Federal Communications Law Journal

Volume 64 | Issue 3 Article 9

5-2012

An End to End-to-End? A Review Essay of Barbara van Schewick's Internet Architecture and Innovation

Adam Candeub
Michigan State University College of Law

An End to End-to-End? A Review Essay of Barbara van Schewick's *Internet Architecture and Innovation*

Adam Candeub*

Barbara van Schewick's *Internet Architecture and Innovation* surveys broad areas of computer engineering and economic theory to argue that some types of network neutrality regulation may be necessary to optimize innovation. My central critique of her argument is its use of economic theory to bolster one side of a highly politicized debate, rather than using economic analysis to clarify that debate. Van Schewick relies on an impressive array of economic approaches, but fails to acknowledge their ambiguity. Her argument strings together a succession of questionable economic generalizations, thereby greatly weakening her conclusions.

Van Schewick is not alone in using economics in this way. Too many law professors rely on theoretical models but ignore their limiting assumptions, failing to sort through the massive ambiguity inherent in their application. A close examination of van Schewick's argument, therefore, leads to general recommendations for legal interdisciplinary research methods.

On December 23, 2010, the FCC released its landmark "network neutrality" Report and Order ("Order").[1] It prohibits a dominant Internet service provider, such as Verizon or Comcast, from discriminating in favor

* Professor of Law, Director of Intellectual Property, Information, and Communications Program, Michigan State University College of Law.

1. Preserving the Open Internet Broadband Indus. Practices, *Report and Order*, 25 F.C.C.R. 17905 (2010).

of traffic or content that it owns or with which it is affiliated.[2] For example, the Order prohibits Comcast (or any other broadband provider) from blocking or degrading competitor content, such as Netflix downloads.[3]

Washington, D.C. policy pandemonium greeted the Order, releasing the bile accumulated over the past decade of ideological debate over Internet openness. A *Washington Post* headline blared, "FCC Approves Net-Neutrality Rules; Criticism Is Immediate."[4] On the right, House Energy and Commerce Committee Chair, Representative Fred Upton, vowed to "use every resource available . . . to strike down the FCC's brazen effort to regulate the Internet."[5] Senator Kay Bailey Hutchison promised to slash funding to the FCC,[6] and on the *Wall Street Journal*'s opinion page, John Fund labeled the move "a coup" fomented by a cabal of communications communists.[7]

On the left, the reaction was also hostile, with the consensus that the Order had little substance and failed to deliver a meaningful network neutrality regulation.[8] Given that President Obama's campaign promised to enact strong network protection, cries of betrayal echoed through the Internet activist community.[9]

---

2. *Id.* at paras. 62–69.

3. *Id.*

4. Cecilia Kang, *FCC Approves Net-Neutrality Rules; Criticism Is Immediate*, WASH. POST (Dec. 22, 2010, 12:47 A.M.), http://www.washingtonpost.com/wp-dyn/content/article/2010/12/21/AR2010122106110.html.

5. Chloe Albanesius, *Republicans Vow to Take Down FCC's Net Neutrality Rules*, PCMAG.COM (Dec. 22, 2010, 4:25 PM), http://www.pcmag.com/article2/0,2817,2374661,00.asp.

6. Cecilia King, *Sen. Hutchison Moves to Block Funds for FCC on Net Neutrality Rules*, WASH. POST (Dec. 16, 2010, 5:56 PM), http://voices.washingtonpost.com/posttech/2010/12/senator_kay_bailey_hutchison_r.html.

7. John Fund, *The Net Neutrality Coup*, WALL ST. J., Dec. 21, 2010, http://online.wsj.com/article/SB10001424052748703886904576031512110086694.html.

8. *See, e.g.*, Press Release, FCC Net Neutrality Order Falls Short (Dec. 21, 2010), *available at* http://www.publicknowledge.org/public-knowledge-fcc-net-neutrality-order-falls-sh ("[T]he Commission could have established clear rules that would give more protections to Internet users than the one approved today. Instead, these rules will be subject to manipulation by telephone and cable companies."); Press Release, Free Press, Free Press: FCC Net Neutrality Order a 'Squandered Opportunity' (Dec. 21, 2010), *available at* http://www.freepress.net/press-release/2010/12/21/free-press-fcc-net-neutrality-order-%E2%80%98squandered-opport unity%E2%80%99 ("We are deeply disappointed that the chairman chose to ignore the overwhelming public support for real Net Neutrality, instead moving forward with industry-written rules that will for the first time in Internet history allow discrimination online. This proceeding was a squandered opportunity to enact clear, meaningful rules to safeguard the Internet's level playing field and protect consumers.").

