Monopolization Through Product Design: Is a Balancing Rule Administrable?

Nathan H. Miller[*] and Alexander Raskovich[**]

February 3, 2015

Abstract. There is broad consensus that antitrust enforcement is self-defeating if it chills innovation, but also that changes in product design are not immune to antitrust scrutiny. U.S. Circuit Courts of Appeal have differed, however, on whether product design changes should be subject to a balancing rule, weighing harms against benefits of the change. Neither the D.C. Circuit, which endorsed such balancing, nor the Ninth Circuit, which rejected balancing as not administrable, have revealed much about the bases for their conclusions. To shed light on the question of administrability, we model an industry characterized by a succession of incumbent monopolists and cumulative innovation, deriving necessary and sufficient conditions for product design change to harm welfare. The analysis highlights challenges to administering a balancing rule and provides a novel rationale for the blanket prohibition on naked monopoly extension.

[*] Georgetown University, McDonough School of Business, 37th and O Streets NW, Washington DC 20057. Email: nhm27@georgetown.edu.

[**] Economic Analysis Group, Antitrust Division, US Department of Justice, 450 Fifth Street NW, Suite 9000, Washington DC 20530. Email: alexander.raskovich@usdoj.gov. The views expressed herein are solely the authors' and are not purported to reflect those of the US Department of Justice.

1. Introduction

In no field of antitrust law are the issues thornier or the stakes higher than in monopolization through product design—the prospect that an incumbent firm may preserve or extend its monopoly position by altering the design of its product. There is broad consensus among U.S. courts and antitrust agencies that antitrust enforcement is self-defeating if it chills innovation, but also that changes in product design are not immune to antitrust scrutiny. The nature of that scrutiny remains unsettled, however. U.S. Circuit Courts of Appeal have differed over whether product design changes should be subject to a balancing rule, which would weigh the harms and benefits of the change. The D.C. Circuit, which endorsed (but has not employed) such a rule, said little about how a balancing rule might be administered. The Ninth Circuit, which rejected balancing as not administrable, revealed little of the basis for this conclusion. The Supreme Court may at some point be called upon to resolve this conflict among the Circuits.

We seek insight into the administrability of a balancing rule through economic analysis. Our objective is to develop a simple model that captures relevant tradeoffs, derive a set of necessary and sufficient conditions for product design change (PDC) to harm welfare, and thereby determine what information a court would need within our setting to reliably implement a balancing rule.[1]

Our model is reduced-form and highly stylized—in part to reflect the limited information available to courts. We do not claim that the model captures all of the

[1] We believe our use of a welfare criterion is consistent with antitrust jurisprudence. Antitrust authorities commonly describe their objective as preserving the competitive process, but it is generally understood that preserving competition is a means to the end of preventing welfare harm. Some antitrust scholars have argued for a consumer welfare standard in antitrust, while others favor a total welfare standard. Our analysis applies to both standards, as we explain below.

important features of any real-world market. Rather, our goal is to develop a model that is as simple as possible while still generating the kinds of welfare tradeoffs that would be weighed in a balancing rule. In this sense, we mark out a "lower bound" to the challenges a court would face in administering a balancing rule for monopolization through PDC.

We model a Schumpeterian industry in which PDCs are undertaken sequentially by a succession of incumbent monopolists.[2] Each incumbent i maximizes profit by choice of a magnitude of PDC,[3] a continuous variable denoted by $y_i \geq 0$. PDC has two effects in our framework: (1) increasing the rate of surplus flow over the preceding incumbent's rate, and (2) extending the current incumbent's lifespan in the market. We characterize the second effect by a function $\lambda(y)$ that yields the incumbent's lifespan as a function of the incumbent's PDC.[4]

PDC thus has countervailing welfare effects in our framework. If each successive monopolist were to engage in PDC somewhat more, the industry's periodic jumps in

[2] To our knowledge, ours is the first study of the welfare effects of single-firm conduct in a dynamic setting with cumulative innovation. The paper closest to ours is that of Segal and Whinston (2007), whose modeling framework, like ours, is broadly in the spirit of Schumpeterian growth theory (e.g., Aghion and Howitt, 1992; Grossman and Helpman, 1991). In the main case they study, however, Segal and Whinston (2007) assume the incumbent monopolist does not innovate, nor do they analyze the issue of monopolization through product design. Their analysis focuses on barriers erected by an incumbent against an innovative entrant.

[3] One could think of each new incumbent as displacing the old through a drastic innovation that yields a discrete jump in surplus flows. We omit that feature here for simplicity. Incorporating drastic innovation into the model alongside PDC would not qualitatively change our results.

[4] Although we treat $\lambda(\cdot)$ as a black box, for concreteness one could think of potential entrants in our setting as receiving a stream of private ideas over time, as in O'Donoghue et al (1998). Upon getting a sufficiently good idea, an entrant displaces the incumbent, but this takes longer the greater the incumbent's PDC y. Let n be the number of potential entrants. Suppose that within a given (small) interval of time Δt, each potential entrant obtains a private idea as an i.i.d. draw from the c.d.f. $F(\cdot)$. If the idea's value exceeds y, the entrant displaces the incumbent. In this case, the probability of displacement within Δt is $1 - F(y)^n$ and the incumbent's expected lifespan is $[1 - F(y)^n]^{-1}\Delta t$, which increases with y. Again, for simplicity, we omit such structural details and treat incumbent lifespan as a deterministic function of PDC.

surplus flow would be higher, but the jumps would come less frequently as each monopolist's lifespan in the market would lengthen. These countervailing effects correspond to a positive and a negative externality. PDC tends to raise surplus flows for future generations who "stand on the shoulders of giants,"[5] but also delays the arrival of future PDCs by lengthening incumbent lifespan.[6]

The balance of these countervailing effects, which we call the (net) *intertemporal externality* of PDC, bears a straightforward interpretation (Proposition 1): at the margin, the intertemporal externality of PDC is positive (negative) if its contribution to current surplus flow is more than (less than) proportionate to its extension of the current incumbent's lifespan.

