MONOPOLIZATION VIA VOLUNTARY
NETWORK EFFECTS

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The term "voluntary network effects" (VNE) requires some elucidation. Network effects have long been known to influence market dynamics in numerous and diverse ways, including potential tipping to monopoly, generating path dependence, and strengthening the advantage of a large installed base.[1] Many scholars have studied the competitive implications of network effects in a wide variety of contexts, and legal applications abound.[2]

Nonetheless, most of these studies assume network effects are an exogenous product characteristic, either present or not—depending on the product in question. Simply put, network effects are assumed to exist wherever the utility garnered from use of the product increases with the number of other users. Users of the product are considered within the same "network" when interaction (direct or indirect) exists. If similar products are incompatible, they create separate networks, and com-

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[1] The basis for analysis of network effects was laid by Jeffrey Rohlfs, *A Theory of Interdependent Demand for a Communications Service*, 5 BELL J. ECON. 16 (1974). *See also* Joseph Farrell & Garth Saloner, *Standardization, Compatibility, and Innovation*, 16 RAND J. ECON. 70 (1985); Joseph Farrell & Garth Saloner, *Installed Base and Compatibility: Innovation, Product Preannouncements, and Predation*, 76 AM. ECON. REV. 940 (1986); Michael L. Katz & Carl Shapiro, *Network Externalities, Competition, and Compatibility*, 75 AM. ECON. REV. 424 (1985). For a general easy-to-read survey, see Michael L. Katz & Carl Shapiro, *Systems Competition and Network Effects*, J. ECON. PERSP., Spring 1994, at 93.

[2] For an extensive survey, see Joseph Farrell & Paul Klemperer, *Coordination and Lock-In: Competition with Switching Costs and Network Effects, in* 3 HANDBOOK OF INDUSTRIAL ORGANIZATION 1967–2072 (Mark Armstrong & Robert H. Porter eds., 2007).

petition among networks arises—usually with each vying for market leadership via increase of network size.[3]

VNE go beyond this basic assumption. These are network effects that need not exist but for strategic decisions by the firms in question. When network effects can be added to an otherwise standard product or can be enhanced beyond exogenously given levels, the added term "voluntary" is appropriate. Here, the archetype is a stand-alone product, initially exhibiting no network effects at all, to which the producing firm "adds-on" collaboration benefits between users, either through technological change or through pricing tactics.

A product considered "standard" is thus transformed into a "network product"—shifting market dynamics in the process. In the extreme, competition in the market, which previously relied on the product's characteristics and their appeal to consumers, turns into "competition for the market" as a winner-takes-all dynamic emerges.

This article is a first step towards understanding the nature of VNE, their applications in commercial endeavors, and especially their antitrust implications. Being a preliminary investigation, I will focus on the basic structure VNE might take, when firms would choose to introduce them, and their effects on consumers. Applications where VNE currently operate will be used to illustrate their dynamics, and motivate further research. The legal ramifications—i.e., whether to classify VNE as active pursuit of monopoly power and, thus, illegal under Section 2 of the Sherman Act, will be discussed in light of the welfare implications of potential uses and abuses of VNE. Finally, I will outline a number of future directions for research and areas where VNE are likely to be employed, as well as the structure they might take.

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[3] Farrell and Klemperer focus on choice of compatibility in their description of endogenous network effects. *See id.* While compatibility affects network structure and thus appropriation of network benefits by individual firms, it is irrelevant where the network effects themselves have not yet been added on to the product in question—the issue at stake here. For studies of strategic incentives of this sort in the bank ATM market, see Christopher R. Knittel & Victor Stango, *Incompatibility, Product Attributes and Consumer Welfare: Evidence from ATMs* (Nat'l Bureau of Econ. Research, Working Paper No. 10962, 2004); Christopher R. Knittel & Victor Stango, *Compatibility and Pricing with Indirect Network Effects: Evidence from ATMs* (Nat'l Bureau of Econ. Research, Working Paper No. 10774, 2004); Garth Saloner & Andrea Shepard, *Adoption of Technologies with Network Effects: An Empirical Examination of the Adoption of Automated Teller Machines*, 26 RAND J. ECON. 479 (1995). A more general analysis can be found in Neil Gandal, *Compatibility, Standardization, and Network Effects: Some Policy Implications*, 18 OXFORD REV. ECON. POL'Y 80 (2002), and Richard J. Gilbert, *Symposium on Compatibility: Incentives and Market Structure*, 40 J. INDUS. ECON. 1 (1992).

I. GUIDING EXAMPLES

Video games are a useful example of VNE. These have been in existence for decades, first appearing in specialized machines placed in arcades, moving on to production for home use, and finally approaching their current form when consoles were made that could accommodate a variety of games imprinted on interchangeable silicon chips. The ability to choose among several games made for one platform introduced indirect network effects, insofar as each player benefited from the availability of a wide variety of available games and the increasing number of games playable on a specific console increased the demand for that specific console. Conversely, increasing the customer base using a specific console increased the number of console-compatible games offered. Note the difference from the more commonly discussed direct network effects, which arise from interaction between users, such as the ability to work on each other's files in software industries or the ability to communicate with other users in telephony applications.[4]

Indirect network effects are created through interaction of users with suppliers, rather than with other users. In the video game example, users value variety in game titles. The larger the number of customers using a specific console, the more games will be produced for that console. Thus, from the user's perspective, purchasing a popular console creates a benefit because game developers are likely to continue producing additional games that the users may select from later on. Here, consumers do not collaborate directly, but still benefit each other through their joint effect on producers.[5]

The situation changed markedly with the introduction of online play. First, through computers' Internet connections, and then through add-on components to game consoles, video game players found themselves benefiting from the popularity of their particular console and game title

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[4] Software is probably the most obvious and well-known example of network effects within legal scholarship. Telephony (from basic landline telephones, through facsimile applications, and onwards with seemingly never-ending innovation as to new applications) is the original guiding example. Both will be discussed below.

[5] For a comparison of direct and indirect network effects, see Nicholas Economides & V. Brian Viard, *Pricing of Complements and Network Effects* (N.Y.U. Working Paper No. EC-05-12, 2007, rev. 2010), *available at* http://ssrn.com/abstract=407280; Nicholas Economides & Lawrence J. White, *One-Way Networks, Two-Way Networks, Compatibility, and Public Policy* (N.Y.U. Working Paper No. EC-93-14, 1994, rev. 2008), *available at* http://ssrn.com/abstract=6519.

