *ChatGPT Turns One: How AI Chatbot Has Changed the Tech World*, TECHNOLOGY MAGAZINE, Nov. 30, 2023.

[178] *See, e.g.*, Theodore Chen, *Open vs. Closed-Source Generative AI*, PERSPECTIVE (Nov. 22, 2023), https://www.deloitte.com/uk/en/Industries/technology/blogs/open-vs-closed-source-generative-ai.html ("Historically, one of the biggest challenges in using open-source applications—especially in enterprise solutions—has been ease of use, particularly for non-technical users.").

[179] *See, e.g.,* Marr, *supra* note 168 ("There are, though, advantages to this model for the end user. As commercial products, closed-source AI tools have to be accessible and easy to use; otherwise, vendors will have a hard time selling them. In theory, they'll make them as user-friendly as possible and offer customer and technical support services. One reason that businesses will choose closed-source over open-source tools, despite the additional cost, is that they expect it to be reliably maintained and supported.").

[180] *See* Irene Solaiman, *The Gradient of Generative AI Release: Methods and Considerations*, *in* FACCT '23: PROCEEDINGS OF THE 2023 ACM CONFERENCE ON FAIRNESS, ACCOUNTABILITY, AND TRANSPARENCY 111, 116 (2023) ("Language models with fewer than six billion parameters have generally been towards the open end of the gradient, but more powerful models, especially from large companies, tend to be closed.") *See also* Alex Heath, *Meta Releases the Biggest and Best Open-Source AI Model Yet*, THE VERGE, July 23, 2024.

[181] All are on the closed end of the scale according to Schrepel & Potts, *supra* note 170.

explain why OpenAI decided to launch its GPT Store, which opens its ecosystem by enabling users to build custom AI tools in much the same way as was seen when Apple added the App Store to the iPhone.[182]

The industry has also seen an influx of new large players, such as Mistral AI and Meta's Llama AI, which have successfully launched open-source foundational models. These services may prove to be geared more toward sophisticated audiences that are willing to trade the convenience of an out-of-the-box online service for the greater flexibility and adaptability offered by an open-source service.

Initially, at least, the additional benefits offered by open-source alternatives may be relevant only for a relatively small subset of highly sophisticated users. For instance, the download required to run Meta's Llama AI locally—750 GB[183]—would prove insurmountable for most novice users, as it is close to the storage limit of a typical laptop. This suggests that the strategy of open-sourcing these models is not *directly* aimed at the average consumer.

Nonetheless, it *could* benefit those consumers if intermediaries emerge, and a wider community begins to develop improvements and complementary services for these foundation models. The Stable Diffusion image-generation AI provides another example of the relevant tradeoffs. On the one hand, the software is reportedly less intuitive to use than competing services are. As one commentator put it:

> As is common with open-source software, using Stable Diffusion isn't quite as straightforward as using commercial, proprietary tools like ChatGPT. Rather than having its own web interface, it's accessed through third-party tools built by commercial entities, including DreamStudio and Stable Diffusion Web. The alternative is to compile and run it yourself locally, and this requires providing your own compute resources as well as technical know-how.[184]

On the other hand, the service offers the potentially huge advantage that it can be run locally on more computers (because third parties can alter them to run on less powerful hardware) and can be modified to better cater to users' specific needs.[185] In short, it is clear that the optimal tradeoff between open and closed services in AI (and elsewhere) depends, among other things, on the sophistication of a service's target audience, as well as its intended use.

Finally, we expect that open-source AI models will face many of the same challenges and opportunities that relatively open projects have faced in other tech markets. Offering an open-source service would be expected, all else being equal, to render monetization more complicated (as users will, at least in theory, be able to fork the most recent version of the software).[186] Competition policy will also have a role to play in this regard: If antitrust authorities around the globe persist with their heightened scrutiny of AI markets,[187] incumbent online platforms such as

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[182] *See, e.g.*, Wes Davis, *OpenAI's Custom GPT Store is Now Open to All for Free*, THE VERGE, May 13, 2024 ("The store lets ChatGPT Plus subscribers create their own chatbots, called GPTs, and share them. Some of the trending bots right now include an image-generating bot, a chatbot called Consensus that's geared toward helping with scientific research, and a logo-making bot. OpenAI said it would offer an engagement-based revenue sharing program for GPT builders.").

[183] *See, e.g.*, David Chien, *Meta Unveils Biggest, Smartest, Royalty-free Llama 3.1 405B AI*, NOTEBOOKCHECK, July 26, 2024.

[184] *See, e.g.*, Bernard Marr, *7 Essential Open-Source Generative AI Models Available Today*, FORBES, May 7, 2024.

[185] *What Is Stable Diffusion?*, AMAZON, https://aws.amazon.com/what-is/stable-diffusion/ (last visited, Aug. 7, 2024).

[186] *See* Chen, *supra* note 178 ("By prioritising adoption over monetisation, open-source platforms are hoping to become the default platform of choice for machine learning developers, and in doing so, drive adoption into more profitable enterprise solutions.").

[187] Joint Statement on Competition in Generative AI Foundation Models and AI Products, Eur. Comm'n, U.K. Competition & Mkts. Auth., U.S. Dep't of Just. & U.S. Fed. Trade Comm'n, July 23, 2024.

Meta might struggle to deploy the "complementary goods" strategy that is often essential to monetize open-source projects (i.e., antitrust scrutiny might prevent a platform such as Meta from tying its Llama service to its online platforms such as Facebook, Instagram, and WhatsApp).[188]

In fact, there is evidence that this may already be happening in Europe, where Meta's Llama AI will face a delayed release schedule and where it will presumably not be tied to the firm's primary platforms.[189] This raises questions as to whether and how this open-source service will be profitable on the continent. On the upside, open-sourcing projects could mean that those AI services are able to reach a broader audience and be optimized for all sorts of (often less powerful) devices, which may have countervailing commercial benefits. As we have discussed in section III.B.1, this is, *mutatis mutandis,* what happened with the emergence of the Google Android ecosystem.

