CONWAY'S LAW, THE MIRRORING HYPOTHESIS, AND THE OVERLOOKED IMPORTANCE OF TECHNOLOGICAL CONSIDERATIONS

BY CHRISTOPHER S. YOO[1]

1 John H. Chestnut Professor of Law, Communication, and Computer & Information Science and Founding Director of the Center for Technology, Innovation and Competition, University of Pennsylvania.

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Conway's Law, the Mirroring Hypothesis, and the Importance of Technological Considerations in Antitrust Divestitures

By Christopher S. Yoo

The current debate about antitrust divestitures has focused on how combining business units under the same corporate umbrella can allow digital platforms to favor their own services over those provided by third parties. To the extent that these debates have framed the issues in economic terms, they have overlooked the enduring importance of Conway's Law and the Mirroring Hypothesis, which assert that a firm's organizational structure must reflect the underlying technology of its products. These principles suggest that enforcement officials should not mandate the structural separation of an existing firm without taking into account the task interdependencies that determine the natural modular structure of a platform industry. Proper analysis of any proposed divestiture will also require antitrust law to shed the reluctance to engage in detailed balancing of technical considerations reflected in its technological tying precedents.

I. INTRODUCTION

One of the most prominent issues in the current debates about antitrust law is the extent to which combining business units under the same corporate umbrella can allow big tech firms to favor their own services over those provided by third parties. These concerns about vertical exclusion have led to calls to deploy one of the least frequently used and most powerful remedies available to antitrust enforcement officials and require these companies to divest some of their subsidiaries. They have also prompted consideration of less intrusive alternatives that can redress the same problems, such as prohibiting firms from bundling certain products together or from favoring their own offerings over their competitors'.

The conventional wisdom on vertical exclusion has undergone something of a sea change since the middle of the 20th Century, influenced by several lines of scholarship. Studies motivated by price theory raised questions whether a monopoly in one market could be used as leverage over another market[2] or when vertical combinations can yield efficiencies, such as through the elimination of double marginalization or the rationalization of inputs that can be combined in variable proportions.[3] Another line of commentary has focused on how combining complementary functions in a single firm can minimize transaction costs.[4]

The growing emphasis on economic considerations, while important, has largely supplanted the focus on technical considerations that once dominated the study of vertical integration.[5] I contend that the pendulum has swung too far to the point where the role of technology is given too little weight and that analysis of vertical exclusion would benefit from reincorporating consideration of technical considerations, albeit in a manner updated to reflect the modern digital economy. While the prior work on the role of technology focused almost exclusively on operational complementarities in manufacturing, modern analyses should reflect how platforms rely on modularity to address the challenges of managing complex systems. It also draws on concepts from the computer science and management literature that emphasize how the institutional configuration of an industry must parallel its underlying technological structure if it is to realize its potential. The need for congruence between an industry's technical and organizational structure places underappreciated natural limits on policymakers' ability to restructure it to satisfy other concerns.

II. CONWAY'S LAW, THE MIRRORING HYPOTHESIS, AND THE IMPORTANCE OF MAINTAINING CONGRUENCE BETWEEN ORGANIZATIONS AND TECHNOLOGY

Those who would curb the power of digital platforms either by breaking them up or by blocking them from favoring their own offerings must consider the innate connection between organizational structure and technology. Computer scientists first captured the deep linkage between technology and organizations in what became known as *Conway's Law*, which holds that "The structure of any system designed by an organization is isomorphic to the structure of the organization."[6]

This concept has become embodied in the management literature as the *mirroring hypothesis*, which posits that the organizational structure of an industry necessarily mirrors the design of the underlying technical system, although the theory is agnostic as to which direction the causal arrow points. This theory asserts that technical design is also tied to the natural boundaries between firms. Empirical studies have confirmed the mirroring hypothesis is a common phenomenon while identifying areas in which other considerations play a role.[7]

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2 See, e.g. Ward S. Bowman, Jr., *Tying Arrangements and the Leverage Problem*, 67 Yale L.J. 19, 20-21 (1957) (providing the seminal critique of leverage).