The type of competition that emerges is referred to as "platform competition" and analyzed in the two-sided-markets literature. An excellent overview is provided by Roberto Roson, *Two-Sided Markets: A Tentative Survey*, 4 Rev. Network Econ. 142 (2005). For a discussion of applications and directions in current research, see Jean-Charles Rochet & Jean Tirole, *Two-Sided Markets: A Progress Report*, 37 RAND J. Econ. 645 (2006).

when seeking additional players to collaborate with. Direct network effects were introduced to the market through the manufacture of these add-on components (e.g., modems designed to attach onto previously stand-alone consoles), causing gamers to take into consideration not only price and quality, but popularity of games as well.

Introduction of direct network effects into the video game market did not occur on its own. In order to facilitate this change, firms were required to invest first in research and development, and later in supporting an infrastructure to sustain collaboration. Firms considering these types of investments need to take into account not only the direct implications vis-à-vis the market they currently operate in, but also the shift in market dynamics induced by direct network effects. In the extreme, market structure may be affected, transforming a (relatively) competitive framework accommodating many firms into a winner-take-all race for monopoly status. A less extreme description would view "standard" and "network" markets as two extremes of a continuous scale, with the online component introduction as a shift towards "network" status, strengthening network effects in the video console market.

These dynamics affect not only the firm in question, but also other firms in the market, as well as consumers. All involved find themselves required to adapt to a changing marketplace, where the change was induced by one firm's decision to voluntarily introduce network effects. If this change makes the market more conducive to monopoly, allowing a firm to more readily create or maintain monopoly power, antitrust concerns might arise.

Another example of voluntary network effects is the advent of "free in-net" calling plans in the cellular market. These plans are essentially a pricing mechanism that firms with large market shares can use to their advantage. Consumers considering which cellular phone to purchase could previously count on technological compatibility (mandated by regulation) to create one large network of telephone users. Direct network effects were long realized in this market, as each user's benefit from subscribing to a phone network increases with the number of other subscribers she can reach (regardless of their provider). Since all landline, cellular, and even broadband phones are equally able to interconnect, no one company could appropriate the network benefits.

All this changed when cellular companies (Verizon followed by Cingular and others in the United States) introduced "free in-net calling." When in-net calls are free, subscribers benefit from joining a large network, as chances are higher that they can find a potential contact subscribing to the same network and enjoy free telephone conversa-

tions. Obviously, no firm will offer truly free calls; thus the cost of these calls is defrayed either by marking up off-net calls, or increasing the monthly fixed-fee that makes up most of the bill.[6] Nonetheless, from the consumers' point of view, these plans created a direct network effect that might be taken into account when deciding which firm to subscribe to.

When competition is along dimensions of network size, concerns arise as to the prevalence of path-dependence, the ability of new entrants to compete with long-standing firms, and the monopoly rents associated with markets that tip, rather then accommodate, many firms.[7] In such circumstances, public policy concerns and the potential for monopolization need to be addressed.[8]

While many more examples of VNE exist, the two noted above represent two distinct types: those creating technological network effects and those arising purely from pricing practices. Technological VNE belong to the broad class of network effects most often studied—where consumers gain utility from direct collaboration in using the product in question. Exogenous technological network effects are studied in the software and telephony examples, and the video game add-on component allowing for online play creates a similar dynamic, through strategic firm investment—hence the added term "voluntary."

Price-mediated network effects (PMNE), on the other hand, are those which depend purely on price to create incentives for consumers to coordinate their purchases, increasing industry concentration. In cases of pure PMNE, consumers do not collaborate post-purchase; thus they gain from an increase in network size only insofar as this reduces their purchase price.[9]

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[6] To the extent that the cost of providing in-net communication is lower, there is a technologically determined economy of scale operating here as well. It is important to note, though, that the consumer network effect is the major strategic goal assessed here, above and beyond true cost savings that may result from increasing the firm's size. The discount offered to consumers for in-net calls can thus be much higher than the true difference in costs.

[7] *See, e.g.*, Daniel L. Rubinfeld, *Antitrust Enforcement in Dynamic Network Industries*, 43 Antitrust Bull. 859 (1998).

[8] *See, e.g.*, Timothy F. Bresnahan, *Network Effects and Microsoft* (Stanford Inst. of Econ. Pol'y Research, Working Paper No. 00-51, 2001), *available at* http://www.stanford.edu/group/siepr/cgi-bin/siepr/?q=system/files/shared/pubs/papers/pdf/00-51.pdf; David S. Evans & Richard Schmalensee, *Some Economic Aspects of Antitrust Analysis in Dynamically Competitive Industries* (Nat'l Bureau of Econ. Research, Working Paper No. W8268, 2001).

[9] For brevity, the focus here is on purchase price as a one-time deal. Nonetheless, continuous pricing is an important issue here as well. Where payment is for continued use (subscription rather than purchase), price could depend on the size of the network, so that future changes affect future payments. Current purchasers will rationally take expec-

The difference between technological and price-mediated VNE is explored below, as are the public policy implications of firms' ability to induce network effects to begin with. One implication for public policy looms large: if firms are able to transform the market in which they operate into a network-driven one, gaining market share in the process, this may, to some, sound like an investment in creating monopoly. Actively pursuing such a strategy might then be interpreted as "willful acquisition . . . [of monopoly] power," illegal under Section 2 of the Sherman Act.[10] While "competition for monopoly" may be tolerated as a necessary attribute of network markets, this may not be so for markets where "standard" competition may have existed absent deliberate introduction of voluntary network effects.

Classifying the introduction of voluntary network effects as illegal monopolization is problematic. Restricting investment in technological innovation is not something one should take lightly, especially as the focus here is on technology allowing for collaboration among consumers, presumably increasing the utility gained by the product's use. Similarly, antitrust intervention in firms' pricing practices may stifle innovation in business strategies, as well as unnecessarily constrain firms from adapting to a constantly shifting marketplace. The fact that the most obvious examples for VNE come from high-tech markets, where innovation is fast-paced, should give one pause before recommending intervention. I will therefore examine the effects of VNE on consumer welfare and efficiency for each case separately, returning then to assess the appropriate public policy response.

II. TECHNOLOGICAL VNE

The basic method of describing network effects is modeling utility from a product's use as: $U = a + \beta N$, where a describes the product's "inner" benefit, the direct enjoyment of its use by the consumer, and βN the "outer" network benefit, the utility gained due to the existence of

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tations of network size into consideration, creating a dynamic not only of competition for users later on, but competition for effect on current users' expectations. The "chicken-and-egg" problem of expectations driving results, prevalent in network markets, is thus introduced by firms through pricing tactics alone.