9. *See* Dan Gillmor, *The FCC's Weak New "Open Internet" Rules*, SALON.COM (Dec. 21, 2010, 2:45 PM), http://www.salon.com/2010/12/21/fcc_network_neutrality.

The beating of breasts and gnashing of teeth seemed excessive, even bizarre, given the esoteric regulation at issue. After all, as insiders and telecommunication specialists know, the Order itself has big loopholes, such as exempting wireless, rendering it close to toothless.[10] More significantly, it stands on weak jurisdictional grounds that the U.S. Court of Appeals for the D.C. Circuit is not likely to uphold.[11] That the Order, likely never to be law, should cause the policy "Chicken Littles" to see falling skies suggests mass confusion or perhaps, more cynically, efforts to influence the appellate outcome.

In this context, Stanford University professor Barbara van Schewick's book, *Internet Architecture and Innovation*,[12] could not be more timely. It defends Internet regulation, like that which the FCC recently promulgated, as necessary to control Comcast's, Verizon's, and other broadband providers' anticompetitive tendencies[13] and, above all, to ensure the optimal amount of innovation.[14] Van Schewick is a one-time colleague of Larry Lessig, who popularized the "law as code" idea[15] and is a long-time advocate of the "end-to-end" Internet design principle discussed below. Van Schewick's prominent role in Internet debates—the FCC's Order cites and relies on her work in several instances—will make *Internet Architecture* an important and influential contribution within Internet policy debates.

In a nutshell, van Schewick argues that (1) the Internet's "original" so-called "broad" e2e architecture[16] enables all applications; (2) real options economic theory suggests that Internet architecture should enable

---

10. Nate Anderson, *Wireless Gets a Free Pass on New Neutrality*, ARS TECHNICA (Dec. 1, 2010), http://arstechnica.com/tech-policy/news/2010/12/ throttle-away.ars.

11. The Order bases its authority on Title I of the Communications Act, which the D.C. Circuit recently ruled as failing to give the FCC authority to regulate Comcast's blocking of peer-to-peer Internet traffic. *See* Comcast Corp. v. FCC, 600 F.3d 642, 652–54, 660–61 (D.C. Cir. 2010). Verizon has already appealed the Order. Amy Schatz, *Verizon Appeals Net Regulations*, WALL ST. J., Jan. 21, 2011, http://online.wsj.com/article/SB10001424052748704747904576094354292080580.html.

12. BARBARA VAN SCHEWICK, INTERNET ARCHITECTURE AND INNOVATION (2010).

13. *See id.* at 233.

14. *Id.* at 388 ("If the Internet's value for society is to be preserved, policy makers will have to intervene."). Frustratingly, van Schewick does not answer the $64,000 question of *how* they should intervene, but does tell us that "potential policy interventions will have to be more sophisticated than simply requiring network providers to adhere to the broad version of the end-to-end arguments . . . . [but] the broad version is at least a serious contender to be one of the design principles for the future Internet." *Id.* at 388–89.

15. *See* LAWRENCE LESSIG, CODE AND OTHER LAWS OF CYBERSPACE (1999).

16. Van Schewick distinguishes two versions of e2e: "the narrow version only applies to some functions within a system, the broad version applies to the complete functionality of a system." VAN SCHEWICK, *supra* note 12, at 38.

as many different innovators as possible; (3) "modular" Internet design reduces coordination and transaction costs of innovation; (4) dominant network operators have the incentive to discriminate against competing applications providers even if they are more innovative; and (5) evolutionary economic theory suggests more diverse innovators will provide better innovation.[17] Van Schewick then concludes that Internet regulation—of the sort the FCC just mandated in its Order—is necessary to protect Internet innovation.[18]