3 See, e.g. Joseph J. Spengler, *Vertical Integration and Antitrust Policy*, 58 J. Pol. Econ. 347 (1950) (providing the seminal analysis of the elimination of double marginalization); Lionel McKenzie, *Ideal Output and the Interdependence of Firms*, 61 Econ. J. 785 (1951) (providing the seminal analysis of variable proportions).

4 All transaction cost analyses stem from R.H. Coase, *The Theory of the Firm*, 4 Economica 386 (1937). For the seminal works applying this framework to the antitrust law of vertical integration, see, e.g. Oliver E. Williamson, Markets and Hierarchies: Analysis and Antitrust Implications 16-19, 90-116 (1975); Oliver E. Williamson, *The Vertical Integration of Production: Market Failure Consideration,* 61 Am. Econ. Rev. (Papers & Proc.) 112 (1971); Benjamin Klein, Robert G. Crawford, & Armen A. Alchian, *Vertical Integration, Appropriable Rents, and the Competitive Contracting Process*, 21 J.L. & Econ. 297 (1978).

5 See, e.g. Williamson, *supra* note 3, at 112. For a classic example of this earlier work, see, e.g. Joe S. Bain, Industrial Organization 156, 357 (1968).

6 Edward Yourdan & Larry L. Constantine, Structured Design: Fundamentals of a Discipline of Computer Program and Systems Design 363 & n.* (1975) (offering this strong statement of Conway's Law and noting that the term was coined by the 1968 National Symposium on Modular Programming). The original statement comes from Melvin E. Conway, *How Do Committees Invent?*, Datamation, Apr. 1968, at 28, 31.

7 See, e.g. Lyra J. Colfer & Carliss Y. Baldwin, *The Mirroring Hypothesis: Theory, Evidence, and Exceptions*, 25 Indus. & Corp. Change 709 (2016) (coining the term and providing an excellent literature review).

The coupling between technology and organizations stems from the institutional aspects of innovation. Systems embody technological trajectories and design hierarchies that establish a technical agenda for an industry that serve as filters for determining which avenues are the most likely to prove successful. The paradigm also becomes embodied in the communications channels within organizations as well. The institutionalization of a technological trajectory both enables tremendous capability while creating resistance to changes inconsistent with that trajectory.[8]

Conway's Law and the mirroring hypothesis sound important cautionary notes for those seeking to restructure industries based purely on competitive concerns. They suggest that if such efforts fail to take technical considerations into account, they may force the organization of the industry away from the structure entailed by the underlying technology in ways that are likely to impose significant underappreciated harms to consumers and innovation. Divestitures and nondiscrimination mandates that may make sense from the standpoint of competition policy may conflict with the mandates of the underlying technology.

III. THE MODULAR STRUCTURE OF PLATFORM INDUSTRIES

Any attempts to address problems of vertical exclusion must thus incorporate a proper understanding of the structure of the underlying technology. This in turn raises the fundamental question: What is the technical structure of platform industries?

The primary organizing principle around which digital platforms are organized is modularity. Following the work of Nobel Laureate Herbert Simon, modularity manages complex systems by clustering together components with strong linkages in the same subsystem while placing components with weak linkages to exist in separate subsystems. This process of near decomposition permits experimentation to occur at the module level instead of with the system as a whole.[9]

The problems of complexity and the solutions offered by modularity have long been apparent to computer scientist. Brooks's Law has noted that when task partitioning is impossible, the addition of personnel to a software project that is running behind only slows it down still further largely because it causes the number of pairwise interpersonal communications needed to coordinate within the team to explode combinatorially.[10] The solution is to design interfaces to include only the information associated with interdependencies intended to be shared across module while hiding all of the information relating to interdependencies intended to be encapsulated within one module by omitting it from the interface.[11]

The result is an approach to analyzing the vertical structure of an industry that diverges from the conventional wisdom in striking ways. For example, it places significant weight on technological interactions that are not adequately captured by price theory by identifying clusters of tasks that can be performed effectively only within the same organization. At the same time, it identifies what Carliss Baldwin has called *transaction free zones*.[12] This insight can be conceived of as the polar case within the transaction cost paradigm in which transaction costs are infinite or as a qualitatively different phenomenon in which the impossibility of transactions renders the magnitude of transaction costs irrelevant.