[10] United States v. Grinnell Corp., 384 U.S. 563, 570–71 (1966). *See also* Timothy J. Brennan, *Saving Section 2: Reframing U.S. Monopolization Law, in* THE POLITICAL ECONOMY OF ANTITRUST 417, 424–25 (Vivek Ghosal & Johan Stennek eds., 2007); *see generally,* Avishalom Tor, *Unilateral, Anticompetitive Acquisitions of Dominance or Monopoly Power, infra* this issue, 76 ANTITRUST L.J. 847 (2010). For a discussion of the necessity of showing actual harm versus potential for harm, see Timothy J. Muris, *The FTC and the Law of Monopolization,* 67 ANTITRUST L.J. 693 (2000), and David A. Balto & Ernest A. Nagata, *Proof of Competitive Effects in Monopolization Cases: A Response to Professor Muris,* 68 ANTITRUST L.J. 309 (2000).

other users. In this formulation, β is the measure of network benefit (usually assumed to be constant), and N denotes the number of users. Modeling voluntary network effects essentially relaxes this assumption, so that the measure of network benefit is determined by firm investment. Consumer demand, often modeled via the linear equation $D(p) = 1 - p$, can thus be modified slightly as $D = 1 - p + vN$, a combination of standard linear demand and a voluntary network component, vN. N continues to denote the number of users purchasing the product, while v is determined by firm investment (such as development and marketing costs of new online capabilities, or maintaining a server upon which interaction is facilitated). Thus, demand remains negatively affected by price but also positively affected by firm investment in network characteristics and the number of existing users of the product (each of whom also gains from other existing users, creating the "chicken and egg" dynamic of network industries).

Investment in technological VNE is similar to investment in other research and development strategies. Innovation does not always pay off, as development of a technology allowing for cross-consumer collaboration is not guaranteed to succeed. Nonetheless, the striking difference from other investments in innovation is that the upside here is not only commercial success, but potential monopoly as well.

Where VNE are successful, transformation of the market is achieved. Most models of network markets assume competition between providers of the network good, leading to a tipping dynamic. The issue of tipping arises when consumers benefit from a larger network and the firms in question provide an identical good—differing only in network size. Of course, products need not be perfectly homogeneous. The network dynamic is stressed where competition centers on network size rather than product-specific quality—in the mathematical terminology above specifying the user's utility function as $U = a + \beta N$, where the difference in βN trumps any difference in α. Since along the network dimension "bigger is better," an initially small difference (in actual or anticipated market share) will quickly cascade into all-out monopoly, as each additional consumer on the network makes the advantage loom larger still for subsequent adopters.[11]

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[11] This dynamic underlies issues of path-dependence, as addressed by Paul A. David, *Clio and the Economics of QWERTY*, AM. ECON. REV., May 1985, at 332. On the other hand, there are those who dispute the inefficiency of that result specifically, and the prevalence of market-shifting network effects more generally. *See* S.J. Liebowitz & Stephen E. Margolis, *Network Externality: An Uncommon Tragedy*, J. ECON. PERSP., Spring 1994, at 133.

When the network effect in question is voluntary in nature, tipping will not always occur. Since the network characteristic can be introduced by one firm as an add-on to an existing product, one may observe cases where only one firm provides a network good, while still in competition with others providing the same good absent the network component. Multiple equilibria exist where the result is not tipping towards monopoly, but the emergence of differentiated competition. In essence, some consumers will flock to the VNE-introducing firm, while others will continue to purchase the standard good, attracted by a lower price or other features of competing products.[12]

Telling which cases will lead to tipping and which will allow differentiated competition to persist is easier in theory than in practice. One parameter is of utmost importance, and that is the strength of network effects. In order for a market to tip to monopoly after VNE introduction, consumers' benefit from collaboration must be sufficiently high to outweigh the higher price they will be required to pay for the network product. When one firm introduces VNE while others are still able to offer the standard product, consumers are basically offered a choice between the two versions. Essentially, what were previously homogeneous goods are now differentiated and allow for multiple equilibria where some consumers prefer the network good to the standard one, and some prefer the latter's low price and are willing to forgo collaboration.

Predicting ex ante which markets will tip and which will retain differentiated competition is possible, but requires a precise estimate of the strength of network effects introduced. The problem is that estimation of the strength of network effects is a difficult endeavor, requiring much data on consumers' preferences.[13] What makes this even more problematic is that in order to avoid tipping, intervention must be carried out prior to the good's introduction, otherwise any public policy response would be "too little, too late." Estimating the strength of network effects of an innovation, prior to its implementation, is an ambitious project, unlikely to be attainable in practice.[14]

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[12] Presenting the full model and formal proofs of the propositions discussed is beyond the scope of this paper. *See* Adi Ayal, Voluntary Introduction of Technological Network Effects (Apr. 15, 2009) (unpublished manuscript, on file with author).

[13] For an attempt at empirical analysis of network effects, see Marc Rysman, *Competition Between Networks: A Study of the Market for Yellow Pages*, 71 Rev. Econ. Stud. 483 (2004). One should keep in mind that network strength may depend not only on the product, but other attributes of the firm itself, or consumer perception thereof. *See, e.g.*, Venkatesh Shankar & Barry L. Bayus, *Network Effects and Competition: An Empirical Analysis of the Home Video Game Industry*, 24 Strategic Mgmt. J. 375 (2003).

[14] Even ex post measurement of network effects is a difficult endeavor, as other factors complicate analysis and are difficult to extrapolate. *See, e.g.*, Toker Doganoglu & Lukasz

Here theory helps. Modeling the issue shows that while introduction of VNE by one firm may lead to tipping, neither consumer surplus nor aggregate efficiency need be harmed.[15] The problem, though, is that as far as the legal definition employed, VNE introduction in the aim of achieving monopoly might still be viewed as illegal monopolization, regardless of the ultimate true effect on consumers.[16]

From a dynamic perspective, VNE introduction by one firm may be aimed not at present profits, but at shifting a market to monopoly only to extract rents in future periods. For this to be relevant, though, the market in question would have to exhibit significant entry barriers, blocking both new entrants and existing competitors from introducing VNE of their own. Generally, one would expect that innovation by one firm be quickly followed by similar components being offered by competing firms, leading back to symmetric competition, only now in network products rather than standard ones.

The benign result of VNE introduction by one firm benefiting consumers and efficiency undergoes a slight change if other firms' responses are taken into account. When firms compete in a network market offering incompatible but homogeneous goods, the expectation is that consumers will cascade toward one firm or the other in their quest to maximize the utility gained from collaboration within a network. Basically, three equilibria are possible: two involving tipping toward one firm or the other, and the third, a knife-edge result of consumers splitting between the two. Having the market split maintains competitive pressure on the offering firms; hence the result that both consumer welfare and efficiency are always enhanced by VNE introduction in the splitting equilibrium.