Internet Architecture's fatal weakness is that none of the areas of economics on which van Schewick builds her argument lends itself to simple conclusions. Disregarding ambiguity in the economic models on which she relies, van Schewick strings together overbroad claims and questionable conclusions to construct *Internet Architecture*. She uses economic theories to support conclusions, but too often neglects to show in a rigorous way why the assumptions that allow the models to produce her results are more believable than opposing ones. Instead, she uses anecdotes to demonstrate theory. While case studies and narrative may be highly effective tools of persuasion, formal economic models are designed for rigorous econometrics (i.e., properly sampled and controlled data). As the old saw goes, the plural of anecdote is not data. When legal academics claim the power of the social science game, they need to keep its rules.

Van Schewick shows that some economic models suggest that Internet regulation *may* enhance innovation. But she does not attempt to address her myriad models' ambiguities or examine data rigorously to conclude whether this result is at all likely. Given that *Internet Architecture* uses economic analysis to justify the specific public prescription of regulating the Internet, this shortcoming is not minor. To paraphrase David Hume, "maybe" does not imply "ought."[19]

Professor van Schewick is not alone. *Internet Architecture* sadly enters a long *syllabus errorum* of interdisciplinary legal telecommunications scholarship.[20] Thus, a close examination of van

---

17. VAN SCHEWICK, *supra* note 12, at 299.

18. *Id.* at 373–75.

19. *See* DAVID HUME, A TREATISE ON HUMAN NATURE 320 (Batoche Books, 1999) (1739) ("In every system of morality, which I have hitherto met with, I have always remark'd, that the author proceeds for some time in the ordinary way of reasoning, and establishes the being of a God, or makes observations concerning human affairs; when of a sudden I am surpriz'd to find, that instead of the usual copulations of propositions, *is*, and *is not*, I meet with no proposition that is not connected with an *ought*, or an *ought not*.") (emphasis added).

20. *See infra* note 68 for a discussion of the work of professor Christopher Yoo.

Schewick's argument leads to recommendations applicable to legal interdisciplinary research method generally.

Building on Lessig's work, van Schewick's work first distinguishes between what she calls the "broad" and "narrow" versions of the e2e network design principle.[21] For nondevotees of Internet wonkery, e2e network design requires that "intelligence" (i.e., application functions) should be located at its "ends" (i.e., the users).[22] The protocols that exchange information between users do not do much except transport.[23] This allows individuals to build-on new applications that can still network and communicate.

To get a sense of what this means, compare e2e network design to its predecessor, the Bell Public Switched Telephone Network ("Bell PSTN") (i.e., how we all communicated before 1995 or so). With e2e, the network smarts are widely distributed and modular. Taking advantage of the Internet's common transport function, users can independently add applications and functions. In the Bell PSTN, by contrast, all the intelligence resided at the switch (i.e., the central place in the network that the telephone company controls). [24] End-users could not add functions; instead, the phone company provided all services (such as voice communications, voicemail, call waiting, speed dialing, and 800 services) centrally.[25]

Notice the tradeoff between e2e and centralized, integrated designs such as the phone network or cable system. Some network functions require greater coordination and centralization than e2e can provide. For instance, the Internet can neither provide the old telephone network's level of security or quality of service, nor match cable systems' video delivery capacity. But the telephone system limits potential uses that e2e permits.[26] Different networks perform some functions better than others.

---

21. VAN SCHEWICK, *supra* note 12, at 41.

22. *Id.* at 88–91.

23. *Id.* at 56.

24. JONATHAN E. NUECHTERLEIN & PHILIP J. WEISER, DIGITAL CROSSROADS: AMERICAN TELECOM POLICY IN THE INTERNET AGE 170 (2005).