There is another area where open-source AI projects might have a comparative advantage. Ever since generative AI came into the limelight, numerous voices have been cautioning about the societal risks posed by artificial intelligence. Evaluating whether those fears are founded or unfounded is beyond the scope of this paper. What is clear, however, is that their prevalence could conceivably give open-source projects a competitive advantage that they have not historically enjoyed in other industries.

By their very nature, open-source projects tend to be more amenable to external audit, as no single firm can control *who* audits the system.[190] Consequently, there is a widespread (although certainly not unanimous) belief that open-source foundational models are, all else being equal, safer than closed ones. Of course, given the generative AI industry's young age, it would be wrong to presume that things will necessarily pan out as experts currently believe. And conversely, some decentralized systems might find it harder to demonstrate compliance with complex legal and regulatory regimes.

These security-related differences might also have other ramifications for competition in generative AI. The AI industry has recently been the subject of intense regulatory scrutiny.[191] The European AI Act, for instance, imposes somewhat substantial requirements on providers of foundational AI models ("general-purpose AI models," under the regulation); other jurisdictions could go further still.[192] More importantly, the requirements that the AI Act places on

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[188] *See, e.g.*, Dahlander, *supra* note 149. Dahlander analyzed the appropriation strategies of a number of firms producing open source software and found that they often rely on complementary assets to create appropriability. *See also* Teece, *supra* note 66, at 287; Josh Lerner & Jean Tirole, *Some Simple Economics of Open Source*, 50 J. INDUS. ECON., 197 (2002); Sidney G. Winter, *The Logic of Appropriability: From Schumpeter to Arrow to Teece*, 35 RSCH. POL'Y, 1100 (2006). Winter argues that Teece made a significant contribution to the notion of appropriability, notably by focusing on the use of complementary assets to solve the appropriability problem.

[189] *See, e.g.*, Dan Milmo, *Meta Pulls Plug on Release of Advanced AI Model in EU*, THE GUARDIAN, July 18, 2024.

[190] *See, e.g.*, Elliot Mckernon and Deric Cheng, *Open-Source AI: A Regulatory Review*, LESSWRONG (Apr. 29, 2024), https://www.lesswrong.com/posts/vzGC4zh73dfcqnFgf/open-source-ai-a-regulatory-review ("Many experts are still staunch advocates for open-sourcing . . ., and believe it is essential for an accountable and transparent AI ecosystem.").

[191] *AI Watch: Global Regulatory Tracker*, WHITE & CASE (last visited, Aug. 7, 2024), https://www.whitecase.com/insight-our-thinking/ai-watch-global-regulatory-tracker#home.

[192] *See*, *in particular*, Regulation 2024/1689 of the European Parliament and of the Council of 13 June 2024 on Laying Down Harmonised Rules on Artificial Intelligence and Amending Regulations (EC) No. 300/2008, (EU) No. 167/2013, (EU) No. 168/2013, (EU) 2018/858, (EU) 2018/1139, and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797, and (EU) 2020/1828 (Artificial Intelligence Act) (Text with EEA Relevance), art. 53–54. *See, e.g.* Owen Hughes, *EU's AI Act: Europe's New Rules for Artificial Intelligence Enters into Force*, TECHREPUBLIC, Aug. 1, 2024 ("Providers of general-purpose AI systems must meet certain transparency requirements under the AI Act; this includes creating technical documentation, complying with

foundational AI models are weaker for open-source models than for proprietary ones.[193] The weaker requirements could give open-source systems a competitive edge in this space. More generally, regulators might also perceive more open systems to be safer and, thus, subject their closed rivals to more intense regulatory scrutiny in other areas, such as competition enforcement.

Whether all of these factors would suffice to offset some of the other difficulties that open systems typically face is another question. What matters for the purpose of this paper is that it would be wrong to assume that closed systems are *always* safer than open ones (as in the example of app stores discussed in section III.B.1), and this may have knock-on regulatory effects that could tilt the scales of competition. In other words, the respective tradeoffs between open and closed systems may differ from one industry to another, and what has held true in the mobile operating space may not prove true in generative AI.

In the end, relatively open generative AI projects will likely continue to face many of the same challenges that long have made many open-source software platforms harder to gear toward a mass audience, although this feature may also make them uniquely suited to sophisticated business users. In other words, though it is impossible to predict which types of AI systems will become industry paradigms (if such paradigms emerge), we can at least guess as to the factors that will ultimately tilt the scales of competition in favor of one model or the other.

C. The perils of excessive centralization

As the case studies cited in section III.B demonstrate, consumers routinely opt for ecosystems that are more centralized than policymakers would like. It is important, however, to remember that platforms can, and often do, fail because they are overly centralized. Although this point is less contentious than the previous one—many policymakers wrongly assume that decentralization is good in and of itself—it is important to at least briefly explain why it is so. In that respect, the evolution of Apple's iOS operating system neatly illustrates the perils of excessively closed and propertized platforms (in this case, Apple astutely avoided those traps).

In section III.B, we argued that Apple's iOS was one of the most closed and highly propertized mainstream platforms. And yet, despite this, Apple's iOS is first and foremost a *platform.* As such, it is to a significant degree open to third-party developers of all sorts. Apple could have imagined a completely closed device, where all applications were developed by Apple or outsourced to third parties, but without the relatively permissionless access to users that the App Store entails. In fact, the first iPhones shipped without the App Store.[194] It was only subsequently, with the second version of the iPhone in 2008, that Apple and Steve Jobs realized that some openness—what business school scholars would refer to as "becoming a platform"—was key to the iPhone's success.

It is also worth noting that, at its launch, the iOS software sat somewhere between Nokia's open-source Symbian operating system and the much more closed BlackBerry ecosystem, both of

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European copyright laws and providing detailed information about the data used to train AI foundation models. The rule applies to models used for generative AI systems like OpenAI's ChatGPT.").

