



ARTICLE

Computational Rule of Reason Analysis in Antitrust

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Abstract. The goal of this paper is to reduce the rule of reason analysis in antitrust to a quantitative or computational exercise. The rule of reason consists, at bottom, as many courts have said, in balancing anticompetitive harms against procompetitive benefits. Such a balancing exercise should be amenable to precise calculation. We provide a framework here for such a computational approach to the rule of reason.

KEYWORDS: Rule of Reason; Monopolization; Computational Antitrust; Optimal Penalties; Innovation; Injunctions; Antitrust Enforcement.

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I. Introduction

Although it is unusual for an antitrust paper to begin with a reference to a philosopher, there is an especially apt reference for this paper. Leibniz was such a proponent of applying rational and scientific analysis to all matters of controversy that he once said that all disputes should be resolvable by measuring and quantifying the interests at stake.¹ The paper adopts the same optimistic view of antitrust cases.

The goal of this paper is to reduce the rule of reason analysis in antitrust to a quantitative or computational exercise. The rule of reason consists, at bottom, as many courts have said, in balancing anticompetitive harms against procompetitive benefits. Such a balancing exercise should be amenable to precise calculation. We provide a framework here for a computational approach to the rule of reason.

A computational approach to antitrust should incorporate static and dynamic tradeoffs. By static tradeoffs, we refer to the balancing of anticompetitive harm and procompetitive benefit in relation to any monopolizing (or cartelizing) act.² The anticompetitive harm resulting from a monopolizing act – such as, for example, an exclusive dealing arrangement – consists of the transfer of consumer surplus to the monopolizing firm and the deadweight loss that results from the monopolistic reduction in output. The procompetitive or efficiency gain consists of supply cost reductions or value enhancements that might be generated by the monopolizing act. We refer to such efficiency gains as operational efficiencies. For example, an exclusive dealing arrangement could increase monopoly power (anticompetitive harm) and at the same time reduce supply chain costs (operational efficiency gain).

By dynamic tradeoffs, we refer to the balancing of innovation efficiencies against the net harm from monopolization. Thus, even if the net static effect is harmful, in the sense that the anticompetitive harm outweighs the operational efficiency gain, there may be innovation efficiencies that justify as socially desirable the monopolist’s conduct.³ The innovation efficiency could consist of the additional consumer welfare created by the monopolizing firm’s investment in innovation. For example, if the firm invests in creating a new product in the first period and then executes a monopolizing act in the second period within the market it has created, a rule of reason balancing approach should compare the innovation efficiency benefit (new market surplus) to the static inefficiency cost.

We provide a framework, capable of quantification, for applying the rule of reason by conducting a balance of static and dynamic welfare effects in antitrust. We

¹ BERTRAND RUSSELL, *A HISTORY OF WESTERN PHILOSOPHY* 591-92 (1st ed. 1945).

² Static efficiency is the core matter in the so-called Chicago School of antitrust. See Richard A. Posner, *The Chicago School of Antitrust Analysis*, 127 U. PA. L. REV. 925, 925-948 (1979).

³ JOSEPH A. SCHUMPETER, *CAPITALISM, SOCIALISM, AND DEMOCRACY* (1st ed. 1942); J. Gregory Sidak & David J. Teece, *Dynamic Competition in Antitrust Law*, 5 J. COMPET. LAW ECON. 581, 581-613 (2009); David S. Evans & Keith N. Hylton, *The Lawful Acquisition and Exercise of Monopoly Power and Its Implications for the Objectives of Antitrust*, 4 COMPETITION POLICY INTERNATIONAL 203, 203-241 (2008).

provide simulations of the computational approach as well. With sufficient data, an econometrician could estimate the consumer surplus, deadweight loss, and other welfare components to implement the computational approach suggested here. Using this quantitative analysis, a court could reach a statistically reasonable assessment of the proper rule of reason balancing equation. To paraphrase Leibniz, there would be no more need of disputation between two antitrust lawyers than between two accountants.⁴

In Part II, we explain the basic terms of the model in this paper and its connection to the antitrust literature. In Part III, we detail the rule of reason approach in antitrust law. Part IV provides a model of monopolization with innovation efficiencies. Part V sets out the computational approach to rule of reason analysis. Part VI derives the optimal penalty. Part VII applies the computational approach to rule of reason balancing. Part VIII applies the model to injunctions, which are the most common remedy in antitrust courts. Part IX addresses implementation issues. Part X concludes.

II. Monopolization

Our explicit focus in this paper is on the rule of reason in monopolization cases. The view of monopolization we adopt is that implicitly presented in Becker⁵ and explicitly discussed in Williamson⁶ and Landes.⁷ In these models, monopolization consists of mixed effects. On the one hand, monopolization, or a monopolizing act, contributes to or bestows monopoly power on the actor or actors. On the other hand, monopolization generates procompetitive benefits or efficiencies. These two offsetting welfare effects must be considered in an examination of the desirability of enforcing monopolization law in any case.

To offer an example, suppose the monopolizing act consists of the formation of an exclusive dealing relationship with a supplier of a necessary input.⁸ Because of the input's necessity, the exclusive dealing contract excludes horizontally rival firms and therefore transforms the input purchaser into a monopolist in its output market. The resulting monopoly power enables the firm to charge the monopoly price and reduce output to the monopoly level. However, because of synergies between the input purchaser and the input supplier, the cost of supplying the necessary input falls

⁴ RUSSELL, *supra* note 1, at 592 (quoting Leibniz: "If controversies were to arise, there would be no more need of disputation between two philosophers than between two accountants.").

⁵ Gary S. Becker, *Crime and Punishment: An Economic Approach*, 76 J. POLIT. ECON. 169, 169-217 (1968).

⁶ Oliver E. Williamson, *Economies as an Antitrust Defense: The Welfare Tradeoffs*, 58 AM. ECON. REV. 18, 18-36 (1968).

⁷ William M. Landes, *Optimal Sanctions for Antitrust Violations*, 50 U. CHI. L. REV. 652, 652-678 (1983).

⁸ On contracting efficiencies and antitrust, see, e.g., Howard P. Marvel, *Exclusive Dealing*, 25 J. LAW ECON. 1, 1-25 (1982); Benjamin Klein & Lester F. Saft, *The Law and Economics of Franchise Tying Contracts*, 28 J. LAW ECON. 345, 345-361 (1985).

dramatically as a result of the exclusive dealing contract. The efficiency properties of exclusive dealing contracts have been recognized in antitrust law since the Supreme Court’s opinion in *Standard Oil Co. of California v. United States (Standard Stations)*.⁹ Thus, in this example, monopolization generates a harm or injury to consumers, in the form of a transfer of consumer surplus and a gain to society in the form of cost efficiencies. The standard description is illustrated in Figure 1, where the area *D* represents the harm to society, and the area *E* represents the gain to society from monopolization.

