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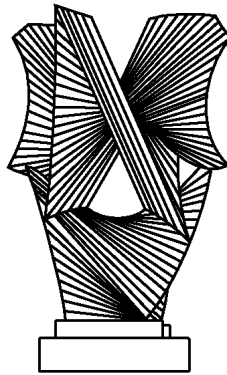
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Property Rights in Emerging Platform Technologies

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ABSTRACT

This paper considers an externality that affects a broad range of markets, specifically markets where one set of firms sells some platform technology like a computer, video game console, or operating system, while another possibly overlapping set of firms sells peripherals compatible with that platform, for example computer software or video game cartridges. The externality causes certain peripheral sellers to charge prices that are unprofitably high. That is, these firms could earn *greater* profits if only they could coordinate to charge *lower* prices. In many markets, such coordination is possible; firms can contract, for example, or integrate. In markets based on relatively new platform technologies, however, coordination will typically be difficult. The paper explains why, and argues that intellectual property law can and should facilitate price coordination in these "emerging technology" settings.

I. Introduction

Ever since Apple lost to IBM, technology firms have recognized the important role third-party innovation plays in the development of emerging "platform" technologies.¹ The story is by now well known. Apple designed its first desktop computers with easy-access hardware ports and an accessible operating system, the purpose being to facilitate third-party development of compatible hardware and software accessories. But, when IBM entered the home computer market, Apple decided that its best strategy was to offer a more integrated product. Thus, the same year IBM unveiled the IBM PC -- a machine with built-in expansion slots for hardware and well-publicized hardware and software specifications -- Apple introduced the Macintosh, a unit that had some

^{*} Assistant Professor, University of Chicago, The Law School. Special thanks to Marshall van Alstyne for numerous conversations in which the nature of the externality described here was first discovered, and to John Pfaff for excellent research assistance. Sincere thanks as well to readers Douglas Baird, Scott Baker, Dan Fischel, Wendy Gordon, Deb Healy, Mark Janis, Bill Landes, Gene Lee, Saul Levmore, Anup Mulani, Casey Mulligan, Randy Picker, Eric Posner, and Richard Posner, and to workshop participants at USC, the University of Chicago, and the SSRC Workshop in Applied Economics. I can be reached online at dgl@uchicago.edu.

¹ For the purposes of this paper, the term "platform" refers to any object a consumer can purchase at a non-zero price to enhance the value of some number of independently purchased goods, and the term "peripheral" refers to any purchased good whose value is in that manner increased. VCRs, desktop computers, and operating systems are thus "platforms," while videotaped movies, modems, and applications software are all "peripherals."

advantages over the IBM PC out of the box but was markedly less accessible to third-party development. Within a few years, hundreds of available hardware and software add-ons made the IBM PC the dominant home computing platform.²

IBM's approach -- what is today referred to as open architecture -- has been the focus of considerable attention these last many years, both on Wall Street³ and in Silicon Valley.⁴ Yet, despite all this attention, intellectual property law has in no way taken account of it. This is problematic, not only because it means that intellectual property law is somewhat out of step with current industry practice -- in the market for handheld computers, for example, both Palm⁵ and Handspring⁶ have published the interface specifications for their respective computers online -- but also because it turns out that the strategy has a significant flaw, the implications of which can be mitigated, but in many instances only if several specific patent and copyright doctrines are adjusted so as to better reflect the dynamics of the modern platform/peripheral market structure.

To see all this, think first about peripheral prices. Early in the development of any peripheral market, hardware and software developers enjoy significant discretion to set their prices instead of being forced by competitive pressures to charge marginal cost. This is true in large part because the first firm to identify any add-on category is a monopolist until other firms create comparable goods. Such discretion would not itself be troubling except for the fact that each firm's pricing decision affects every other firm's sales. If a given firm were to charge a lower price, consumers would be more likely to purchase the associated platform and, hence, more likely to then purchase other firms' peripherals. This is an externality: it is a consequence of each firm's pricing decision that is ignored when each firm sets its price.⁷

What this means -- and here let us continue to focus on the pricing externality although parallel arguments can be made with respect to decisions regarding product quality, advertising investments, and so on -- is that in markets based on emerging platform technologies, third-party developers as a group will charge prices that are too high. That is, if these firms could internalize the externality, they would

² This account was drawn from Peter Norton, *In Praise of an Open Lotus 1-2-3 Aftermarket*, 4 PC Week 32 (March 3, 1987); Steve Gibson, *The Macintosh's Nubus Delivers on Apple's Open Architecture Promise*, InfoWorld 10 (June 22, 1987); *Open Architecture: Room for Doubt*, 2 PC Week 20 (Dec. 10, 1985); David Sanger, *Will I.B.M. Shift Strategy?*, The New York Times (March 22, 1984) at D-2.

³ See, e.g., <citations to Wall Street analysis of Palm and Handspring, including those from ZDNet>

⁴ See, e.g., <citations to various technical articles on open architecture and open source>.

⁵ Interface specifications for Palm's line of handheld computers are available at no charge from the company website, www.palm.com (last visited October 1, 1999).

⁶ Interface specifications for Handspring's recently unveiled handheld unit are also available at no charge and to all comers; see www.handspring.com (last visited October 1, 1999).

⁷ Note that this is not a "pecuniary externality" as that term is traditionally defined. See Andreu Mas-Colell et al., *Microeconomic Theory* 352 (1995).

- charge lower prices, a result that would benefit consumers in a distributional sense and also increase efficiency by lessening the gap between price and marginal cost;
- and earn greater profits, since under reasonable assumptions each firm would lose money as a result of its own price drop but gain much more thanks to the increase in sales brought on by other firms' reciprocal price reductions.

Price coordination would also increase the pace of innovation, since higher profits ex post would mean greater incentives to enter the market ex ante; and, through both lower prices and faster innovation, it would increase the rate of platform adoption as well.

Price coordination is possible in most peripheral markets. Firms can contract, for example, or integrate. But coordination is virtually impossible in markets based on still-emerging technologies. The problem is that there is never an opportunity to bring all or nearly all of the affected firms together to negotiate a mutually beneficial price reduction because, at these early stages, firms are constantly entering and exiting the market. Obviously a firm currently in the market cannot coordinate with one that has yet to enter; but in this setting such negotiations are of critical importance since a consumer's decision as to whether to purchase an emerging platform technology is often as much based on the consumer's expectations with respect to the price, quality, and availability of future peripherals as it is based on the price and quality of peripherals already available for purchase.

Negotiations among the subset of firms in the market at any given time is still an option; but, alone, negotiations of this sort will prove largely ineffective. After all, current firms will always be reluctant to lower their prices for fear that any price concessions they achieve will be offset by price increases from future firms. This is in fact the externality itself at work: lower prices for current peripherals leads to increased demand for the platform which, in turn, leads to increased demand for future peripherals; that increased demand tempts future firms to raise their prices, and those higher prices undermine the benefits of the original price reductions. Note that this same problem makes vertical integration unworkable. The platform owner could in theory buy out current peripheral sellers and lower the prices of their peripherals; but, when new peripheral sellers would enter the market, those sellers would charge correspondingly higher prices, eliminating or reducing the benefits of the original integration.

Where does this leave us? The above arguments combine to suggest that pure open architecture strategies are decidedly second-best. The best way for a platform owner to introduce a new platform technology might indeed be to make it

profitable for a large number of unidentified firms to develop compatible hardware and software accessories⁸; but accomplishing that goal by making the platform's technical specifications publicly available invites inefficiency. Every time, consumers will face prices that are unnecessarily high. Every time, peripheral sellers will earn profits that are unnecessarily low.

Platform owners choose the open architecture approach, however, because under current legal rules they have no better alternative. Instead of giving away interface information, these firms should be using that information as leverage, sharing it with all interested third-party developers but only on the condition that the firms participate in some sort of a price-reduction or profit-sharing program. But intellectual property law gets in the way. Without even considering the possibility of socially beneficial coordination, the modern intellectual property regime undermines platform owners' influence by allowing unauthorized firms to reverse engineer the platform and, in that way, develop compatible peripherals without the platform owner's permission. Worse, every time platform owners attempt to compensate -- say, requiring that platform purchasers agree to use the platform only in conjunction with authorized peripherals -- courts interpret one or another intellectual property doctrine so as to block the adjustment, again without even considering the possibility that broader intellectual property rights might facilitate a beneficial form of price coordination.

The argument here, then, is not that all platform owners should enjoy absolute control over which firms, if any, develop compatible peripherals. Nor is it that platform owners should always enjoy absolute control with respect to emerging platform technologies -- that is, absolute control over the first generation of some handheld computer or the first release of a new operating system. The point, instead, is that when courts interpret the intellectual property rights recognized in platform technologies, they should consider the possibility that broader readings would facilitate price coordination which, in turn, might lead to lower prices for consumers and higher profits for producers. For the reasons sketched above, that possibility is especially strong in markets based on emerging platform technologies; although there are surely exceptions to that rule and, conversely, settings involving more established technologies where these same arguments might hold.

This argument has implications for a number of patent and copyright doctrines; those are considered later in the paper. As readers familiar with the intellectual property literature will recognize, however, it also has implications for an important debate in intellectual property law, a debate that began with a famous

⁸ Accord <http://www.palm.com/devzone/business.html> (last visited October 1, 1999) ("Recognizing [third-party developers'] crucial role in our success, we are committed to supporting [their] efforts with information, ideas, development and marketing support. [Their] business success will also be ours."; "Our role is to get devices into customer's hands, build demand for [our] platform, and help create new uses for the product through technology and innovation.", "[Third-party developers'] role is to provide third-party hardware and software solutions, peripherals, accessories or other products that enhance the platform and the usability of the devices . . .").

article by Edmund Kitch⁹ and concerns the wisdom of allowing original inventors to coordinate the process through which later firms improve and develop their inventions.¹⁰ That debate has, up until now, focused on only one type of coordination: coordination designed to reduce the resources wasted when rival firms either inadvertently duplicate one another's research or race to be first to complete some incremental step. This paper introduces to the debate a second type of coordination: coordination with respect to price. The shift in emphasis is important since, as others have pointed out¹¹, given transaction costs and uncertainty, downstream coordination as traditionally conceived is virtually impossible for an original inventor to bring about. After all, original inventors hoping to lessen the risk of duplicative follow-on investment face the Herculean task of negotiating detailed contracts with every incremental innovator, avoiding overlap by specifying exactly which research paths each is authorized to pursue. The type of coordination considered here, by contrast, can be significantly achieved through more manageable means. For example, the original innovator can impose price caps keyed to rough peripheral categories, or develop a profit-sharing plan where the percentage each firm contributes is constant across all firms. Thus, the argument presented here supports what was Kitch's original claim: intellectual property law should, in certain cases, empower original inventors to coordinate the follow-on innovation process.