The problem, however, is that knife-edge results are inherently unstable. Their very existence depends on equality among the offers made by firms, insofar as each generating identical benefits for participating con-

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Grzybowski, *Estimating Network Effects in Mobile Telephony in Germany*, 19 INFO. ECON. & POL'Y 65 (2007) (attempting to overcome these difficulties in the context of cellular markets).

[15] This is true when the increase in consumer welfare derived from collaboration overcomes the decrease in welfare due to monopoly pricing. In the presence of potential competition from the standard product, consumers essentially choose their preferred balance between price and compatibility. *See* Ayal, *supra* note 12 (providing a precise analysis).

[16] Spectrum Sports, Inc. v. McQuillan, 506 U.S. 447 (1993). *See generally* 3B PHILLIP E. AREEDA & HERBERT HOVENKAMP, ANTITRUST LAW ch. 8 (3d ed. 2008) (reviewing the law of attempt to monopolize); Herbert J. Hovenkamp, *The Legal Periphery of Dominant Firm Conduct* (Univ. of Iowa Legal Stud., Research Paper No. 07-21 2007), *available at* http://ssrn.com/abstract=1014426. *See also infra* text accompanying notes 25 and 32.

sumers. These benefits depend on network size as well as the network component itself. Since consumers' choice is based on their beliefs of benefits to be garnered, not only physical aspects are important, but also consumer perceptions thereof, as well as consumer expectations regarding future growth (which will, in turn, affect benefits from collaboration). Thus, small perturbations may cause one firm's offer to attract more consumers, immediately leading to a cascade towards one of the firms.

With non-homogeneous products, market splitting is easier to explain, as differentiated competition is possible. Still, differentiated goods are subject to competition between them as well; thus the network dynamic elaborated here remains relevant. The difference is one of degree—whereas homogeneous goods are identical and VNE introduction becomes the sole distinction analyzed, differentiated goods enjoy a consumer-perception "wedge" between them. Thus, the extreme result of complete tipping to monopoly in the homogeneous case is somewhat mitigated when product differentiation exists. In short, the extent of monopoly enjoyed by a VNE-introducing firm may be attenuated by pre-existing differentiation. Real-world applications typically include at least some extent of differentiation, as even technologically identical products may be perceived differently by consumers, due to firm reputation, branding efforts, and the like. The extent of harm to consumers (and aggregate efficiency) continues to depend on the strength of network effects introduced by the firms, both as a measure of the benefit of collaboration and in comparison to the relative importance of differentiation. Tipping to monopoly, which can occur in either the homogeneous or differentiated case, remains a source of potential consumer harm.

III. VOLUNTARY PRICE-MEDIATED NETWORK EFFECTS

Generally stated, price-mediated network effects are created whenever a firm uses prices to confer upon consumers a benefit from concentrating collective purchases with that firm. From the consumers' point of view, such a pricing scheme creates incentives for coordination, leading their purchase decision to be guided (among other considerations) by their expectation of other consumers' behavior.

Similar to the case of technological VNE, PMNE allow firms to unilaterally transform the market into one dominated by network competition. Still, it is important to remember that more than a pricing strategy is required. In perfectly competitive markets, PMNE bestow no advantage on the firm, as concentration in itself yields no profit for the firm that it might pass on to its consumers. Without a real economic benefit

from concentration, no firm can offer better terms in the long term. In other words, if the benefit to one firm of selling to an additional consumer is the same as other firms derive from selling to that same consumer, none of them has an underlying advantage to utilize and PMNE will be irrelevant.

The interesting question then is: what interaction, if any, is there between exogenous factors inducing concentration and the use of PMNE? In another study, two such factors were assessed: the presence of technological network effects and economies of scale.[17] In both cases, concentration is efficient, though for different reasons. With technological network effects, consumers derive utility from the fact that others have purchased the same (or a compatible) good, as collaboration between them is now possible.[18] With scale economies, productive efficiencies are realized by the firm as quantity increases. Essentially, these are demand-side and supply-side advantages to size, respectively, both factors inducing concentration in the market.

One caveat should be noted: basing the discussion on assumptions of efficient concentration naturally leads to a relatively benign interpretation of PMNE. The fact that one firm ends up dominating the market does not cause welfare loss itself, although if it is able to extract monopoly rents, allocative inefficiency may occur. Where entry barriers are high, present-period monopoly may lead to future-period high prices, requiring consumers to make intertemporal tradeoffs when considering the benefits offered by PMNE.[19] Nonetheless, such concerns with network markets and natural monopolies generally have been studied extensively elsewhere, and the contribution aimed for in this paper is the added complexity when PMNE are used.

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[17] Adi Ayal, Strategic Introduction of Price-Mediated Network Effects (Apr. 15, 2009) (unpublished manuscript, on file with author).

[18] We focus on incompatible products, as only then do firms compete on the dimension of network size. When products are compatible, the relevant network for consumers includes those purchasing other firms' goods as well, thus tipping never arises as a competitive concern.

[19] The ability of consumers to rationally assess intertemporal tradeoffs is not an obvious assumption to make. Perfect foresight as to future periods is more easily modeled in theory than achieved in practice. Introducing present-biased preferences (or myopia) seems adequate if we are aiming at understanding real-world dynamics. In such a framework, firms will offer deals granting current benefits at the expense of future costs. The competition for network dominance in real-world applications is likely to include such dynamics. Still, the current exposition is complex enough to warrant abstraction away from these issues. Forthcoming applications and case studies should undoubtedly include them. For a theoretical analysis of competition where consumers differ in their attention to such issues, see Xavier Gabaix & David Laibson, *Shrouded Attributes, Consumer Myopia, and Information Suppression in Competitive Markets*, 121 Q.J. Econ. 505 (2006), and Kfir Eliaz & Ran Spiegler, *Contracting with Diversely Naïve Agents*, 73 Rev. Econ. Stud. 689 (2006).

When considering pricing strategies, the obvious benchmark to measure against is the prevalent use of uniform prices. It is here that PMNE show their full strength. When one firm sets a uniform price, a competitor introducing PMNE will be able to attract all consumers, pushing the first out of the market. PMNE thus transform competition, as either all or none of the firms in a market will offer them. While competition between firms simultaneously offering PMNE is still possible, in many markets firms differ in their ability to offer PMNE, as this depends on branding, consumer perception and trust, the firms' ability to bundle products and create customer loyalty through consumer clubs, and more. It is possible that very few, or even just one, will survive in such an environment.

As explained above, offering PMNE requires a means of assuring consumers that price will indeed fall with quantity supplied. When consumers purchase sequentially, this may be very difficult to do. One firm may enjoy an advantage in reputation, due to a long term of incumbency in the market, successful branding, investment in advertising, or a variety of other reasons. When this is true, consumers may be more willing to believe promises made (or pricing mechanisms offered) by that firm, trusting it to implement PMNE while requiring more assurances from its competitors.