Although our focus is on monopolization, the same tradeoff analysis can be applied to instances of concerted action where efficiencies may be present. The Supreme Court has recognized the possibility of efficiencies in the concerted action setting in cases such as *Broadcast Music, Inc. v. CBS, Inc. (BMI)*,¹⁰ *Continental T.V., Inc. v. GTE Sylvania Inc.*,¹¹ *California Dental Ass’n v. FTC*,¹² and *American Needle, Inc. v. National Football League*.¹³

From an economic perspective, the rule of reason would require a balancing of the social gain against the social harm from monopolization. One could balance the net social gain against the net social harm. This would require a comparison of the net gain area *E* in Figure 1 with the net loss area *D* in the same figure. Alternatively, one could balance the total firm gain against the total consumer harm. This would require a comparison of area *T+E* in Figure 1 with the consumer harm area *T+D* in the same figure. The two comparison approaches are equivalent.

⁹ *Standard Oil Co. of California v. United States*, 337 U.S. 293 (1949).

¹⁰ *Broad. Music, Inc. v. CBS, Inc.*, 441 U.S. 1 (1979).

¹¹ *Cont’l T.V., Inc. v. GTE Sylvania Inc.*, 433 U.S. 36 (1977).

¹² *Cal. Dental Ass’n v. FTC*, 526 U.S. 756 (1999).

¹³ *Am. Needle, Inc. v. Nat’l Football League*, 560 U.S. 183 (2010).

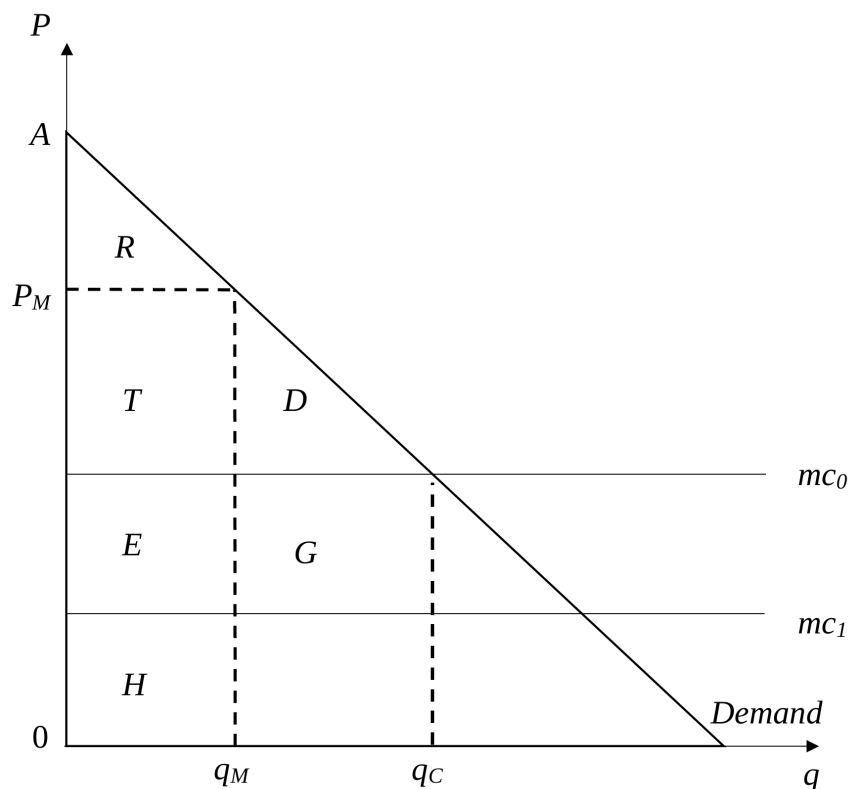


Figure 1. Welfare Effects of Monopolization

The efficiency gain contemplated in Figure 1 results from a reduction in operating costs. Thus, Figure 1 depicts a case in which the harm from monopolization can be balanced against operational efficiency. Generally, efficiencies can result from other sources. An efficiency gain might arise from increasing the value of the output produced by the monopolizing firm.¹⁴ In this case, the value increase would cause an outward shift in the demand curve in Figure 1, generating a new surplus. Such value-side efficiencies can be treated as equivalent to cost-side efficiencies. Both cost-side and value-side efficiencies are examples of operational efficiencies.

Another type of potential efficiency is an innovation welfare gain. Suppose the monopoly firm generates the market in which it operates by making an investment in the prior period. In other words, the firm creates, through investment, the market that it later monopolizes. Enforcing antitrust law against such a monopolist may harm its incentive to invest.¹⁵ In balancing monopolization harms

¹⁴ For a straightforward model of this approach, see Keith N. Hylton, *The Law and Economics of Monopolization Standards*, in *ANTITRUST LAW AND ECONOMICS* 82, 82-115 (Keith N. Hylton ed., 2d ed. 2010).

¹⁵ Keith N. Hylton & Haizhen Lin, *Innovation and Optimal Punishment, with Antitrust Applications*, 10 *J. COMPET. LAW ECON.* 1, 1-25 (2014). For earlier economic contributions on the general topic, see Sidak & Teece, *supra* note 3, and Evans & Hylton, *supra* note 3 (both discussing informally the relationship between innovation and antitrust); Glenn C. Loury, *Market Structure and Innovation*, 93 *Q. J. ECON.* 395 (1979) (examining formally how competition influences innovation).

against efficiencies, the welfare generated through innovation must be incorporated into the balance.

III. The Rule of Reason and Antitrust Enforcement

There have been several formulations of the rule of reason in the antitrust case law, since its incorporation into the Sherman Act in *Standard Oil Co. of New Jersey v. United States*.¹⁶ For our purposes, the most recent formulation in *United States v. Microsoft Corp. (Microsoft III)*¹⁷ is sufficient.¹⁸ Under *Microsoft III*, the rule of reason is applied as follows:

First, to be condemned as exclusionary, a monopolist’s act must have an “anticompetitive effect.” That is, it must harm the competitive process and thereby harm consumers. In contrast, harm to one or more competitors will not suffice. (...) Second, the plaintiff, on whom the burden of proof of course rests, (...) must demonstrate that the monopolist’s conduct indeed has the requisite anticompetitive effect. (...) Third, if a plaintiff successfully establishes a *prima facie* case under Section 2 by demonstrating anticompetitive effect, then the monopolist may proffer a “procompetitive justification” for its conduct. (...) If the monopolist asserts a procompetitive justification—a nonpretextual claim that its conduct is indeed a form of competition on the merits because it involves, for example, greater efficiency or enhanced consumer appeal—then the burden shifts back to the plaintiff to rebut that claim. (...) Fourth, if the monopolist’s procompetitive justification stands un rebutted, then the plaintiff must demonstrate that the anticompetitive harm of the conduct outweighs the procompetitive benefit.¹⁹

Microsoft III provides an algorithm for applying the rule of reason in antitrust. The burden-shifting language of the *Microsoft III* test will not be of use to us in this paper because it addresses procedural details, which are unimportant to this analysis. However, the key part of the test, for our purposes, is the balancing language,

¹⁶ *Standard Oil Co. of New Jersey v. United States*, 221 U.S. 1 (1911).