The paper proceeds as follows. Part II characterizes the basic externality that can cause prices to be unprofitably high in platform/peripheral markets. This part shows that, while the effect can obtain in a variety of circumstances, it is particularly likely in markets based on emerging platform technologies. The section also confirms that the externality can be significant, thus justifying legal intervention. Part III plays out the implications for intellectual property law, considering in some detail how patent, copyright, trademark, and trade secret law mediate the relationship between platform owners and peripheral developers, and how minor adjustments to several specific patent and copyright doctrines might facilitate downstream coordination and thereby benefit not only platform owners but also third-party developers and consumers as well.

II. The Need for Coordination

This section begins with a somewhat stylized example designed to introduce the basic platform/peripheral interaction. The section then presents a

⁹ Edmund Kitch, *The Nature and Function of the Patent System*, 20 J. L. & Econ. 265 (1977).

¹⁰ For a sense of the debate, see Robert Merges & Richard Nelson, *On the Complex Economics of Patent Scope*, 90 Columbia L. Rev. 839 (1990); Mark Lemley, *The Economics of Improvement in Intellectual Property Law*, 75 Tex. L. Rev. 989 (1997); Donald McFetridge & Douglas Smith, *Patents, Prospects, and Economic Surplus: A Comment*, 23 J. Law & Econ 197 (1980); Suzanne Scotchmer, *Protecting Early Innovators: Should Second-Generation Products Be Patentable*, 27 Rand J. Econ. 322 (1996).

¹¹ The point was first made explicit by Merges & Nelson, *supra* note ___, at 874-75.

discussion of related work and sets up the more formal model that is ultimately presented in the appendix. The section concludes with some estimates as to the size of the price and profit distortions caused by the demand externality.

A. How Peripheral Prices Relate

Consider a single peripheral/platform pair -- say, a word processor and the associated desktop computer. To keep things simple, let us suppose that the computer has no intrinsic value, so consumers purchase it only if they also plan to purchase the word processor. Assume the computer is sold at a price, P , and the word processor is sold at a price, P_{WP} .

Figure 1 is a number line that divides consumers into three groups based on how much they value the word processor. Group 1 is made up of consumers who value the word processor below its retail price. These consumers would not purchase the word processor even if they already owned the computer since, to them, the software's price exceeds its value. Group 2 is composed of consumers who value the word processor above its cost, but not enough to warrant purchasing the computer. Unlike the consumers in group 1, these consumers would purchase the word processor if they already owned the computer. Group 3 consists of consumers who value the word processor so much that, for this reason alone, they are willing to purchase both the computer and the word processor.

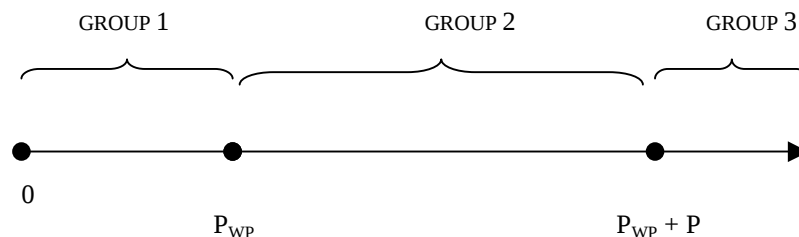


FIGURE 1. Consumer valuations for a hypothetical word processor, represented on a number line which increases from left to right and starts at zero.

Now introduce a second peripheral to the market, this time a spreadsheet. To the seller of the word processor, this is an important event. True, the introduction of a second peripheral does nothing to change the behavior of consumers in the first and third groups¹²; the former will refuse to purchase the word processor regardless, and the latter were ready to buy both the computer and

¹² This is a bit of a simplification. The existence of the spreadsheet could increase consumer demand for the word processor if word processors and spreadsheets are complements, and could decrease demand for word processors if word processors and spreadsheets are substitutes. These effects are considered in the next two subsections.

the word processor even before the spreadsheet became available. For some consumers in the second group, however, the spreadsheet alone or in combination with the word processor will be enough of a reason to purchase a computer. In other words, for some consumers in this group, the spreadsheet will tip the balance, leading them to purchase the spreadsheet, the computer, and the word processor.

This is the externality that motivates the paper. Think of a random consumer drawn from group two. Holding constant the prices of the word processor and the computer, this consumer's decision as to whether to purchase the *word processor* turns entirely on the price of the *spreadsheet*. If the spreadsheet is cheap relative to the consumer's valuation of the spreadsheet, the consumer might decide to purchase the computer, the spreadsheet, and the word processor. If, by contrast, the spreadsheet is sold at a price too close to or above the consumer's valuation, the consumer will forgo all three components. This is an externality in that it is a consequence of the spreadsheet seller's pricing decision that has no direct effect on the spreadsheet seller's profit; in the absence of coordination, it is therefore a consequence he will ignore when choosing his price.

B. Why Profits Might Rise

That there is an externality in this market is of course only half the story; what we really want to know is whether the firms can earn greater profits by accounting for it. That is, this externality is interesting only if it is also true that, were the spreadsheet seller to lower its price, profits from word processor sales would increase by more than profits from spreadsheet sales would diminish.

To answer this question, we need to develop a more formal model; that is the task of the next subsection. Here, we can use a simpler analysis to preview the results. The peripheral/peripheral externality arises because consumers are in essence amortizing the cost of a platform across several purchasing decisions. This is why lower peripheral prices are so helpful: a lower peripheral price allows consumers to retain extra surplus from a particular transaction, and that surplus makes the platform seem cheaper when consumers are considering every other possible purchase. The cheaper platform makes consumers more willing to buy, and the effect propagates across all peripherals.

The fact that several peripherals are compatible with the same platform is therefore enough to set up the possibility of a profitable price reduction; lowering price by a small amount would have a negligible effect on each firm's profits but, overall, those small price reductions would add up to what consumers would perceive to be a substantial reduction in the platform's total cost. Whether that possibility can be realized in any given case, however, depends on the strength of two additional factors. First, when a given peripheral firm lowers its price, some

of the other firms are made worse off. Suppose, for example, that Microsoft were to lower the price of its popular word processor. Makers of competing word processors would surely experience a drop in sales; even though Microsoft's lower price would increase demand for most peripherals by making desktop computers seem less expensive, it would decrease demand for these substitute goods. True, the other firms could lower their prices as well, but that still would not change the key result: these firms would be worse off, not better, by virtue of Microsoft's hypothetical price reduction.

Second and working in the opposite direction, when a given peripheral firm lowers its price, some of the other firms are made better off in ways that have nothing to do with the increase in platform sales. To stay with the above example, for some consumers owning a word processor makes owning an electronic spreadsheet more desirable since, together, the programs create better documents than either program can alone. Thus, a lower price for word processors would increase the demand for spreadsheets above and beyond any increase caused by the increase in platform sales. Firms that sell electronic spreadsheets would thus be even better off than our initial analysis suggested.

Whether firms overall can lower prices and increase aggregate profits, then, depends on the number of firms in each of the above categories, on the strength of each effect, and on the number of firms in neither category and thus subject to just the basic analysis. This makes general observations somewhat complex; nevertheless a few general statements can be made. For example, in markets where consumers tend to have strong preferences for particular peripherals, a lower price for any one peripheral will typically not significantly reduce demand for any other peripheral, and so there will almost always be some opportunity for profitable price reductions. Examples here might include the market for trendy video games or the market for popular music. By contrast, in markets where peripherals are all almost perfect substitutes, mutually beneficial price reductions are unlikely. Lowering the price of a given brand of ink cartridge or blank videotape, for instance, would probably decrease overall profits, since a lower price for one brand would force competing brands to either lose sales or lower their prices as well.

Of particular interest here: there will typically be an opportunity for mutually beneficial price reductions in any market based on an emerging platform technology. There are two reasons. First, early in the development of a peripheral market only a small number of peripherals are available. These peripherals are in most cases unique, and so lowering the price of one will rarely much diminish sales of any other. Second, peripherals in these markets tend to be unique for another reason: at these early stages peripheral firms are identifying entirely new types of hardware and software add-ons. To take a timely example, at the moment even the firms that manufacture handheld computers have little sense of how these limited-function but light-weight computers can best be put to use at work or play.

Part of the role for third-party developers in this market is therefore to identify new applications.¹³ Every time a firm does so, that firm will create a peripheral tailored to the new use, and that peripheral will be unique as compared to all available peripherals at least until the firm's first-mover advantages dissipate.¹⁴

C. A Formal Model

The formal model that follows builds on a foundation first set out by Augustin Cournot in 1838.¹⁵ Cournot noted that independent monopolistic sellers of complementary goods earn maximal profits if each charges a price below its individually rational price. Sellers of complementary goods face a problem similar to the one faced by peripheral sellers: a lower price for one product increases sales of all complementary products, but those benefits are ignored when complementary goods are priced independently. Cournot proved this result for the narrow case where products are direct complements and are useful only as direct complements¹⁶, and he framed but was unable to solve the more complicated case where the products have uses in addition to their use as part of the complementary combination.¹⁷

Many papers have extended and recast Cournot's work¹⁸; of particular relevance here is a series of recent papers applying it to the platform/peripheral setting.¹⁹ These papers assume that one or several firms sell some platform at a supra-competitive price while another, non-overlapping set of firms sell peripherals also at supra-competitive prices. They show that if the platform sellers

¹³ That is how Palm Computing explains its open architecture program. See <http://www.palm.com/devzone/business.html> (last visited October 1, 1999) ("As we focus on the platform, we're relying on [our third-party developers] to reach new markets, extend existing applications to the handheld, and work with real-life users to find entirely new ways to use this platform .").

¹⁴ Sometimes intellectual property rights further ensure that a given peripheral is unique, as where a firm is granted copyright or patent protection for its peripheral. For a discussion of the implications of layered intellectual property rights of this sort, see Lemley, *supra* note __, and Scotchmer, *supra* note __.

¹⁵ Augustin Cournot, *Researches into the Mathematical Principles of the Theory of Wealth* 1838 (transl. by Nathaniel Bacon, Oxford Press, 1897).

¹⁶ *Id.* at 99-107.

¹⁷ *Id.* at 107-108.

¹⁸ These papers show how Cournot's original insight explains core features of, for example, the automobile and newspaper industries. For an overview of the literature, see Dennis Carlton & Jeffrey Perloff, *Modern Industrial Organization* 523-33 (2d ed. 1999).