25. *Id.*

26. Mark A. Lemley & Lawrence Lessig, *The End of End-to-End: Preserving the Architecture of the Internet in the Broadband Era*, 48 UCLA L. REV. 925, 933 (2001) ("The Internet's design principles are different from the design principles that governed the telephone . . . the telephone network was not governed by the Internet's principle of e2e. It was instead governed by a different end-to-end philosophy--that the telephone company controlled the network from end to end. This meant that AT&T would not be neutral about the uses to which the telephone system could be put. For much of the history of the telephone network, it was forbidden to use the network in ways not specified by AT&T. It was a unlawful, for example, to attach devices that performed services not offered by AT&T

Larry Lessig and Mark Lemley famously argued that e2e plays a necessary role in Internet innovating.[27] Their argument has great appeal. Indeed, the Internet allows program developers to build the applications that define contemporary life—from email and Facebook to Google and YouTube. Innovators can distribute their creations without approval from (or coordination with) providers like Verizon or Comcast. Rather, the Internet protocol "dumbly" provides transport to the ends doing the application-specific computation. Lessig and Lemley argued that we should protect this vitality from Comcast's or Verizon's anticompetitive desire to control matters centrally—transforming the Internet into cable television or the old telephone system.[28] This general policy prescription was known as "network neutrality" and it was what December's controversial FCC Order mandated (in an addlepated form).

Building on Lessig and Lemley, van Schewick identifies two different versions of the e2e argument: the narrow and the broad. The narrow version has a presumption that a "function should not be implemented in a lower layer, if it cannot be completely and correctly implemented at that layer."[29] In other words, the smarts (the error detection and other protocols necessary to run real live applications) should be at the edges when such placement would not impair an application's performance. In contrast, the broad version states that "a function or service should be carried out within a network layer [i.e., available to all clients of the network] only if it is needed by all clients of that layer."[30] Put another way, under van Schewick's broad analysis, if a function is needed by all applications, it *must* be at a lower level to be available to all.

Van Schewick then argues for her broad e2e architecture as the regulation's guiding principle. Even before reaching analysis of van Schewick's use of economics, this claim is fraught. First, it is not clear that any network designer ever adopted the broad e2e architecture. As the quotation from Lessig and Lemley suggests, it was never a formalized rule, but rather an idea that emerged after years of network design, and arguably

---

or to provide services that competed with the services provided by AT&T.").

27. *Id.* at 930 ("The e2e argument organizes the placement of functions within a network. It counsels that the "intelligence" in a network should be located at the top of a layered system—at its "ends," where users put information and applications onto the network.").

28. *Id.* at 936–38.

29. VAN SCHEWICK, *supra* note 12, at 60 (quoting LARRY L. PETERSON & BRUCE S. DAVIE, COMPUTER NETWORKS: A SYSTEMS APPROACH 387 (4th ed. 2007)).

30. *Id.* at 67 (internal quotations omitted).

was never implemented anywhere.[31] Lacking descriptive weight, the claim must be entirely prescriptive.

Second, and much more critically, van Schewick's definition contains circularity and could, in fact, chill innovation. This is a key question, given van Schewick's central goal of protecting innovation. Because the broad version of e2e would require every existing application to have access to Internet transport functionality, it could entrench existing applications and chill the development of applications requiring some specialization at the network level. Further, van Schewick could mean that networks should support any *potential* network application. If this is her meaning, she in effect converts the Internet design into a tremendous subsidy (and innovation disincentive) from network builders to application designers.

Near the end of *Internet Architecture*, van Schewick recognizes this subsidy, which she sees as a tradeoff between "long-term evolvability" of new applications[32] and what she terms "short-term performance optimizations."[33] She argues that we should prefer long-term evolvability, because "there are many more applications that have yet to be invented, which makes the long-term evolvability of the network more important than short-term performance optimizations."[34]

It is not clear, however, that the potential of future applications justifies any particular architecture. Maybe important new innovations require short-term performance optimization. There are things, such as guaranteeing quality of service or providing better security and streaming video, that current Internet design does not do as well as the telephone networks or cable systems. After all, many innovations that people like, such as the Kindle or the iPad, appear to violate the broad version of network neutrality because they do require specialized network and transport functions, rendering their functionality resistant to modular innovation that the broad e2e protects. If van Schewick cannot say why long-term innovation is better than other types, her regulatory prescription based on her preference for long-term evolvability loses its power.