¹⁷ *United States v. Microsoft Corp.*, 253 F.3d 34 (D.C. Cir. 2001).

¹⁸ A seemingly different formulation of the rule of reason test was provided, in a Supreme Court case decided after *Microsoft III*, in *Ohio v. American Express Co. (Amex)*, 585 U.S. 529 (2018). There the Court said that the rule of reason requires a three-step, burden-shifting test, where the plaintiff has the initial burden to prove that the challenged restraint has a substantial anticompetitive effect, and, if the plaintiff carries that burden, then the burden shifts to the defendant to show a procompetitive rationale for the restraint. If the defendant shows such a rationale, the burden shifts back to the plaintiff to demonstrate that the procompetitive efficiencies could be reasonably achieved through less restrictive means. This last less restrictive alternative prong of the rule of reason test is unique to *Amex*. The test articulated in *Amex* is drawn from an appellate court decision that states nearly the same formulation, *Capital Imaging Associates, P.C. v. Mohawk Valley Medical Associates, Inc.*, 996 F.2d 537 (2d Cir. 1993), but includes an additional sentence emphasizing the balancing nature of the test. Hence, although *Amex* appears, at first glance, to deviate from the *Microsoft III* balancing framework, such an interpretation is very likely mistaken.

¹⁹ *Microsoft III*, 253 F.3d at 58–59.

which requires the court to balance the anticompetitive harms against the procompetitive justifications. If the anticompetitive harm outweighs the procompetitive benefit, then the defendant firm is guilty of monopolization under the test. If, on the other hand, the anticompetitive harm is less than the procompetitive benefit, the defendant is innocent under Section 2 of the Sherman Act. In other words, the *Microsoft III* test generates a dichotomous decision, either a win or a loss, depending on the balance of harm and gain.

How precisely a court should apply the *Microsoft III* balancing test is unclear. How one should calculate the value of the anticompetitive harms or the value of the efficiencies remains a mystery in the case law. One approach, reflected in a few cases,²⁰ is to simply eyeball the evidence to determine if the procompetitive benefit appears to be substantial and supported by credible and verifiable evidence. There is, therefore, no balancing but rather a double-checking of procompetitive benefits. If so, the court will hold that the defendant is innocent of violating Section 2. The cases where the court finds against the defendant, therefore, will be those in which the efficiency benefit is speculative, seems insignificant, or unsupported by the evidence (“pretextual”). This approach seems consistent with the application of Section 2 in *Microsoft III*, where the court did not actually balance a measure of the procompetitive benefit against a measure of the anticompetitive harm. Another theoretical approach, however, would involve an actual balancing of some measure of anticompetitive harm against a measure of the procompetitive benefit.

Yet another approach would require moving away from the dichotomous framework and the imposition of a penalty that internalizes the net social harm from the defendant’s conduct in each case. Such an approach would generate a penalty whenever the marginal social harm from the defendant’s conduct exceeded the marginal social benefit. The penalty would be designed to equate the marginal gain to the defendant to the marginal social harm from its conduct.

In a world of perfectly informed courts, the foregoing approaches should all result in the same optimal enforcement. In the dichotomous case, only efficient instances of monopolization would be permitted to occur. In the case where the authority imposes a variable fine, the fine level would optimally internalize social costs in a manner that would induce only efficient instances of monopolization.

We develop these approaches in the remainder of this paper.

IV. Model of Monopolization with Innovation

In this part, we present a model of monopolization with innovation. The model is based on Hylton and Lin.²¹ The monopolist invests in innovation in the first period. The investment creates a market that the monopolist then monopolizes by

²⁰ See *Aspen Skiing Co. v. Aspen Highlands Skiing Corp.*, 472 U.S. 585 (1985); *Eastman Kodak Co. v. Image Technical Servs., Inc.*, 504 U.S. 451 (1992).

²¹ Hylton & Lin, *supra* note 15.

taking an action that excludes existing and potential rivals (entrants) and, at the same time, generates operational efficiencies. The monopolized market is assumed to be invulnerable to technological change that would erode market power.

The model concludes that the optimal antitrust penalty is likely to be a weighted average of the penalty that internalizes consumer harm and a subsidy reflecting the innovation surplus. Thus, antitrust punishment requires a balancing of static deterrence and innovation-supporting goals.

The mathematical framework is from Hylton and Lin.²² However, here we provide additional background to justify the simplicity of the model. The model assumes, again, investment in the first period followed by monopolization in the second. In the second period, the monopolist is constrained. The monopolist cannot price above an externally imposed ceiling level,²³ otherwise it is subject to competition and loses its monopoly power. Figure 2 illustrates this set of assumptions.

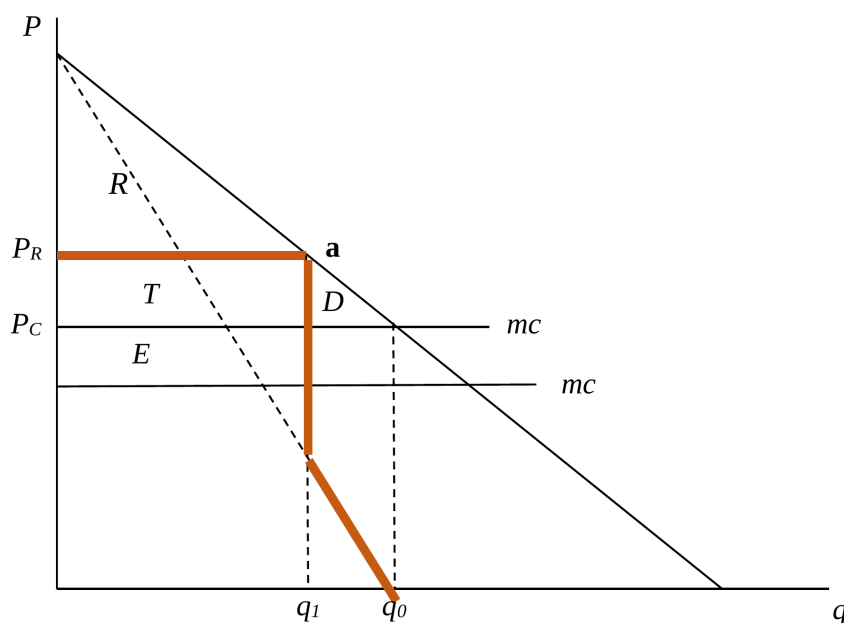


Figure 2. Constrained Monopoly after Innovation

The notion of a restrained monopolist is not new. Williamson²⁴ posits restraints from other sellers as a basis for predicting that the efficiency gains from a supply cost reduction will outweigh the deadweight loss in many instances.