The intertemporal externality plays a central role in the analysis, as the welfare effect of PDC depends on the sign and size of the externality. We measure welfare as the discounted present value of the surplus stream, net of R&D costs. If the intertemporal externality is non-negative, PDC certainly improves welfare (Corollary to Proposition 2). If the intertemporal externality is both negative and sufficiently large in absolute value, PDC harms welfare (Proposition 2).

We take the objective of antitrust policy toward single firm conduct to be to block such conduct only if the conduct would harm welfare. The foregoing welfare results then

---

[5] This externality commonly operates in models of endogenous innovation, such as Aghion and Howitt (1992) and Grossman and Helpman (1991), as well as in the patent literature, e.g. Green and Scotchmer (1995), O'Donoghue (1998) and O'Donoghue et al (1998).

[6] In models of "creative destruction," such as Aghion and Howitt (1992), Grossman and Helpman (1991), Romer (1990) and others, the private gains from R&D by a potential entrant include an externality of stealing business from the displaced incumbent. We focus instead on what might be called "creative preservation," PDC by the incumbent that delays entry, thereby stealing business from the incumbent's successors, similar to the "preemptive patenting" of Gilbert and Newbury (1982).

imply a Balancing Rule, based on the necessary and sufficient conditions for welfare harm from PDC in Proposition 2, as well as a subsidiary Safe Harbor Rule. The analysis suggests that the informational burden facing a hypothetical court in administering the Balancing Rule could be substantially heavier than that for the Safe Harbor Rule.

Next, we extend the analysis by introducing a second type of conduct in which an incumbent might engage: naked monopoly extension (NME). NME (which might take the form of a "sham innovation"[7]) differs from PDC in that NME yields no direct gains in current surplus flow; the conduct merely extends the monopolist's lifetime.

NME affects the magnitude of PDC the incumbent undertakes; the direction of this effect is the sign of the intertemporal externality (Proposition 3). The reason is that NME helps to internalize the intertemporal externality, spurring greater PDC when the externality is positive and paring PDC back when the externality is negative. NME thus harms welfare in our two-conduct setting only if PDC is welfare-enhancing at the margin but the intertemporal externality of PDC is negative (Proposition 4).

The result in Proposition 4 suggests a novel rationale for a blanket prohibition on NME, rooted in an institutional judgment by the court system that the intertemporal externality of PDC is typically negative. We discuss how such a judgment can be rationalized within a broader context in which antitrust and patent policy interact.

The remainder of the paper is organized as follows. In Section 2, we discuss the leading court cases on monopolization through product design, highlighting features of the legal analysis that we incorporate into the model. The model's economic setting is laid out in Section 3 and welfare results for product design change are derived in Section

[7] See e.g. Gilbert (2007).

4. In Section 5, we discuss how the welfare results of Section 4 give rise to a Balancing Rule and a Safe Harbor Rule for product design change. We then extend the model in Section 6, deriving a welfare result for naked monopoly extension in the presence of product design change. In Section 7, we discuss possible policy implications for the administrability of a balancing rule. We also describe a novel rationale for the blanket prohibition on naked monopoly extension. Section 8 concludes.

2. Case Law

In recent years, competition agencies on both sides of the Atlantic have undertaken systematic reevaluations of their enforcement policies toward monopolization.[8] This process was spurred in part by the unsettled nature of the law on single firm conduct, which reflects the difficulties inherent in the subject. The central problem with which the agencies have grappled is how to reliably identify exclusionary single firm conduct that is harmful, so as to condemn such acts without chilling beneficial conduct. The problem of inference is particularly challenging when the conduct in question involves a change in product design.

The D.C. Circuit Court of Appeal's 2001 opinion in the *Microsoft* case[9] provides perhaps the most detailed description of how U.S. courts might assess allegations of monopolization through product design. The Court begins its analysis by noting that

[8] The European Commission initiated a lengthy review of its policies on abuse of dominance in 2003, which ultimately led to the issuance of guidance on enforcement priorities in 2009. In the United States, the US Department of Justice (DOJ) and Federal Trade Commission (FTC) jointly initiated a series of public hearings on single-firm conduct in 2006. At the conclusion of these hearings, the DOJ issued findings in 2008, in a report in which the FTC did not join. With the change in administrations in 2009, the DOJ withdrew the report.

[9] *United States v. Microsoft Corp*. 253 F.3d 34 (D.C. Cir. 2001) (*en banc*).

> "As a general rule, courts are properly very skeptical about claims that competition has been harmed by a dominant firm's product design changes… Judicial deference to product innovation, however, does not mean that a monopolist's product design decisions are per se lawful."[10]

On what grounds might a monopolist's product design change be condemned? The *Microsoft* court outlined three analytic steps: (1) plaintiff must first establish a prima facie case for monopolization, after which (2) defendant must proffer a procompetitive justification, in which case (3) plaintiff must rebut the justification and show that on balance the harm outweighs any benefit of the conduct.[11]

The first two of these steps have gained broad acceptance in the case law. It is the third, balancing step that has given rise to controversy (about which more later). Courts both before and after *Microsoft* have made oblique references to a need for balancing in cases involving allegations of monopolization through product design.[12] Moreover, the FTC has recently stated—in the context of the agency's Consent Order with Intel[13]—that

---

[10] *Id*. at 36.

[11] *Id.* at 39-40. When a firm's contractual restrictions are at issue—as opposed to product design—there is another step to the legal analysis. If the defendant has succeeded in proffering a procompetitive justification, the analysis turns to whether there are less restrictive means of accomplishing the firm's legitimate ends.