After defining broad e2e, van Schewick turns to economics to show that this broad version leads to greater innovation. First, she asks whether there is an optimal level of innovation.[35] For this, she looks to real options theory, a branch of economics that borrows from finance and portfolio theory by viewing actual investments as bets (not unlike options) on future

---

31. *See* Lemley & Lessig, *supra* note 26 and accompanying text.
32. VAN SCHEWICK, *supra* note 12, at 389.
33. *Id.*
34. *Id.*
35. *See, e.g.*, *id.* at 115–22.

value.[36] She envisions the Internet as a portfolio of investments—of real options.[37] In a novel and interesting move, she then asks what type of network architecture would maximize value.[38]

Not surprisingly, van Schewick concludes that the broad e2e allows for greater diversity of investments, which portfolio theory would prefer.[39] She argues that broad e2e lowers the cost of innovation because it increases modularity, the ability of parts of the Internet to develop independently.[40] Modularity "enables innovation . . . . [that] do[es] not affect the rest of the system," allowing for adoption of innovations that do *not* require systemic network change.[41] And thus, investments in modular networks have lower costs. Further, the rate of change in modular networks will increase with uncertainty because "modular architecture enables innovators to capture the potentially large benefits associated with risky projects and avoid the downsides."[42]

Van Schewick's reliance on real options theory is misplaced. She is no doubt correct that broad e2e encourages more investment (and presumably innovation), but only *innovation of a certain type*—little innovations that do not require greater changes in the network. In other words, broad e2e encourages only those innovations that do not need specialization at the transport layer or other layers. Conversely, modular architecture makes innovations requiring a high level of coordination, such as those involving security or quality of service, *more* expensive. But, just as no one knows if long-term evolvability is better than short-term optimization, no one knows whether little innovations requiring little change in the network are more valuable from an investment perspective than big innovations that affect the entire Internet.

Van Schewick next looks to transaction cost economics to defend the broad version of Internet architecture. Led by Oliver Williamson and others, this branch of economics looks to the costs of information between employees and contracting parties.[43] It asks why some transactions are performed within a firm and others by arm's length market dealings

---

36. *Id.* at 124.

37. *Id.* at 125.

38. *See id.*

39. *Id.*

40. *Id.* at 125–26.

41. *Id.* at 125 (citation omitted).

42. *Id.* at 127; *see also id.* at 145 ("According to real-options analysis, hidden modules with low core costs of innovation may justify a large number of parallel approaches aimed at improving the module . . . .").

43. *See* Oliver Williamson, *Transaction-Cost Economics: The Governance of Contractual Relations*, 22 J.L. & ECON. 233 (1979).

between firms. There are costs and efficiencies associated with both types of transactions. Intrafirm dealings permit lower monitoring costs.[44] They function well in endeavors with high coordination costs, but create agency problems (i.e., employees will do what employers want but may take advantage of them in other ways). Arm's length transactions can eliminate agency costs and work well in endeavors with low coordination costs, but they present higher monitoring costs (i.e., firms typically do not have closely coordinated operations with independent contractors, but do have to make sure that they are not being sold a bill of goods).[45]

Van Schewick argues that modular architecture creates a "cost structure [that] lets a wide range of innovators with diverse motivations and funding models develop new applications."[46] Further, she asserts that "the architecture of the Internet" makes "arm's-length relationships and vertical integration among providers of different components [] equally feasible."[47] Here, she seems to say that modular architecture offers a sort of Williamsonian free lunch. Modularity allows for more actors to innovate and produce applications more cheaply, without raising coordination costs above those that an integrated firm faces.

This claim is quite expansive and potentially quite important. Perhaps it is true, perhaps it is not. However, the economic models van Schewick cites do not demonstrate this importance.[48] Van Schewick does not provide any formal modeling, but instead she supports her claim with many anecdotes.[49] No one can doubt there has been tremendous innovation under modular Internet design pursuant to arm's length transactions. But, again, it has been innovation of a certain type—that which requires minimal coordination. People may want innovations that require greater network integration.

Van Schewick then confronts the central question of Internet regulation: assuming that the broad e2e architecture provides more innovation, do broadband providers, like Comcast or Verizon, have the economic incentive to support the broad e2e design?[50] And, if they do not,

---

44. *See generally id.* at 238–45.

45. *See* OLIVER E. WILLIAMSON, THE ECONOMIC INSTITUTIONS OF CAPITALISM (1985).