²² *Id.*

²³ Every monopolist has a ceiling based on consumer preferences. However, the externally imposed ceiling in this model is due to pressure from rivals or government regulation. The purpose of the externally imposed ceiling is to simplify the model because, in the absence of a ceiling, changes in the penalty would change all the relevant welfare components of the model, which would unnecessarily complicate the presentation.

²⁴ Williamson, *supra* note 6.

In Figure 2, P_R is the “restrained price” of the “restrained monopolist” after it engages in innovation. For portions of the demand schedule below point **a**, the restrained monopolist becomes an unrestrained monopolist.

The assumptions are essentially the same as in the preceding case examined. Here, the firm, if it does not monopolize, will exist in a competitive environment first, with cost level mc_0 , and will be forced to accept the competitive price P_c . If it takes the monopolizing act, it will gain pricing power, as well as operational efficiencies. In other words, the monopolizing act is both necessary and sufficient to obtain both the pricing power and the operational efficiencies, but the firm’s pricing power will be restrained, as shown in Figure 2.

The resulting marginal revenue schedule of the restrained monopolist is represented by the red jagged line in Figure 2. When the monopolizing act reduces supply cost, as shown in Figure 2, the firm’s price restraint remains fixed.

With these assumptions behind us, let the harm to the consumer due to monopolization be given by $v = T + D$. Let the gross gain from monopolization be $M = T + E$. The total potential welfare due to the creation of the market is given by $S = T + D + R$. The penalty for an antitrust violation is given by F . The probability of antitrust enforcement resulting in penalization is given by z . Thus, the expected penalty for an antitrust violation is zF . The cost of an antitrust enforcement action is c .

We make the following distributional assumptions. M , the gross gain to the antitrust offender, is governed by the probability distribution function H with corresponding density function h , where $h(M) > 0$ for $0 < M$. The first-period investment cost, k , is assumed to be governed by the probability distribution Ψ , where $\text{Prob}(k < k_0) = \Psi(k_0)$, with corresponding density ψ .

In the second period, the firm monopolizes when and only when $M > zF$, so that the probability of monopolization is $1 - H(zF)$. In the first period, the potential antitrust violator invests when and only when the cost of investment is less than the expected future return

$$k < \hat{k}_0 = [1 - H(zF)][E(M > zF) - zF]$$

and, thus, the probability of investment is $\Psi(\hat{k}_0)$. Let the hazard rate for the investment distribution be given by $\lambda_\psi = \frac{\psi}{1-\Psi}$, and let the hazard rate for the monopolization probability distribution be given by $\lambda_h = \frac{h}{1-H}$.

Given the foregoing, the optimal fine maximizes social welfare, W , which is given by

$$W = \Psi(\hat{k}_0) \{ (1 - H(zF)) [E(M > zF) - E(k|k < \hat{k}_0) + S - v - zc] + H(zF)S \} \quad (1)$$

Using the hazard rate terms introduced earlier, the first-order condition for the optimization problem can be expressed as

$$(v + zc - zF^*) \left\{ \frac{\Psi}{1 - \Psi} \lambda_h^2 + \lambda_\psi (1 - H) \lambda_h \right\} \omega_{Uninternalized\ Social\ Harm} - S \lambda_\psi \lambda_h \omega_{Innovation\ Benefit} = 0 \quad (2)$$

Equivalently,

$$(v + zc - zF^*) \{ \lambda_h \Psi + \lambda_\psi (1 - H) \} \omega_{Uninternalized\ Social\ Harm} - S \lambda_\psi \omega_{Innovation\ Benefit} = 0 \quad (3)$$

where the terms inside the bracket and the hazard rate terms are themselves functions of F . However, this equation can be simplified greatly under some distributional assumptions.

How should one interpret the first-order condition for welfare optimization? As shown in (3), the first term represents the marginal uninternalized social harm from monopolization. The uninternalized static harm is equal to the harm to consumers and the expected cost of law enforcement. The second term in (3) represents the innovation benefit from investment. As the penalty increases, the marginal static harm term falls as the threat of punishment works to deter monopolization. However, as the penalty increases, the incentive to innovation decreases, so that the cost of forgone innovation increases.

If the sensitivity of innovation to punishment is zero, that is, $\lambda_\psi = 0$, then the optimal punishment problem resolves to setting the expected penalty at a level that internalizes marginal static harm as in Landes.²⁵

$$F^* = \frac{T + D}{z} + c \quad (4)$$

On the other hand, if the sensitivity of monopolization to punishment is zero, that is, $\lambda_h = 0$, then the optimal penalty is equal to a (most likely) subsidy based on the residual consumer surplus

$$F^* = -\frac{R}{z} + c \quad (5)$$

V. Computational Rule of Reason Analysis

A computational approach to rule of reason analysis begins with noting that the rule of reason test is a balancing inquiry. In the welfare objective function (1), we considered the monetary penalty necessary to generate the optimal level of deterrence, which is one way of carrying out antitrust enforcement. Rule of reason considerations are embodied in the penalty algorithm.

However, the rule of reason that operates in courts is a dichotomous test that results in a simple yes or no answer: the defendant's conduct violates the antitrust laws, or it does not. Still, the balancing test suggested by the optimization condition in (3) is suggestive of factors courts should consider in the dichotomous inquiry.

²⁵ Landes, *supra* note 7; see also Becker, *supra* note 5, at 191-92, 199.

For a court, rule of reason, as a dichotomous test, must compare static net social harms against dynamic gains. Thus, a rule of reason analysis involves a comparison of the static social harm due to monopolization

$$D - E + zc$$

with the expected net social gain from innovation

$$R + T + E - k$$

Alternatively, the expected net social gain from innovation can be written as

$$S - (D - E) - k$$

A dichotomous rule of reason analysis implies a comparison of these two expressions. However, in many cases, instead of an entirely new market being created by innovation, the innovation creates only a marginal improvement in an existing market. In such a case, the proper comparison is between

$$D_2 - E_2 + zc$$

and

$$R_2 + T_2 + E_2 - S_1 - k$$

In this comparison, the outcome of the dichotomous test is ambiguous. Indeed, consider the worst-case scenario in which there is no innovation and only monopolization without an efficiency benefit. In this worst-case scenario, the static harm is unambiguously positive, and the gain from innovation is zero.