[12] As early as 1981, the Southern District of New York ruled that a monopolist's design change must be "reasonable," a term suggestive of a balancing test (*GAF Corp. v. Eastman Kodak Co.*, 519 F. Supp. 1203, 1227-8 (S.D.N.Y 1981)). That same district court found as recently as 2007 that if the defendant "presents evidence that the modifications improved the product or otherwise served valid business reasons, then the Court or a jury may have to weigh these justifications against the alleged anticompetitive effect" (*Xerox Corp. v. Media Scis. Int'l, Inc.*, 511 F. Supp. 2d 372, 389 (S.D.N.Y. 2007)). These and other such court rulings are cited in Popofsky (2008).

[13] For the FTC's Complaint, see: *In the Matter of Intel Corp.*, Docket No. 9341 (FTC Dec. 16, 2009), available at http://www.ftc.gov/sites/default/files/documents/cases/091216intelcmpt.pdf.

"[a] balancing test would be appropriate in a legal challenge to an Intel design change under Section 5 of the FTC Act or Section 2 of the Sherman Act."[14]

While the *Microsoft* court endorsed a balancing test for product design change, the court provided little guidance on how such a test would be conducted. For each of the three allegations of monopolization through product design in *Microsoft*, the Court concluded its analysis without the need to reach the third, balancing step.[15]

The *Microsoft* court did note in passing that the balancing of harms against benefits in a case of monopolization through product design would be "similar" to the Rule of Reason analysis that is applied to cases of agreement between firms.[16] Such Rule of Reason analyses, however, typically involve a balancing of *contemporaneous* harms and benefits—at least in principle.[17] For example, in the case of a horizontal merger between sellers of differentiated products, the loss of competition between the merging firms tends to raise their profit-maximizing prices, while merger-specific marginal cost savings tend to have the opposite effect. In principle, these countervailing effects could be balanced to determine whether a merger is likely on net to result in an anticompetitive price increase (Werden, 1996; Farrell and Shapiro, 2010).

---

[14] See "Analysis of Proposed Consent Order to Aid Public Comment" at 13, available at http://www.ftc.gov/sites/default/files/documents/cases/2010/08/100804intelanal_0.pdf.

[15] Either plaintiff failed to establish a prima facie case for harm (for the Internet Explorer Access Kit, *supra* note 8 at 41), or defendant failed to proffer a specific procompetitive justification (for the commingling of code between Internet Explorer and Windows, *supra* note 8 at 39-40), or plaintiff failed to rebut defendant's procompetitive justification (for Microsoft's overriding of the consumer's choice of default browser in certain circumstances, *supra* note 8 at 40).

[16] *Supra* note 8 at 27.

[17] Carrier (2009) finds that of 495 Rule of Reason cases adjudicated between 1977 and 1999, only about 4% involved balancing, and this proportion fell to 2% for rule of reason cases between 1999 and 2009. In the overwhelming majority of these cases, plaintiff failed to establish a prima facie case for harm.

The harms and benefits flowing from an exclusionary change in product design, by contrast, may not typically be contemporaneous. If the change in product design represents a genuine innovation, benefits may flow immediately upon its introduction, while any associated harm from anticompetitive exclusion may not affect surplus flows until years into the future, or vice versa. Microsoft, for example, was found to have engaged in a variety of conduct to maintain its operating systems monopoly against an emerging middleware threat that was years away from offering consumers a viable alternative that could constrain operating systems pricing.[18]

In conflict with the Seventh Circuit's endorsement in *Microsoft* of a balancing test for monopolization through product design, the Ninth Circuit rejected such a test in *Tyco*.[19] Tyco Healthcare, a monopolist in the U.S. pulse oximetry sensor market, had designed a new system of monitors and sensors called OxiMax. Although there was undisputed evidence that OxiMax was an improvement over the older R-Cal monitors and sensors, plaintiffs claimed that Tyco had unlawfully maintained its monopoly by designing OxiMax to be incompatible with the R-Cal system.

The Ninth Circuit rejected plaintiffs' claim, finding that a product improvement does not constitute monopolization "absent some associated anticompetitive conduct."[20] The court went on to note that

> "There is no room in this analysis for balancing the benefits or worth of a product improvement against its anticompetitive effects. If a monopolist's design change is an improvement, it is 'necessarily tolerated by the

[18] *Supra* note 8 at 18-19.

[19] *Allied Orthopedic v. Tyco Healthcare*, 592 F.3d 991 (9th Cir. 2010); No. 08-56314, D.C. No. 2:05-cv-06419-MRP-AJW.

[20] *Id*. at 409.

> antitrust laws'… unless the monopolist abuses or leverages its monopoly power in some other way when introducing the product."[21]

Although the court offered no concrete example of what kind of associated conduct could render a product improvement unlawful,[22] it did elaborate on why "there is no room" for balancing:

> "To weigh the benefits of an improved product design against the resulting injuries to competitors is not just unwise, it is unadministrable. There are no criteria that courts can use to calculate the 'right' amount of innovation, which would maximize social gains and minimize competitive injury. A seemingly minor technological improvement today can lead to much greater advances in the future. The balancing test proposed by plaintiffs would therefore require courts to weigh as-yet-unknown benefits against current competitive injuries."[23]

The Ninth Circuit thus concludes that a balancing test is unadministrable because of the intertemporal nature of the balancing, together with the unpredictability of future innovation. To an economist, a natural way to extend Rule of Reason balancing to cases of single firm conduct, where the harms and benefits of the conduct may not be contemporaneous, would be to incorporate a net present value rule. The more fundamental problem identified by the Ninth Circuit, however, is assessing how a firm's current conduct may affect the future course of innovation.

---

[21] *Id*. at 411.

[22] The academic literature has investigated a variety of mechanisms by which dominant firms might maintain monopoly power. For example, Carlton and Waldman (2002) show how tying could play the role of the Ninth Circuit's "associated anticompetitive conduct." In a two-period setting, tying may maintain a monopoly in the primary (tying) market by denying scale to a producer of a complement who otherwise could profitably enter the primary market in the second period. Interestingly, Carlton and Waldman's (2002) analysis suggests that such a tying strategy might be especially effective at monopoly maintenance in industries where the pace of innovation is rapid and product lifetimes are short.