It is here that the question turns to methods of implementing PMNE. In a static simultaneous-choice model, firms are assumed to make credible commitments which consumers take as binding. Models can be easily built such that consumers choose which firm to buy from based on a menu of prices, discovering only later whether they receive the discount associated with other consumers choosing the same firm. In most markets, though, consumers are not willing to "bet" on the price they pay, instead requiring an exact quote before committing to purchase. Most firms' offers of uniform prices cater to this preference, but if one is able to more successfully convince consumers of its PMNE plan, it may be able to dominate the market.[20]

There are methods of offering PMNE other than asking consumers to agree to contingent pricing. Average cost pricing in the presence of scale economies is one example. An alternative, becoming more relevant with the prevalence of information-economy goods, is subscription pricing. In subscription pricing, consumers pay per period of use, where prices are usually guaranteed only in the short term, if at all. Wireless

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[20] While "betting" on prices sounds unattractive, it is quite similar to the more prevalent assumption that consumers purchase network goods based on their expectation of future benefits, which in turn are dependent upon the future growth path of the network.

calling plans and bank accounts, for example, often enjoy enhanced customer loyalty through increased (physical as well as psychological) switching costs. Prices may change throughout the firm-customer relationship in a way impossible to anticipate ex ante, in addition to the product itself undergoing transformation due to changes in usage or lifestyle. Internet-based services often follow this dynamic as well, often shifting from free initial usage to paid subscriptions, as well as changes being made to the service itself.

Consider, for example, the sale of software used by connecting to the company's Web site and downloading updates (or merely paying for continued use of the product). A firm able to commit to a price schedule that moves in inverse proportion to the number of consumers currently signed up creates PMNE in a dynamic setting. A consumer purchasing today will consider not only today's price, but the potential of price decreases in the future as well. While waiting for prices to fall might seem attractive, that would entail forgoing the benefits of present consumption, a strategy unappealing to those who value today's use no less than tomorrow's. In essence, this type of pricing allows the firm to achieve two aims simultaneously—promise PMNE to long-term users and "skim" the market by temporally price discriminating (because high-value users are unwilling to wait—and pay dearly for their preference).

Well beyond software, subscription pricing can be employed wherever a mechanism for per-period payment exists, and PMNE can be incorporated into such a mechanism. Commonplace examples include cable television programming, long-distance calling, cellular phones, consumer clubs, and more. Furthermore, rather than offer falling prices for the same good, the firm could charge a constant price while increasing the size or scope of the package offered, essentially a mirror-image PMNE offering similar benefits. Thus, consumers may take into account that as the network grows, additional services will be added to their subscription, e.g., cable channels, digital services, included free products or minutes of use, and more. The challenge still remains of convincing consumers of the network's growth potential (as this affects the long-term price they expect to pay) and credibly committing not to alter the pricing strategy as market share is gained. Again, if one firm enjoys an advantage over others in being able to implement this pricing mechanism, it may be able to offer PMNE when others cannot, enticing consumers and increasing concentration along the way. Reputation may well be key.

With network effects this result is much more problematic than with scale economies. Both scenarios allow a PMNE-offering firm to tip the

market in its direction, but with scale economies the second firm offers potential competition that keeps prices low and profits nonexistent.[21] With network effects, tipping the market allows the winning firm to extract all surplus as well. The difference stems from the fact that in scale economies, price is a sufficient statistic for consumers' benefit from the purchase, while with network effects it is post-purchase collaboration that confers added utility upon them. When PMNE are used to tip the market, consumers end up paying ex ante for the privilege of ex post collaboration, gaining nothing at the end of the day.

The use of pricing mechanisms to extract network benefits is a novel result, and causes special concern. As discussed above, in a variety of circumstances one firm may have an advantage in offering PMNE, and here such "competition for the market" does not yield the benefits for consumers some commentators assume.[22]

Returning to the assumption that PMNE can be offered by multiple firms, it is comforting to note that when this is the case, market tipping yields no profit for the monopolistic firm and consumers retain all surplus from increasing concentration. Of course, this result is sensitive to the assumption that firms compete in prices and no entry barriers are present. Winning the market is thus dependent on offering prices at least as low as those offered by the losing firm. Potential competition prevents monopoly pricing in the short run and, as long as entry barriers are low, in the long run as well.

The assumptions for perfect contestability are stronger than one would like for practical applications to rely on them.[23] Still, in this context all that is required for the result of consumers retaining surplus to hold is that ex ante firms are equally able to compete for dominance, and the term of dominance is anticipated by all firms equally. If this holds, firms compete for dominance by reducing prices in the present

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[21] Obviously, this is true at the extreme. More moderate levels of potential competition will constrain pricing and profits, though not necessarily to the perfect competition equilibrium. The result here is a special case of the more general phenomenon of contestability and is subject to similar caveats. *See generally* WILLIAM J. BAUMOL, JOHN C. PANZAR & ROBERT D. WILLIG, CONTESTABLE MARKETS AND THE THEORY OF INDUSTRY STRUCTURE (rev. ed. 1988).

[22] *See, e.g.*, Richard Schmalensee, *Antitrust Issues in Schumpeterian Industries*, 90 AM. ECON. REV. 192 (2000).

[23] This point was made early on by Marius Schwartz & Robert J. Reynolds, *Contestable Markets: An Uprising in the Theory of Industry Structure: Comment*, 73 AM. ECON. REV. 488 (1983).

period, and consumers barter current discounts against future price increases, purchasing from the firm offering the lowest lifetime price.[24]

IV. POLICY IMPLICATIONS

The use of VNE allows firms to induce a network structure that might make monopoly sustainable, encompassing technological and pricing mechanisms that transform market dynamics to winner-takes-all competition. Technological VNE include add-on components to existing products, either creating collaborative opportunities among consumers or enhancing pre-existing ones. Pricing strategies may be used to achieve the same result, creating incentives for consumers to coordinate their purchases through PMNE.

The main question, from an antitrust perspective, is whether the introduction of VNE should be viewed with concern as a form of monopolization forbidden by antitrust law. On the one hand, innovative technological components or pricing strategies that are aimed at (or otherwise assist in) achieving monopoly power may be problematic.[25] On the other hand, innovation generally raises long-run welfare and competition policymakers would be loath to unnecessarily constrain it.

