

Approval Regulation and Learning, with Application to Timing of Merger Control*

Marco Ottaviani[†] Abraham L. Wickelgren[‡]

June 2009

Abstract

This paper analyzes the optimal combination of ex ante and ex post regulation of an activity. Additional information about the sign and extent of the externality associated with the activity becomes available only once a private party undertakes the activity, but undoing the activity at that stage is costly. We characterize when the regulator should commit not to reevaluate the activity ex post. The case for ex post regulation is strengthened if the private party can signal its private information about the consequences of the activity, but it is weakened if the cost of undoing the activity can be manipulated.

Keywords: Regulatory approval, competition policy, merger review, learning, signaling.

JEL Classification: D18 (Consumer Protection); D62 (Externalities); D83 (Search; Learning; Information and Knowledge); K21 (Antitrust Law); K32 (Environmental, Health, and Safety Law); L51 (Economics of Regulation).

*We are grateful for comments by our discussants (Louis Kaplow, Alvin Klevorick, Kai-Uwe Kühn, and Rune Stenbacka), as well as by Amy Ando, Andrei Barbos, Umberto Garfagnini, Jerry Hausman, Emeric Henry, Lynne Kiesling, Niko Matouschek, Volker Nocke, Martin Peitz, Patrick Rey, Scott Stern, Andrew Thomson, Helen Weeds, and seminar participants at Duke, HEC Montreal, the NBER Law and Economics Program, the Searle Conference on Antitrust Economics and Policy at Northwestern University, the NIE Conference at the UK Competition Commission in London, the 2009 International Industrial Organization Conference in Boston, and the ZEW Conference on Ex-Post Evaluation of Competition Policy in Frankfurt. Financial support from the Searle Center on Law, Regulation, and Economic Growth is gratefully acknowledged. This paper is the winner of the 2009 Robert F. Lanzillotti Prize for best paper in antitrust economics at the International Industrial Organization Conference.

[†]Kellogg School of Management, Northwestern University, 2001 Sheridan Road, Evanston, IL 60208-2013, USA. Email: m-ottaviani@northwestern.edu.

[‡]Northwestern University School of Law, 357 East Chicago Avenue, Chicago, IL 60611, USA. Email: a-wickelgren@law.northwestern.edu.

1 Introduction

Regulation is imperfect in large part because regulators have limited information about the effects of imposing a regulation. The extent to which a regulator's information is limited, however, is not completely exogenous. The timing of the decision to regulate can affect the degree to which the regulator learns about the possible consequences of its regulation. Of course, the timing of regulation also alters the effectiveness of the regulation. In this paper, we analyze this tradeoff in the context of approval regulation—the choice to approve or deny a firm's ability to undertake a particular activity.

When deciding whether to approve private economic activities, regulators are often unsure about the sign and extent of the externality associated with the activity. One option is to allow initially the firm to undertake the activity and only later decide whether to reverse it. An advantage of this *ex post* approach to regulation is that typically more information becomes available about the effects of the activity only once the activity is undertaken. On the other hand, social damage is incurred if the activity is undertaken. In addition, it is often significantly more costly to reverse an activity that has already begun than it is to prohibit the firm from engaging in the activity in the first place. To reduce damage and save reversal costs, the regulator may prefer to regulate *ex ante*, before the firm has even begun undertaking the activity.

In this paper, we investigate a regulator's tradeoff between approving an activity *ex ante* based on little information and waiting to acquire more information. We then analyze three additional issues raised by this tradeoff. First, we show that *ex post* regulation can result in a commitment problem in that the possibility of *ex post* regulation can lead the firm to decide not to propose an activity that, in expectation, is both profitable and increases social welfare. Second, *ex post* regulation can lead to a socially desirable discipline effect in which the firm deviates from profit-maximizing behavior to increase social welfare in order to avoid *ex post* reversal of a profitable activity. Third, the threat of *ex post* regulation can lead firms to increase deliberately the social cost of undoing the activity after having undertaken it.

For concreteness, throughout the paper we apply our model to the implementation of merger control policies by the Federal Trade Commissions (FTC). Before the passage of the Hart Scott Rodino (HSR) Act in 1976, the U.S. government could only challenge

mergers after they had been consummated.¹ The HSR Act now requires firms to notify the government of proposed mergers whose size is beyond certain thresholds, giving the government sufficient opportunity to challenge and, if successful, block the merger before it is consummated. Nonetheless, ex post intervention is not precluded under HSR. In fact, two recent mergers have been reversed ex post,² and a recent speech by former FTC Chairman Timothy Muris suggests a renewed interest in government enforcement of mergers after the fact:³

If you have clients that are concerned with a transaction, let us know—whether or not it has been consummated. We are quite prepared to go after consummated mergers or mergers that are too small to require an HSR filing.