[193] EU Artificial Intelligence Act, *supra* note 192, at art. 53, 2 ("The obligations set out in paragraph 1, points (a) and (b), shall not apply to providers of AI models that are released under a free and open-source licence that allows for the access, usage, modification, and distribution of the model, and whose parameters, including the weights, the information on the model architecture, and the information on model usage, are made publicly available. This exception shall not apply to general-purpose AI models with systemic risks.").

[194] 9to5 Staff, *Jobs' Original Vision for the iPhone: No Third-Party Native Apps*, 9TO5 MAC, Oct. 21, 2011.

which were rapidly overthrown by the iPhone.[195] This suggests that designing a platform is about more than just maximizing openness versus closedness. It is about striking a balance among all parties in the ecosystem—with the corollary, discussed in detail throughout section III.B, that more open and less propertized ecosystems are not always better from the perspectives of developers and users alike.

The App Store effectively enables third-party developers to design and distribute "native" apps for the iPhone.[196] What may seem like a story of Apple suddenly realizing it needed to open its platform to third-party developers is, in fact, slightly more complex. Although the first iPhone launched without an app store, the plan was initially to enable third parties to offer apps through the Safari browser. This plan seemingly failed to gain traction with developers, presumably because it limited the functionality that could be included in apps and made development more difficult. It also created incentives for users and developers to "jailbreak" iPhones, thus effectively bypassing Apple's middleman position. Recognizing this problem, Apple ultimately decided to introduce the App Store and deal with the security issues it entailed; nefarious actors might rely on the APIs that Apple offered to harm consumers.

The rest is history, as the App Store has become almost synonymous with the success of the iPhone. This example also shows, in turn, that the challenge for closed platforms is not recognizing that some level of openness is necessary to attract users on both sides of the ecosystem, but figuring out where best to let third parties access the platform. For example, Apple—perhaps wisely—did not let third-party *hardware* developers onto its platform.

This is not the only area where the iPhone has evolved to become more open and likely to better meet consumer and developer demand. For instance, Apple has over the years opened up the iMessage app to third-party developers, enabling them to plug their own apps into the service, as well as creating so-called stickers that users can share with their friends.[197] Along similar lines, iPhone users have been able to install third-party keyboards since the eighth version of the iOS software.[198] Apple also added Facebook integration to the iPhone with the sixth version of its software.[199] Finally, Apple recently created an API that enables third-party app developers to better integrate their products into the Siri voice assistant ecosystem.[200]

A final example of the iOS ecosystem becoming more open involves the Safari web browser. With the 14th version of the iOS software, iPhone users can for the first time change the default web browser on their devices.[201] Although this change undeniably marks a step toward further openness, it is much less clear whether the move was dictated by consumer and developer demand or merely by regulatory pressure. Indeed, other successful platforms, such as Windows OS and Android, have faced antitrust scrutiny for installing the platform's own web browser as the default. The looming implementation of digital market regulations across the globe, most notably

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[195] Sylvie Barak, *Symbian Officially Declared Closed Source*, RCRWIRELESSNEWS, Apr. 8, 2011.

[196] *See* 9to5 Staff, *supra* note 194.

[197] *See* Nathan Ingraham, *The iPhone's Hardware May Be Closed, but iOS Is More Open Than Ever*, ENGADGET, Sept. 16, 2016. *See also iMessage*, APPLE (last visited, Oct. 17, 2022), https://developer.apple.com/imessage/.

[198] Ingraham, *supra* note 197.

[199] *See* Sudeep Srivastava, *The Evolution of Apple iOS: From iOS 1 to iOS 13*, APPINVENTIV, Apr. 12, 2021.

[200] *See* Eric Hal Schwartz, *Apple WWDC Showcases App Intents API for Siri Shortcuts*, VOICEBOT.AI, June 6, 2022.

[201] *Change the Default Web Browser or Email App on Your iPhone, iPad or iPod Touch*, APPLE, https://support.apple.com/en-gb/HT211336 (last visited, Oct. 2, 2024). *See also* Parth Shah, *iOS 14: How to Change the Default Browser on iPhone*, IJUNKIE, Sept. 11, 2020.

that of the European DMA, may have further swayed Apple to enable its users to change the default browser on its devices.

Of course, none of this is to say that iOS is open or weakly propertized compared to a rival such as Android or the idealized platforms that policymakers seem intent on creating.[202] Android remains the only mainstream mobile operating system that allows users to install a competing app store, sideload applications, and opt for rival hardware producers and that allows developers to modify the underlying source code of the operating system, to cite a few examples. Instead, the point is that even relatively closed ecosystems must continuously iterate to find the right level of centralization for a given point in time. This optimum level of centralization can also change over time because of technological progress and the evolution of consumer preferences.

Perhaps more importantly, it is worth noting that Apple's success may also be due to its ability to orchestrate these changes of course. An argument can be made that it is easier for a centralized platform, such as Apple, to strategically open parts of its ecosystem, while more decentralized rivals may struggle to close their overly open ecosystems. In other words, Apple's relatively high degree of centralization might have given it an edge at a time when the industry (i.e., its environment) was rapidly evolving and key strategic decisions were required to adapt and survive.

The upshot is that platforms realize that they need to strike a balance between centralized and decentralized platforms to retain consumers. This viewpoint is a far cry from that expressed by policymakers and critics, who tend to assume that decentralization is the result of competition, while centralization reflects market power. Such a perception is deeply misguided; there is simply no clear correlation between platform openness or propertization and market power.

D. Partial conclusion

The preceding case studies show that, on the demand side, consumers do not always prefer more open and more weakly propertized platforms and that, on the supply side, closed and tightly propertized ecosystems may sometimes present advantages that encourage firms to invest in them.

Our survey suggests that today's most successful platforms are often the fruit of market selection—that is, firms surviving and thriving against competition—rather than random chance. Indeed, there are objective reasons why the app store model has proliferated. Windows overcoming the open-source Linux was not merely a case of path dependence or network effects. It is no coincidence that Amazon, the world's most successful marketplace, started life as a reseller, while eBay, the first successful marketplace, never managed its transition to retail. Finally, it is no surprise that, in the extremely decentralized world of Web3, it is one of the most centralized nonfungible token platforms that took an early lead. In short, these platforms' successes appear to be linked to their design choices.