Regulation, or at least careful monitoring, of network markets may be warranted due to the difficulty of such a market self-correcting in the face of path dependence and lock-in effects.[26] Still, some stress the difficulty of formulating any appropriate policy response due to the impossibility of teasing apart procompetitive and anticompetitive explanations for the same strategies when employed in network markets.[27] Yet others would prefer a more hands-off approach, trusting competition for the market to replace inefficient monopolies with superior ones through a Schumpeterian process of "creative destruction."[28]

With the introduction of VNE, a new level of problems is revealed. Now, it is not only firm *response* to the existence of network effects that

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[24] This is similar, but not identical to, the "competition for the market" result of David S. Evans & Richard Schmalensee, *Some Economic Aspects of Antitrust Analysis in Dynamically Competitive Industries* (Nat'l Bureau of Econ. Research, Working Paper No. W8268, 2001). Here, I limit myself to price competition with perfect foresight, while Evans and Schmalensee consider competition in drastic innovation.

[25] The issue of intent as a subjective aim vs. objective effect is taken up in 3B AREEDA & HOVENKAMP, *supra* note 16. At this stage, we need not dwell on the distinction, though future application of the rule will obviously require overcoming evidentiary hurdles regarding both specific intent and predicted effect. *See also infra* text accompanying note 32.

[26] *See* Rubinfeld, *supra* note 7.

[27] Joseph Farrell & Michael L. Katz, *Competition or Predation? Consumer Coordination, Strategic Pricing and Price Floors in Network Markets*, 53 J. INDUS. ECON. 203 (2005).

[28] *See, e.g.*, Schmalensee, *supra* note 22.

must be evaluated, but the strategies of *creating* those same markets as well.

The implications of VNE created through technological innovation and those created via pricing mechanisms prove to be markedly different. Broadly stated, technological innovation in network components is generally welfare enhancing, despite the fact that tipping to monopoly may very well occur. This is due to the fact that monopoly status, if attained, is the result of consumers preferring the network good over the stand-alone one, judging the increase in price well worth the utility from enhanced collaboration that was previously unavailable.[29] Where pricing alone is used to achieve network effects, no added utility from the product's use is offered. Thus PMNE are successful only in circumstances where exogenous factors exist to promote concentration. When such exogenous factors are present, high concentration is generally efficient, regardless of the pricing strategy employed. PMNE then are used as a competitive device by firms that want to ensure that they, rather than their rivals, will be those remaining in the market, hopefully attaining monopoly rents in the process.

Linking both mechanisms, a firm may initially introduce technological VNE, to be complemented with PMNE thereafter. In this case, pricing operates both as a tactic to attract consumers in the firms' race to monopoly and as a method of extracting surplus from consumers by the winning firm. Because consumer expectations in network markets are key, PMNE may be a method of solving the "chicken-and-egg" problem. When one firm has an advantage in technological innovation, leading it to be the first to introduce a network component, or if its reputation is such that consumers are more likely to believe its PMNE strategy, symmetric competition breaks down. In this case potential competition loses its deterrent force (such as when lock-in occurs, affecting future periods) and the inefficiencies of monopoly power arise.

While introduction of VNE may be aimed at influencing the competitive process, this is not necessarily a bad thing. Technological VNE can increase welfare through consumer collaboration and price-mediated

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[29] Of course, this formulation assumes a rational decision-making process by consumers assessing benefits vs. costs. If consumers are realistically unable to conduct such a comparison, the argument for ex ante regulation obviously grows stronger. Such arguments are indeed raised in the literature, usually due to an array of cognitive difficulties assessed in the behavioral economics literature, or coordination failures when consumers make decisions sequentially and can be offered differing contracts. *See* Colin Camerer et al., *Regulation for Conservatives: Behavioral Economics and the Case for "Asymmetric Paternalism,"* 151 U. PA. L. REV. 1211 (2003), for an example of the former, and Eric B. Rasmusen et al., *Naked Exclusion*, 81 AM. ECON. REV. 1137 (1991), for an example of the latter.

VNE may be used as a device employed by firms competing for the market when concentration is efficient due to unconnected factors. While purposefully limiting competition in the market raises obvious antitrust concerns, I have shown here that, in many cases, allowing it will increase welfare, benefiting consumers along the way.[30]

Interestingly, from an efficiency standpoint it is actually the converse situation that causes concern. With technological VNE, introduction comes at a cost. A firm must invest in research and development and, even if successful, the cost of providing the infrastructure necessary for consumer collaboration may prove larger than the potential profit. Non-introduction of possible VNE may be then chosen by a firm, despite the fact that had they been introduced, efficiency and consumer surplus would be enhanced. This is true not only where competition dissipates the profits of the introducing firm, but even when it is the sole owner of the network standard. Introduction of technological VNE thus depends on the network effects being sufficiently strong—increasing both consumer welfare and the chances for tipping to monopoly. In a legal regime where VNE might be construed as an antitrust offense (if seen as attempted monopolization), costs of introduction include the risk borne, thus antitrust policy might overly deter socially efficient firm strategy.

As to the distinction between technological and pricing tactics aimed at creating VNE, pricing is the more obvious candidate for antitrust intervention. The same reasons justifying intervention in the willful creation of market power through other means are relevant here as well. When one can clearly argue that technological innovation has an independent consumer welfare advantage, shifting the market towards monopoly may be seen as an unfortunate (but unavoidable) side effect. When technological and pricing VNE are combined, the welfare implications are more problematic and intervention might be warranted. Teasing apart the pro-consumer and anticompetitive aspects is likely to be difficult, as a profit-maximizing firm has incentives for combining both, and empirical verification is difficult.

From a public policy perspective, intervention is limited by the difficulty of identifying the level of network effects prior to their actual implementation in the marketplace. How does one value the utility of a

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[30] *See* Howard H. Chang, David S. Evans & Richard Schmalensee, *Has the Consumer Harm Standard Lost Its Teeth?* (MIT Sloan, Working Paper No. 4263-02, 2003) (discussing inference of consumer harm from harm to the competitive process). While a useful heuristic, they review several antitrust cases where non-standard market dynamics obviated such an inference.

network allowing for online play of video games—prior to consumers actually experimenting with them and discovering for themselves if and how much they appreciate the option? Waiting to intervene after the fact may be necessary to avoid false positives, but within the context of network markets this is unhelpful. Furthermore, if policymakers truly want to tackle the problem, intervention will call for either a return to the competitive framework governing the market previously—or treating the market as a natural monopoly due to its network characteristics.

Recalling a product component in order to shift the market back to its previous competitive framework is not a plan that should be seriously entertained. Not only does it remove a useful component from consumers' reach, but the potential for such intervention might stifle innovative activity ex ante. What remains is treating the market as one with an unavoidable tendency to monopoly, essentially allowing competition for the market in lieu of competition within it. Similar to other network markets, specific regulation may be called for, but only on a case-by-case basis, depending on the nature of the product in question.