The FTC’s unanimous decision not to challenge in advance the acquisition of Avant! Corporation by Synopsys, Inc. in 2002 provides a good illustration of why the FTC has partially moved away from the dominant paradigm of ex ante merger enforcement. As with almost any merger investigation, the FTC had to determine whether, in the words of Commissioner Sheila Anthony, “efficiencies will be sufficient to outweigh any potential harm to competition.”⁴ Commissioner Anthony emphasized that there was a great deal of uncertainty regarding the answer in this particular case. Thus, while all Commissioners voted to close the investigation, Anthony and two other Commissioners also issued statements suggesting that the Commission should carefully monitor the market to consider a later, ex post, challenge to the merger. As Commissioner Thomas Leary (2002) put it:⁵

¹According to Johnson and Parkman’s (1991) historical account, before the HSR Act the government was unable to win preliminary injunction against mergers because it could not prove their definite intention to merge. Although the government was often successful in ex post challenges, the cases lasted for years and finding effective remedies after the fact was difficult. See Leibeskind (2004). There is no mandatory notification program for mergers in some countries and notification is voluntary in other countries, as in the U.K. Recently, a number of consummated mergers that were exempt from notification (Genzyme/Novazyme; Hologic Inc./Fischer Imaging Corp; Enterprise Product Partners, L.P. and TEP-PCO Partners, L.P.; Aspen Technology; and Dairy Farmers of America Inc.) have been investigated and reversed post hoc.

²These two are the cases involving the merger of Evanston Northwestern Healthcare and Highland Park Hospital and the Chicago Bridge & Iron case.

³See Prepared Remarks of Timothy J. Muris, Antitrust Enforcement at the Federal Trade Commission: In a Word—Continuity, before American Bar Association Antitrust Section Annual Meeting, Chicago, IL, August 7, 2001.

⁴See Statement of Commissioner Sheila F. Anthony, Synopsys Inc./Avant! Corporation, FTC File No. 021-0049.

⁵See Statement of Commissioner Thomas B. Leary, Synopsys Inc./Avant! Corporation, FTC File No. 021-0049.

. . . the agencies may have tended to de-emphasize scrutiny of consummated transactions. Conditions are somewhat different now, and the Chairman of the Commission has already expressed an interest in some post-transaction reviews. (One advantage of post-hoc review, of course, is that it can focus more on history than on predictions.) It is likely that caveats of the kind expressed in the separate statements here will become more common in the future.

The Muris speech and the Synopsys decision along with the recent FTC enforcement actions against several consummated mergers (see Compton and Sher 2003 and Leibeskind 2004 for a discussion of these enforcement actions) all suggest that the antitrust agencies in the United States are grappling with the tradeoffs between ex ante and ex post enforcement.

This paper formulates a simple model that provides a useful framework for determining the optimal mix of ex ante and ex post enforcement in approval regulation. As Commissioner Anthony noted in her Synopsis statement, the degree of uncertainty about the likely effects of the activity in question is an important factor.⁶ As many have noted, the difficulty and cost of developing an effective remedy ex post is also important. The duration of the potential effects also plays an important role because the longer lasting these effects are, the more important it is to make an accurate decision.

Our analysis reveals that ex post control may have an undesirable *chilling effect* on ex ante incentives to undertake some socially desirable activity. In some cases, an activity would not be undertaken unless the government is able to commit not to undo it when it turns out to be socially detrimental. We identify situations in which the government benefits from committing to a regime based exclusively on ex ante review. In some instances, the government might be able to commit ex ante to an ex post standard that is not ex post optimal—we characterize situations in which it is optimal for the government to adopt a relatively lenient ex post standard to alleviate the chilling effect.

We extend the analysis to cases in which the new information regarding an activity's effects are observed only privately by the firm. The firm might then have incentives to distort its actions to influence the government's ex post regulatory decision. Our analysis

⁶The importance of ex ante uncertainty about the effect of mergers is also stressed by PricewaterhouseCoopers (2005) and Competition Commission (2008) in their evaluation reports of merger control policy in the UK.

uncovers instances in which this signaling distortion actually increases efficiency without loss of information. Some of the informal statements by policy makers reported above are consistent with this *discipline effect*, according to which the threat of ex post review has the advantage of disciplining a firm's post-merger market conduct.

In some instances, the firm might have an incentive to increase the cost of reversing the activity so as to reduce the occurrence of ex post control. For example, this strategic behavior was widely perceived before the introduction of the pre-merger notification program, when mergers were evaluated almost exclusively ex post.⁷ To analyze this *manipulation effect* we also extend the model to allow for endogenous reversibility cost.

Beyond the application to competition policy, our analysis is relevant for the wide set of regulatory approval processes set in place by governments to protect consumers from potential damage from private economic activities. There is often substantial uncertainty about the sign and magnitude of the externality generated by the private activity, but more precise information becomes available only once the activity is undertaken. At that stage, some of the damage has already been done and the activity becomes costly to reverse.

Our model broadly applies to the design of sequential approval processes for consumer protection in the health, safety, and environmental area. For example, consider an energy company interested in making an investment in an environmentally sensitive area (e.g., drilling for oil in the Alaskan wilderness) amid uncertainty about both the profitability of the investment and the ultimate environmental impact. Local government authorities will have much more precise information about how best to resolve this tradeoff once the activity has been undertaken for some time and its actual effects have been observed. However, shutting down the project at that stage is more costly than not starting it in the first place.

Next consider an agricultural biotechnology corporation seeking approval for a genetically modified organism.⁸ Regulators (such as the Environmental Protection Agency) will know much more about the safety of the organism after it has been used. At that point, however, substantial sunk costs will have already been incurred in the manufacture and distribution of the organism. Similarly, consider a pharmaceutical firm introducing a new drug. While both the Food and Drug Administration (FDA) and the firm have

⁷See the discussion in Johnson and Parkman (1991).