If our analysis is correct, then policymakers cannot and should not assume that, at the margin, more openness and less propertization are always better for consumers. This is certainly not to say that centralized ecosystems are always (or even generally) superior, that policymakers should never intervene to decentralize an ecosystem, or that firms operating centralized platforms never anticompetitively exclude their rivals. But these case studies dispel the persistent myth that (de)centralization involves a simple tradeoff between the interests of consumers and edge developers, on the one hand, and those of platform operators, on the other. Put differently,

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[202] *See, e.g.*, Chris Hoffman, *Android Is "Open" and iOS Is "Closed"—But What Does That Mean to You?*, HOW-TO GEEK, May 20, 2015.

preferences for centralization or decentralization do not appear to hinge on simple categorizations, such as whether the economic agent in question is a consumer, a platform, or a third-party developer. Certain tropes commonly repeated by policymakers, such as the idea that more choice and interoperability always benefit consumers, fail to capture this nuanced reality.

In evolutionary terms, our investigation appears to show that today's dominant platforms were particularly well adapted to their environments, and this feature enabled them to thrive. Indeed, they are the ones that managed to solve complex optimization problems, managing (with varying degrees of success) to balance the interests of all stakeholders. They succeeded partly because those stakeholders preferred the relatively centralized model on which they relied and partly because that model left them in a better position to execute key strategic decisions. This does not mean that these platforms are perfect or that, at the margin, they could not be fine-tuned via light-touch regulatory intervention. However, a good baseline assumption is that the design choices on which they rely are more likely to be features than bugs. And with the examples of Apple's App Store and emerging generative AI technology, our paper also shows that the optimal balance between openness and closedness is inherently dynamic. It changes along with the needs and sophistication of users and other stakeholders.

In more concrete terms, critics often assume that Apple, Android, Amazon, and Windows succeeded because they were in the right place at the right time. If it was not them, it would have been someone else. Complexity theory scholars sometimes argue that randomness and path dependency (notably owing to network effects) can radically alter the business models that succeed.[203] In other words, maybe the GAFAM firms (Google, Apple, Facebook, Amazon, and Microsoft) were simply lucky and the particulars of how online markets are structured, including how centralized they are, were largely dictated by random events.

We believe our work tends to dispel this myth. None of the GAFAM firms was alone on the market when it launched (or, in those cases where a firm arguably was alone, it lasted for only a very short period). Early success was not merely due to random chance, but to critical design choices that influence how these platforms operate to this day. To put it simply, what might appear to be random path-dependent outcomes may, in fact, reflect superior capabilities (notably firms' ability to rapidly change their platforms to adapt to constantly changing environments) and product offerings. Although randomness might have influenced *who* won the race in these markets, the design choices of the winning platforms seem considerably more deterministic. To cite a famous episode of *The Simpsons*, Homer could have gone back in time and killed as many mosquitoes as he desired,[204] and we still would not be using Linux (as we know it) today.

Of course, random events *do* occur, and they can reshape markets. Most recently, the COVID-19 pandemic led to the explosive (and somewhat temporary) growth of the Zoom platform.[205] But being the first platform to launch or the first to scale does not mechanically drive success. Instead, our case study suggests that platform design choices and firmwide capabilities (among other

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[203] W. Brian Arthur, *Competing Technologies, Increasing Returns, and Lock-In by Historical Events,* 99 ECON. J. 116, 116 (1989) ("Modern, complex technologies often display increasing returns to adoption in that the more they are adopted, the more experience is gained with them, and the more they are improved. When two or more increasing-return technologies 'compete' then, for a 'market' of potential adopters, insignificant events may by chance give one of them an initial advantage in adoptions.").

[204] Lovely Simpsons, *The Simpsons—Homer Travels Back in Time*, YOUTUBE (June 25, 2021), https://www.youtube.com/watch?v=P1hmiaNReCg&t=66s.

[205] Felix Richter, *Zoom's Post-Pandemic Growth Slows to a Crawl*, STATISTA (Feb. 27, 2024), https://www.statista.com/chart/21906/zoom-revenue.

factors) determine whether firms thrive or falter when random events occur. In other words, today's dominant platforms are the ones that survived Schumpeter's "gales of creative destruction."[206]

At a more granular level, our case studies suggest that the benefits of centralization are broader than is typically recognized. It is not just that closed ecosystems can be safer, be more convenient, or offer better curation. It is that, by giving control to an intermediary, centralization enables the sort of decisions that make platforms more fit for survival against rivals—hence the evolutionary explanation. For example, having centralized control appears to have helped firms such as Google and Microsoft make strategic design choices that were all but impossible in the fragmented Linux ecosystem. Control enables firms to obtain information, act on it quickly, and create incentives for stakeholders to align themselves with these choices (think of Android's antifragmentation strategy). As Jeff Bezos himself argued:

> The most important thing for doing well against competition—in business and also, I think, with military adversaries—is to be both robust and nimble.
>
> . . .
>
> The most important factor for nimbleness is decision-making speed. The second-most important factor is being willing to be experimental. You have to be willing to take risks. You have to be willing to fail, and people don't like failure.[207]

This sort of decision-making power is impossible if firms merely act as passive intermediaries. Instead, it supposes the sort of control that is possible only with some centralization. A platform making those decisions supposes that someone else is not, which implies rules and limits as to how third parties interact with the platform. Rational firms will invest time in these decisions only if they expect to turn a profit, which implies some level of propertization. All of this has important consequences. Policymakers should ask themselves whether undoing those features via regulatory *fiat* and mandated platform design choices may cause the opposite of the initial virtuous circle that enabled the internet economy to prosper. In section IV, we offer suggestions that could help policymakers to mitigate these risks.

IV. An Evolutionary Path Forward

The previous sections paint a complex picture of digital platforms. Although our case studies suggest that centralized platforms often outcompete their comparatively more open rivals, they say little about the optimal platform design in a given market. This significantly complicates the task of policymakers, as no single policy intervention is likely to be appropriate across the board. But they are not entirely in the dark. As we argue in this section, there are some simple heuristics that could mitigate the risk of policy interventions that harm competition and chill innovation. These heuristics mostly concern the thought processes that should inform regulatory intervention, rather than the concrete steps that regulators should pursue (or not) in any given case.