It seems then that introduction of a voluntary network effect can be a successful monopolization strategy, and one that would be immune from antitrust intervention, as long as the focus is on economic goals. Those who call for a more interventionist approach, protecting competition itself rather than efficiency (or consumer welfare), would see here a dangerous loophole.[31] Nonetheless, it can be argued that VNE introduction should be viewed similarly to the creation of a new network good, one which creates a market prone to monopoly. Admittedly, in this case the network market comes at the expense of a previously competitive one, but this may also be said of innovations that replace previous goods, making them obsolete and requiring those who competed in their manufacture to seek other markets to operate in.

Inquiring whether introduction of VNE into the market could fall within the "intent to monopolize" language of Section 2 of the Sherman Act, one might start with the broad formulation offered by Areeda and Hovenkamp:

> The attempt charge is properly directed against a course of exclusionary conduct other than competition on the merits, which, if continued or successfully consummated, would probably produce the degree of market power that would constitute monopoly for purposes of the

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[31] *See, e.g.*, A. Douglas Melamed, *International Antitrust in an Age of International Deregulation*, 6 Geo. Mason L. Rev. 437 (1998) (reviewing different concepts of "competition" and its role as means vs. end).

monopolizing offense (that is, as a substantial degree of market power).[32]

Under this broad definition, the introduction of VNE, which shifts the market towards network competition, might be considered "predatory or unfair" and thus an attempt to monopolize in violation of Section 2 of the Sherman Act.[33] The question thus turns to the extent (or strength) of VNE introduced, as this is the deciding factor as to the extent of market power created and the exclusion of rivals from the market. Of course, to argue for liability, one would need to pass the hurdle of proving the relevant conduct (introducing VNE, here) either actually achieved this result, or creates a "dangerous probability of success" as formulated in early antitrust jurisprudence and restated in *Spectrum Sports.*[34]

V. APPLICATIONS AND EXTENSIONS

Various applications of VNE exist, and new ones are bound to arise. Cellular "in-net calling" and video consoles' online play, referred to above, are obvious examples, chosen for clarity of exposition as well as prevalence and market size. More generally, any kind of social network upon which collaboration is possible, raises a possibility of marketing products that utilize social connections, broadly construed. As online social networks develop and become prevalent (e.g., Facebook, LinkedIn, MySpace, etc.), "viral advertising" is observed to be taking place through "friends" passing on information and product branding through what originated as an informal communication device.

When branding is a major component of willingness-to-pay for the product in question, and popularity among peers a major component of brand-recognition and brand-image, the network structure of peer groups becomes paramount to commercial interests. Utilizing existing social networks or extending marketing activities to emerging electronic networks could be merely an initial tactic. Further strategic investments

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[32] 3B AREEDA & HOVENKAMP, *supra* note 16, at 404–05.

[33] *See* Spectrum Sports, Inc. v. McQuillan, 506 U.S. 447 (1993).

[34] *Id.* at 448. Early cases requiring the same include *Swift and Co. v. United States*, 196 U.S. 375, 396 (1905), and *American Tobacco Co. v. United States*, 328 U.S. 781, 785 (1946). Another relevant issue is whether successful introduction of VNE is assisted by pre-existing monopoly power. If an incumbent monopolist is better placed to introduce VNE relative to new entrants or viable competitors, the governing standard will differ. The monopolization offense encompasses "the creation, maintenance, or expansion of monopoly power," and "behavior that otherwise might comply with antitrust law may be impermissibly exclusionary when practiced by a monopolist." *See* 3 AREEDA & HOVENKAMP, *supra* note 16, ¶ 650a, at 90–91 (for first quote); United States v. Dentsply Int'l, Inc., 399 F.3d 181, 187 (3d Cir. 2005) (for second quote).

would likely include integration between online communities and product placement, as well as pricing tactics designed to employ emerging patterns of social interaction for creation of path-dependent commercial success. When the network structure is built into the product itself, or its marketing strategies, strengthening the tendency towards tipping and widening its scope might foster the emergence of market power as well as its sustainability over time. Innovation in business strategy in this changing world has implications that may sooner or later be part of the public policy debate regarding which tactics may cause antitrust concerns and whether intervention is warranted.

Regarding other applications, there is no need to limit ourselves to the obvious ones where network structure is readily apparent. Consider, for example, lotteries.[35] Generally speaking, a lottery can be characterized as a group of people purchasing tickets bearing a small probability of large gains, in essence exchanging large probabilities of small losses for the converse. Rational economic models where actors willingly join this negative-sum game (especially if the profits of the organizers are taken into account, beyond the considerable transaction costs), depend on their utility of money being marginally increasing, the opposite of most models' assumptions of risk-aversion. Even if a model incorporates narrow framing, so that actors consider this lottery as a different "game" than other economic decisions, the crucial element is that the consumer value a .001 percent chance to win $50,000 (or any other amount less than $100,000) more highly than the ticket price of $1.[36]

One way to make sense of risk-aversion in some decisions and risk-seeking in lotteries is to posit that the large sums announced as "grand prizes" are attractive to consumers beyond their expected value. Since this phenomenon is most readily seen when prizes are very large (not many people would pay $1 for a one-in-eleven chance of winning $10), lotteries exhibit demand-side returns to scale, precisely the definition of network effects. As more consumers concentrate their purchases on a single lottery, the revenue raised by selling tickets increases, allowing for

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[35] I thank Steven Salop for this example.

[36] Narrow framing models lend themselves to the view that people separate the lottery decision from others, treating it differently. Note, though, that most narrow framing models assume declining marginal utility of money in *each decision separately*—thus increasing overall risk aversion, sometimes to extreme levels. Here, a further step is necessary, assuming that different decisions are treated differently—with differing approaches to risk—essentially positing different *preferences* insofar as the utility of money is concerned, strong assumptions to be sure. Still, reality dictates the phenomena that we strive to understand (and model). For further discussion of narrow framing, see Nicholas Barberis, Ming Huang & Richard H. Thaler, *Individual Preferences, Monetary Gambles, and Stock Market Participation: A Case for Narrow Framing*, 96 AM. ECON. REV. 1069 (2006).

a larger pot to be distributed in prizes. Of course, at the same time, the probability of winning drops, but if preferences are non-linear in expected value, larger prizes may become more attractive at a faster rate than the decline in probability of actually receiving them.

Lotteries may incorporate PMNE in a number of ways. The most direct would be an announcement of the prize being a function of the number of tickets sold, though this might take the fun and mystery out of the process—attributes central to real-life marketing success. Having the grand prize announced upfront, with larger-than-usual prizes attracting huge crowds, is a dynamic version of the same idea. Rather than many consumers creating a big pot, the organizing firm bets on its success in reversing causality—investing the prize money to create demand.