⁸See Ando and Khanna (2000) and references therein for a discussion of the large amount of uncertainty about the social costs and benefits associated with the introduction of genetically modified organisms.

some information from clinical trials, there remains a great deal of uncertainty about the longer-term safety of the drug. This uncertainty will only be resolved if the FDA approves the drug and many have experienced its effects. The tradeoff between ex ante and ex post approval regulation analyzed here is relevant also for professional licensing and urban planning permits.

The paper proceeds as follows. Section 2 casts our contribution within the literature. Section 3 formulates our baseline model with symmetric learning about the consequences of the activity. Section 4 analyzes the main tradeoff between flexibility and commitment. Section 5 extends the model to allow the firm to observe privately the consequences of the activity. Section 6 analyzes the firm’s incentives to increase the cost of reversing the activity so as to reduce the occurrence of ex post control. Finally, Section 7 discusses our main findings and concludes. All proofs not presented in the text are collected in Appendix A. Appendix B reports details on the derivation of the payoff functions for a simple example of our leading application to merger control.

2 Literature

The value for a principal from committing to an ex post sub-optimal standard to obtain a beneficial change in the agent’s behavior is familiar from the contracting literature—see, for example, Taylor and Yildirim’s (2008) recent analysis of the commitment value of blind reviews. To the best of our knowledge, however, the tradeoff we identify here between ex ante and ex post approval has not been analyzed before. In his broad discussion of the timing of government oversight, Rey (2003, Section 4.2) identifies informally, among other factors, the value of flexibility to adapt to ex post circumstances and the value of commitment not to exploit the firm ex post. His verbal discussion anticipates the chilling effect characterized in our formal model.

In perhaps the closest antecedent to our work, Besanko and Spulber (1993) analyze the strategic effects of the merger approval process when the merging firms have private information about the efficiency consequences of the merger. They model how commitment to a consumer welfare standard influences the merger filing decision in a way that increases social welfare.⁹ Given our different focus on learning about the effect of the merger, we

⁹We also refer to Farrell and Katz (2006) for a broad discussion of the incentive effects of different welfare standards in merger policy.

instead analyze a setting in which the firm has no pre-existing private information. Ex post information arrives only if the merger takes place—in our dynamic setting we then compare ex ante with ex post review.¹⁰

Shavell (1984) compares ex ante and ex post regulation but focuses on a different tradeoff from the one we identify here. He obtains an informational advantage for ex post tort liability over ex ante safety regulation because the ex post regime induces injurers to take optimal ex ante precautions on the basis of their private information.¹¹ In his model, the only reason the ex post regime does not achieve the first best is that ex post liability is insufficient due to judgment-proof injurers and plaintiffs who do not always sue.¹²

More generally, our model contributes to the understanding of the option value of delay in strategic environments when uncertainty is resolved over time. We depart from the real options literature (see Arrow and Fisher 1974 and Henry 1974) in two important ways. First, in our model information arrives only if the activity is undertaken, while in the real options literature information arrives exogenously. Thus, there is active experimentation rather than passive learning. Second, our two decision makers (firm and regulator) interact strategically, while the real options literature mostly focuses on non-strategic environments.¹³

While most of the literature on optimal experimentation analyzes non-strategic problems faced by an individual decision maker, our model features collective experimentation by two parties (firm and regulator) who share the authority to make a decision that generates information about the social desirability of the decision. The decision is delegated to the firm, and this decision affects the payoff of the regulator who, in turn, decides whether to allow it, while being unable to force a firm to undertake the action. The firm is biased ex ante toward undertaking the activity, but the regulator does not know ex ante whether

¹⁰Barros (2003) analyzes the European Union’s shift from a system requiring prior notification for horizontal agreements to a system of ex post control. He focuses on the effect of this change on the restrictiveness of the agreements firms propose.

¹¹Daripa and Varotto (2005) contrast ex ante versus ex post regulation of bank capital. As in Shavell’s model, the advantage of ex post regulation is that it allows the bank manager to use her private information about risk. On the other hand, ex post regulation is more vulnerable to unknown managerial risk aversion.

¹²Kolstad et al. (1990) also analyze ex ante safety regulation and ex post tort liability. In their model, uncertainty about how a court will determine negligence can lead to inefficiencies in ex post tort liability, which can be corrected with appropriate ex ante regulation.

¹³The strategic interaction that has been considered in the real options literature is very different from ours. For example, in Weeds’ (2002) analysis of strategic preemption, the players are firms that compete to invest after learning has taken place, whereas in our model the regulator and the firm must agree ex ante for the activity to be undertaken.

the activity is desirable.

In the first paper analyzing collective experimentation, Strulovici (2008) characterizes general conditions for collective experimentation to be inefficiently too low.¹⁴ Note that collective experimentation is fundamentally different from strategic experimentations (as analyzed, for example, by Bolton and Harris 1999) in which agents experiment independently from each other, rather than collectively deciding whether to experiment. To the nascent literature on collective experimentation we contribute a simple two-period model in which experimentation requires unanimity.

Our paper also relates to the literature on optimal delegation without transfers, initiated by Holmström (1984) and recently advanced by Amador, Angeletos, and Werning (2006), Alonso and Matouschek (2008), and Armstrong and Vickers (2008). Our contribution is to embed a special version of the delegation problem (with complete information and a binary action set) into a simple dynamic social experimentation problem (with two periods). While in the optimal delegation literature the regulator is free to constrain the action set to any subset of the set of feasible actions, in our setting the regulator can prohibit the activity but cannot force one.