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[206] SCHUMPETER, *supra* note 37, at 73 ("Every piece of business strategy acquires its true significance only against the background of that process and within the situation created by it. It must be seen in its role in the perennial gale of creative destruction; it cannot be understood irrespective of it or, in fact, on the hypothesis that there is a perennial lull.")

[207] Jeff Bezos, *How Amazon Thinks About Competition*, HARV. BUS. REV., Dec. 21, 2020.

A. First, do no harm

A crucial challenge for antitrust policymakers is to ensure that interventions in digital markets do not unintentionally *harm* innovation. Economists have long agreed that dynamic competition—where firms compete to deliver new and improved products and services to consumers—is far more important for economic growth than static competition, where firms merely compete on price. As Joseph Schumpeter once wrote:

> [I]t is not [price] competition which counts but the competition from the new commodity, the new technology, the new source of supply, the new type of organization . . . . This kind of competition is as much more effective than the other as a bombardment is in comparison with forcing a door, and so much more important that it becomes a matter of comparative indifference whether competition in the ordinary sense functions more or less promptly; the powerful lever that in the long run expands output and brings down prices is in any case made of other stuff.[208]

Technological advances generate enormous welfare gains for consumers. There is a robust body of literature establishing the contributions of technological innovation to economic growth and social welfare.[209] Indeed, one of the persistent lessons from the economic literature on innovation has been that even apparently small innovations can generate large consumer benefits.[210] And, importantly, there is strong evidence that technological progress gives rise to tremendous spillovers that are not fully captured by innovators.[211] Less obviously, but of at least equal importance, it is also the case that *business model* innovations—innovations in organization, production, marketing, or distribution—can have similar, far-reaching consequences.[212]

Given all of this, the question becomes one of identifying the policies that are most likely to boost innovation. Because of the highly uncertain nature of innovation, this task is obviously much easier said than done. There are likely as many suggestions to achieve this goal as there are economists.

This is not to say, however, that policymakers are completely in the dark. There is mounting consensus concerning the policies that governments should *avoid*. In other words, although it may not always be clear what policymakers can actively do to *boost* innovation, it is becoming clear that some policies will almost invariably *harm* technological progress. Nassim Taleb refers to this policy approach as *via negativa*—the notion that policymakers should first do no harm.[213] As Adam Thierer has argued, "if public policy is guided at every turn by the fear of hypothetical worst-case scenarios and the precautionary mindset, then innovation becomes less likely."[214]

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[208] SCHUMPETER, *supra* note 37, at 74.

[209] *See*, *e.g.*, Jerry Hausman, *Valuation of New Goods Under Perfect and Imperfect Competition*, in THE ECONOMICS OF NEW GOODS 209 (Timothy F. Bresnahan & Robert J. Gordon eds., 1997).

[210] *See, e.g.*, Peter Cohen, Robert Hahn, Jonathan Hall, Steven Levitt & Robert Metcalfe, *Using Big Data to Estimate Consumer Surplus: The Case of Uber* 1 (Nat'l Bureau of Econ. Rsch., Working Paper No. 22627, 2016) (The authors estimate that the UberX service generated $6.8 billion of consumer surplus in the United States in 2015). *See also*, Amil Petrin, *Quantifying the Benefits of New Products: The Case of the Minivan*, 110 JOURNAL OF POLITICAL ECONOMY 705, 727 (2002) (The author concludes that the invention of the minivan increased economic welfare by $2.9 billion, between 1984 and 1988).

[211] Nordhaus, *supra* note 67, at 1 ("We conclude that only a miniscule fraction of the social returns from technological advances over the 1948–2001 period was captured by producers, indicating that most of the benefits of technological change are passed on to consumers rather than captured by producers.").

[212] *See generally* OLIVER E. WILLIAMSON, MARKETS AND HIERARCHIES: ANALYSIS AND ANTITRUST IMPLICATIONS (1975).

[213] NASSIM NICHOLAS TALEB, ANTIFRAGILE: THINGS THAT GAIN FROM DISORDER (2012) ("In action, [*via negativa*] is a recipe for what to avoid, what not to do.").

[214] *See* THIERER, *supra* note 27, at viii (2016).

According to this widely shared vision of competition and innovation, policymakers should be sure not to *unnecessarily* narrow the realm of technological solutions that vie for consumer adoption. Crucial to encouraging investment and innovation is not only the encouragement of technological progress, but also the promotion of policies that enable innovators to implement and commercialize their technology.

> Hence, public policy aimed at promoting innovation must focus not only on R&D, but also on complementary assets, as well as the underlying infrastructure. If government decides to stimulate innovation, it would seem important to clear away barriers which impede the development of complementary assets which tend to be specialized or cospecialized to innovation. To fail to do so will cause an unnecessary large portion of the profits from innovation to flow to imitators and other competitors. If these firms lie beyond one's national borders, there are obvious implications for the internal distribution of income.[215]

In the case of digital markets, this observation militates strongly in favor of allowing firms to design their platforms in ways that maximize the value of those ecosystems for all stakeholders. More precisely, the preceding sections suggest that policymakers should not blindly pursue policies that decentralize platforms—such as broad interoperability mandates, outright bans on self-preferencing, or stringent limits on vertical integration. Policies of this sort may undermine the business models that have driven the tremendous growth of the internet economy and that have time and again been chosen by consumers at the expense of more decentralized solutions.

B. Recognize you are dealing with complex systems

A second important recommendation is for policymakers to recognize that markets are complex systems that may be hard for outside observers to understand. This view cuts in favor of proceeding on a case-by-case basis and designing evidence-based regulations that contain feedback loops to avoid chilling competition and innovation.