¹⁹ See Steven J. Davis, Jack MacCracken & Kevin M. Murphy, *Integrating New Features into the PC Operating System: Benefits, Timing, and Effects on Innovation* 27-31 (1998) (mimeo, on file with author); Nicholas Economides, *The Incentive for Non-Price Discrimination by an Input Monopolist*, 16 *International Journal of Industrial Organization* 271 (1998); Nicholas Economides, *The Incentive for Vertical Integration*, Discussion Paper EC-94-05, Stern School of Business, N.Y.U. (1997); Nicholas Economides, *Network Externalities, Complementarities, and Invitations to Enter*, 12 *European Journal of Political Economy* 211 (1996); Nicholas Economides, *Quality Choice and Vertical Integration*, forthcoming *International Journal of Industrial Organization* (1999); Nicholas Economides & Steven Salop, *Competition and Integration Among Complements, and Network Market Structure*, 40 *J. Industrial Economics* 105 (1992); Randall Heeb, *Innovation and Vertical Integration in Complementary Software Markets* (Ph.D. dissertation, University of Chicago, 1999).

were to integrate with the peripheral sellers, prices would decrease and profits would rise.

The current paper takes the next step by showing that a similar dynamic takes hold even in markets where the relevant platform is sold at a competitive price. The prior papers focus on a price distortion caused by vertically stacked monopolies: the platform monopolists are upstream, peripheral monopolists are downstream, and each monopolist chooses its price without considering implications for firms in the other group. This paper, by contrast, focuses on the Cournot distortion caused by independent horizontally arrayed monopolists. Whether the platform developer has market power is irrelevant; the externality here is an externality among peripherals.

For the purposes of the model, let us now formally define the term "platform" to mean any object a consumer can purchase at a non-zero price, or any state of the world a consumer can bring about through non-trivial investment, to enhance the value of some number of independently purchased goods; and the term "peripheral" to refer to any purchased good whose value is in that manner increased. This is a broader definition than that previously adopted²⁰, and the model thus has relevance to a broader class of products and activities. In this paper, however, the primary focus will remain on physical technology platforms purchased through financial investments and the peripherals associated with those platforms.

Because of their relationship with the platform, the price of any one peripheral affects sales of every other peripheral. As was pointed out in the intuitive discussion, however, peripherals are often linked in other ways as well. To be precise: peripherals are "substitutes" if, were the relevant platform available at zero cost, a decrease in the price of one would lead to a decrease in demand for the others; and peripherals are "complements" if, were the relevant platform available at zero cost, a decrease in the price of one would lead to an increase in demand for the others.

The model assumes that each peripheral is sold by only one firm and, further, that each firm sells only one peripheral. More complicated cases follow the same general patterns. The model also assumes that peripheral firms are independent, meaning that each makes its own decision with respect to price. One could easily extend this work to address decisions with respect to other product features, for example product quality or service support.²¹ Using these definitions and under these conditions, the following Proposition and two related Corollaries are proven in the appendix.

²⁰ The terms were originally defined supra note 1.

²¹ The papers cited supra note ___ make this point with respect to their models as well.

PROPOSITION. In settings where two or more firms sell peripherals and those peripherals are neither complements nor substitutes, each firm would earn greater profit if each charged a price lower than its individually rational price.

COROLLARY 1. In settings where some fraction of the peripherals are complements, the Proposition continues to hold for all firms.

COROLLARY 2. In settings where some fraction of the peripherals are substitutes, the Proposition continues to hold for firms that do not sell substitutes, and the Proposition may or may not hold for firms that sell substitutes.

The comments in the prior subsection should help to make clear the relevance and implications of these more formal statements. Note that, while the Proposition references only the benefits price coordination confers on peripheral developers, coordination in fact also benefits consumers and the platform owner. For consumers, the reward is lower prices, greater efficiency from closer-to-marginal-cost pricing, and an increase in the rate of peripheral innovation. For the platform owner, the primary payoff is greater consumer demand, an increase that comes about thanks to both the lower peripheral prices and the increased rate of peripheral innovation.

D. The Size of the Effect

The work of the previous subsection was to develop the paper's core economic claim: under certain conditions, peripheral firms will charge prices that are unprofitably high. The appendix presents some additional information about this effect, showing in greater detail how peripheral interdependence shifts and distorts demand for any given peripheral. This section uses the model presented in the appendix to estimate the size of the price and profit distortions for some representative cases. The purpose is to confirm that these distortions are sizeable and hence legal intervention is justified.

To keep the mathematics manageable, we consider here only cases with two peripherals and a platform that has no intrinsic value. Demand for each peripheral is assumed to be uniform on $[0, V]$, and consumer valuations for the two peripherals are assumed to be uncorrelated. These restrictions cause the two firms to behave identically, allowing us to focus on just one of them in the graphs that follow.

Figure 2 shows how prices change as a function of platform price. The top line represents the prices each firm would charge in the absence of coordination, while the lower line represents the lower prices the firms would charge if the two could coordinate. Platform price is marked on the horizontal axis and it increases from left to right. The axis is labeled as a function of V in order to give it meaningful context. For example, a price greater than V means that consumers purchase the platform only if they are willing to purchase both peripherals. Platform price is capped at $2V$ since, at higher prices, no consumer values the peripherals enough to purchase the platform.

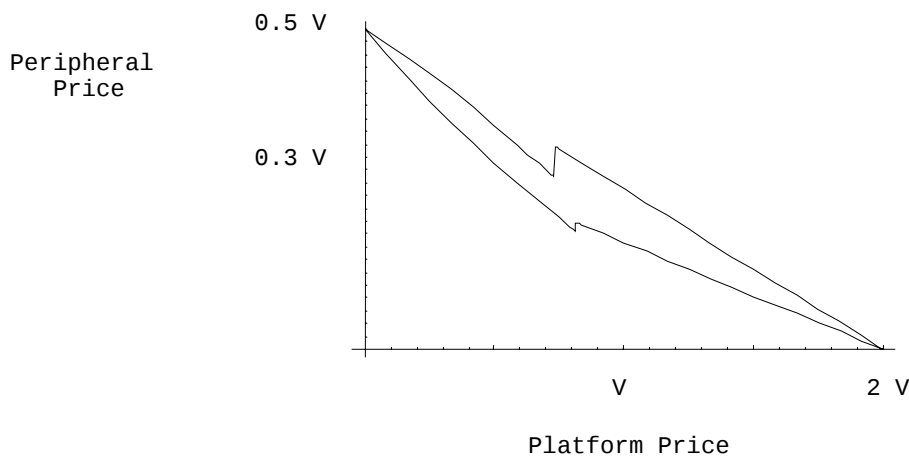


FIGURE 2. Uncoordinated (top line) and coordinated (bottom line) prices for the two-firm setting with consumer demand uniformly and independently distributed on $[0, V]$. Platform price increases left to right.

Several features of the graph warrant brief comment. First, at a platform price of zero, the uncoordinated price and the coordinated price are identical. This makes sense since, in cases where the platform is free, the price of one peripheral does not affect demand for the other, so each firm will set price appropriately. Second, as platform price rises, peripheral prices fall. Again, this follows intuition. Since consumers consider the platform price when determining how much they are willing to pay for any given peripheral, a higher platform price eats away at consumer willingness-to-pay as seen by the peripheral firms, leading the firms to compensate with lower prices.

Third, both lines are kinked because, above a certain platform price, no consumers are in "group three" with respect to either peripheral. That is, at some point, no consumers are willing to purchase the platform simply because they value one of the peripherals highly. In this example, a platform price of V is the

absolute highest platform price for which any consumer could conceivably value one peripheral enough to purchase both that peripheral and the platform. The kinks fall slightly below V since the peripherals themselves are sold at non-zero prices, and thus group three is emptied even before the platform reaches a price of V . This also explains why the kinks are not aligned. The lower line represents lower prices, so at a given platform price, there are always more consumers in group three when prices are coordinated than there are when prices are not coordinated. This naturally implies that group three is emptied in the uncoordinated case before it is emptied in the coordinated one.

Figure 3 compares the coordinated and uncoordinated prices shown in figure 2. The vertical axis depicts the price distortion as a percentage of the uncoordinated price. Thus, at a platform price of V in this example, each firm will choose a price that is approximately 33% higher than the one it would have chosen under coordination. The kinks in the line are caused by the kinks shown in the previous figure. The percentage is constant once the platform is so expensive that the only consumers who purchase it are consumers who purchase both peripherals.

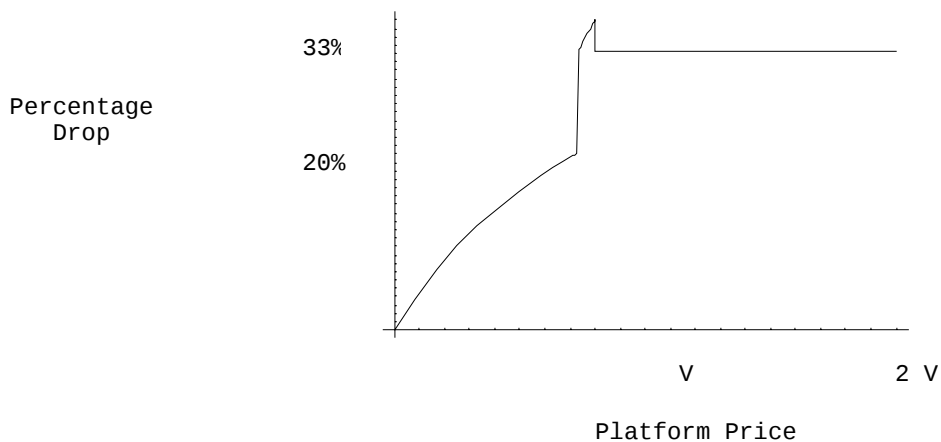


FIGURE 3. Price distortion as a percentage of uncoordinated price, graphed as a function of platform price.

Figure 4 comparably depicts the profit distortion, again as a function of platform price. This time, the vertical axis represents the profit loss as a function of uncoordinated profits. Again, and for the same reasons as explained above, the line is kinked and the distortion is constant once the platform exceeds a certain price.

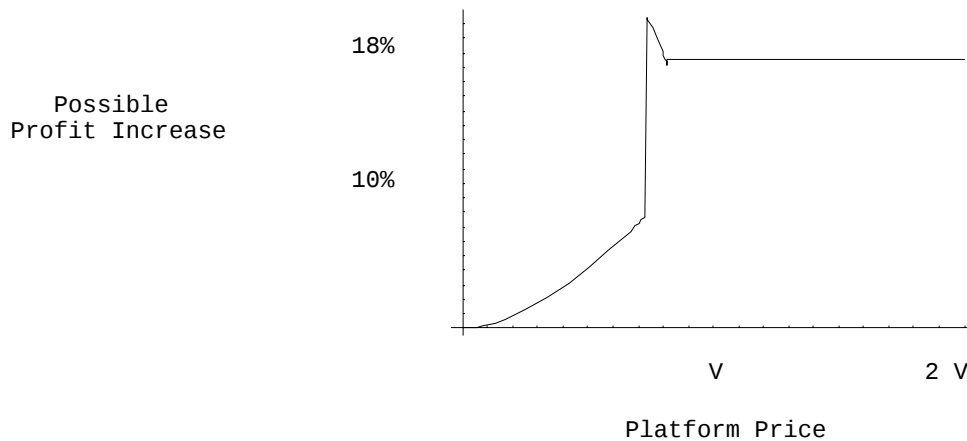


FIGURE 4. Profit distortion as a percentage of uncoordinated profit, again graphed as a function of platform price.