3 Baseline Model with Symmetric Learning

In period 0, a risk-neutral firm, F , is considering undertaking some activity, A , such as a merger, an exclusive contract, the construction of a new plant in an environmentally sensitive area, or the introduction of a new product (e.g., a drug or a genetically modified organism) requiring regulatory approval. The firm's payoff if activity A is in place is $\pi(\theta)$ in period 1 and $n\pi(\theta)$ in period 2, where θ is the state of the world (which measures social welfare) and n represents the discounted duration of period 2 relative to period 1. We will focus on situations in which $\pi(\theta)$ is monotonic, either increasing or decreasing.¹⁵

In period 0, the state, θ , is unknown. The state is distributed according to distribution function $G(\theta)$ with associated support $[\underline{\theta}, \bar{\theta}]$ and density function $g(\theta)$. The firm can only undertake activity A if it is approved by a risk-neutral and benevolent regulator, R . The

¹⁴See also Fernandez and Rodrik (1991) who show that preference uncertainty results in a status quo bias in an environment without experimentation.

¹⁵In the application to merger control, $\pi(\theta)$ is increasing in θ when θ represents the uncertainty about the cost synergy generated by the merger, and it is decreasing in θ when θ represents the uncertain substitutability between the products offered by the merging firms. See Appendix B for details.

state measures R 's payoff (equal to social welfare) from activity A , which is given by θ in period 1 and $n\theta$ in period 2. In each period in which the activity is not in place, we normalize the firm's payoff and social welfare to zero. To avoid trivial cases we focus on situations in which there is genuine uncertainty about the social desirability of activity A by assuming that $0 < G(0) < 1$, so that $\underline{\theta} < 0 < \bar{\theta}$. Note that $\theta - \pi(\theta)$ measures the externality associated with activity A .

In the baseline version of the model, we assume that the value of θ becomes publicly known in period 1 only if the firm undertakes A in period 0, so that the state remains unknown if the activity is not undertaken. The regulator has the choice of blocking A in period 0 or waiting until period 1 to learn θ (assuming F undertook A in period 0) and mandate F to undo A . Once A has been undertaken in period 0, F must bear a cost equal to $k \geq 0$ to undo A in period 1. This cost also enters the payoff of R . Parameter k measures the extent of irreversibility associated with the activity.

To summarize, the timing of the game is as follows. At period 0:

- R decides whether to allow or block activity A .
- If R allows activity A , F decides whether to undertake activity A .
- If activity A is not undertaken by F , the game is over and both R and F obtain the baseline payoff of 0.

If activity A is undertaken by F at period 0, at period 1:

- θ becomes publicly known.
- R obtains payoff θ , and F obtains payoff $\pi(\theta)$.
- R decides whether F should undo activity A , in which case F bears cost k and the game is over.

If activity A is in place at the end of period 1, at period 2:

- R obtains payoff $n\theta$ and F obtains payoff $n\pi(\theta)$.

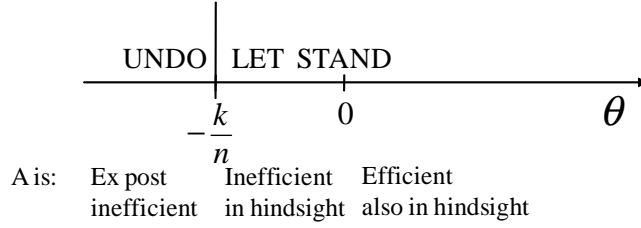


Figure 1: Ex post control

4 Flexibility versus Commitment: Chilling Effect

We begin by considering the ex post optimal decision made by the regulator in period 1. If the firm undertakes activity A in period 0, in period 1 the regulator only undoes the activity going forward if the future social cost of the activity, $-n\theta$, exceeds the social cost of undoing the activity, k . If instead $\theta \geq -k/n$, R allows the activity to continue. The regulator's ex post decision reflects the information that becomes available in period 1, while also taking into account that reversing the activity is costly. When θ lies in the interval $(-k/n, 0)$, in hindsight the regulator should have blocked the activity in period 0. See Figure 1.

For simplicity, we make the following assumption so that the firm does not find it optimal to undo voluntarily the activity in period 1 after learning θ .

Condition 1 $\pi(-k/n), \pi(\bar{\theta}) \geq -k/n$.

If $\pi(\theta)$ is monotonically non-decreasing, the first part of the condition guarantees that the firm will continue the activity whenever the regulator approves it ex post. If instead $\pi(\theta)$ is monotonically non-increasing, the second part of the condition guarantees continuation by the firm since the firm's lowest profit state is at $\bar{\theta}$, where the regulator will certainly allow the action to continue. Note that the second part of the condition implies that there exists a $\check{k} = -n\pi(\bar{\theta})$ that provides a lower bound on the admissible k in our model. This condition is trivially satisfied whenever $\pi(\theta) \geq 0$ for all θ .¹⁶

The expected social welfare resulting ex ante is then

$$W[k, n, g(\theta)] := (1+n) E[\theta] + \int_{\theta}^{-k/n} [-n\theta - k] g(\theta) d\theta, \quad (1)$$

¹⁶If these conditions are not satisfied, allowing the firm to undo A voluntarily in period 1 introduces a second option value to the model. The analysis of the model in the presence of this second option value is of independent interest but would distract from the main message of this paper.

where $E[\theta] = \int_{\underline{\theta}}^{\bar{\theta}} \theta g(\theta) d\theta$ is the unconditional expected social welfare from activity A and $-k/n$ is the *ex post threshold* of the state below which the regulator undoes A in period 1.