It is largely accepted that markets are complex, emergent systems. Economists of diverse ideological and methodological backgrounds—from Adam Smith to Kenneth Arrow and from Friedrich A. Hayek to Joseph Stiglitz—all recognize that markets are greater than the sum of their parts.[216] In other words, the whole is invisible if one is looking merely at a single part of the system.[217] Markets are also highly dynamic, such that the properties of a market today may differ significantly from its properties in the near future.[218] In one famous example, the economics of video rental changed dramatically with the advent of the internet, turning Blockbuster's physical distribution network—previously a competitive advantage—into a liability.[219] The point is not just that firms' competitive positions can change rapidly, but, more fundamentally, that key

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[215] Teece, *supra* note 66, at 304.

[216] For a discussion, *see* Gavin Kennedy, *Adam Smith and the Invisible Hand: From Metaphor to Myth*, 6 ECON JOURNAL WATCH 239, 240–41 (2009).

[217] *Id.*

[218] Teece, Pisano & Shuen, *supra* note 41, at 509 ("The dynamic capabilities framework analyzes the sources and methods of wealth creation and capture by private enterprise firms operating in environments of rapid technological change.").

[219] Bill Taylor, *To See the Future of Competition, Look at Netflix*, HARV. BUS. REV., July 18, 2018 ("Netflix began, of course, with a pretty simple innovation—crushing Blockbuster by shipping DVDs by mail and abolishing late fees. It then transitioned from mailing content to streaming movies and TV shows digitally. Today, Netflix is most noteworthy as a creator of content; it will spend a staggering $12 billion this year alone on programming. Here again, Netflix is entering an industry by challenging its conventions.").

aspects of the market (including the optimal network on which to deliver goods) can turn on a dime, rendering previous insights obsolete.

Some have argued that something similar may be occurring in the microprocessor industry, where technological progress could render Intel's x86 chip architecture obsolete.[220] If this is true, then one of the world's leading semiconductor companies—not long ago seen as an entrenched monopolist by many competition authorities—could quickly find itself years behind the competition.[221]

Again, it is not just that market positions fluctuate rapidly in digital industries, but that the drivers of success change over time. The capabilities that made Facebook the world's leading social network might not be useful to compete against rivals such as TikTok. This is, in large part, Clayton Christensen's insight in "The Innovator's Dilemma":

> Principle #4: An Organization's Capabilities Define Its Disabilities
>
> An organization's capabilities reside in two places. The first is in its processes—the methods by which people have learned to transform inputs of labor, energy, materials, information, cash, and technology into outputs of higher value. The second is in the organization's values, which are the criteria that managers and employees in the organization use when making prioritization decisions. . . . But processes and values are not flexible. A process that is effective at managing the design of a minicomputer, for example, would be ineffective at managing the design of a desktop personal computer. Similarly, values that cause employees to prioritize projects to develop high-margin products, cannot simultaneously accord priority to low-margin products. *The very processes and values that constitute an organization's capabilities in one context, define its disabilities in another context*.[222]

In such an environment, proceeding with humility is crucial. Elinor Ostrom aptly summarizes the problem in her work concerning the "tragedy of the commons." She observed that the intricacies of markets often elude policymakers, who are guided by untested models and sweeping assumptions about how the world operates:

> The intellectual trap in relying entirely on models to provide the foundations for policy analysis is that scholars then presume that they are omniscient observers able to comprehend the essentials of how complex, dynamic systems work by creating stylized descriptions of some aspects of these systems. With the false confidence of presumed omniscience, scholars feel perfectly comfortable

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[220] *See, e.g.,* Ben Thompson, *Intel and the Danger of Integration*, STRATECHERY (June 25, 2018) https://stratechery.com/2018/intel-and-the-danger-of-integration ("Intel, meanwhile, was hemmed in by its integrated approach. The first major miss was mobile: instead of simply manufacturing ARM chips for the iPhone the company presumed it could win by leveraging its manufacturing to create a more-efficient x86 chip. . . . Intel took the same mistaken approach to non general-purpose processors, particularly graphics: the company's Larrabee architecture was a graphics chip based on—you guessed it—x86; it was predicated on leveraging Intel's integration, instead of actually meeting a market need. . . . The latest crisis, though, is in design: AMD is genuinely innovating with its Ryzen processors (manufactured by both GlobalFoundries and TSMC), while Intel is still selling variations on Skylake, a three year-old design.").

[221] *See, e.g.,* Ben Thompson, *The Intel Split*, STRATECHERY (Jan. 18, 2022), https://stratechery.com/2022/the-intel-split ("The problem is that Intel, used to inventing its own tools and processes, gradually fell behind the curve on standardization. . . . Intel itself was wasting time building tools that once were differentiators, but now were commodities.").

[222] CLAYTON M. CHRISTENSEN, THE INNOVATOR'S DILEMMA: WHEN NEW TECHNOLOGIES CAUSE GREAT FIRMS TO FAIL 16 (Harvard Business Review Press, 1997) (emphasis added).

> in addressing proposals to governments that are conceived in their models as omnicompetent powers able to rectify the imperfections that exist in all field settings.[223]

The risks associated with naive intervention in complex systems are neatly illustrated by several well-intentioned interventions in the public health sphere. For example, it was long assumed that food with high cholesterol content was directly responsible for serum cholesterol levels—the association appeared obvious.[224] This assumption led public health experts to advise against consuming foods such as butter and eggs. However, further research found that cholesterol in food did not mechanically translate into higher cholesterol in the blood,[225] that serum cholesterol was itself not the root cause of certain poor health outcomes,[226] and that previously discredited foods might actually have health benefits.[227] The point is that biological systems are complex, as is human behavior, making it difficult to amass good evidence concerning the likely effects of public health policies.[228]

Nassim Taleb makes a similar point regarding financial markets, criticizing tools that attempt to quantify the extent of possible financial losses, notably so-called value at risk (VaR).[229] In simplified terms, Taleb's underlying intuition is that, in the dynamic and complex world of finance, future shocks are unlikely to resemble previous ones. Accordingly, tools that rely on

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[223] OSTROM, *supra* note 135, at 215. *See also* Theodore C. Bergstrom, *The Uncommon Insight of Elinor Ostrom*, 112 SCANDINAVIAN J. ECON. 245, 246 (2010) ("Ostrom emphasizes that every real-world commons has its own peculiarities. She argues that actual commons problems are usually far more complex than the models that economists like to write down. Achieving efficiency by means of centrally imposed taxes or quotas will often be infeasible because central authorities misunderstand the local situation and because the participants have no incentive to reveal the information needed to achieve efficiency.").