As with any presentation of this sort, the graphs shown here are only representative. The price distortion is a function of many factors, and it can be made to look worse or better by varying any of several assumptions. The assumptions used to generate these graphs, however, were chosen because they seem reasonable: the two peripherals were assumed to be of comparable popularity; the distortion is shown under the full range of platform prices; and so on. If the assumptions are indeed fair, then the graphs confirm that the effect can be sizeable.

III. Implications

The externality identified in the preceding section likely affects a wide variety of platform/peripheral markets. It probably affects markets where consumers purchase video game consoles separately from compatible cartridges, and markets where consumers purchase computer hardware separately from niche or locked-in software. In cases like these, though, affected firms can mitigate the externality's implications by coordinating prices through contract, integration, or some other formal or informal mechanism. So, while the externality might be important in these markets, these markets are not of particular interest here.

In markets based on emerging platform technologies, however, voluntary coordination is unworkable. The dynamic nature of still-maturing markets makes it almost impossible to bring all affected firms together for a single negotiation. And negotiations among any subset of the firms will rarely result in a significant price reduction since the involved firms will be hesitant to lower their prices for fear that any price concessions they achieve will be offset by corresponding price increases from the other firms. In emerging technology cases, then, the only way to internalize this externality is to empower one party -- the obvious choice being the platform owner -- to coordinate all the other firms.

The issue thus becomes an issue for intellectual property law. Patent, copyright, trademark, and trade secret protection combine to give platform owners a certain degree of influence over would-be peripheral developers. That influence has traditionally been constrained, the courts not willing to recognize too much influence for fear that platform owners would use it to exclude firms from the peripheral market.²² But that, as the introduction makes clear, is an outdated assumption. Many platform owners today rely on third-party innovation both to develop their platforms quickly and to identify new applications.²³ These platform owners would use additional influence not to exclude peripheral firms from the market, but instead to make the peripheral market more profitable. Thus, there is another factor for courts to consider when applying any of the various doctrines that determine the scope of a platform owner's intellectual property rights: the possibility that broader rights will be used to facilitate downstream coordination to the benefit of consumers, third-party developers, and also the platform owner.

The first subsection below sketches the basic rights intellectual property law recognizes in platform owners as a matter of course. This provides a baseline for the analysis that follows. The second subsection considers discretionary rights courts at their option recognize on a case-by-case basis. The subsection is organized around four main inquiries -- in patent law, the distinction between repair and reconstruction, and the doctrine of patent misuse; and, in copyright law, the definition of the term "derivative work" and the doctrine of fair use -- and argues that each of these inquiries should be guided in part by the arguments presented earlier in the paper. The third and final subsection considers two possible objections to this proposal: that courts might not have the expertise required to engage in the analysis endorsed here; and that, even with broader rights, as a practical matter platform owners will not be able to coordinate follow-on innovation.

A. The Intellectual Property Baseline

If platform owners were able to patent interface details -- say, claiming the precise layout of the pins that make up the platform's serial port, or the specific dimensions of the diskettes accepted by the platform's disk drive -- platform owners would fully control the associated peripheral markets. Any peripheral developer using the patented detail without the patent holder's permission would

²² See, e.g., *Sega Enterprises Ltd. v. Accolade, Inc.*, 977 F.2d 1510, 1526 (9th Cir. 1993) ("If disassembly of copyrighted object code is per se an unfair use, the owner of the copyright gains a de facto monopoly over [the sale of add-on goods]"); *Sage Products, Inc. v. Devon Industries, Inc.*, 45 F.3d 1575, 1579 (Fed. Cir. 1995) ("[The platform owner] thus seeks to keep for itself a market in parts which are intended to be periodically replaced -- this is no more than an attempt to expand patent rights to an unpatented [add-on] product.").

²³ An open market in peripherals might also be a credible commitment mechanism. Consumers would hesitate to purchase a platform if they thought that the platform owner would later have monopolistic power in the market for peripherals. On a related theme, see Joseph Farrell & Nancy Gallini, *Second-Sourcing as Credible Commitment*, 103 Q. J. Econ. 673 (1988).

be an infringer, vulnerable to an action for damages as well as injunctive relief. This is rarely the case, however, because interface details are for the most part "obvious" given the prior art.²⁴ Sony, for example, did not and probably could not patent the rather ordinary compact discs that bring data and instructions to the Sony PlayStation since the basic idea of using optical encoding to store digital data in a multiplex fashion was already well known by the time Sony filed its patent on the console.²⁵ Dell likewise did not and probably could not claim the particular port configurations that allow hardware add-ons to interface with the Dimension XPS desktop computer since, no matter how original other aspects of the machine might have been, the serial connections themselves were commonplace at the time Dell filed its patent claims.²⁶

For similar reasons, copyright, too, rarely gives platform owners significant influence over peripheral developers. The main limitation here is that interface specifications conceivably eligible for copyright -- for example, the specific pattern of 0s and 1s necessary to cause an operating system to read data from a diskette -- typically do not satisfy section 102(a)'s originality requirement.²⁷ According to the Supreme Court's interpretation of that provision in *Feist*, to be eligible for copyright protection a work not only must be original to the author (literally, "not copied") but also must demonstrate some modicum of creative achievement.²⁸ Protocols for the most part fail to demonstrate that modicum of creative achievement since many are in fact arbitrary patterns.²⁹

Even where protocols do evidence sufficient originality, copyright protection is still typically denied. The courts are inconsistent as to how this point is framed, with some courts invoking the merger doctrine while others invoke the doctrine of scenes a faire, section 102(b), or the somewhat blurred abstraction-filtration-comparison test from *Altai*³⁰; but the various approaches all emphasize

²⁴ 35 U.S.C. § 103(a) ("A patent may not be obtained . . . if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.").

²⁵ The primary PlayStation patent is U.S. Patent No. 4,977,550 (1990).

²⁶ Among the relevant patents are U.S. Patent Nos. 5,291,585 (1994) (software for accessing I/O devices) and 5,668,696 (1997) (system for heat dissipation). Some interconnection details do qualify for patent protection. For example, Nintendo earned a patent for the design of the cartridge/console interface on one of its early video game consoles. See U.S. Patent No. 4,799,635 (1989). Similarly, the 8-track cassette is a patented means of bringing information to the compatible cassette player. See U.S. Patent No. 3,403,868 (1968). Even in cases where a patent issues, however, protection is not air-tight. In *Hewlett-Packard Company v. Repeat-O-Type Stencil Manuf.*, 123 F.3d 1445 (Fed. Cir. 1997), Hewlett-Packard's patents on a particular ink jet printer cartridge were held not to be infringed by a competitor's practice of purchasing cartridges on the open market, modifying them so as to make them refillable, and, without HP's consent, selling the modified cartridges for use with Hewlett-Packard printers.

²⁷ 17 U.S.C. § 102(a).

²⁸ *Feist Publications v. Rural Tel. Serv. Co.*, 499 U.S. 340, 345 (1991) ("Original, as that term is used in copyright, means only that the work was independently created by the author . . . and that it possesses at least some minimal level of creativity").

²⁹ See, e.g., *Mitel, Inc. v. Iqtel, Inc.*, 124 F.3d 1366, 1373 (10th Cir. 1997).

³⁰ The cases apply and intermix these four basic inquiries. Some cases pursue them separately and explicitly; others pursue them in the context of the *Altai* (*Computer Assocs. Int'l, Inc. v. Altai, Inc.*, 982 F.2d 693, 709-10 (2d Cir.1992)) abstraction-filtration-comparison framework. See, e.g., *Mitel, Inc. v. Iqtel, Inc.*, 124 F.3d 1366 (10th Cir. 1997) (within

the same fundamental copyright principle: copyright protection extends only to the expressive elements of a work, and even creative protocols are more functional than they are expressive.

Trademark law gives platform developers some influence over peripheral sellers, although in most cases this is likely but a modest factor. Even unauthorized firms can advertise that their peripherals are compatible with the platform since that is a truthful claim and, if appropriately crafted, it would not lead to any confusion as to the source of the peripheral.³¹ What unauthorized firms cannot do is claim that their peripherals are "officially licensed" or, as the above implies, use platform brand names or logos in ways that would mislead consumers as to the peripheral's source.³²

A platform owner's most significant influence, however, likely comes from the fact that the platform owner can deny uncooperative firms access to private information about the platform interface. As a formal matter, trade secret law helps platform owners keep this information private by, for example, forbidding former employees from divulging technical details; but, truth be told, this is more a practical remedy than it is a legal one. The firm that designs a platform quite obviously has special expertise about the platform's inner-workings and can choose when and whether to divulge that information.

The value of this private information of course varies with the costs of reverse engineering. In instances where technology makes it inexpensive for an unauthorized firm to extract protocol information either from the platform or from authorized peripherals, the platform owner will find its influence severely constrained. In fact, in these cases, the best possible outcome might represent such a small profit gain that the platform owner will not even attempt coordination, since any attempt involves both risk and administrative expense. Such cases might be more common than intuition at first suggests. After all, peripheral firms are not simply being asked to lower their prices in a static setting, but are instead being asked to lower their prices even as demand for their products is increasing thanks to other firms' price reductions; thus, when we say that the platform owner will find it difficult to coordinate the market in settings where the

Altai framework relying on 102(a), 102(b), and scenes a faire); *Gates Rubber v. Bando Chem. Indus., Ltd.*, 9 F.3d 823 (10th Cir. 1993) (within *Altai* framework relying on 102(a), 102(b), merger, and scenes a faire); *Bateman v. Mnemonics, Inc.*, 79 F.3d 1532 (11th Cir. 1996) (questioning application of *Altai* framework in this context). Menell discusses the history of *Altai* and its application to the above cases in Peter Menell, An Epitaph for Traditional Copyright Protection of Network Features of Computer Software, 43 Antitrust L. Bulletin 651 (1998).

³¹ As a general rule, one firm can use another firm's trademark to market products or services provided that the use is truthful and there is no likelihood of confusion as to source. See, e.g., *Smith v. Chanel, Inc.*, 402 F.2d 562 (9th Cir. 1968) (competitor's trademark used in comparative advertising). This is especially true in cases where the mark is essentially the only means of informing consumers as to the true nature of the product.