When lotteries compete, they are selling expectations their consumers have of winning (some would call them dreams), based on beliefs in the lottery's financial backbone (ensuring a "win" will actually be paid off). Some actually sell subscriptions to weekly lotteries, directly banking on their reputations as long-term players, thus allowing for repeat transactions by which consumers flock to the larger pots announced, thereby increasing the funds that allow for next week's lottery to be equally successful. This is precisely the dynamic of network industries antitrust aficionados have come to know elsewhere—relying on early adopters to generate demand, which in itself attracts later consumers to "join the club." Here, PMNE pricing drives demand, and with some foresight and subtlety, many strategies based on shifting network dynamics are possible.

Other, more obvious examples exist as well. "Friends and family" programs are familiar in the telecom landscape, essentially the precursor of "free in-net calling" discussed above.[37] Similar programs may be offered and extended in other markets, building on loyalty programs, such as "frequent flyer" bonuses. Consider an airline company's offer whereby the consumer receives bonuses based not only on her own past flights, but also on those of her "friends." These friends can be those who joined through her recommendation, thus more of a referral-compensation program, or a larger group, such as dentists, or some other identifiable group. Suddenly, members of that group have an incentive to concentrate on one specific airline, whether they know each other or

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[37] Essentially, the "free in-net calling" program is a reduced calling price applicable to a select group of targets, exactly as is a "friends and family" program. The first sets a low price (usually zero) to all members of the cellular provider's network, and the second sets a low price (potentially zero) to all members of a smaller network, chosen by the subscriber.

not. The airline might institute a specific network structure, such as granting one mile for every mile flown, one mile for every two miles flown by those referred, one mile for every four miles flown by those referred by them, and so on. This is precisely the method by which multi-level marketing schemes create herding effects—creating a network structure based on pricing and bonuses, with "down-lines" and "up-lines" becoming determinants of each member's final payoff. With an open mind and some creativity, many applications lend themselves to "endogenous networking" of this type.[38]

Herding effects, or "consumer cascades," are based on network effects of the type studied extensively in the antitrust literature. Once VNE are understood to be at the base of such business strategies, antitrust analysis of competition among firms creating such effects is paramount. While in some cases consumer cascades are temporary and competitively benign, they may be less so in other cases. Distinguishing the "good" from the "bad" is difficult, but subject to the criteria of "willful acquisition of monopoly power" and "legitimate business justification."[39] Specific applications will require analysis of entry barriers and path-dependence potential within the specific market.

Once we are able to envision creation of network dynamics through strategic planning, there are many ways of incorporating them, well beyond the examples presented above. Since pricing becomes a determinant of eventual network effects, there is much flexibility in shaping them. As presented in Part II above, the standard formulation used in the antitrust literature for network effects is based on models of the type $U = a + \beta N$. This assumes the utility gained from network interaction to be linear in the number of other users. Mathematically, this is a simple model to work with, essentially assuming each additional user on the network generates a benefit uniformly externalized onto other users. While simplicity is a valued expository device, real-world networks are

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[38] Much effort goes into distinguishing between permissible multi-level-marketing structures and forbidden "pyramid schemes." While delving into this issue is well beyond the scope of this paper, their common feature highlighted here is the strategic creation of network effects among participants. *See generally* Debra A. Valentine, Gen. Counsel, Fed. Trade Comm'n, Pyramid Schemes, Prepared Statement Presented to the IMF Seminar on Current Legal Issues Affecting Central Banks (May 13, 1998), *available at* http://www.ftc.gov/speeches/other/dvimf16.shtm.

[39] In such cases, other consumer welfare implications arise as well. Latecomers might be forced to follow cascades they neither prefer nor benefit from, and firms might collude with early adopters to externalize costs onto those arriving after the cascade took place. Since such cases have more to do with consumer protection than antitrust, I will not explore them at length here. Still, the subject is both interesting and important. *See* Avinash Dixit, *Clubs with Entrapment*, 93 AM. ECON. REV. 1824 (2003).

unlikely to be linear, as some users are more "valuable" than others, and network benefits may be "used up" after a certain threshold is attained.

As firms realize their ability to influence the *strength* of network effects, as modeled here, the next step of strategic manipulation should extend to the *structure* of networks within which these effects propagate. Minute but precise changes can have large effects on firm profitability. Models of "scale-free" networks, exhibiting a "hub and spoke" structure, will probably be more realistic.[40] In these models, firms vie to attract "hubs," consumers with more connections or more influence than others. While delving into the details of specific applications is beyond the scope of this article, it is worth noting that since incentives depend on pricing, firms have considerable playing room to adapt voluntary network dynamics to the specifics of their markets.[41] Recognizing which of these cases is more worrisome from a consumer welfare standpoint is bound to be a difficult task. Still, insofar as using pricing to shift market structure towards monopoly is a threat, antitrust policymakers will need to address these practices.

VI. CONCLUSION

Voluntary network effects are a method of creating network effects where none were present before, or of strengthening existing ones. In both cases, competitive dynamics are altered in a way facilitating a "race for monopoly" impossible before VNE introduction. In this article, two types of VNE introduction were assessed—through technological innovation and through pricing tactics changing consumers' incentives. While from an antitrust perspective the second type is more problematic than the first, practical applications are likely to include combinations of both, possibly creating consumer harm and limiting competition.

Despite the market-shifting properties of VNE, they should not be construed as necessarily harmful. Technological innovation especially, but also innovative pricing tactics, are welfare-enhancing in various settings. It is the uneasy challenge of antitrust practitioners and agencies to distinguish the beneficial applications from the harmful ones, a difficult but necessary task. The discussion here of real-world applications, both

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[40] *See, e.g.*, Duncan J. Watts & Steven H. Strogatz, *Collective Dynamics of "Small-World" Networks*, 393 NATURE 440 (1998); *see also* Albert-Laszlo Barabasi & Eric Bonabeau, *Scale-Free Networks*, SCI. AM., May 2003, at 60. For an excellent and simple introduction, see ALBERT-LASZLO BARABASI, LINKED: THE NEW SCIENCE OF NETWORKS (2002).

[41] Models of network formation may prove especially helpful in this regard. *See, e.g.*, Alison Watts, *A Dynamic Model of Network Formation*, 34 GAMES & ECON. BEHAVIOR 331 (2001); Venkatesh Bala & Sanjeev Goyal, *A Noncooperative Model of Network Formation*, 68 ECONOMETRICA 1181 (2000).

current and forthcoming, is aimed at promoting awareness of these issues and where they are likely to arise. Future research into the structure of networks created through VNE applications is warranted, extending these first tentative steps towards understanding the antitrust implications of this fascinating subject.