[224] *See, e.g. Do High-Cholesterol Foods Raise Your Cholesterol?* N.Y. TIMES, Nov. 2, 2018.

[225] *Id.*

[226] *See, e.g.* Emily Oster, *Eat More Nuts (and Vegetables, and Don't Forget to Exercise and Quit Smoking)*, FIVETHIRTYEIGHT, May 7, 2014 ("Things like cholesterol and triglycerides are intermediate outcomes when it comes to health. We worry about them not because they are problematic per se, but because high levels of cholesterol and triglycerides correlate with stroke, heart attacks and mortality in general.").

[227] *Butter: Are There Health Benefits*?, WEBMD (Sept. 17, 2023), https://www.webmd.com/diet/health-benefits-butter#1.

[228] This problem may notably lead to important biases in research. *See, e.g.,* Emily Oster, *Health Recommendations and Selection in Health Behaviors*, 2 AM. ECON. REV.: INSIGHTS, 143, 143–44 (2020) ("This paper . . . argues that in the presence of differential response to new health advice, bias in estimates of the impact of health behaviors on health outcomes may be dynamic. To be concrete, consider a hypothetical case in which researchers are evaluating the relationship between pineapple and cardiovascular health. Imagine that although the true effect is zero, sampling variability leads to a study showing that pineapples significantly reduce heart attacks. One result may be positive pineapple-related news coverage or even a change in official guidelines about pineapple consumption. In response, some people will increase their consumption of pineapple. These may be the people who are most concerned about their health. But this group is also likely to be engaged in other heart-healthy behaviors (exercise, not smoking, etc.). As a result of this differential adoption of the recommendation, later observational studies of the pineapple–heart-health relationship may see a more substantial link between pineapple and health, since a bias has now been created by changes in selection.").

[229] NASSIM NICHOLAS TALEB, STATISTICAL CONSEQUENCES OF FAT TAILS: REAL WORLD PREASYMPTOTICS, EPISTEMOLOGY, AND APPLICATIONS, 221 (2020) ("Another stringent—and dangerous—example is the 'default VaR' (Value at risk) which is explicitly given as I_2, i.e. default probability $x(1 - \text{expected recovery rate})$, which can be quite different from the actual loss expectation in case of default. Finance presents erroneous approximations of CVaR^7, and the approximation is the risk-management flaw that may have caused the crisis of 2008. The fallacious argument is that they compute the recovery rate as the expected value of collateral, without conditioning by the default event. The expected value of the collateral conditionally to a default is often far less [than] its unconditional expectation. In 2007, after a massive series of foreclosures, the value of most collaterals dropped to about 1/3 of its expected value!"). For an introduction to VaR, *see, e.g.*, Will Kenton, *Value at Risk (VaR)*, INVESTOPEDIA, June 3, 2022.

extrapolations from historical data, such as VaR, may significantly underestimate the magnitude of potential future losses.[230]

Returning to the realm of antitrust enforcement, the critical point is that digital markets are more complex than policymakers often credit. Policy instruments that rely on simple models to support one-size-fits-all prohibitions are unlikely to be appropriate in such a dynamic environment. It is also unlikely that the effects of such regulations—be they positive or negative—will lend themselves to accurate measurement.

Given these difficulties, policymakers should make efforts to intervene at the local level (i.e., on a firm-by-firm basis) to limit the risk of unintended consequences. To a first approximation, antitrust law that proceeds on a case-by-case basis is thus preferable to regulation that imposes uniform obligations across the board. If policymakers do decide to adopt new regulations, however, effort should be made to include feedback loops in the process—for example, by examining how regulated sectors perform compared with similarly situated unregulated ones. Practices such as regulatory sandboxes—that is, regulatory schemes that offer carve-outs for firms to experiment and innovate—can also play a role in ensuring that regulation does not excessively harm innovation. Finally, sunset clauses should be inserted into regulations, thus ensuring that policymakers frequently reassess the likely effectiveness of regulatory interventions.

C. Enable experimentation

Unless policymakers believe that we have reached the end of history, they should be careful not to enact policies that prevent regulated firms from maintaining successful business models or, more importantly, experimenting with new ones and entering new markets. As we have written previously:

> The antitrust literature surrounding digital competition is also beset by a strong and often-problematic sense of nostalgia. Scholars (and certain aspects of antitrust doctrine) are skeptical or fearful of change, even though change is a hallmark of digital industries where disruption has been the norm for decades.[231]

Let us take a step back. In general, competition is facilitated by several complementary factors. Competing providers (or, at least, potential competitors) are required, of course.[232] But competition also requires access by and demand from consumers for competitors' offerings. Conversely, competition is undermined by barriers to entry that can occur on either side of a market: New providers may be impeded from entering to compete with incumbents, and consumers may be impeded from accessing their preferred providers.

On the supply side, regulation can increase the costs of entry or prohibit it outright. It can notably lead to homogeneity. Product differentiation is crucial to competition, but if regulatory requirements force all providers to offer virtually identical products and services, differentiation is impossible.

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[230] TALEB, *supra* note 229.

[231] Manne & Auer, *supra* note 76, at 1302.

[232] William J. Baumol, John C. Panzar & Robert D. Willig, *Contestable Markets: An Uprising in the Theory of Industry Structure: Reply*, 73 THE AM. ECON. REV. 1, 14 (1983) ("In the limit, when entry and exit are completely free, efficient incumbent monopolists and oligopolists may in fact be able to prevent entry. But they can do so only by behaving virtuously, that is, by offering to consumers the benefits which competition would otherwise bring. For every deviation from good behavior instantly makes them vulnerable to hit-and-run entry.").