VI. Optimal Penalty

We will start by considering the enforcement regime in which a variable monetary penalty is applied to the antitrust defendant. We calculate the optimal antitrust penalty under various parameter assumptions, using (3). To simplify, we assume that the underlying probability distributions are exponential, so that the corresponding hazard rates are constant. Given this, we examine the function

$$\begin{aligned} f(F) = & (v + zc - zF^*) \left\{ \frac{\Psi}{1 - \Psi} \lambda_h^2 \right. \\ & \left. + \lambda_\psi (1 - H) \lambda_h \right\} \underbrace{\quad}_{\text{Uninternalized Social Harm}} \\ & - S \lambda_\psi \lambda_h \underbrace{\quad}_{\text{Innovation Benefit}} \end{aligned} \quad (6)$$

where λ_h and λ_ψ are constants.

Note that in the above formulation,

$$f(F) > 0 \rightarrow \text{deterrence benefit} > \text{innovation benefit}$$

and therefore, the penalty is too low to be optimal. The penalty should be increased. To elaborate, finding that the f function is positive means that the marginal uninternalized social harm from monopolization exceeds the marginal innovation benefit at the given level of the penalty. Put another way, the static negative externality from monopolization exceeds the dynamic gain from

innovation. Put even more simply, deterring the static harm of monopolization by increasing the penalty is more valuable to society than the incremental innovation thereby lost.

One may ask why the static efficiency gain term E does not appear in the optimality condition. That is largely due to an illusion created by the abbreviation of terms. Both distributions are affected by the total private gain from monopolization, which in turn is a function of the static efficiency gain. Thus, the static efficiency gain is embedded in the distribution terms of the equation above.

Under the assumption that the underlying distributions are exponential, the innovation benefit term on the far right of (6) is constant as the penalty changes. As the penalty increases, the uninternalized static harm declines until it equals the marginal innovation benefit (or, equivalently, the marginal innovation cost of raising the penalty).

The first simulation is shown immediately below in Figure 3 (where we have assumed that the consumer harm $v = \$2,000$, the potential surplus $S = \$3,000$, and the probability of enforcement $z = 0.6$).²⁶ The downward-sloping blue curve shows the declining marginal deterrence benefit as the penalty increases.

Returning to (6), if we find that

$$f(F) < 0 \rightarrow \text{deterrence benefit} < \text{innovation benefit}$$

then the penalty is too high and should be decreased for social optimality. In this case, the deterrence benefit is less than the innovation benefit generated by reducing the penalty. By reducing the penalty, the marginal deterrence benefit increases to equal the marginal benefit from innovation. Figure 4 illustrates this. Under the assumptions in Figure 4 (where we have assumed that the consumer harm $v = \$100$, the potential surplus $S = \$2,000$, and the probability of enforcement $z = 0.5$), the marginal deterrence benefit is less than the marginal innovation benefit even at a penalty level of zero, so that the optimal penalty is negative – that is, a subsidy.

²⁶ These values were chosen for the sake of example and not to reflect any depiction of real-world quantities.

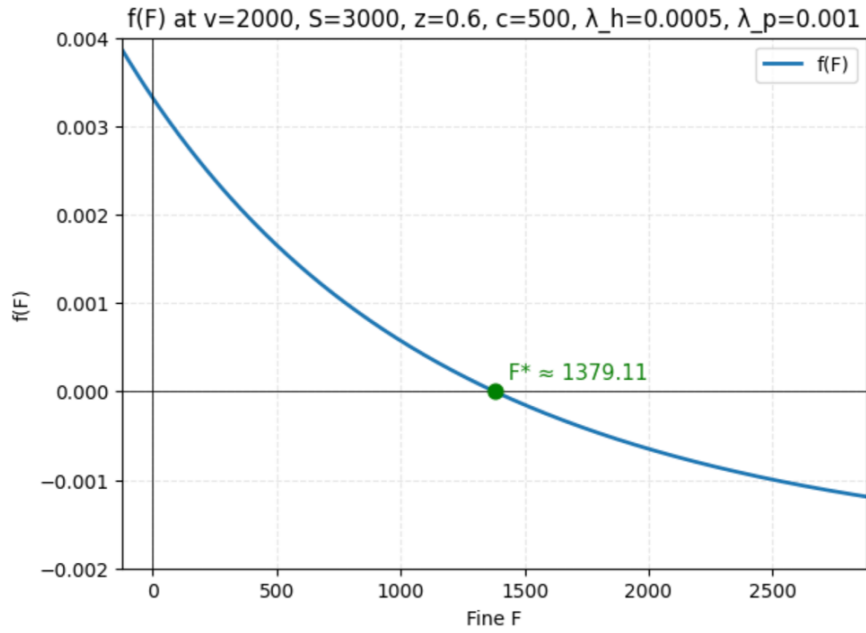


Figure 3. Positive Optimal Penalty

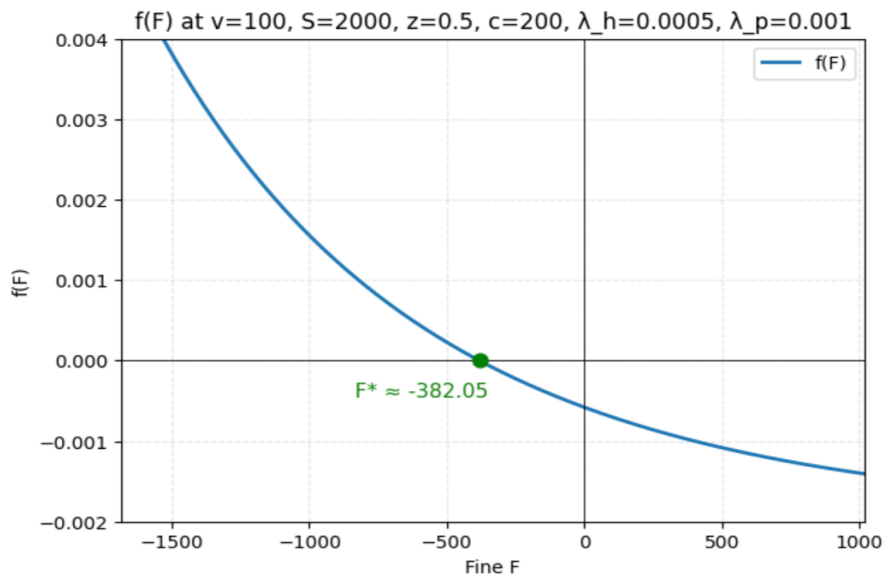


Figure 4. Negative Optimal Penalty

Another perspective on the penalty-subsidy tradeoff is offered by Figure 5. In this figure, we fix the probability of enforcement and the cost of an enforcement action and vary the levels of consumer harm and innovation surplus. The third axis is the penalty, which is represented by the bar to the right of the square diagram. The results accord with the rule of reason intuition. The diagram shows that as consumer harm increases relative to the innovation surplus (moving toward the bottom-right corner), the optimal penalty increases. However, as consumer harm decreases relative to the innovation surplus, the optimal penalty is negative (represented by the blue region). The white line in the diagram marks the region where the optimal penalty is zero. The slope of the white line is 4.19, which implies that for zero punishment (and

zero subsidization) to remain optimal, every \$1 increase in consumer harm must be offset by \$4.19 of innovation surplus.