To analyze R 's decision in period 0 whether to block A , we begin by supposing that the differential profits, π , are sufficiently large that F undertakes A regardless of R 's policy. Focusing initially on the case in which F is willing to undertake A in period 0 regardless of whether A is undone in period 1, we obtain the following result.

Proposition 1 *If it is profitable for the firm to take activity A in period 0, it is optimal for the regulator to block A ex ante if and only if the cost of undoing A in period 1 is sufficiently high, $k > \hat{k}$, and $E[\theta] < 0$.*

Proof. Whether it is optimal for R to block A in period 0 depends on $W[k, n, g(\theta)] \stackrel{\leq}{\geq} 0$. Computing the expected welfare, W , at the lower bound $k = 0$ we obtain $W[0, n, g(\theta)] = E[\theta] + n \Pr(\theta \geq 0) E[\theta | \theta \geq 0]$. As illustrated in Figure 2, W is a decreasing function of k , with

$$\frac{\partial W}{\partial k} = -G\left(-\frac{k}{n}\right) < 0 \quad (2)$$

for $k < -n\underline{\theta}$; it reaches $(1+n)E[\theta]$ at $k = -n\underline{\theta}$; and it then remains constant for $k > -n\underline{\theta}$. We conclude that in period 0 the regulator blocks A whenever $k \geq \hat{k}$, and does not block otherwise, where \hat{k} is interior as long as $E[\theta] + n \Pr(\theta \geq 0) E[\theta | \theta \geq 0] > 0$ and $E[\theta] < 0$. If $E[\theta] > 0$, it is never optimal to block A in period 0. If $E[\theta] + n \Pr(\theta \geq 0) E[\theta | \theta \geq 0] < 0$, it is optimal to block A in period 0 for all k . *Q.E.D.*

Clearly, it is never optimal to block ex ante (in period 0) an activity that increases expected welfare. When instead the expected social welfare effect of the activity is negative, this proposition says the activity should be blocked ex ante if and only if the cost of undoing it later, k , is large enough. When the cost k is low, it is optimal to allow the activity in period 0 even though the activity results in an expected reduction in social welfare. In this case, by allowing the activity to go ahead in period 0, R obtains more information and is then able to decide in period 1 whether to undo the activity. Intuitively, the smaller is the cost of undoing the activity when it turns out to reduce social welfare, the larger is the option value of learning the precise welfare effect of the activity.

Next, we show that the parameter region for which it is optimal for R to block A ex ante shrinks as the weight of the second period payoff increases. Similarly, the option value

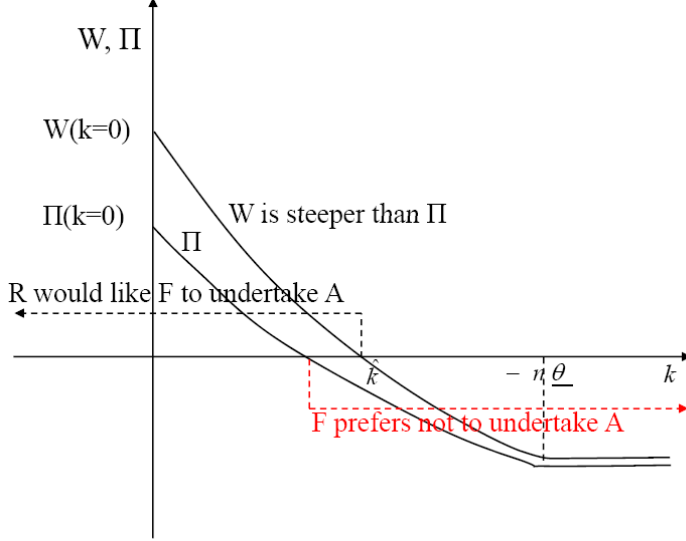


Figure 2: Value of commitment

of ex post review increases with a first-order stochastic shift and with a mean-preserving spread in the distribution of the state.

Proposition 2 *An increase in the duration, n , of the second period, a first-order stochastic increase in the distribution of θ , and a mean-preserving spread in the distribution of θ lead to an increase in the ex ante control threshold for the reversal cost, \hat{k} .*

4.1 Ex Post Control

So far we supposed that the firm is willing to undertake activity A even when it is subject to ex post review by the regulator. Next, we illustrate cases in which the threat of ex post review makes it unprofitable for the firm to undertake the activity. In particular, we characterize a range for the reversal cost for which R 's ability to undo A ex post (when A turns out to be socially undesirable) deters the firm from undertaking A in the first place, even when A is ex ante socially beneficial.

The firm's expected profit from activity A in period 0 is

$$\Pi[k, n, g(\theta)] := (1 + n) E[\pi] + \int_{\underline{\theta}}^{-k/n} [-n\pi(\theta) - k] g(\theta) d\theta, \quad (3)$$

where we suppress the dependence of π on θ in the expectation. When this is negative, the firm is deterred from undertaking activity A . If so, R might benefit from committing *not*

to review the merger ex post. The following proposition gives a necessary and a sufficient condition for this possibility.