46. VAN SCHEWICK, *supra* note 12, at 205.

47. *Id.* at 202.

48. She cites to a dizzying array of economists. Her principal citations to modularity and innovation, CARLISS YOUNG BALDWIN AND KIM B. CLARK, DESIGN RULES: THE POWER OF MODULARITY VOL. 1, (2000), do not make such sweeping arguments. While Baldwin and Clarke do examine conditions in which modularity is optimal, application of their ideas to current Internet markets is not clear.

49. *See generally* VAN SCHEWICK, *supra* note 12, at 297–353.

50. *Id.* at 337.

van Schewick asks whether government should mandate network regulation, as in the FCC's recently released Order, to counter these anticompetitive tendencies.[51] Van Schewick says that foreclosure is likely and regulation necessary.[52]

The question of whether Comcast or Verizon will allow a thousand innovative applications to bloom—or whether they will block competitors—is *the* economic question of network regulation and a perennial question in economic theory.

The laissez faire opponents of Internet regulation point to the "single monopoly" rent theorem to argue against Internet regulation.[53] They argue that because Comcast is already receiving monopoly rents for providing broadband, it can maximize profits by providing the most valuable and diverse offerings.[54] Building on this argument, economists argue that the monopolists can internalize complementary efficiencies and thereby provide content more efficiently than the nonmonopolists.[55]

Economic models for foreclosure are various, complex, and, given that economists write them, ambiguous in their application. Further, as some legal scholars point out, focusing on market power only in the last mile mischaracterizes the Internet market.[56] The Internet is more than Comcast's and Verizon's control of the last mile. The Internet includes the host of backbone providers that constitute the network (the "Internet

---

51. *Id.* at 345–47.

52. *Id.*

53. Davina Sashkin, *Failure Of Imagination: Why Inaction On Net Neutrality Regulation Will Result In A De Facto Legal Regime Promoting Discrimination And Consumer Harm*, 15 COMMLAW CONSPECTUS 261, 297 (2006) ("For example, a company selling monopolized broadband Internet service bundled with a portal service could, per the 'one monopoly rent' theory, only collect one monopoly price for the bundled service; because the company controls the underlying facility and can therefore charge the monopoly price for access to it, monopolizing the complementary portal market would not offer additional profit.").

54. *Id.*

55. Joseph Farrell & Philip J. Weiser, *Modularity, Vertical Integration, and Open Access Policies: Towards a Convergence of Antitrust and Regulation in the Internet Age,* 17 HARV. J.L. & TECH. 85, 103 (2003) ("ICE [the internalizing complementary efficiency theory] maintains that the platform monopolist cannot increase its overall profit by monopolizing the applications market, because it could always have charged consumers a higher platform price in the first place; it has no incentive to take profits or inefficiently hamper or exclude rivals in the applications market because it can appropriate the benefits of cheap and attractive applications in its pricing of the platform. To the contrary, ICE claims that a platform monopolist has an incentive to innovate and push for improvements in its system — including better applications — in order to profit from a more valuable platform.").

56. *See* Adam Candeub & Daniel J. McCartney, *Law and the Open Internet*, 64 FED. COMM. L.J. 493 (2012).

cloud").[57] By ignoring market dynamics deep within the Internet cloud, van Schewick relies exclusively on vertical foreclosure models that arguably have little relationship to reality.[58]

Van Schewick recognizes this ambiguity. Nonetheless, she states that "some general observations are possible,"[59] including that the monopolist broadband provider will use discriminatory pricing to increase its profits to "disadvantag[e] certain classes of applications"[60] and that this "reduce[s] the profits of independent developers of complementary products, thus reducing their incentives to innovate."[61] Van Schewick recognizes, but minimizes, the inherent theoretical ambiguity that weakens her argument.[62]

This whole section jars the reader. Van Schewick describes, in great detail, exceptions to the single monopoly rent theorem.[63] But she follows, with little argument, as to whether these exceptions in fact apply to the Internet. Such argument would require teasing apart the multitude of foreclosure models, identifying their assumptions, and using the best empirical data to see which sets of assumptions best fit the data. The seriousness of van Schewick's work, and her own scholarly ambitions, require her to take these additional steps.