Global slope of $F^*=0$ line: $dS/dv \approx 4.1943$, intercept ≈ 83.83

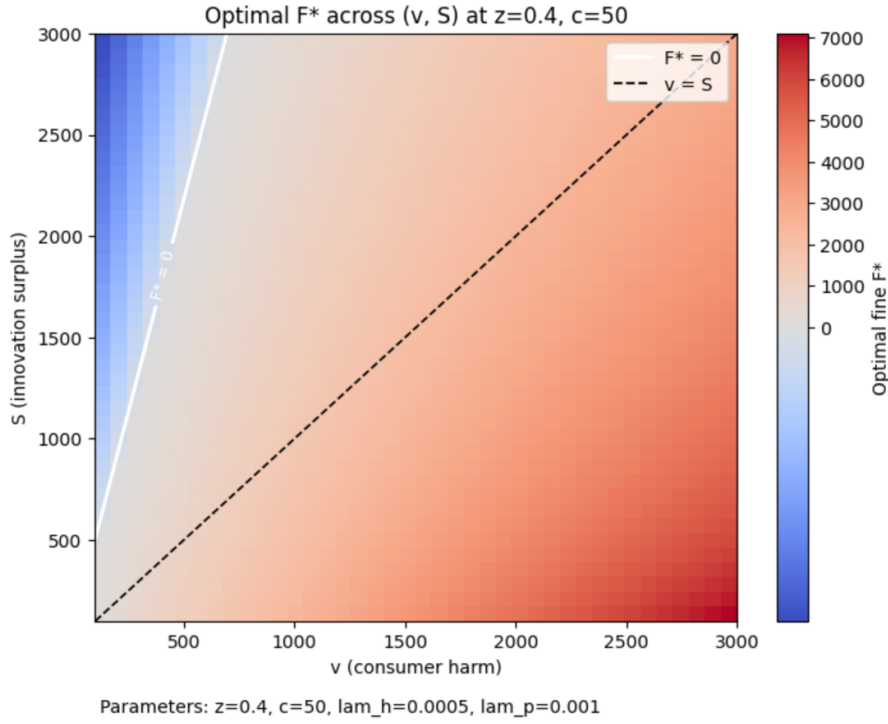


Figure 5. Heat Map Showing Optimal Penalties

VII. Computational Rule of Reason Balancing

In the previous part, we considered the calculation of an optimal penalty to be imposed on an antitrust defendant. We examined how rule of reason considerations affect the penalty. However, the rule of reason in antitrust law is typically employed by courts to answer questions that have a simple dichotomous answer: to punish or not to punish, to enjoin or not to enjoin. What, then, would be a computational approach to the standard rule of reason examination?

Let us consider the marginal analysis first. Drawing on the approach taken before, a court in the rule of reason framework should consider the marginal social static harm and the marginal innovation benefit. To make such a comparison easier and closer to our previous analysis, let us suppose that the court can use the penalty to balance the static harm against the dynamic gain. Under such an approach, the court would consider the marginal social welfare function:

$$\begin{aligned}
 g(F) = & (D - E + zc)\{\lambda_h\Psi + \lambda_\psi(1 - H)\}_{\text{Static Social Harm}} \\
 & - (R + T + E \\
 & - k)\lambda_\psi_{\text{Innovation Benefit}}
 \end{aligned} \tag{7}$$

or, equivalently,

$$\begin{aligned}
g(F) = & (D - E + zc)\{\lambda_h\Psi + \lambda_\psi(1 - H)\}_{\text{Static Social Harm}} \\
& - [S - (D - E) \\
& - k]\lambda_\psi_{\text{Innovation Benefit}}
\end{aligned} \tag{8}$$

The first term, $D - E + zc$, represents the static social harm from monopolization. The probability term attached to it, $\lambda_h\Psi + \lambda_\psi(1 - H)$, is a mixture of hazard rates and shows how the marginal static harm changes as the penalty adjusts. The second term, which consists of the innovation hazard rate multiplied by $[S - (D - E) - k]$, represents the forgone innovation benefit that results from an increase in the penalty. As the penalty is increased, the marginal static harm component (assuming it is positive) is reduced. The reason is that the probability terms Ψ and $1 - H$ are decreasing in the penalty. As long as the hazard rates are nondecreasing (which is a common assumption), then increasing the penalty also increases the marginal forgone innovation payoff (i.e., more innovation is forfeited).

Return, to simplify, to the assumption that the distributions are exponential, in which case the hazard rate terms are constant. Also to simplify, let us treat $k = 0$ in the court's balancing analysis (and S can be varied to allow for the investment cost factor). Under this simplification, the second term in equations (7) and (8) is constant in the penalty and the first term is declining in the penalty.

Since the welfare components in the above equations are all constant terms, the marginal social welfare function changes through the probability rate terms as the penalty varies. Consider several cases.

Case (1): Negative static social harm ($D - E + zc < 0$). In this case, the marginal static harm from monopolization is negative because the efficiency gain exceeds the total static cost, which is the sum of the deadweight loss and the expected enforcement cost. Monopolization benefits society at both the dynamic and static levels - by generating substantial operational efficiencies as well as dynamic efficiencies. The marginal social cost function is therefore negative at all levels of the penalty. The penalty should therefore be reduced until it is a subsidy sufficient to internalize the residual consumer welfare generated by innovation.

Case (2): Statically welfare-neutral monopolizing act ($D = E$). In this case, the marginal social welfare function simplifies to

$$\begin{aligned}
g(F) = & zc\{\lambda_h\Psi + \lambda_\psi(1 - H)\}_{\text{Static Social Harm}} \\
& - S\lambda_\psi_{\text{Innovation Benefit}}
\end{aligned} \tag{9}$$

If the expected enforcement cost is small relative to the innovation surplus, then the marginal social cost function is likely to be negative, as in the previous case considered. Again, it would be desirable to keep reducing the penalty until it becomes a subsidy.