³² Some anecdotal evidence: For a minimum fee of \$500, Palm Computing allows peripheral developers to use a special Palm logo, the only condition being that the peripheral pass certain compatibility tests. The details are available at <http://www.qpqa.com/palm/base-pr.html> (last visited on October 1, 1999).

costs of reverse engineering are low, we mean low relative to the requested price drop, which in many cases can turn out to be a rather large number.

B. Discretionary Doctrines

The baseline rights outlined above -- mainly, trade secret protection of interface information -- will in many instances not give the platform owner sufficient leverage to coordinate downstream innovators. The cases introduced below bear evidence to that fact; if the simple act of keeping interface information secret was enough to give platform owners significant influence over would-be peripheral developers, platform owners would never have resorted to the licensing and related schemes summarized below. That trade secret protection might be too weak, however, is only one of two arguments in favor of the recognition of broader rights. The other argument applies even in cases where trade secret protection is sufficient.

In cases where reverse engineering is expensive, a platform owner gains significant influence by threatening to withhold interface information. In these cases, the platform owner already enjoys significant influence, so it is hard to see any harm in recognizing that influence explicitly. Yet such recognition would likely increase societal efficiency since it would eliminate several bad incentives that trade secret law today creates. For example, firms attempting to keep the costs of reverse engineering high will, at the margin, be tempted to design awkward, cumbersome protocols. Simple protocols are something of a liability to a firm relying on the expense of reverse engineering; complicated handshakes are more difficult to reverse engineer. In other words, by not recognizing broader rights, the current intellectual property regime creates a perverse incentive for platform owners to design unwieldy interface specifications. And, more troubling, in a competition between two otherwise-equivalent platforms, the more cumbersome technology will prevail -- first attracting more developers through the promise of coordination, then, thanks to the higher availability of peripherals, attracting more consumers as well.

Similarly, a firm relying exclusively on trade secret protection will be tempted to increase its influence over would-be peripheral developers by delaying the introduction of its platform to market. Reverse engineering is impossible so long as the platform never leaves its owner's physical control; thus, to a firm relying on the expense of reverse engineering as a substitute for explicit intellectual property protection, delay is at the margin attractive. Considering that one of the fundamental purposes of intellectual property protection is to promote

the prompt disclosure of innovative ideas, this sort of behavior seems undesirable.³³

The text below surveys four discretionary inquiries in intellectual property law that, in different settings, determine the relative rights of platform owners and peripheral developers. It is in the context of these inquiries that the analysis presented in this paper could most easily be brought to bear. The purpose here is not to offer detailed explanations of the various doctrines and interpretations, but instead simply to point out that these are the key inquiries affected by the paper.

1. Repair/Reconstruction (Patent Law)

Plaintiff in *Sage Products v. Devon Industries*³⁴ developed and sold a disposal system designed for use with hazardous medical materials. One component of the system was a removable inner container that would actually make contact with the hazardous waste. This component was designed to be used once and then discarded. Plaintiff held a patent on the complete disposal system -- the inner container *as used in combination with* the rest of the apparatus -- but its patent did not, and on obviousness grounds probably could not, explicitly claim the inner container itself. When a competitor began selling replacement containers, plaintiff-patentee sued, arguing that every time one of its customers used a container made by its competitor, the consumer was impermissibly "reconstructing" the patented combination and therefore the competitor was liable for either contributory or induced infringement.

The distinction raised in a case like *Sage* is the distinction between the *repair* and *reconstruction* of a patented combination.³⁵ The issue arises in instances where a peripheral is listed as an element of a patent claim. The patent holder argues that, by replacing the listed element, users infringe the combination patent -- and note that this is a plausible argument given that patent law frequently recognizes exclusive rights in particular combinations, for example the combination of unpatentable glue and unpatentable paper to form the fully patentable Post-It note.³⁶ Alleged infringers respond that this type of hyper-literal infringement should be excused, in essence on an implied license theory.

The distinction between repair and reconstruction is thus a question of patent scope -- a question that in this context determines whether peripheral developers need the platform owner's permission to sell compatible peripherals.

³³ Cf. William Landes & Richard Posner, An Economic Analysis of Copyright Law, 18 J.L. Stud. 325, 331 (1989) (arguing that copyright law should recognize broad rights in derivative works because, in the absence of such protection, authors would at the margin delay publication in order to first prepare derivative works themselves).

³⁴ 45 F.3d 1575 (Fed. Cir.1995).

³⁵ See *Aro Manufacturing Co. v. Convertible Top Replacement Co.* 365 U.S. 336 (1961) (Aro I) and *Aro Manufacturing Co. v. Convertible Top Replacement Co.*, 377 U.S. 476 (1964) (Aro II). Additional cases are collected and analyzed in Mark Janis, A Tale of the Apocryphal Axe: Repair, Reconstruction, and the Implied License in Intellectual Property Law, 58 Md. L. Rev. 423 (1999).

³⁶ U.S. Patent No. 5,153,041 (1992).

To the extent replacing the peripheral is deemed reconstruction, it is under the patent holder's exclusive purview; to the extent those replacements are deemed repair, the patent holder has no exclusive right. This is a judicially developed distinction; and courts today consider the "totality of the circumstances" when determining whether a given act infringes.³⁷ One implication of the current paper is thus to suggest that one factor courts should consider as part of this inquiry is how each result would affect the structure and existence of the market for replaceable components.

2. Patent Misuse

Platform owners have from time to time attempted to control peripheral developers by imposing restrictive licenses on purchasers of the platform. For example, in *Motion Picture Patents Company v. Universal Film Manufacturing Company*³⁸, plaintiff-patentee conditioned each sale of its patented film projector on the stipulation that the purchaser rent films only from distributors approved by the patentee. When three unauthorized film distributors started to offer films for sale, the patentee sued, arguing that (1) because no purchaser of the projector could use unauthorized films without violating the license, and (2) because after violating the license purchasers would be using the patented invention without the patent holder's permission, that (3) by selling unauthorized films the distributors were illegally inducing patent infringement.

Under modern law, patent holders and purchasers of patented goods are free to "contract as they choose, provided that no law is violated thereby."³⁹ That is, the inquiry in a case like this is phrased in the negative: restrictive licenses are to be upheld so long as other bodies of law do not prohibit that result. Contract law, for example, precludes enforcement of "unconscionable" conditions⁴⁰, and specific patent doctrines condemn certain conditions, for example conditions that serve to extend the patent term beyond its statutory duration.⁴¹ What is troubling about this analytical approach as applied here is that one of the legal barriers emphasized in the negative inquiry is the doctrine of patent misuse.

Patent misuse is traditionally an affirmative defense to a charge of patent infringement. It is an equitable doctrine, the notion being that a court should not use its power to assist a patent holder where, in this or any other interaction, the

³⁷ *Aktiebolag v. E.J. Company*, 121 F.3d 669 (Fed. Cir. 1997).

³⁸ 243 U.S. 502 (1917).

³⁹ *Mallinckrodt v. Medipart, Inc.*, 976 F.2d 700, 703 (Fed. Cir. 1992). *Accord B. Braun Medical Inc. v. Abbott Laboratories*, 124 F.3d 1419 (Fed Cir. 1997).

⁴⁰ See E. Allan Farnsworth, *Contracts* 4.28, at 307-17 (3d ed. 1999).

⁴¹ *Brulotte v. Thys Co.*, 379 U.S. 29, 32 (1964) ("patentee's use of a royalty agreement that projects beyond the expiration date of the patent is unlawful per se"); *Boggild v. Kenner Prods.*, 776 F.2d 1315, 1320-21 (6th Cir. 1985), cert denied, 477 U.S. 908 (1986) (where pre-expiration and post-expiration royalties are identical, agreement is unlawful per se).

patent holder is exercising its rights in a manner against public policy.⁴² The defense can be invoked in any case. An alleged infringer, for example, can argue that a given patent should not be enforced because, in some entirely unrelated instance, the patentee has impermissibly used its patent power. A patent holder whose actions are found to constitute misuse loses *all* rights vis-à-vis *all* parties until the practice is discontinued and its effects on the market are "fully dissipated."⁴³

Why is this troubling? As a practical matter, bringing this interpretation of patent misuse into the negative inquiry means that patent holders cannot even attempt to use restrictive licenses for this purpose. The stakes are too high; one misstep and the patent holder in essence forfeits patent protection on the platform entirely.⁴⁴ Because the arguments presented in this paper would favor, in certain circumstances, the enforcement of restrictive licenses of this sort, the draconian penalties of patent misuse seem unnecessarily chilling. Courts would better serve equity by in these instances narrowing the maximum patent misuse penalty and thus enabling firms to attempt what might turn out to be permissible and socially beneficial licensing regimes.

3. *Fair Use (Copyright)*

Platform owners have also tried to control peripheral developers by using copyright to limit the reverse engineering process. For example, in *Sega Enterprises Ltd. v. Accolade, Inc.*⁴⁵, Accolade purchased from Sega video game cartridges compatible with Sega's video game console and proceeded to reverse engineer the cartridges in order to identify the relevant interface specifications. Intermediate steps in that process required that Accolade duplicate and manipulate Sega's copyrighted video game code. (Accolade had to translate the code from machine language to a form more accessible to human readers.) So Sega sued, not arguing that Accolade had illegally used the interface specifications -- an argument not available to Sega because, as noted previously, interface information itself is generally not eligible for copyright protection -- but arguing instead that, in the process of reverse engineering, Accolade had infringed Sega's rights in the validly copyrighted video games.

Two prominent cases evaluate arguments of this sort: the Ninth Circuit's *Sega* case summarized above, and a contemporary Federal Circuit case, *Atari*

⁴² See *Morton Salt Co. v. G.S. Suppinger Co.*, 314 U.S. 488 (1942).

⁴³ *B.B. Chem. Co. v. Ellis*, 314 U.S. 495, 498 (1942) (after a finding of patent misuse, a patent holder's rights should not be enforced until the patent holder "is able to show that it has fully abandoned its present method of restraining competition in the sale of unpatented articles and that the consequences of that practice have been fully dissipated").

⁴⁴ For some anecdotal evidence that patent holders are reluctant to risk vulnerability to the defense, see Richard H. Stern, *Post-Sale Patent Restrictions after Mallinckrodt: An Idea in Search of Definition*, 5 *Alb. L.J. Sci. & Tech.* 1 (1994).

⁴⁵ 977 F. 2d 1510, as amended by 1993 U.S. App. Lexis 78 (9th Cir. 1993).