Near composition and modularity have important organizational implications. They suggest that firm boundaries are determined in part by the level of technical interdependence among tasks and not just by economic considerations. They also imply the dangers of attempting to restructure the boundaries between firms based purely on competitive considerations. Instead, such boundaries can occur only at the "thin crossing points" where the technical interactions are the weakest.[13] In short, technical considerations may prevent dividing firms or mandating nondiscrimination at particular locations even when competitive exigencies support doing so.

8 Christopher S. Yoo, *Product Life Cycle Theory and the Maturation of the Internet*, 104 Nw. U. L. Rev. 641, 650-58 (2010).

9 Christopher S. Yoo, *Modularity Theory and Internet Regulation*, 2016 U. Ill. L. Rev. 1, 6-9

10 Frederick P. Brooks, The Mythical Man-Month: Essays on Software Engineering 18-19 (1975).

11 David L. Parnas, *Information Distribution Aspects of Design Methodology*, 1 Info. Processing 71: Proc. IFIP Cong. 1971, at 339, 344 (C.V. Freiman ed., 1972).

12 Carliss Y. Baldwin, *Where Do Transactions Come From? Modularity, Transactions, and the Boundaries of Firms*, 17 Indus. & Corp. Change 155, 157-58, 180-86 (2008).

13 *Id.* at 166.

IV. OVERCOMING ANTITRUST'S AMBIVALENCE TOWARD TECHNOLOGY

These principles militate against analyzing vertical exclusion based on purely economic considerations. Instead, they suggest that enforcement officials and antitrust courts addressing these problems will have to take the underlying technology into account.

Historical examples have largely borne out these insights. For example, studies of telecommunications industries suggest that such mandatory divestiture or opening of an interface are likely to succeed only when the market boundary is simple and involves relatively little exchange of information. This explains the success of the U.S. Federal Communications Commission's *Carterfone* rules that opened the market customer premises equipment to competition from third parties.[14] It also explains the mixed outcomes for regulatory and statutory requirements to provide unbundled access to all elements of telecommunications networks. While this approach enjoyed some modest success for relatively isolated elements, such as copper local loops, it failed for components that were more tightly integrated into the overall system.[15]

The problem is that courts have often expressed apprehension about delving too far into technological details. For example, Chief Justice Taft was so unnerved by the idea that broadcast radio was invisibly and unstoppably conveying multiple channels of programming that he kept the Supreme Court from having to address the new technology, declaring that "interpreting the law on this subject is something like trying to interpret the law of the occult. It seems like dealing with something supernatural."[16]

Courts' reluctance to delve into the details of technology is also reflected the hands-off approach that U.S. courts have adopted with respect to technological tying, which occurs when a monopolist redesigns its product in a way that combines two products that were previously sold independently. Lower courts have declined to apply the modified rule of per se illegality usually applied to tying to technological tying because of courts' lack of experience with the practice and concerns that too strict a standard of liability risked disincentivizing competition on the merits through product innovation.[17] In addition, although some courts have followed the conventional rule-of-reason approach of examining whether particular examples of technological tying are procompetitive or anticompetitive,[18] most courts confronting valid engineering disputes have adopted a more deferential posture that finds any showing of technological tie legal out of concerns of courts' institutional lack of competence to determine whether a technological tie represents procompetitive product innovation or an effort to harm competition.[19] Most notably, the Ninth Circuit has rejected calls for undertaking more searching inquiries into technological tying, noting that the D.C. Circuit had only nominally adopted a balancing approach without applying it and finding that "having courts oversee product design" risked "dampening of technological innovation," lacked administrable "criteria that courts can use to calculate the 'right' amount of innovation" in light of the uncertain nature of innovation, and "would . . . require courts to weigh as-yet-unknown benefits against current competitive injuries."[20]