[23] *Id*. at 412.

To address these issues, we build a model in which welfare is measured as the net present value of surplus flows across product generations. The model captures, in a simple way, the relevant tradeoff between current gains from the introduction of an innovative design change and possible future losses from delays in follow-on innovation. As such, the model supplies the kinds of "criteria…to calculate the 'right' amount of innovation" to which the Ninth Circuit refers in *Tyco*. After developing such criteria, we discuss the informational burdens a court or antitrust agency would bear in implementing a balancing rule, to assess whether such a rule could be administrable in our highly stylized setting.

3. Economic Setting

We begin by modeling a single type of PDC, whose magnitude is denoted y. The incumbent firm is a monopolist whose lifespan is $\lambda(y)$, where $y \geq 0$ and $\lambda(0),\ \lambda' > 0$.[24] The PDC thus satisfies the first step of the monopolization analysis: plaintiff could show that defendant has monopoly power and that the challenged conduct extends the monopoly. Such findings might establish a prima facie case for harm.

During incumbent *i*'s tenure in the market, the flow rate of total surplus is given by

$$s_i = {y_i}^{\beta} s_{i-1}, \qquad (1)$$

[24] Although we treat $\lambda(\cdot)$ as a black box, for concreteness one could think of potential entrants in our setting as receiving a stream of private ideas over time, as in O'Donoghue et al (1998). Upon getting a sufficiently good idea, an entrant displaces the incumbent, but this takes longer the greater the incumbent's innovation y; alternatively, displacement takes longer the greater the artificial entry barrier y the incumbent erects.Let n be the number of potential entrants. Suppose that within a given (small) interval of time Δt, each potential entrant obtains a private idea as an i.i.d. draw from the c.d.f. $F(\cdot)$. If the idea's value exceeds y, the entrant displaces the incumbent. In this case, the probability of displacement within Δt is $1 - F(y)^n$ and the incumbent's expected lifespan is $[1 - F(y)^n]^{-1}\Delta t$, which increases with y. For simplicity, we treat incumbent lifespan as a deterministic function of incumbent conduct.

where β is the elasticity of contemporaneous surplus flow with respect to PDC. For $\beta = 0$, the product design change would be a form of naked monopoly extension. We assume β is strictly positive, so that the PDC satisfies the second step of the monopolization analysis: defendant could show a procompetitive rationale for the conduct.[25] This sets the stage for analyzing the third, balancing step of the monopolization analysis.

The second step of the monopolization analysis turns on the value of β. If $\beta > 0$, defendant could potentially rebut plaintiff's prima facie case for harm by showing that the conduct yields some innovation benefits. Hereafter, unless noted otherwise, we assume $\beta > 0$ and analyze the conduct's welfare effects, to determine what principles an antitrust authority would have to follow in our setting to carry out a third, balancing step.

Let period i denote the incumbency of firm i. From equation (1), the present value of the stream of surplus flows s_i realized within period i, evaluated as of the beginning of the period, can be written as

$$\int_0^{\lambda(y_i)} s_i \, e^{-rx} dx = \frac{1}{r} {y_i}^{\beta} \left(1 - e^{-r\lambda(y_i)}\right) s_{i-1} \equiv b(y_i) s_{i-1}, \qquad (2)$$

where r is a discount rate common to all incumbents and consumers across periods. Equation (2) describes the present value of *contemporaneous* gross welfare—the portion of the surplus stream (gross of R&D and other costs of implementing the PDC) realized within period i and thus potentially appropriable by incumbent i. The right-hand side of equation (2) expresses this contemporaneous gross welfare as a product of two factors:

[25] Hereafter, we take "product design change" as interchangeable with "design improvement," "innovation" or "genuine innovation." The latter phrases emphasize the assumption that $\beta > 0$.

the surplus flow incumbent i inherits from her predecessor, s_{i-1}, and i's multiplicative contribution to surplus flow,

$$b(y_i) \equiv \frac{1}{r} y_i^{\beta}\left(1 - e^{-r\lambda(y_i)}\right).$$

We refer to $b(y_i)$ as the (contemporaneous) marginal social benefit of the conduct.

The cost of attaining y_i, which firm i incurs at the outset of period i, is

$$k_i(y_i) = c(y_i)\, s_{i-1}, \tag{3}$$

where $c(0) = c'(0) = 0$ and $c', c'' > 0$ for $y > 0$. PDC by earlier incumbents thus makes later innovative PDC more difficult, consistent with empirical evidence.[26]

Incumbent i captures the portion μ of surplus flows s_i, $\mu \in (0, 1]$, the remainder going to consumers.[27] Innovation benefits appropriated by firm i are thus $\mu b(y_i) s_{i-1}$. Incumbent i's profit is the difference between the present value of innovation benefits appropriated by the incumbent and the associated costs,

$$\Pi_i = \left(\mu b(y_i) - c(y_i)\right) s_{i-1}\,, \tag{4}$$

and the first-order condition for maximum is

$$\mu b'(y_i) - c'(y_i) = 0\,. \tag{5}$$

From equation (2), the first derivative of $b(y)$ is [28]

$$b'(y) = \frac{1}{r} y^{\beta-1}\left(\beta - [\beta - r\, y\, \lambda'(y)] e^{-r\lambda(y)}\right). \tag{6}$$

---

[26] E.g., Kortum (1997) finds that patents per researcher have declined substantially over time.

[27] The value of μ depends in part on the firm's ability to price discriminate. Carlton and Heyer (2008) distinguish single-firm conduct that raises μ ("extraction") from exclusionary conduct ("extension"), maintaining that the former should not generally be condemned by the antitrust laws. We note that an increase in μ, by lessening the contemporaneous externality of innovation, increases the privately optimal magnitude of innovation and thereby raises total welfare. The effect on consumer surplus is ambiguous.