Proposition 3 *For ex post review to deter ex ante socially beneficial activities it is necessary that, under ex post review, the firm benefits from A less than the regulator if ex post reversal is costless. That is, it is necessary that:*

$$E[\pi] + n \Pr(\theta \geq 0) E[\pi|\theta \geq 0] < E[\theta] + n \Pr(\theta \geq 0) E[\theta|\theta \geq 0]. \quad (4)$$

Recall that $\check{k} = -n\pi(\bar{\theta})$. If $\pi' < 0$, then for ex post review to deter ex ante socially beneficial activities it is sufficient that (i) $-n \Pr(\theta \geq -\check{k}/n) E[\pi|\theta \geq -\check{k}/n] + \check{k}G(-\check{k}/n) > E[\pi] > 0$ (the unconditional expected profit from A is positive but the firm's total expected benefit from A under ex post review is negative at $k = \check{k}$) and (ii) $E[\theta] > 0$, in which case there exists an $\varepsilon > 0$ such that it is optimal for the regulator to commit ex ante to approve A unconditionally if $k \in [\check{k}, \check{k} + \varepsilon)$.

Proof. To obtain the necessary condition, note that for a marginal increase in the ex post cost of undoing A, the change in F's ex ante expected profits from A is equal to

$$\frac{\partial \Pi}{\partial k} = \left[\pi \left(-\frac{k}{n} \right) + \frac{k}{n} \right] g \left(-\frac{k}{n} \right) - G \left(-\frac{k}{n} \right), \quad (5)$$

where the first term corresponds to the savings (in terms of profits accrued and break-up costs not spent) associated with the marginal activity that is now not reversed as the reversal cost k increases by an infinitesimal amount, while the second term is equal to the increase in reversal cost for the inframarginal activities (for $\theta < -k/n$) that are still reversed at the higher k . The savings are multiplied by the probability density of the marginal state, while the unit increase in inframarginal reversal costs is multiplied by the probability (equal to the distribution function computed at the marginal state) that the activity is undone in period 1. Comparing (5) with (2), we conclude that W decreases faster than Π , $\partial W/\partial k < \partial \Pi/\partial k$, provided that the firm does not want to voluntarily undo the activity, $n\pi(-k/n) > -k$, as guaranteed by Condition 1. Thus, if Π lies above W at $k = 0$, or equivalently, if

$$E[\pi] + n \Pr(\theta \geq 0) E[\pi|\theta \geq 0] \geq E[\theta] + n \Pr(\theta \geq 0) E[\theta|\theta \geq 0],$$

then it is optimal for the firm to undertake the activity ex ante even though the regulator will review it ex post. We conclude that condition (4) is necessary for ex post review to deter an ex ante socially beneficial activity.

To obtain the sufficient condition, note that F 's ex ante expected profit Π from activity A when A can be undone at cost $k = \check{k}$ is negative under the condition

$$E[\pi] < -n \Pr(\theta \geq -\check{k}/n) E[\pi | \theta \geq -\check{k}/n] + \check{k}G(-\check{k}/n).$$

By continuity, for k belonging to a neighborhood to the right of \check{k} the firm would not take activity A under ex post review (because $\Pi < 0$). This occurs even though A would be socially optimal (because $W > 0$ by the assumption $E[\theta] > 0$). The regulator can instead induce A ex ante by committing not to undo A ex post for all states, in which case the firm would be willing to undertake A because $E[\pi] > 0$. *Q.E.D.*

Figure 2 illustrates the necessary condition. We know that while social welfare from ex post review is declining in k , expected profits do not decline as quickly. The reason is that increases in k benefit the firm by reducing the number of states in which the regulator will undo the activity. Thus, in order for there to be a region in which expected social welfare is positive but expected profits are negative, social welfare must be greater than profits at $k = 0$. Otherwise, whenever expected profits become negative, expected social welfare must also be negative.

To understand the sufficient conditions, note that $\theta \geq -\check{k}/n$ is the region in which the regulator will allow the activity to continue for the minimum possible value of k (for $\pi' < 0$). This minimum exists by our assumption that the firm does not voluntarily undo activity A because of a bad realization of the state for its profits. Our sufficient conditions guarantee first that although A is profitable if R will not undo it (since $E[\pi] > 0$), if R has the option of undoing it, then expected profits from A are negative for k near \check{k} . Thus, when these conditions are satisfied, for k near \check{k} , F will undertake A if and only if R commits not to review A ex post. This commitment is socially desirable if $E[\theta] > 0$, the second sufficient condition.

Intuitively, the condition requires that $E[\pi | \theta \geq -\check{k}/n]$ is small enough that, when R does not undo A , profits will be swamped by the cost of undoing A when $\theta < -\check{k}/n$. This is likely to be satisfied when the conflict of interest between R and F is substantial. In this situation, the firm expects to make small profits or even losses when the activity will

not be undone by the regulator. Thus, it does not want to undertake A because of the cost it expects to bear later to undo the activity when the activity turns out to be ex post socially inefficient. When ex ante the activity is socially beneficial, it is optimal for the regulator to forego the option of ex post review and approve the activity unconditionally.¹⁷

It may be helpful to consider the sufficient conditions in the simple context when profits are independent of the state, $\pi(\theta) = \pi > 0$. In this case, commitment to only ex ante control is desirable provided $(1+n)\pi - (k+n\pi)G(-k/n) < 0$ (so that F will not undertake A with ex post review) and $E(\theta) > 0$ (so the expected social benefit is positive). Such a situation could occur in the context of environmental regulation in which the firm knows how profitable oil drilling is likely to be, but there is uncertainty over the extent of the environmental damage. If this damage turns out to be large, the regulator will force the firm to dismantle its drilling operation. It is possible that the risk of having to dismantle its operations would be sufficient to deter the firm from undertaking the activity, even if it is socially desirable in expectation.