Saying that the assessment of vertical exclusion should go further in taking technological considerations into account will raise difficult questions about how to strike the right balance. The courts' previous reluctance to weigh contested questions of engineering are subject to a number of caveats. Questions of institutional competence play differently in enforcement agencies, which have greater latitude to engage staff qualified to assess delicate questions of engineering and to present those findings in court. In addition, courts have proven adept at striking the right balance between scrutiny and deference when crafting doctrines such as hard look review under administrative law.[21] The nature of judicial expertise can also change over time, as has occurred with respect to economic analysis in the U.S. courts and is increasingly occurring in European courts. Indeed, the *Microsoft* cases presented may difficult questions about the desirability of technical integration and included a request to force the company to divest its software businesses that the court found itself competent to address. Having undertaken the inquiry, courts must take the steps necessary to ensure that it is done properly.

14 Gerald R. Faulhaber, *Policy-Induced Competition: The Telecommunications Experiments*, 15 Info. Econ. & Pol'y 73 (2003).

15 Yoo, *supra* note 8, at 39-42.

16 Clarence C. Dill, Radio Law: Practice and Procedure ix-x (1938) (emphasis omitted).

17 *United States v. Microsoft Corp.*, 253 F.3d 34, 90-95 (D.C. Cir. 2001); *Foremost Pro Color, Inc. v. Eastman Kodak Co.*, 703 F.2d 534, 542 (9th Cir. 1983).

18 *Microsoft*, 253 F.3d at 58-59; *Transamerica Computer Co. v. IBM Corp.*, 481 F. Supp. 965, 1002-05, 1006-08 (N.D. Cal. 1979), *aff'd*, 698 F.2d 1377 (9th Cir. 1983).

19 *Allied Orthopedic Appliances Inc. v. Tyco Health Care Group LP*, 592 F.3d 991, 1000 (9th Cir. 2010); Response of *Carolina, Inc. v. Leasco Response, Inc.*, 537 F.2d 1307, 1330 (5th Cir. 1976); *ILC Peripherals Leasing Corp. v. IBM Corp.*, 458 F. Supp. 423, 439-41 (N.D. Cal. 1978), *aff'd per curiam sub nom. Memorex Corp. v. IBM Corp.*, 636 F.2d 1188 (9th Cir. 1980); *Telex Corp. v. IBM Corp.*, 367 F. Supp. 258, 347 (N.D. Okla. 1973), *rev'd on other grounds*, 10 F.2d 894 (10th Cir 1975).

20 *Allied*, 592 F.3d at 1000.

21 Christopher S. Yoo et al., *Due Process in Antitrust Enforcement: Normative and Comparative Perspectives*, 94 S. Cal. L. Rev. (forthcoming 2021) (see pp. 56-61 of the preprint draft available at https://wwrn.com/abstract=3558179).

V. CONCLUSION

Policymakers confronting digital platforms no doubt find it tempting to impose remedies that would break up companies or force them to open their interfaces to services provided by third parties. Any such widescale restructuring of an industry should take into account the natural limitations imposed by the underlying technology recognized by Conway's Law and the mirroring hypothesis, both of which emphasize the importance of congruence between an industry's institutional structure and its underlying technology. These insights make clear industries cannot be restructured based on purely competitive considerations without sacrificing considerable benefits to consumers. In addition, modularity theory reveals that the underlying technology constrains where the interfaces between separate companies can exist. Antitrust enforcement agencies and courts must take these limitations into account when deciding whether to impose these remedies. Doing so will require them to overcome their longstanding reluctance to weigh the relative merits of disputed questions of engineering and to restructure their operations and training to ensure that they possess the expertise necessary to perform this important task.

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