Finally, van Schewick argues that decentralized architectures create more innovation, looking to evolutionary economics to make her point.[64] Evolutionary economics models innovation like natural evolution. It breaks from traditional economics in that it assumes that actors work under Knightean uncertainty.[65] Economics generally holds that actors can estimate risk; Knightean uncertainty holds that risk is not susceptible to estimation.[66] In other words, Knightean uncertainty holds that actors know future events are uncertain, but cannot attach a number to their probability of occurrence. As in blind evolution, evolutionary economics predicts that

---

57. Rob Frieden, *Internet 3.0: Identifying Problems and Solutions to the Network Neutrality Debate*, 1 INT'L J. COMM. 461, 474 & n.47 (2007) ("The Internet cloud refers to the vast array of interconnected networks that make up the Internet and provider users with seamless connectivity to these networks and the content available via these networks.").

58. *Id.*

59. VAN SCHEWICK, *supra* note 12, at 277.

60. *Id.*

61. *Id.* at 281.

62. *Id.* at 471 n.238.

63. *See id.* at 230–62.

64. *See id.* at 280–82.

65. RICHARD A. POSNER, THE CRISIS OF CAPITALIST DEMOCRACY 289 (2010) ("Knight . . . distinguished . . . between calculable risk—risk to which a numerical probability can be assigned . . . —and uncertainty, to which a numerical probability and distribution cannot be assigned with any confidence that it is correct.").

66. *Id.*

better results come from diverse populations. Van Schewick claims "[n]ot only will a large, diverse group of potential innovators discover a larger number of opportunities for innovation than a small group of homogenous network providers; they will also realize a larger number of the opportunities that were discovered."[67] Thus, van Schewick concludes regulation must ensure network neutrality to ensure a diversity of innovation.

Van Schewick is probably correct that evolutionary economics shows in general that greater diversity leads to greater innovation. But evolutionary economics in no way points to the optimal level of innovation. Investment costs money. There is a tradeoff between this cost and the payoff from innovation investment, including opportunity costs. Van Schewick fails to acknowledge that at some point there is a diminishing return to investing in diversity. She therefore cannot say when the benefit of preserving broad e2e exceeds its costs.

Further, van Schewick's reliance on evolutionary economics and its Knightean uncertainty to determine the value of Internet investment leads to another contradiction. She previously relied on real options theory, which explicitly assumes that risk for Internet applications can be estimated. Either uncertainty in Internet application development resists estimation, or it does not. Switching bedrock theoretical assumptions undermines the power of both analyses.

Van Schewick has shown that it is plausible that her broad e2e promotes innovation. The weakness of her economic analyses, for economists, is that she pays too little attention to the likelihood of her claim's correctness. Under certain conditions, her economic conclusions may be correct. But, van Schewick does not investigate in a rigorous way what those conditions are or how likely they are. Indeed, even if we posit a two-thirds chance that she is correct about each step in her argument, the odds that she would be correct on all steps would be quite low.

This critique of van Schewick's work is applicable to a distressing amount of law and economics research, perhaps because of foundational differences in methodology. When an economist develops a model, the model formalizes an intuition, showing the precise parameters and assumptions for which it is valid. Surprising theoretical results expand our understanding of the logically and mathematically possible mechanisms working in the world.

Legal academics, however, must go beyond the merely possible and show the advisability of a given rule. This requires insight into likelihood.

---

67. VAN SCHEWICK, *supra* note 12, at 301.

In its selective use of economic theory, *Internet Architecture* is sadly not alone. Rather, it reflects a disturbing, perhaps endemic trend in communications legal scholarship—on both the right and left—to latch on to some model, treat it as truth, and avoid critically engaging its limitations and assumptions.[68]

---

68. Christopher Yoo, fierce opponent of network neutrality regulation and van Schewick's ideological enantiomer, often does the same thing. To take one particularly glaring example, Yoo's articles on Fifth Amendment regulatory takings all depend upon what is known as the efficient component pricing rule ("ECPR"). *See, e.g.*, Daniel F. Spulber & Christopher S. Yoo, *Access to Networks: Economic and Constitutional Connections*, 88 CORNELL L. REV. 885, 993–96 (2003) [hereinafter Spulber & Yoo, *Access to Networks*]. This theory holds that when a regulator mandates interconnection between a competitor and incumbent network (i.e., a formerly regulated monopolist such as AT&T), the price the competitor pays must include "lost profits" that the monopolist was not permitted to make during its regulated existence. *Id.* Or, as Yoo puts it:

> The proper cost valuation of making an input available is the direct cost of the input plus the reduction in the value of the output. Thus, prices set at economic cost of an input must represent the sum of the direct incremental cost of providing the input and the opportunity costs associated with providing the input to a competitor.