In the merger context, commitment may be desirable if the merger is likely to generate substantial efficiencies, but those efficiencies will mostly be passed onto consumers when the merger results in a small increase in market power. If the merger generates a lot of market power, then the regulator will want to undo the merger. Then, the merger may not generate enough profits (when the regulator lets it stand) to compensate the firm for the costs of having to undo the merger. Ex ante, however, the merger may be socially beneficial if the efficiency benefits to consumers in the low market power states are quite large and these states are quite likely.

4.2 Ex Ante Optimal Ex Post Standard

Rather than forgoing completely the option of ex post review, the regulator may prefer to commit to a more lenient ex post standard that avoids chilling ex ante socially beneficial activities. Intuitively, by committing not to reverse the activity in enough states in which the activity is profitable in order to make the firm earn non-negative expected profits from proposing the activity, the regulator can still induce the firm to propose a socially desirable activity while eliminating the reduction in social welfare from the activity in at least some of the states in which the activity is welfare reducing. One natural approach is to continue

¹⁷See Appendix A for a simple analytical example of Proposition 3.

to use a single cutoff for reversing the activity but to lower this cutoff so that the activity is allowed in some states that reduce social welfare a little in order to meet this zero-profit constraint.¹⁸ The following proposition shows sufficient conditions under which the ex ante optimal ex post standard takes this form.

Proposition 4 *Suppose $E[\pi] + n \Pr(\theta \geq -k/n) E[\pi|\theta \geq -k/n] < 0$, $E[\pi] > 0$ and $E[\theta] > 0$. If the regulator can commit to an ex post review policy, then the optimal ex post review policy is to reverse activity A if and only if $\theta \in [\underline{\theta}, \theta^c]$ where $\theta^c < -k/n$ is such that $E[\pi] + n \Pr(\theta \geq \theta^c) E[\pi|\theta \geq \theta^c] - kG(\theta^c) = 0$ under the following conditions: $\pi'(\theta) < 0$, $\pi''(\theta) < 0$ for $\theta < 0$, and $\pi(-k/n) \geq 0$.*

It is worth commenting on the conditions in the proposition. In the merger context, the assumptions that $\pi'(\theta) < 0$ and $\pi''(\theta) < 0$ for $\theta < 0$ say that, when the merger generates enough market power to reduce social welfare, further increases in market power have a diminishing benefit for the firm. This is quite consistent with most models of competition so long as there is substantial market power. Increases in market power when the market is close to being perfectly competitive usually have increasing returns, but as the market gets closer to the monopoly level, they have decreasing returns. So, if a merger that decreases social welfare puts the market far enough away from perfect competition, then the assumption that $\pi''(\theta) < 0$ is quite plausible.

While both of the last two propositions require some form of commitment ability on the part of the regulator, the commitment required in Proposition 4 is much harder to implement than the one in Proposition 3. It is much easier to verify whether the regulator has reversed a previously approved activity than to determine if the regulator is using a particular ex post standard for reversing the activity. In most cases, the actual standard is not a hard and fast rule but is a reasoned judgment made based on a variety of factors. Thus, even if it is possible to commit not to examine an activity after the regulator has given the activity ex ante approval, it is often practically impossible to commit to a particular standard of ex post review that is not ex post optimal for the regulator.

¹⁸This is somewhat reminiscent of Mason and Weeds' (2008) result that a more lenient merger policy may stimulate entry.

5 Ex Post Asymmetric Information: Discipline Effect

In this section, we relax the assumption that the state becomes common knowledge in period 1. Instead, we consider what happens if the regulator cannot observe the state, which is instead privately observed by the firm. In addition, the firm can take some action a that might serve to signal the state to the regulator. Under certain assumptions, detailed below, on how a affects firm profits, this signaling game has a partially-separating equilibrium in which, although the regulator may not learn the precise value of the state, it learns perfectly whether activity A is ex post efficient, i.e., whether $\theta \geq -k/n$. In this equilibrium, the regulator's ex post decision is identical to what it would be under complete information.

Formally, we modify the model by assuming that when activity A is undertaken in period 0, F *privately* observes θ in period 1. Furthermore, after learning θ at period 1, F takes an observable action, a , that affects period 1 profit $\pi(a, \theta)$, with $\pi_1(a, \theta) > (<)0$ for $a < (>)\bar{a}(\theta)$ and $\pi_{12}(a, \theta) < 0$, so that the action $\bar{a}(\theta)$ that maximizes period 1 profit is decreasing in the state, θ .¹⁹ In the merger context, where a is the period 1 price, these assumptions say that profit initially increases (and beyond some level decreases) in price, and that increasing the price raises profit less (or reduces it more) the larger is θ (the more competitive the market is or the greater the efficiencies from the merger).²⁰ As explained above, we assume that R observes this action, a , but does not observe the state, θ .

We also allow for action a to affect social welfare. To account for this in our model, we slightly refine our prior definition of social welfare. Social welfare is given by $\omega(a, \theta)$ with $\omega_2 > 0$ and $\omega(\bar{a}(\theta), \theta) = \theta$. This means that, as we assumed above, social welfare is given by θ if F chooses its profit-maximizing action in period 1. Since θ was commonly observable in period 1 in our baseline model, there was no reason for F to choose any different action. Thus, this extension is consistent with our definition of θ as social welfare in the previous sections.