[28] Equation (6) is written this way to highlight the bracketed expression $\beta - r\, y\, \lambda'(y)$, whose sign is the sign of the intertemporal externality, as explained below. When this expression is zero, $b'(y_i) s_{i-1} = \frac{1}{r}\frac{\partial s_i}{\partial y_i}$.

Note that $b'(0) > 0$ and recall that $c'(0) = 0$. Thus a strictly positive y_i is privately profitable by equation (5). We further assume $c''(y) > b''(y)$, so that profit is concave,

$$\mu b''(y) - c''(y) < 0 \,, \tag{7}$$

and the private optimum is therefore unique. Finally, observe that incumbent i's optimum does not depend on s_{i-1}. There is thus a steady state equilibrium y and a constant growth rate in surplus flows from one period to the next, consistent with evidence on "growth without scale effects" (Jones, 1995a,b).[29]

We drop subscripts i hereafter, denoting the steady state equilibrium value of PDC as y^*, or often simply as y, to avoid notational clutter where the context is clear. In the derivatives below, the y-notation should be read as "differentiating with respect to y, evaluated at $y = y^*$.

4. Welfare

For any given steady state y, the present value of the associated stream of surplus net of R&D costs, evaluated as of the beginning of the game, can be written as

$$W(y) = w(y)X(y) \,, \tag{8}$$

where

$$w(y) \equiv b(y) - c(y) \tag{9}$$

is proportional to the welfare realized within any given period and

$$X(y) \equiv \sum_{i=0}^{\infty} \left(y^{\beta} e^{-r\,\lambda(y)}\right)^i \equiv \sum_{i=0}^{\infty} x(y)^i \tag{10}$$

is an intertemporal scaling factor. If

[29] We thus consider our reduced-form modeling approach to be broadly consistent with the approach taken in the "second wave" of endogenous growth theories (e.g., Jones, 1995b; Kortum, 1997; Segerstrom, 1998; Howitt, 1999; Aghion et al., 2001).

$$x(y) = y^{\beta} e^{-r\,\lambda(y)} < 1\,, \tag{11}$$

the series in equation (10) converges to

$$X(y) = \frac{1}{1 - x(y)}\,. \tag{12}$$

Differentiating welfare with respect to steady state conduct y yields

$$W'(y) = w'(y)X(y) + w(y)X'(y). \tag{13}$$

The term $w'(y)X(y)$ in equation (13) is a contemporaneous effect of conduct y at the margin, whereas $w(y)X'(y)$ is an intertemporal effect. The sign of the contemporaneous effect of PDC on welfare depends on the appropriation rate, μ. For $\mu = 1$, $w'(y^*) = 0$, by equations (5) and (9). Likewise, $w'(y^*)X(y^*) = 0$. For $\mu < 1$, the contemporaneous effect is strictly positive at y^*. Note that these points do not depend on the precise value of β, so long as $\beta > 0$. Even if β is close to zero, so that PDC is almost entirely unproductive entry deterrence, a reduction in this conduct would not improve contemporaneous welfare. A welfare rationale for restricting the conduct, in our model setting, depends on PDC's intertemporal effects.

Definition. The *intertemporal externality* of product design change is $w(y)X'(y)$.

Differentiating equation (12) yields

$$X'(y) = \frac{x'(y)}{\big(1 - x(y)\big)^2}\,. \tag{14}$$

Thus the sign of the intertemporal externality is the sign of $x'(y)$. Differentiating the expression for $x(y)$ in (11), $x'(y)$ can be written as

$$x'(y) = [\beta - r\,y\,\lambda'(y)]\; y^{\beta-1}\; e^{-r\lambda(y)}. \tag{15}$$

Note that the sign of $x'(y)$ is the sign of the bracketed expression $\beta - r\,y\,\lambda'(y)$ in equation (15). Recall that β is the elasticity of contemporaneous surplus flow with

respect to PDC. It is convenient hereafter to normalize the measurement of time so that $\lambda(y^*) = \frac{1}{r}$.[30] The term $r\, y\, \lambda'(y)$ in equation (15) can then be interpreted as the elasticity of incumbent lifespan with respect to PDC, $\frac{\lambda'(y)}{\lambda(y)} y$. Proposition 1 follows immediately:

Proposition 1. *At the margin, a product design improvement has a positive (negative) intertemporal externality if its contribution to contemporaneous surplus flow is more than (less than) proportionate to its extension of the incumbent's lifespan.*

Substituting equations (12) and (14) into (13) yields

$$W'(y) = \left(\frac{1}{1 - x(y)}\right)\left[w'(y) + w(y)\left(\frac{x'(y)}{1 - x(y)}\right)\right]. \qquad (16)$$

The sign of $W'(y)$ is the sign of the bracketed expression in equation (16). Proposition 2 immediately follows:

Proposition 2. *The privately optimal product design change exceeds (falls short of) the social optimum if* $\frac{x'(y^*)}{1-x(y^*)}$ *is less than (greater than)* $-\frac{w'(y^*)}{w(y^*)}$.

If there were neither contemporaneous nor intertemporal externalities in steady state equilibrium, i.e., $w'(y^*) = x'(y^*) = 0$, the private and social incentives to engage in PDC would be aligned. But $w'(y^*) = 0$ only if $\mu = 1$. In the more realistic case that the incumbent appropriates less than all of the contemporaneous surplus gains from PDC, $w'(y^*) > 0$. Given a positive contemporaneous externality, the intertemporal externality must be negative for the private and social gains from PDC to be aligned.

A negative intertemporal externality means that the monopoly-extending effect of PDC over-compensates the incumbent for the marginal contribution to the present value

[30] Although this normalization aids our interpretation of subsequent results, note that a court could not determine an incumbent's expected lifespan by calculating discount rates.

of the surplus stream over all future periods.[31] If $\frac{x'(y^*)}{1-x(y^*)} = -\frac{w'(y^*)}{w(y^*)}$, the intertemporal over-compensation exactly corrects for the contemporaneous under-compensation, thereby aligning the private and social gains from PDC at the margin.