Id. at 906; *see also* Daniel F. Spulber & Christopher S. Yoo, *Toward a Unified Theory of Access to Local Telephone Networks*, 61 FED. COMM. L.J. 43, 95–96 (2008) (advocating EPCR); Daniel F. Spulber & Christopher S. Yoo, *On the Regulation of Networks as Complex Systems: A Graph Theory Approach*, 99 NW. U. L. REV. 1687, 1713 n 53 (2005) (advocating EPCR). Spulber and Yoo go so far as to argue that the Fifth Amendment Takings Clause mandates use of EPCR by regulators. Spulber & Yoo, *Access to Networks*, *supra*, at 1023–24. Incumbent telephone companies, of course, adore this theory because it requires new entrants to pay very high interconnection rates, but the Supreme Court explicitly rejected the ECPR. *See* Verizon Comm., Inc. v. FCC, 535 U.S. 467, 514 (2002). Leading scholars have also thoroughly debunked the ECPR as a rule that the Constitution mandates. *See* Jim Chen, *The Death of the Regulatory Compact: Adjusting Prices and Expectations in the Law of Regulated Industries*, 67 OHIO ST. L.J. 1265, 1313 (2006) ("The futile effort to constitutionalize any ratemaking rule, let alone a backward-looking methodology that repudiates decades of regulatory wisdom, runs into the teeth of Supreme Court doctrine."). But for the purposes of this Review, what is significant is that economists' opinions are, to say the least, highly mixed about ECPR's theoretical validity. In the words of Nicholas Economides, an international leader in the field of network economics at the New York University,

> "In economics, typically 'efficient' is meant to be 'socially efficient,' that is, maximizing total social welfare or total surplus. Does the ECPR or the M-ECPR, in general, maximize social surplus? Absolutely not! Although the rule has been debated for the last 18 years, neither its creators nor its present supporters have ever provided a proof that the use of either of these two rules maximizes social surplus . . . ."

Nicholas Economides, *The Tragic Inefficiency of the M-ECPR*, *in* DOWN TO THE WIRE: STUDIES IN THE DIFFUSION AND REGULATION OF TELECOMMUNICATIONS TECHNOLOGIES 142, 144 (Allan L. Shampine ed., 2003). Yet, one searches in vain in Yoo's writings for an acknowledgement of the limits of the theory he espouses with such vigor. Despite their ideological differences, both he and van Schewick base their legal scholarship on blinkered economic predicates.

Well, so what? Lawyers and judges selectively use expert economic opinions and their models, so why not legal academics? Yet legal academics have a duty to get at the right answer, not simply advocate a model. This requires recognizing a model's limitations, assumptions, and, above all, likely applicability to the real world. Failure to adhere to this principle diminishes legal scholarship. When legal scholars forcefully assert that some other field has clear and valuable insights for the law, as van Schewick does,[69] they are usually addressing a scholarly audience without background in that other field. Without explicitly teasing out the limits of their theories, such scholarship incompletely engages the readership, potentially reducing scholarly debate to slogans or ideological predilection now resting on the mystique and irrefutability of another discipline.

This returns us to where this review started—the absurdly partisan debate surrounding network neutrality. Legal scholarship could bring some *lux* to the *aetas* through critical examination of economic models of Internet behavior and empirical data, in order to analyze their implications for regulation. Shoehorning the Internet into economic models that serve one particular ideological view hardly achieves that goal. Legal scholarship must do better.

69. VAN SCHEWICK, *supra* note 12, at 2 ("After decades of research on innovation, we understand how changes in law, in norms, or in prices affect the economic environment for innovation and how they affect innovators' decisions to innovate.").