Games v. Nintendo.⁴⁶ Both courts ultimately held any such infringement was excused under the doctrine of fair use. Fair use is an affirmative defense to copyright infringement that must be raised on a case-by-case basis.⁴⁷ It is meant to excuse literal infringement where public policy favors that result. A book reviewer, for example, can invoke the doctrine to defend an infringement charge arising out of his unauthorized use of a book excerpt, and a comedian can similarly use it to defend an unauthorized parody. The defense is codified at section 107 of the Copyright Act, but codification has not significantly constrained the doctrine's scope. This is still, as it originally was, an all-inclusive, equitable inquiry.⁴⁸

The courts in *Sega* and *Nintendo* considered a number of factors in determining that copyright infringement necessary to the creation of compatible peripherals should be excused on this public policy exception; but, as it was in patent law with the distinction between repair and reconstruction, the fair use inquiry pursued in these cases did not weigh in the possibility that a finding of infringement would have forced would-be peripheral developers to negotiate with the relevant platform owners and thus would have empowered those platform owners to coordinate peripheral prices. This is not to say that this factor will always be determinative or even that it should have been determinative in these particular cases; but it should in the future be considered since, as this paper argues, public policy will in some cases be better served by rejecting the fair use defense and thereby expanding the scope of platform owners' intellectual property rights.

4. Derivative Work (Copyright)

A last application for the analysis presented in this paper is in the interpretation of section 106(2) of the Copyright Act, which grants to copyright holders the exclusive right "to prepare derivative works" based on a copyrighted work.⁴⁹ In *Micro Star v. Formgen, Inc.*⁵⁰, Formgen held copyright in a popular video game that, in addition to twenty-nine playable levels of monsters and scenery, came with a utility that allowed users to create additional game levels. Micro Star, an independent firm, collected 300 user-created levels and sold them on a single compact disc as an accessory to Formgen's game. The disc did not replace the original game; it only contained data that would allow users who

⁴⁶ 975 F.2d 832 (Fed. Cir. 1992). The two cases have been the subject of extensive legal commentary. See, e.g., Julie Cohen, *Reverse Engineering and the Rise of Electronic Vigilantism: Intellectual Property Implications of "Lock-Out" Technologies*, 68 S. Cal. L. Rev. 1091 (1995); Dennis Karlaja, *Copyright Protection of Computer Documents*, *Reverse Engineering*, and Professor Miller, 19 U. Dayton L. Rev. 975 (1994).

⁴⁷ 17 U.S.C. § 107. For a general introduction, see Marshall Leaffer, *Understanding Copyright* 427-76 (3rd ed. 1999).

⁴⁸ The House Report on the Copyright Act of 1976 makes this point explicitly, H.R. Rep. No. 1476, 94th Cong., 2d Sess. 65 (1975), and the Supreme Court has interpreted § 107 accordingly, see *Harper & Row Publishers, Inc. v. Nation Enterprises*, 471 U.S. 539, 560 (1985).

⁴⁹ 17 U.S.C. § 106(2).

⁵⁰ 154 F.3d 1107 (9th Cir. 1998).

already owned the game to play the additional levels created by other users. Micro Star then sued for a declaratory judgment that its product did not infringe Formgen's copyright, and Formgen counterclaimed for a preliminary injunction barring further distribution of Micro Star's product.

In a case like this, the analysis turns on the question of whether the accessory at issue is a derivative work, which section 101 defines to mean "a work based upon one or more preexisting works."⁵¹ Read literally, of course, that definition would include every work of authorship ever created since, to some extent, "every book in literature, science and art, borrows and must necessarily borrow" from that which came before.⁵² Courts therefore must apply the statutory language narrowly, although exactly how narrowly continues to be an open question both in the platform/peripheral context⁵³ and more generally.⁵⁴

This definitional issue is yet another indirect inquiry into the scope of an underlying intellectual property right. If add-on video game levels are deemed to be derivative work, the platform owner's copyright in essence expands to include control over the market for this additional product. If not, that market remains open to any firm capable of reverse engineering the relevant protocols. Again, the arguments presented in this paper suggest that part of this definitional inquiry should be consequentialist: in addition to considering the trade-off between increased incentives to create copyrightable works on the one hand and increased public access to already-existing copyrightable works on the other, courts should consider whether broader rights might make possible beneficial coordination of the sort introduced earlier the paper.

C. Judicial Competence and Implementation Problems

There are two primary objections that might be raised against the proposals sketched above: first, that courts do not have the expertise required to engage in the suggested market analysis; and, second, that even with broader rights, as a practical matter platform owners will not be able to coordinate follow-on innovation due to various informational and logistical constraints. These are important objections; each is considered in turn below.

To evaluate judicial competence in the current setting, it is helpful to draw an analogy to antitrust law. Practices subject to review under the Sherman and

⁵¹ 17 U.S.C. § 101.

⁵² *Micro Star*, 154 F.3d at 1110 (quoting *Emerson v. Davies*, 8 F. Cas. 615, 619 (C.C.D. Mass. 1845) (No. 4436)).

⁵³ Compare, for example, *Lewis Galoob Toys, Inc. v. Nintendo of Am., Inc.*, 964 F.2d 965 (9th Cir. 1992) (hardware add-on that altered video game performance not derivative work) with *Micro Star*, 154 F.3d (software add-on that altered video game performance found to be derivative work).

⁵⁴ Compare, for example, *Mirage Editions, Inc. v. Albuquerque A.R.T. Co.*, 856 F.2d 1341 (9th Cir. 1988) (purchaser of copyrighted art book created derivative work by removing and framing particular pages) with *Lee v. A.R.T. Co.*, 125 F.3d 580 (7th Cir. 1997) (opposite result for notecards mounted on ceramic tiles).

Clayton Acts are either evaluated case-by-case under the rule of reason, or deemed illegal without regard to the specific facts at hand under a per se rule. Sometimes, the choice between rule of reason review and per se prohibition is straightforward; these are cases where experience suggests that the practice at issue has virtually no pro-competitive application and so the per se rule is obviously appropriate.⁵⁵ In the remaining cases, however, the choice turns in large part on the question of judicial competence. That is, practices that have some pro-competitive application might still be deemed illegal per se, the logic being that, as applied to these practices, the expected benefits of case-by-case review are outweighed by the expected costs -- costs which include the direct costs of litigation, the costs associated with uncertainty, and, most importantly, the costs associated with judicial error.⁵⁶

Thus, in formulating antitrust policy with respect to per se rules, courts in essence asks a question similar to the one being posed here: is the judiciary sufficiently skilled at analyzing market structure so as to justify case-by-case consideration of the specific practice at issue, or are courts so likely to err in their analysis of this practice that a discretionary inquiry is unwise? This question was recently addressed by the Supreme Court with respect to a practice that bears strong similarities to the coordination under consideration in this paper: price coordination through the use of vertical maximum price agreements.

For nearly fifty years, vertical maximum price agreements -- contracts through which an upstream manufacturer or supplier imposes a price cap on related downstream retailers or resellers -- were prohibited under a per se rule.⁵⁷ But, in 1997, the Supreme Court overruled those earlier cases and held that vertical maximum price agreements are rightly judged under the rule of reason.⁵⁸ Truth be told, this most recent case does not offer significant insight into the Court's logic. The opinion makes only a few vague references to the possible harms that might obtain if vertical price agreements are approved in error⁵⁹, and in the end the opinion seems to simply assert that anti-competitive behavior "can be appropriately recognized and punished" case-by-case.⁶⁰

⁵⁵ *National Soc'y of Professional Engineers v. United States*, 435 U.S. 679, 688-92 (1978) (per se rules are appropriate when applied to "agreements whose nature and necessary effect are so plainly anticompetitive that no elaborate study of the industry is needed to establish their illegality").

⁵⁶ Compare Frank H. Easterbrook, *Vertical Arrangements and the Rule of Reason*, 53 *Antitrust L. J.* 135, 157 (1984) (the per se rule is appropriate in instances where "case-by-case adjudication . . . would permit too many deleterious practices to escape condemnation"); Frank Easterbrook, *Maximum Price Fixing*, 48 *U. Chi. L. Rev.* 886, 909-10 (1981) ("The costs of trying to separate beneficial agreements among competitors are large; one particular cost is the chance of error"; "[a]t some point, though, the [possible benefits] become so large in relation to the costs of inquiry (including the costs of error) . . . that there is no longer . . . justification for using per se rules.").

⁵⁷ *Kiefer-Stewart Co. v. Joseph E. Seagram & Sons, Inc.*, 340 U.S. 211 (1951); *Albrecht v. Herald Co.*, 390 U.S. 145 (1968).

⁵⁸ *State Oil v. Kahn*, 522 U.S. 3 (1997), overruling *Albrecht*, supra note ____.

⁵⁹ *Id.* at ____.

⁶⁰ *Id.* at ____.

How to interpret this, then, is admittedly unclear. It might be that the Court thought the issue so obvious that a few words and brief citations sufficed. But that would at least be surprising, given the number of scenarios in which maximum price agreements might plausibly be anti-competitive⁶¹, and the continued debate over both the likelihood of those uses and their severity.⁶² More plausible, it seems, would be to interpret the case as part of a broad trend away from per se rules in the antitrust context. That trend has been well documented elsewhere⁶³ -- the result of a series of exceptions and limited readings by the Court⁶⁴ as furthered by lower court efforts to mitigate any per se rules still in effect.⁶⁵

Indeed, with this most recent ruling, almost all restraints imposed by upstream firms on their downstream counterparts are now evaluated under the rule of reason.⁶⁶ The courts consider the facts when ruling on the legality of restrictions on, say, sales territories or customer lists.⁶⁷ A manufacturer can refuse to deal with an affiliate of long-standing -- perhaps even replace that retailer with another or a wholly-owned subsidiary -- and at worst still be subject only to the case-by-case, rule of reason inquiry.⁶⁸ This is not because there is no chance that courts will err in their evaluation of the consequences of such vertical restraints. This is not because these practices pose no risk of anti-competitive application, nor is it because the costs of litigation and uncertainty have been shown to be trivial in these instances. The prominence of the rule of reason instead reflects a gradual consensus within the judiciary and also the academy that courts are sufficiently competent when it comes to analyzing complicated market structures.

⁶¹ For an overview and citations into the literature, see Easterbrook, Maximum Price Fixing, *supra* note ____.

⁶² <Gather additional sources.>

⁶³ See, e.g., Alan J. Meese, Tying Meet the New Institutional Economics: Farewell to the Chimera of Forcing, 146 U. Penn. L. Rev. 1 (1997); Thomas A. Piraino, Jr., Making Sense of the Rule of Reason, 47 Vand. L. Rev. 1753, 1753-60 (1994); Ernest Gellhorn & Teresa Tatham, Making Sense Out of the Rule of Reason, 35 Case W. Res. 155 (1985).