On the other hand, if the innovation surplus is small and the antitrust enforcement cost is extremely high, it may be desirable to increase the penalty to a

high positive level. Taking the case where this is most highly plausible: suppose the antitrust enforcement cost is positive, and the innovation surplus is zero. In this case, increasing the penalty to a level that completely deters monopolization (and innovation as well) is socially desirable because the monopolist’s conduct gives nothing to society but a costly enforcement action.

To offer a concrete example, suppose the monopolist monopolizes the market for playing cards, and at the same time introduces substantial efficiencies in the supply chain. Because of the supply chain efficiencies, the overall efficiency gain is equal to the deadweight loss. Although society does not lose directly from the monopolizing act, it does suffer a loss because of the expenditure on law enforcement. Hence, it would be optimal for the government to increase the penalty sufficiently to completely deter the monopolist’s conduct, or to enjoin the monopolization of the playing card market.

Case (3): Positive static social harm ($D - E + zc > 0$). In this case, the deadweight loss is greater than the efficiency gain from monopolization. Thus, monopolization is harmful on a static basis and should be deterred. Society benefits, on the static ledger, through increases in the penalty. However, there is a cost to raising the penalty: it discourages innovation. An optimal (positive) penalty will therefore balance these two marginal effects.

VIII. Injunctions

The preceding part examined rule of reason balancing as a comparison of marginal static harm with marginal innovation benefit, carried out through the penalty. Courts must also decide whether to enjoin conduct. In this part, we consider the case for injunctions, the primary remedy in antitrust cases.²⁷

The first thing to note is that an injunction can be viewed as a special type of penalty. An injunction is equivalent to a penalty that eliminates the expected gain from monopolization, and thereby completely deters monopolizing conduct. Hence, let F^* continue to represent the optimal penalty and now let $\hat{F}$ represent the penalty that eliminates the expected gain to the monopolist.

VIII.1 Easy Cases

One case where an injunction is warranted has been considered already. Recall that in Case (2) above, we discussed an example in which the innovation benefit was zero and the static cost positive. Indeed, in any case of a positive static social harm and a zero (or trivial) innovation surplus, an injunction would be appropriate. Thus, if the innovation benefit is trivial and the deadweight loss from monopolization is greater than the efficiency gain, an injunction is optimal. To make this recommendation concrete, return to the example of the playing card monopolist. Obviously, there is

²⁷ See *AMG Cap. Mgmt., LLC v. FTC*, 593 U.S. 67 (2021); Keith N. Hylton, *Remedies, Antitrust Law, and Microsoft: Comment on Shapiro*, 75 ANTITRUST L.J. 773, 773-92 (2009).

no innovation involved in this case. Suppose also that there are significant operational supply-side efficiencies. The optimal punishment policy toward the playing card monopolist is an injunction, or a monetary penalty that has the same effect.

Conversely, recall Case (1), where the efficiency gain exceeds the total static cost ($D+zc$). In this case, there is a social gain at both the operational and innovation levels. Society should not enjoin the monopolizing act, nor should it punish it with any positive penalty. The optimal policy is subsidization, by granting a monetary reward, if such a policy were feasible.

VIII.2 Difficult Cases

That leaves Case (3), where $(D - E + zc > 0)$, as the most difficult. How should a court decide whether to enjoin the monopolist? We can take advantage of the marginal welfare function to design an optimal policy on injunctions. First, suppose that, as an initial matter, the penalty is assumed to be equal to zero. And again, to simplify, assume that the underlying distributions are exponential, so that the hazard rate terms are constant. Under these assumptions, the marginal welfare function evaluated at zero penalty ($F = 0$), is

$$g(0) = (D - E + zc)\{\lambda_h \Psi(0) + \lambda_\psi(1 - H(0))\}_{\text{Static Social Harm}} - [S - (D - E)]\lambda_\psi_{\text{Innovation Benefit}} \quad (10)$$

From here, let us consider several sub-cases.

VIII.2.A Sub-case 3(a)

Sub-case 3(a), $g(0) < 0$: The innovation benefit exceeds the static social harm when the monopolizing conduct goes unpunished. Note also that the static social harm function declines in the penalty (with reasonable assumptions). From these points it follows that there is never a case for punishment if $g(0)$ is negative. Because there is never a case for punishment, there is never a case for enjoining the firm's monopolizing conduct in this sub-case.

VIII.2.B Sub-case 3(b)

Sub-case 3(b), $g(0) > 0$: punishment is potentially desirable in this sub-case because the static welfare cost is greater than the innovation benefit. However, even in this case, courts must be careful about imposing an injunction on the monopolist. The best way to examine this case is to start with the case of penalties and move from that case to that of injunctions. There are two cases to consider within Sub-case 3(b).

Sub-case 3(b)(i): $F^* > \hat{F}$. The penalty that operates in effect as an injunction is less than the optimal penalty. This case is ruled out. The upper bound on the optimal penalty in this analysis is the level that internalizes consumer harm. Thus, the case

where the gain-eliminating penalty is less than the optimal penalty need not be considered.

Sub-case 3(b)(ii): $F^* < \hat{F}$. The penalty that operates in effect as an injunction is greater than the optimal penalty. This is the most difficult case in which to examine the desirability of an injunction against monopolizing conduct. The reason is that in this case, some degree of punishment is desirable, but the injunction operates as an excessive penalty. The question, then, is whether the social cost of excessive punishment is greater than the social gain from punishment. This requires an evaluation of the following expression:

$$\int_0^{\hat{F}} \{ (D - E + zc) [\lambda_h \Psi(F) + \lambda_\psi (1 - H(F))] - [S - (D - E)] \lambda_\psi \} dF \quad (11)$$

The foregoing expression may be positive or negative, depending on the balance between underenforcement and overenforcement costs. However, with estimates of the relevant parameters, a precise determination of its sign can be made.

Although much of this analysis may seem abstract, these are computationally feasible inquiries. All that is required is sufficient data to estimate the welfare components identified in Figure 2 and to determine some approximation of the relevant distributions. The simplest cases would involve distributions that could be approximated by the exponential function. However, even in more complicated cases, the equations derived here should be computationally solvable.

Figure 6 below shows simulations of the marginal welfare function under certain assumptions, as shown in the illustration. The green curve presents the results for the case where the static effect of the monopolizing act ($D - E$) is positive. This means that the deadweight loss from increasing the price to the monopoly level far exceeds the efficiency gain. In this case, the optimal penalty is positive (and equal to \$594). The other cases (static neutral, static negative) generate negative optimal penalties.