This point is easily illustrated by returning to the case of the Android operating system. Our story begins on the morning of January 9, 2007. Few knew it at the time, but the world of wireless communications was about to change forever. Steve Jobs walked on stage wearing his usual turtleneck and proceeded to reveal the iPhone. The rest, as they say, is history. The iPhone moved the wireless communications industry toward a new paradigm. No more physical keyboards, clamshell bodies, and protruding antennae. All of these were replaced by a beautiful black design, a huge touch screen (3.5 inches was big at the time), a rear-facing camera, and (somewhat later) a revolutionary new way to consume applications: the App Store.[233] Sales soared and Apple's stock started an upward trajectory that would see it become one of the world's most valuable companies.

The story could very well have ended there. If it had, we might all be using iPhones today. But years before, Google had commenced its own march into the wireless communications space by purchasing a small startup called Android.[234] A first phone had initially been slated for release in late 2007. But Apple's iPhone announcement sent Google back to the drawing board.[235] It took Google and its partners until 2010 to come up with a competitive answer: the Google Nexus One produced by HTC.

Understanding the strategy that Google put in place during this three-year period is essential to understand the pitfalls of mandated platform design, notably bans on self-preferencing.

To overthrow (or even just compete with) the iPhone, Google faced the same dilemma that most second movers have to contend with: imitate or differentiate. Its solution was a mix of both. It copied the touch screen, camera, and applications, but it departed on one key aspect. Whereas Apple controls the iPhone from end to end, Google opted for a licensed, open-source operating system that substitutes a more decentralized approach for Apple's so-called walled garden.

Although the open-source route has several advantages—notably the improved division of labor—it is not without challenges. One key difficulty lies in coordinating and incentivizing the dozens of firms that make up the ecosystem. Another is in monetizing a product that, by its very nature, is given away free of charge.

Offering a competitive operating system free of charge posed obvious business challenges. How could Google earn a return on the significant resources poured into developing, improving, and marketing Android devices? As is often the case with open-source projects, Google essentially relied on complementarities.[236] The idea was that the Android OS would boost users' consumption of its profitable, ad-supported services (Google Search, in particular). This approach is sometimes referred to as a loss leader or complementary goods strategy.[237]

Google implemented two important sets of contractual provisions to cement this loss leader strategy.[238] First, as previously discussed, it bundled several proprietary applications together (manufacturers had to preload the Google Search and Chrome apps to obtain the Play Store app). Second, Google concluded several "revenue-sharing" deals with manufacturers and network operators. These companies received monetary compensation when Google Search was displayed prominently on a user's home screen. Both measures ultimately nudged users toward using

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[233] *See, e.g.*, Raymond Flandez, *Programmers Jockey for iPhone Users at Apple Site*, WALL ST. J., Aug. 5, 2008.

[234] Peter Rojas, *Google Buys Cellphone Software Company*, ENDGADGET, Aug. 17, 2005.

[235] Daniel Ionescu, *Original Android Prototype Revealed During Google, Oracle Trial*, PC WORLD, Apr. 26, 2012.

[236] *See* Dahlander, *supra* note 149 (analyzing the appropriation strategy of a number of firms producing open-source software that rely on complementary assets for appropriability). *See also* Teece, supra note 66, at 288 (citing operating systems and hardware as an example).

[237] *See* Auer, *supra* note 66, at 658.

[238] *Id.,* 657–60.

Google's most profitable services, ensuring that the company could earn a return on its Android investments.

There is a strong argument to be made that a ban on self-preferencing would have thwarted Google's Android monetization strategy. Indeed, using a platform's design to nudge users toward one's own services is the epitome of self-preferencing. In the absence of such a strategy, one can only guess whether and how Google might ultimately have entered the market. At the very least, it seems clear that a ban on self-preferencing would have harmed the business model differentiation that we currently see in the smartphone world. Given the comparatively low price point of Android devices, this would likely have been an important loss for consumers.

The upshot is that antitrust policymakers and regulators should be particularly careful that their interventions do not thwart valuable product and business model experimentation. Doing so notably entails the adoption (when there is compelling evidence of unavoidable and substantial consumer harm) of technology-neutral regulation that enables differentiated business models to compete unimpeded by government overreach.

D. Some simple recommendations for a complex world

At a more granular level, we believe that our findings hold several simple lessons for policymakers dealing with digital industries. The overarching theme is that, although the complexity of digital markets does not preclude regulatory intervention, policymakers should proceed with appropriate caution.

With that theme in mind, we offer the following recommendations:

First, policymakers should recognize that no design is optimal across the board. Regulatory interventions that shoehorn platforms into a single business model are thus likely to harm consumers, innovation, and competition.

Second, it is important to accept that both antitrust enforcement and regulatory intervention involve tradeoffs. Indeed, although policies such as self-preferencing bans and mandated interoperability may enable new rivals to enter markets, they are not without tradeoffs. As these tradeoffs are unique to each platform, we believe that regulatory intervention, if warranted, should occur on a case-by-case basis.

Third, policymakers should always ask themselves whether the design choice imposed on platforms will ultimately benefit consumers. This inquiry should be based on evidence and should avoid simplistic assumptions, such as the notion that "more choice" is always better for consumers.

Fourth, antitrust policy and regulation should not prevent firms from monetizing their products and services. Otherwise, there is a real risk that policy interventions will undermine firms' incentives to innovate, improve their goods, and enter new markets.

Fifth, policymakers should favor localized interventions, as these interventions generally require less information and are thus less likely to have unintended consequences. They should also seek the least invasive option to address the harms that they have identified. For example, mandated interoperability is, other things equal, more invasive than an outright ban on self-preferencing (especially if such a ban follows a case-by-case investigation).

Finally, regulations should include feedback loops that solicit information on whether the regulations are fulfilling their goals, as opposed to needlessly harming firms and consumers. Such information can notably be obtained by undertaking comparisons with unregulated industries, creating regulatory sandboxes, and regularly reviewing the performance of regulations against a set of clearly defined metrics.