5. Balancing Rule

Proposition 2 implies a Balancing Rule for the third step of the monopolization analysis:

Balancing Rule. *A product design improvement should be condemned (at the margin) if and only if*

$$\frac{x'(y)}{1-x(y)} < -\frac{w'(y)}{w(y)}. \tag{17}$$

Recall that the third, balancing step in the D.C. Circuit's analysis comes after defendant has succeeded in providing a procompetitive rationale for the design change, showing it to be an improvement. If the Balancing Rule above were perfectly applied in our setting, only product design improvements that harm welfare would be condemned in the outcome of the monopolization analysis.

Note that, under the Balancing Rule, PDC should certainly not be condemned (at the margin) if the intertemporal externality is non-negative, i.e., if $x'(y^*) \geq 0$. In this case, the socially optimal level of PDC exceeds the private optimum, by Proposition 2. An increase in PDC would then tend to increase not only contemporaneous surplus flow but also the frequency of PDC innovation across product generations. Equation (15) thus implies a Safe Harbor Rule, subsidiary to the Balancing Rule:

[31] That is, holding the PDC of successor incumbents fixed at y^*, the loss in the present value of welfare from delaying these future innovations by $\lambda'(y^*)$ outweighs the current incumbent's marginal contribution to the present value of surplus generated by her successors.

Safe Harbor Rule. *A product design change should not be condemned (at the margin) if it extends incumbent lifespan no more than proportionately to its contribution to contemporaneous surplus flow, i.e.,* $\beta \geq \frac{\lambda'(y)}{\lambda(y)} y$*, given the normalization* $\lambda(y) = \frac{1}{r}$.

6. Analyzing Naked Monopoly Extension

Up to this point, we have modeled an incumbent monopolist as engaging in a single type of conduct—a product design change. Realistically, firms engage in many types of conduct, and incumbents' durability in the market may depend on all of these choices. In this more general setting, understanding the welfare cross-effects of conduct is important.

Here we extend the model to incorporate naked monopoly extension (NME) as a second type of conduct in which incumbents may engage. For simplicity, we let the lifespan of incumbents be given by an additively separable function:

$$\lambda(y) = \phi(y) + \tau, \tag{18}$$

where $\tau \geq 0$ represents an increase in the incumbent's lifespan through NME. Unlike PDC, NME's only direct effect is to extend the incumbent monopolist's lifespan. NME has no effect on contemporaneous surplus flows. We maintain the other modeling assumptions.

Our purpose in this analysis is twofold. First, incorporating NME into the model offers a striking result on the importance of accounting for cross-effects between types of conduct. We find that, in certain circumstances, NME improves welfare (in the present value sense) through its cross-effect on PDC. This poses a challenge to the conventional understanding of the blanket prohibition on NME, and points toward a novel rationale for this enforcement posture. Second, we believe the result offers broader insight into

antitrust policy toward innovative conduct and the relationship between antitrust and patent policy.

We treat τ as a parameter set by antitrust policy, on the idea that an incumbent monopolist will profit by engaging in NME to the fullest permissible extent. A strict prohibition of NME corresponds to $\tau = 0$.

Proposition 3. *At the margin, an increase in permissible naked monopoly extension increases (decreases) product design change if the intertemporal externality is positive (negative).*

Proof: Differentiating the first-order condition (5) with respect to the τ yields

$$\frac{\partial y^*}{\partial \tau} = \left(\frac{-\mu}{\mu b'' - c''}\right) \frac{\partial b'}{\partial \tau} \tag{19}$$

by the implicit function theorem. The expression in parentheses in equation (19) is positive by condition (7) and thus $\partial y^*/\partial \tau$ has the same sign as $\partial b'/\partial \tau$. Substituting equation (18) into equation (6) and differentiating the result with respect to τ then yields

$$\frac{\partial b'(y^*)}{\partial \tau} = x'(y^*). \tag{20}$$

Therefore $\partial y^*/\partial \tau$ has the same sign as $x'(y^*)$. □

Intuitively, NME helps to internalize the intertemporal externality, spurring the incumbent to increase PDC when the externality is positive and pare back PDC when the externality is negative. The welfare effect of NME thus depends both on the sign of the intertemporal externality and on whether PDC raises welfare at the margin (i.e., whether condition (17) holds).

Proposition 4. *At the margin, an increase in permissible naked monopoly extension:*

(a) *lowers (raises) welfare if the intertemporal externality is positive (negative) and condition* (17) *holds;*

(b) *raises (lowers) welfare if the intertemporal externality is positive (negative) and condition* (17) *does not hold.*

Proof: Follows immediately from Propositions 2 and 3. If condition (17) holds, PDC harms welfare at the margin. In this case, NME also harms welfare when the intertemporal externality is positive, by spurring greater PDC. Conversely, NME improves welfare by inhibiting PDC when the intertemporal externality is negative. This establishes part (a); proof of part (b) is exactly similar. □

7. Discussion

Our main theoretical results are in Propositions 2 and 4, which describe necessary and sufficient conditions for welfare harm to flow from product design change (specifically, improvements in design) and from naked monopoly extension, respectively. We consider these in turn.

7.1 Product Design Change

Proposition 2 implies both a Balancing Rule and a subsidiary Safe Harbor Rule for product design change. Applying the Safe Harbor Rule in our setting would (only) require a hypothetical court to determine the sign of the intertemporal externality. A design change would fall within the Safe Harbor if its intertemporal externality were nonnegative, which would be the case if the change raised contemporaneous surplus flows at least proportionately to its extension of the incumbent monopolist's lifespan in the market. It seems plausible to us that courts could, at least in some cases, have access to enough information to apply such a Safe Harbor Rule.