⁶⁴ See, e.g., *Broadcast Music, Inc. v. CBS* 441 U.S. 1 (1979) (rule of reason analysis appropriate for blanket licensing agreement between composers and CBS; not within per se rule otherwise applied to horizontal price-fixing); *Jefferson Parish Hospital District No. 2 v. Hyde*, 466 U.S. 2 (1984) (limiting per se rule applicable to tying arrangements by introducing requirement of market power); *Monsanto Co. v. Spray-Rite Service Corp.*, 465 U.S. 752 (1984) (manufacturer can refuse to deal with a price-cutter so long as that action is unilateral; evidence that other distributors have complained to the manufacturer will not itself transform unilateral into concerted action for the purposes of antitrust analysis); *Business Electronics Corp. v. Sharp Electronics Corp.*, 485 U.S. 717 (1988) (per se rule against agreements to terminate price-cutting dealer not applicable in cases where firms involved in the concerted action had not themselves agreed as to a specific price).

⁶⁵ See, e.g., *Jack Walters & Sons Corp. v. Morton Building*, 737 F.2d 698, 706 (7th Cir.), cert denied, 469 U.S. 1018 (1984) (mitigating then-valid per se prohibition on vertical maximum price agreements by severely limiting possible damage award).

⁶⁶ The lone hold-out is the per se prohibition on minimum price agreements, a doctrine with roots all the way back to *Dr. Miles Medical Co. v. John D. Park & Sons Co.*, 220 U.S. 373 (1911). Even that per se rule knows limitations; for example, under the *Colgate* doctrine, minimum price agreements enforced by purely unilateral action never fall under antitrust law's purview. See *United States v. Colgate & Co.*, 250 U.S. 300 (1919).

⁶⁷ These and other examples are discussed in Herbert Hovenkamp, *Federal Antitrust Policy: The Law of Competition and Its Practice* 392-440 (1994).

⁶⁸ *Id.*

Would analysis under the four intellectual property doctrines introduced in the previous subsection differ from the analysis required in traditional antitrust cases? Absolutely. The antitrust approach is passive, the law simply *allowing* firms in appropriate cases to coordinate prices without fear of antitrust liability. The proposed approach, by contrast, contemplates affirmative intervention, namely the recognition of broader property rights. But in the choice between bright-line rules and case-by-case analysis, that seems to be a distinction without a difference. The current intellectual property regime functions as a per se denial of affirmative intervention. The recent decision with respect to maximum resale price agreements seems to call that result into question.⁶⁹

As for the second concern raised above -- the worry that, even with broader rights, as a practical matter platform owners will not be able to coordinate third-party developers -- it is certainly true that property rights solve only part of the problem facing platform owners. Broader rights obligate would-be developers to identify themselves to the platform owner since only the platform owner is able to authorize a firm to market peripherals. They further obligate peripheral firms to comply with the platform owner's requests, at least so long as the coordinated network subject to those requests is still more attractive than some competing, uncoordinated option. What these rights do not do, however, is help the platform owner know how to wield this influence in the face of unknown products and uncertain demand.

This is a significant problem; however, experience in other industries suggests that upstream firms can often develop mechanisms that effectively constrain the prices charged by related downstream firms, and can do this despite informational limitations. For example, newspaper publishers typically grant newspaper carriers exclusive sales territories in order to make possible certain economies of scale in the delivery process. Having done so, however, publishers are then interested in limiting delivery prices in order to ensure that carriers do not abuse their exclusive positions. So, newspaper publishers have devised a mechanism -- the aforementioned maximum price agreements -- to constrain carrier discretion, keeping delivery prices down and hence newspaper sales up.⁷⁰ Publishers choose these maximum prices despite the fact that carriers have private information with respect to local demand conditions, the quality of their delivery service, and so on.

A similar difficulty arises in the auto industry. Automobile manufacturers also typically assign their dealers exclusive sales territories, this time as a way of eliminating a free-rider problem with respect to dealer services. (As Carlton and Perloff explain, if car dealers were not assigned exclusive sales territories, a

⁶⁹ See also *United States v. Jerrold Electronics Corp.*, 187 F. Supp. 545 (E.D. Pa. 1960), *aff'd per curiam*, 365 U.S. 567 (1961) (refusing to apply per se rule where technology firm linked sales of new technology to service and maintenance of that technology on grounds that new technology should be treated differently from established ones).

⁷⁰ *Albrecht v. Herald Co.*, 390 U.S. 145 (1968).

cunning dealer would open shop next door to another dealer, keep prices low by skimping on décor and service, and put a sign in the window advising consumers to "test drive there and buy here."⁷¹) Exclusive sales territories in this context again create a situation where retailers have market power; but, perhaps because the informational and monitoring difficulties are more severe in the automobile industry than they are in the newspaper industry, automobile manufacturers have been reluctant to set price caps directly. Instead, car manufacturers offer sales rewards to dealers and salesmen. The lower the price the dealers charge, the more cars they sell, and hence the greater their corresponding sales reward. Sales rewards thus give dealers an incentive to choose lower prices than they otherwise would, reducing the price distortion.

There are other examples of mechanisms that help to constrain prices in situations characterized by at least some degree of imperfect information. For instance, certain malls use profit-sharing programs to tie store profits together and in that way encourage individual store owners to charge prices that account both for the direct effects on their own profits and for the indirect effects on overall mall traffic.⁷² The point here is only that, armed with the appropriate intellectual property rights, platform owners might be able to use these or related mechanisms to mitigate the price and profit distortions discussed in the paper.⁷³ This seems especially likely in cases where prices are considerably higher than optimal since, in those cases, even an imperfect coordination mechanism could still yield significantly increased profits.

III. Conclusion

The externality identified in this paper can arise whenever three conditions are met: (1) consumers make an initial investment that increases the value of some number of products; (2) those products are sold by independent firms; and (3) a subset of those firms have at least limited market power. As was pointed out in the introduction, these conditions can be satisfied in a variety of settings, although this paper has focused on various technology applications.

In theory, the resulting price distortion can be eliminated by contract, vertical integration, or merger; but, in the context of emerging platform technologies, coordination problems make these solutions implausible. The dynamic nature of markets based on emerging technologies makes it difficult to

⁷¹ Adapted from Carlton & Perloff, *supra* note __, at __.

⁷² < Confirm with mall managers.> This same result could in theory be achieved by adjustments to each store's rent, however rent seems to be keyed to other externalities, for example externalities with respect to the decision to open a particular shop in a given mall. On these externalities, see B. Peter Pashigian & Eric Gould, *Internalizing Externalities: The Pricing of Space in Shopping Malls*, 41 J.L. Econ. 115 (1998). 41 J. Law & Econ.

⁷³ To play out one example: platform owners could require would-be peripheral developers to pay a licensing fee up front; the platform owner could then use those fees to fund a system of sales incentives similar to those used in the automotive industry.

gather all affected firms for a single negotiation; and the externality itself undermines the benefits of any negotiation conducted among a subset of the affected firms. These problems can be solved by property rights. Thus, the paper has argued that intellectual property law should take stock of these issues, offering the possibility of stronger rights in cases where coordination would otherwise be implausible.

Recent enthusiasm for legal rules that constrain the behavior of platform owners has to some degree crowded out conversations regarding legal reform of the sort discussed here. That is unfortunate. Just as traditional network economics related to lock-in and network effects suggest that legal intervention limiting platform owner control might in some cases improve societal welfare, the network economics introduced in this paper suggest conversely that legal intervention supportive of owner control can at times increase societal welfare as well.

Appendix

Suppose that N firms each produce one peripheral compatible with a given platform. Each firm $i \in [1, N]$ sells its peripheral at price p_i , and the platform is available at price p , which for the purposes of this model is exogenous. Assume that the platform has no intrinsic value, which is to say that consumers purchase it only because it enables them to use peripherals.

If the platform were free, a given consumer would be willing to pay up to b_i for the peripheral i . Because the platform is not free, however, the consumer is willing to pay only up to b_{ei} where b_{ei} is the consumer's "effective" valuation of the i^{th} peripheral given all prices, p_{-i} , and the platform price, p .

Define $N = \{1, 2, 3, \dots, N\}$ and $N_i = N - \{i\}$. b_{ei} is therefore:

$$b_{ei} = b_i - \left\{ \begin{array}{ll} p - 0 & \text{if } b_i \leq p_i \forall j \in N_i \\ p - \sum_{j \in J} (b_j - p_j) & \text{if } \exists J_k \subseteq N_k \text{ such that } j \in J_k \\ & \text{satisfies } p_j \leq b_j \leq (p_i + p), \\ & \sum_{j \in J} (b_j - p_j) \leq p, \text{ and} \\ & \forall i \in (N - J), b_i \leq p_i \\ p - p & \text{if } \exists J_i \subseteq N_i \text{ such that } j \in J_i \\ & \text{satisfies } p_j \leq b_j \text{ and} \\ & \sum_{j \in J} (b_j - p_j) \geq p \end{array} \right. \quad (A1)$$

where the bracketed portion represents the effective price of the platform given this consumer's valuations and the various peripheral prices. Since the effective platform price varies from consumer to consumer, let us define p_{ei} to be the *expected* effective platform price with respect to the i^{th} peripheral given all prices p_{-i} .

Figure 5 interprets (A1) in the context of a specific example. The right-most line represents demand for one peripheral under the assumption that consumer valuations are uniformly distributed on $[0, 100]$ and the relevant platform is available at no charge. The left-most line shows how demand shifts when the platform price is non-zero; in this example, price was set to 80. The middle line shows how demand is then reshaped by the introduction of two additional peripherals. This particular line shows demand under the assumptions that consumer valuations for the other two peripherals are independent and uniformly distributed on $[0, 100]$, and that the two additional peripherals are each sold at a price of 30.

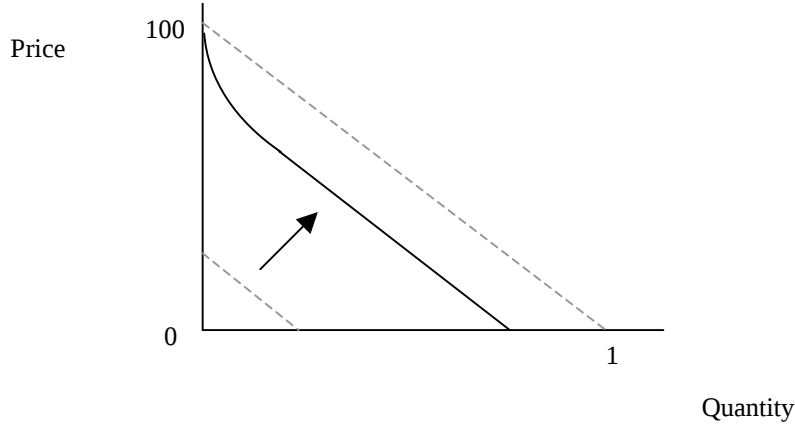


FIGURE 5. Demand as reshaped by the prices of, and demand for, two additional peripherals. The three lines are interpreted in the text.