For the static neutral (orange line) and static negative (blue line) cases in Figure 6, an injunction is never optimal. These are cases in which no punishment should occur. On the contrary, the optimal policy is a subsidy to the monopolizing firm.

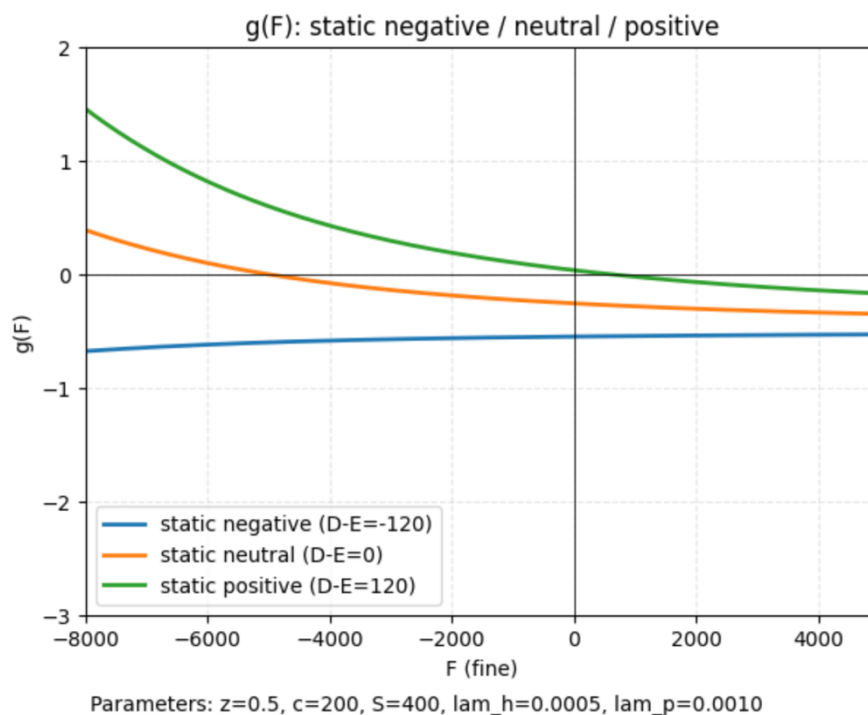


Figure 6. Injunctions, Static Welfare Effect, and Penalty

IX. Implementation Issues

Could the computational rule of reason set out here be implemented? To do so, a court, agency, or litigant would have to first estimate the welfare components of this model, such as the efficiency gain (E), the deadweight loss (D), the consumer harm (v), as well as other terms. Such estimation, although not observed in actual enforcement cases or litigation, is feasible. Whinston²⁸ discusses methods of estimating welfare components. Obviously, data would be necessary to estimate the demand schedule for the relevant market. As artificial intelligence and data analysis tools become more sophisticated, estimation of welfare components relevant to actual enforcement cases will probably become feasible within a reasonable budget.

The more difficult matter is that of estimating marginal cost – also discussed in the comprehensive survey of Whinston.²⁹ The core of the problem here is that the firm has an information advantage; it has information on its own costs that outsiders do not have. Any attempt to estimate marginal cost will be vulnerable to attack from the firm, using its private information on costs. An estimation process would have to be devised that provides the firm with incentives to disclose or report its own costs. Such a process could entail allowing the opposite side in litigation to propose its preferred cost estimate and inviting the firm to provide its estimate of its own

²⁸ Michael D. Whinston, *Antitrust Policy toward Horizontal Mergers*, in 3 HANDBOOK OF INDUSTRIAL ORGANIZATION 2369, 2369-2440 (Mark Armstrong & Robert Porter eds., 2007). The methods discussed by Whinston are equally applicable to cartel and monopolization cases.

²⁹ *Id.*

marginal cost. The court or agency could then choose between the two estimates based on the quality of objective evidence provided by the firm to buttress its own estimate. The decision rule could be biased (e.g., clear and convincing standard) in a manner that incentivizes the firm to provide high-quality evidence.

Integration of machine learning (ML) can partially mitigate these informational asymmetries by flexibly estimating market parameters from available high-frequency pricing and quantity data. For example, as Chiang et al.³⁰ demonstrate, recent adaptations of the Variational Method of Moments (VMM) using neural networks allow for the nonparametric estimation of supply models and markups without relying on restrictive assumptions about firm conduct. Furthermore, estimating the innovation surplus may be aided by natural language processing (NLP) and related text-analytic methods. By extracting structured signals from patents, R&D records, and internal documents (e.g., Schrepel³¹), these tools could help generate proxy measures of innovation and monopolization probabilities.

Because our framework evaluates dynamic monopolization scenarios, agent-based modeling (ABM) provides a natural computational framework for empirical implementation. Rather than imposing fixed parametric assumptions, ABM allows firm behavior, enforcement probabilities, and penalty responses to evolve endogenously. More broadly, as Coglianese and Lehr³² argue, machine learning systems can be embedded within rule-based and agent-based frameworks to operationalize regulatory decision-making that would otherwise be difficult to implement.

X. Conclusion

This paper provides a simple guide for computational analysis in antitrust, in the context of rule of reason cases. The rule of reason has been part of antitrust analysis since *Standard Oil* (1911). However, the analysis has evolved, reaching its most explicit economic formulation in *Microsoft III*, where the court reduced the test to a balance of anticompetitive harm against procompetitive benefit. The courts have so far resisted any formal characterization of that test.

One formal characterization of rule of reason analysis is suggested by the optimal penalty framework of Becker³³ and Landes.³⁴ However, these papers represent a static efficiency approach to antitrust, and neither addresses the rule of

³⁰ Harold D. Chiang, Jack Collison, Lorenzo Magnolfi & Christopher Sullivan, *Enhancing the Merger Simulation Toolkit with ML/AI*, ARXIV (June 5, 2025), <https://doi.org/10.48550/arXiv.2506.05225>.

³¹ Thibault Schrepel, *Computational Antitrust: Evidence From 25 Antitrust Agencies*, NETWORK LAW REVIEW (June 30, 2025), <https://www.networklawreview.org/computational-antitrust-evidence/>.

³² Cary Coglianese & David Lehr, *Regulating by Robot: Administrative Decision Making in the Machine-Learning Era*, 105 GEO. L.J. 1147, 1147-1223 (2017).

³³ Becker, *supra* note 5.

³⁴ Landes, *supra* note 7.

reason test explicitly. In this paper, we have broadened the literature by expanding the analysis to include both static and dynamic efficiencies, and by addressing the computational implementation of rule of reason balancing.