The issue of "product hopping" in pharmaceuticals helps illustrate both the role of intertemporal externality in antitrust analysis and its limitations.[32] Product hopping refers to cases where an apparently small design improvement, such as a switch from capsule to tablet form for a pharmaceutical, yields an extension in the lifespan of the monopoly that seems disproportionately large. Implicitly, then, an assessment that the intertemporal externality of the design change is negative underlies arguments against product hopping raised by some of its critics.[33]

Clinical data on absorption rates, the time pattern of blood serum levels and the like could in principal help a court to assess the magnitude of aspects of the improvement associated with a pharmaceutical design change. The structure of pharmaceutical regulation, involving FDA approval, could likewise give a court some confidence in measuring the life-extending effects of the change. It seems plausible, then, that assessing the sign of the intertemporal externality may be within the reach of courts for at least some cases of pharmaceutical design change.

In our analysis, however, determining the sign of the intertemporal externality would not be the final step in analyzing any allegation of monopolization through product design. The Safe Harbor Rule is just that—a sufficient condition for finding a product design change to be harmless. Conduct that falls outside the Safe Harbor does not necessarily warrant condemnation under the Balancing Rule. Indeed, as discussed above,

[32] Our purpose here is illustrative. We have not studied product hopping in detail, nor do we offer any broad policy prescriptions on this topic.

[33] Cheng (2008, at 1472) puts it this way: "Product hopping brand name manufacturers ('product hoppers') make a slight alteration to their prescription drug and engage in marketing efforts to shift consumers from the old version to the new…The delay to generic manufacturers from developing a new generic equivalent and obtaining FDA approval to market it allows the product hopper to insulate itself from generic competition for several years."

the intertemporal externality must be negative for the private and social gains from PDC to be aligned—in the realistic case of a positive contemporaneous externality, where the incumbent cannot fully appropriate current surplus flows, leaving some to consumers. Most socially desirable design changes would thus likely fall outside the Safe Harbor.

To apply the Balancing Rule in our setting, a hypothetical court would need to do more than assess the sign of the intertemporal externality. A court would need to determine whether a PDC's negative intertemporal externality is sufficiently large in absolute value—swamping the positive contemporaneous externality—to imply welfare harm. This would require fairly detailed knowledge of $\lambda(\cdot)$, y, β and r—a daunting task.

Substituting equations (2), (9), (11) and (15) into condition (17) would yield a very complex condition for a court to evaluate, requiring information that appears to be beyond a court's reasonable reach. It is difficult to see how a balancing rule could be administered, even in our highly stylized setting.

Ordover and Willig (1982) propose a profit test for "predatory innovation" that is much simpler than our Balancing Rule. In their view, an innovation merits condemnation as predatory if it would not be profitable to the incumbent firm but for its exclusionary effects. In our setting, however, we assume that an incumbent's innovation always has some exclusionary effect, if only by raising the bar on the magnitude of innovation a potential entrant would need achieve to displace the incumbent. The privately optimal product design change, moreover, is such that the innovation would not be profitable for the incumbent—at the margin—but for its lifespan-extending effect. Thus Order and Willig's (1982) profit test would always be satisfied for the marginal innovation in our

setting, despite the fact that the privately optimal design change may be either above or below the social optimum.

7.2 Naked Monopoly Extension

Within our framework, Proposition 4 offers a complex rule for determining the welfare effect of naked monopoly extension. This complexity stands in sharp contrast to the blanket prohibition on naked monopoly extension found in antitrust jurisprudence. We believe the difference can be reconciled by positing two plausible institutional judgments on the part of courts:

Judgment 1. *Genuine innovation is typically below the social optimum, being socially excessive only in rare instances.*

Judgment 1 is consistent with the view commonly expressed by courts that genuine innovation has salutary effects—indeed, that antitrust would be self-defeating if it were to chill innovation. The D.C. and Ninth Circuits would both likely agree with Judgment 1.

Judgment 2. *Although below the social optimum, genuine innovation is not too far away, in that its intertemporal externality is negative in virtually all instances.*

Recall that, in our setting, the intertemporal externality of innovation is negative at the social optimum, to offset the positive contemporaneous externality. The intertemporal externality is likewise negative if innovation is not too far from the social optimum.[34]

The U.S. Constitution, as part of its purpose to "promote the general Welfare," authorized Congress in Article I, Section 8, to develop patent rights "to promote the Progress of Science and useful Arts." The patent system is administered by a specialist

[34] If the intertemporal externality were positive, an increment to innovation would not only boost contemporaneous surplus flows but also quicken the pace of innovation across product generations. In this sense, innovation would be far from the social optimum.

agency, the Patent & Trademark Office, with disputes adjudicated by a specialist court, the Federal Circuit. It seems plausible that courts in antitrust cases implicitly adopt Judgment 2, or act as if they do—taking the patent system, for all its faults, as working roughly well to promote welfare, in that innovation is not far from the social optimum.

In our setting, Judgments 1 and 2 together rationalize a blanket prohibition on naked monopoly extension. Judgment 1 implies that condition (17) rarely holds—i.e., that genuine innovation virtually never harms welfare. By Proposition 4(b), then, the welfare effect of naked monopoly extension has the same sign as that of the intertemporal externality. Recall from Proposition 3 that naked monopoly extension helps to internalize the intertemporal externality, thereby raising incumbent innovation when the externality is positive and paring it back when the externality is negative. By Judgment 2, the intertemporal externality of innovation is almost always negative. Therefore naked monopoly extension almost always harms welfare by chilling innovation.[35]

8. Conclusions

There is broad consensus that antitrust enforcement is self-defeating if it chills innovation, but also that changes in product design are not immune to antitrust scrutiny. The nature of that scrutiny remains unsettled, however. We develop a simple model, featuring a succession of incumbent monopolists and cumulative innovation, to assess whether a balancing rule, weighing the harms and benefits of a product design change, would be administrable—a point of disagreement between the D.C. and Ninth Circuits.