The introduction of the two additional peripherals not only shifts demand up and to the right, it also bends it. The upward shift is easy to understand: the effective price of the platform has diminished, so demand partially recovers the loss depicted in figure 3. The bending at the top is more complicated. The intuition is that consumers who value at the highest extreme are especially rare since such consumers must not only value the peripheral highly to begin with, but also must happen to value the other peripherals so much that the platform's effective price is nearly zero. The confluence of these events is rare, and so, at the top of the curve, a given price reduction lures fewer new purchasers than a corresponding change would elsewhere in the curve.

Denote the demand faced by firm $i \in N$ by $D_i(p, p_i, p_{-i})$, which means that the demand for firm i 's peripheral is a function of the price of the platform (p), the price of the peripheral (p_i), and the prices of all other peripherals (p_{-i}). Note that p_{-i} does not affect D_i directly, but instead influences D_i through its effect on the effective price of the platform. Firm i thus chooses p_i to maximize its profit, π_i , where $\pi_i = p_i D_i(p, p_i, p_{-i})$ with both p and p_{-i} taken as given. Firm i 's first-order condition to this maximization problem is

$$\partial \pi_i / \partial p_i = D_i(p, p_i, p_{-i}) + p_i D_i'(p, p_i, p_{-i}). \quad (\text{A2})$$

Let p_i^u be firm i 's uncoordinated price in equilibrium. We assume that the firms settle on a Nash equilibrium for ease of discussion; in cases where there is no equilibrium, prices would churn and our claim would instead be that they churn at levels that are unprofitably high. At p_i^u the FOC in (A2) equals zero, so we get that

$$p_i^u = -D_i(p, p_i^u, p_{-i}^u) / D_i'(p, p_i^u, p_{-i}^u). \quad (\text{A3})$$

Define $p^u = (p_1^u, \dots, p_N^u)$. The various claims made in the paper all assert that p^u is unprofitably high, in other words that lowering prices would raise aggregate profits. To see this, define total network profit, π_N , to be

$$\pi_N = \sum_i p_i D_i(p, p_i, p_{-i}). \quad (\text{A4})$$

For a given p_i , the first-order condition to this maximization problem is

$$\partial\pi_N/\partial p_i = D_i(p, p_i, p_{-i}) + p_i D_i'(p, p_i, p_{-i}) + \sum_{j \neq i} p_j [\partial D_j / \partial p_i]. \quad (A5)$$

The critical point is this: any price for which this derivative is negative is, by definition, a price that is unprofitably high. A lower price increases aggregate profits.

It is helpful to rewrite (A5) as

$$(A5) = (A2) + \sum_{j \neq i} p_j [\partial D_j / \partial p_i] \quad (A5')$$

since we know that (A2) = 0 for all i whenever $p = p^u$. We also know that $p_j \geq 0$ for all j (since these are prices). Thus, at p^u , we must simply determine the sign of (A5'), noting that the claim (weakly) holds whenever

$$\partial\pi_N/\partial p_i = \sum_{j \neq i} p_j [\partial D_j / \partial p_i] \leq 0 \quad (A6)$$

PROPOSITION. *In settings where two or more firms sell peripherals and those peripherals are neither complements nor substitutes, each firm would earn greater profit if each charged a price lower than its individually rational price.*

We prove the proposition in two steps. First, we show that absent coordination every firm will charge too high a price relative to the prices that would maximize aggregate profit. Then we show then, whenever every firm is charging too high a price relative to the prices that would maximize aggregate profit, there exists a set of coordinated prices such that each firm individually earns greater profit than it would under uncoordinated conditions.

Consider (A1). We know from (A1) that changes in the other firms' prices shift demand for the any given peripheral, and in predictable ways. Lower prices for the other peripherals mean increased demand for the original one. Conversely, higher prices for the other peripherals mean lesser demand for the original one. We defined the bracketed term to be the "effective" platform price, and further defined p_{ei} to be the expected effective platform price. We thus know that $\partial D_i / \partial p_{ei} \leq 0$ (that is, demand for the i^{th} peripheral decreases as the effective platform price increases) and $\partial p_{ei} / \partial p_j \geq 0$ (an increase in firm j 's price increases the effective price of the platform as perceived by consumers thinking of purchasing any other peripheral).

The sign of (A6) is determined by the sign of $\partial D_j / \partial p_i$ for all pairs $(i, j) \in N$ where $i \neq j$. Since the peripherals are neither complements nor substitutes, the only relationship between their demand and other firms' prices is the relationship through the platform. Thus, for any pair, we know

$$\partial D_j / \partial p_i = \partial D_j / \partial p_{ej} \times \partial p_{ej} / \partial p_i \quad (A7)$$

which is less than or equal to zero. Thus the inequality in (A6) holds, and we know that every firm can lower its price and (weakly) increase its profits.

Now we want to show that individual profits also rise -- that is, if at the uncoordinated prices (A6) is negative, then there exists some set of prices ($p^* = [p_1^*, \dots, p_N^*]$) such that $p^* \leq p^u$ and for which individual firm profits rise even without side-payments between the firms. This proof proceeds as a proof by induction. First we show that the result holds for the two-firm case, then we show that, if it holds for N firms, it also holds for $(N+1)$ firms.

Define π_{ij}^u to be $\partial\pi_i/\partial p_j$ evaluated at price vector p^u . From the previous proof, we know that, at the uncoordinated prices, a marginal price reduction by either firm increases overall profits. A price reduction lowers a firm's own profits, so it must be true that a price reduction by the first firm lowers its profits by less than it increases the second firm's profits, and vice versa. Thus:

$$|\pi_{11}^u| < |\pi_{21}^u| \quad (A8)$$

$$|\pi_{22}^u| < |\pi_{12}^u| \quad (A9)$$

Accounting for the signs, this implies (which will be useful below)

$$\pi_{11}^u \pi_{22}^u < \pi_{12}^u \pi_{21}^u. \quad (A10)$$

Let us now assume that we have a small downward deviation in prices from p^u . Differentiating each firm's profit function, we get:

$$d\pi_1 = \pi_{11}dp_1 + \pi_{12}dp_2 \quad (A11)$$

$$d\pi_2 = \pi_{21}dp_1 + \pi_{22}dp_2. \quad (A12)$$

If both (A11) and (A12) are greater than zero, then the price reduction will have increased profit for both firms and the corollary would immediately be true. If both are less than zero, then the reduction will have decreased aggregate profits, which we know to be impossible. Thus, the case of interest is the case where one is positive and the other is negative. Without loss of generality, let us assume, then, that (A11) > 0 and (A12) < 0 .

Let us define firm 2's "break-even" price change, dp_2^b , to be the change in p_2 such that, for a given change in p_1 , $d\pi_2$ equals zero. In other words

$$dp_2^b(dp_1) = -[\pi_{21}/\pi_{22}] \times dp_1 \quad (A13)$$

If firm 2 selects this price change, then firm 1's change in profit due to a given change in p_1 is

$$d\pi_1' = [\pi_{11} - (\pi_{12}\pi_{21})/\pi_{22}] \times dp_1 \quad (A14)$$

Since $dp_1 < 0$, firm 1's profit rises only if $[\pi_{11} - (\pi_{12}\pi_{21})/\pi_{22}] < 0$. This follows directly from (A10). Thus, we can make one firm strictly better off and another weakly so by lowering prices. In fact, if the profit functions are everywhere continuous and $\pi_{ij} \neq 0$, then we can lower firm 1's price by ϵ ; firm 1's profit will still be greater than π_1^u , and firm 2's will now be greater than π_2^u as well.

That was the two-firm case. Now, imagine that the property holds for N firms. This means that each firm can lower its price some appropriate amount and, because the other firms have also lowered their prices, experience a net increase in profit. It is easy to see that this property will hold for an additional firm. That firm, after all, benefits from the price drop negotiated by the N firms. If it lowers its price enough to give back almost all of that gain, it will benefit the other firms and still itself be better off. Therefore, by induction, the 2-firm case expands to show that the property holds more generally. ■

COROLLARY 1. *In settings where some fraction of the peripherals are complements, the Proposition continues to hold for all firms.*

Assume some set $J \subset N$ of the peripherals are (direct) complements, meaning that in addition to being complements indirectly through the platform, these peripherals have direct synergies such that, even if the platform were free, a lower price for one would increase demand for the others.

In (A7), because the peripherals were neither complements nor substitutes, we knew that $\partial D_j / \partial p_i = \partial D_j / \partial P_{ej} \times \partial P_{ej} / \partial p_i$. Now, because there is a direct relationship between peripherals, this term becomes more complicated. Define F_j to be D_j evaluated when P equals zero. That is, F_j is the demand for the j^{th} peripheral assuming that the platform is free. (A7) thus becomes

$$\partial D_j / \partial p_i = \partial D_j / \partial P_{ej} \times \partial P_{ej} / \partial p_i + \partial F_j / \partial p_i \quad (\text{A15})$$

where $\partial F_j / \partial p_i$ is negative for complements and zero for all other peripherals. Thus, in the aggregate, (A15) is negative. ■

COROLLARY 2. *In settings where some fraction of the peripherals are substitutes, the Proposition continues to hold for firms that do not sell substitutes, and the Proposition may or may not hold for firms that sell substitutes.*

Assume some set $J \subset N$ of the firms are (direct) substitutes, meaning a decrease in the price of one decreases sales of the others, or more precisely that for these firms $\partial F_j / \partial p_i$ is positive. As in the above corollary,

$$\partial D_j / \partial p_i = \partial D_j / \partial P_{ej} \times \partial P_{ej} / \partial p_i + \partial F_j / \partial p_i \quad (\text{A16})$$

but this time $\partial F_j / \partial p_i$ is either zero or positive. The aggregate effect on network profits for a given firm's price change is thus

$$\partial \pi_N / \partial p_i = D_i(p, p_i, p_{-i}) + p_i D'_i(p, p_i, p_{-i}) + \sum_{j \neq i} p_j [\partial D_j / \partial p_i]. \quad (\text{A17})$$

which at the uncoordinated prices simplifies to

$$\partial \pi_N / \partial p_i = \sum_{j \in J, i \in J, j \neq i} p_j [\partial D_j / \partial p_i] + \sum_{j \in N, i \in N/J, j \neq i} p_j [\partial D_j / \partial p_i]. \quad (\text{A18})$$

The derivatives in the second term are negative, just as they were in the proof of the Proposition. As per (A16), the derivatives in the first term can be either positive or negative depending on the relative magnitude of $\partial F_j / \partial p_i$ as compared to the magnitude of $\partial D_j / \partial P_{ej} \times \partial P_{ej} / \partial p_i$. The overall effect depends on the number of firms in each summation as well as the relative magnitudes. All else equal, as the number of firms in the first summation rises, or the magnitude of $\partial F_j / \partial p_i$ grows, the derivative become more positive, and vice versa. ■