[35] Naked monopoly extension raises contemporaneous innovation, but this salutary effect is overwhelmed by the associated delays to follow-on innovation.

We find that, even in our highly stylized setting, a balancing rule would be very complex, carrying a high informational burden for courts.

Some other adjudicative rules, simpler than our Balancing Rule, would tend to chill innovation. We have discussed two: Ordover and Willig's (1982) profit test and a test that seems implicit in some critiques of product hopping.

In Ordover and Willig's (1982) profit test for "predatory innovation," an innovation merits condemnation if it would not be profitable but for its exclusionary effects. The privately optimal product design change in our setting, however, takes into account the innovation's lifespan-extending effect at the margin. Thus Order and Willig's (1982) test would always be satisfied for the marginal innovation in our setting, despite the fact that the privately optimal design change may be either above or below the social optimum.

Critics of product hopping point to small improvements in pharmaceutical design yielding disproportionately large extensions to the incumbent monopoly's lifespan. The critique can be restated, in the context of our model, as product hopping having a negative intertemporal externality. Although an analysis of product hopping is beyond the scope of this paper, we note that a negative intertemporal externality is necessary but not sufficient for product design change to harm welfare.

Indeed, we show that the intertemporal externality of product design change is negative at (or below but near) the social optimum.[36] For welfare to be harmed at the margin, the intertemporal externality must be a sufficiently large negative, as embodied

[36] For the realistic case of a positive contemporaneous externality, from the incumbent firm not capturing all contemporaneous surplus flows but leaving a substantial portion for consumers.

in the Balancing Rule. A simpler rule condemning any conduct that has a negative intertemporal externality would chill innovation.

Finally, we propose a novel rationale for the per se illegality of naked monopoly extension. In our setting, naked monopoly extension tends to internalize the intertemporal externality, encouraging the incumbent to increase innovation when the externality is positive and to pare innovation back when the externality is negative. If innovation is typically below the social optimum—but not too far below—the intertemporal externality is typically negative. In this case, naked monopoly extension typically harms welfare by chilling innovation.

References

Aghion, Philippe, Christopher Harris, Peter Howitt and John Vickers, 2001. "Competition, Imitation and Growth With Step-by-Step Innovation," *Review of Economic Studies* 68(3), 467-492.

Aghion, Philipe and Peter Howitt, 1992. "A Model of Growth Through Creative Destruction," *Econometrica* 60(2), 323-351.

Carlton, Dennis W., and Ken Heyer, 2008. "Extraction vs. Extension: The Basis for Formulating Antitrust Policy Towards Single-Firm Conduct," *Competition Policy International* 4(2), 285-305.

Carlton, Dennis W., and Michael Waldman, 2002. "The Strategic Use of Tying to Preserve and Create Market Power in Evolving Industries," *RAND Journal of Economics* 33(2), 194-220.

Carrier, Michael A., 2009. "The Rule of Reason: An Update for the 21st Century," *George Mason Law Review* 16(4), 827-837.

Cheng, Jessie, 2008. "An Antitrust Analysis of Product Hopping in the Pharmaceutical Industry," *Columbia Law Review* 108, 1471-1515.

Farrell, Joseph, and Carl Shapiro, 2010. "Antitrust Evaluation of Horizontal Mergers: An Economic Alternative to Market Definition," *B.E. Journal of Theoretical Economics: Policies and Perspectives* 10(1), Article 9.

Gilbert, Richard J., 2007. "Holding Innovation to an Antitrust Standard," *Competition Policy International* 3(1).

Gilbert, Richard J., and David Newbery, 1982. "Preemptive Patenting and the Persistence of Monopoly," *American Economic Review* 72(2), 514-526.

Green, Jerry R., and Suzanne Scotchmer, 1995. "On the Division of Profit in Sequential Innovations," *RAND Journal of Economics* 26(1), 20-33.

Grossman, Gene M., and Elhanan Helpman, 1991. "Quality Ladders in the Theory of Growth," *Review of Economic Studies* 58(1), 43-61.

Howitt, Peter, 1999. "Steady Endogenous Growth with Population and R&D Inputs Growing," *Journal of Political Economy* 107(4), 715-730.

Jones, Charles I., 1995a. "Time Series Tests of Endogenous Growth Models," *Quarterly Journal of Economics* 110(2) (May), 495-525.

Jones, Charles I., 1995b. "R&D-Based Models of Economic Growth," *Journal of Political Economy* 103(4) (August), 759-784.

Kortum, Samuel S., 1997. "Research, Patenting and Technological Change," *Econometrica* 65(6) (November), 1389-1419.

O'Donoghue, Ted, 1998. "A Patentability Requirement for Sequential Innovation," *RAND Journal of Economics* 29(4), 654-679.

O'Donoghue, Ted, Suzanne Scotchmer and Jacque-Francois Thisse, 1998. "Patent Breadth, Patent Life, and the Pace of Technological Progress," *Journal of Economics & Management Strategy* 7(1), 1-32.

Ordover, Janusz, and Robert D. Willig, 1982. "An Economic Definition of Predation: Pricing and Product Innovation," *Yale Law Journal* 91(8), 8-53.

Popofsky, Mark S., 2008. "Section 2, Safe Harbors, and the Rule of Reason," *George Mason Law Review* 15(5), 1265-1296.

Romer, Paul M., 1990. "Endogenous Technological Change," *Journal of Political Economy* 98(5), 71-102.

Segal, Ilya, and Michael D. Whinston, 2007. "Antitrust in Innovative Industries," *American Economic Review* 97(5), 1703-1730.

Segerstrom, Paul S., "Endogenous Growth Without Scale Effects," *American Economic Review* 88(5), 1290-1310.

Werden, Gregory J., 1996, "A Robust Test for Consumer Welfare Enhancing Mergers Among Sellers of Differentiated Products," *Journal of Industrial Economics* 44(4), 409-413.