It is helpful to consider our revised welfare function for the merger application in which a is the price the merged firm charges in period 1. If θ measures efficiencies resulting from the merger (in terms of reduction in the marginal cost of production), then greater

¹⁹In period 2, F will have no reason to deviate from its unconstrained optimal action, $\bar{a}(\theta)$, resulting in payoff $n\pi(\bar{a}(\theta), \theta)$, which is what we denote by $n\pi(\theta)$ as in the baseline model.

²⁰All these conditions are satisfied in the example with increasing $\pi(\theta)$ presented in Appendix B, where there is a single price in the limit case with perfectly substitutable products.

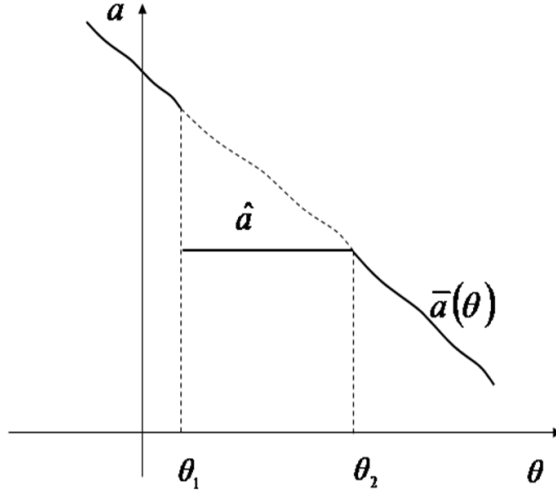


Figure 3: Signaling equilibrium

efficiencies would make lower prices optimal. Furthermore, to the extent that the merged firm has some market power so that $\bar{a}(\theta)$ exceeds marginal cost, lower prices, at least up to a point, would likely increase social welfare.

It is convenient to break up the analysis into three steps. First, Section 5.1 analyzes the firm's best response when the regulator commits to an ex post regulatory policy. Second, Section 5.2 establishes conditions for a partially-separating equilibrium (as illustrated in Figure 3) to exist. Third, Section 5.3 establishes conditions under which the regulator would like to commit to a stricter ex post regulatory policy.

5.1 Firm Behavior

Let $\tilde{\pi}(\theta) = \pi(\bar{a}(\theta), \theta)$ be F 's one-period profit in state θ when the one-period profit-maximizing action a is chosen (this corresponds to $\pi(\theta)$ in our baseline model). Assuming the regulator adopts a cutoff policy in terms of the action taken by the firm in period 1, we obtain the following result.

Lemma 1 *Suppose that the regulator undoes activity A in period 1 if and only if $a > \hat{a}$. Let θ_1 and θ_2 be defined implicitly by $\pi(\hat{a}, \theta_1) + (n - 1)\tilde{\pi}(\theta_1) = -k$ and $\bar{a}(\theta_2) = \hat{a}$. If $\pi_2(a, \theta) > 0$ and $n > 1$, then the firm chooses \hat{a} for $\theta \in (\theta_1, \theta_2]$ and chooses $\bar{a}(\theta)$ for $\theta \in [\underline{\theta}, \theta_1]$ and $\theta \in (\theta_2, \bar{\theta}]$.*

The lemma says that if social welfare and firm profit are both increasing in the state and the regulator adopts a policy of undoing A if and only if a is sufficiently large, then if the state is sufficiently low, the firm gives up on convincing the regulator otherwise and simply chooses its one-period profit-maximizing outcome and the regulator undoes A . In this case, the profitability of A is low enough that it is not worth sacrificing current profits to induce the regulator not to undo A . For a middle range of states, however, the firm chooses the maximum action for which the regulator will not undo A . Even though this action is smaller than the one-period profit-maximizing option, the firm in this range of states finds it profitable because the period 1 loss in profit is small enough relative to the future gain of continuing the activity. Then, for very high states, the firm can choose its one-period profit-maximizing action and still have the regulator not undo A .

It is worth noting that the condition that the firm's profit is increasing in θ is not innocuous. In the merger context, this condition will hold if θ measures efficiencies from a merger (as in the first example presented in Appendix B), but does not hold if θ represents the amount of competition after a merger (as in the second example), because then low θ types (corresponding to high market power created by the merger) have a larger benefit from ex post approval and, therefore, more reason to distort to be approved ex post. For applications to environmental economics, the condition is more easily satisfied since the conflict of interest between the firm and the regulator is generally one of different weighting of interests rather than having directly opposing interests as is the case in antitrust regulation with respect to market power. For instance, if θ represents the ability of a new plant to minimize environmental damage or the ease of extracting oil in an environmentally sensitive area, both profit and social welfare should move in the same direction.

5.2 Equilibrium Analysis

Given the firm's best response, we now examine the regulator's optimal strategy. In the best equilibrium for R , it would set \hat{a} so that $\theta_1 = -k/n$, the state for which the social loss from allowing A to continue exactly equals the social cost of undoing the action.²¹ That is, R sets $\hat{a} = \hat{a}^*$, where \hat{a}^* satisfies $\pi(\hat{a}^*, -k/n) + (n-1)\tilde{\pi}(-k/n) = -k$. This will

²¹This is the best equilibrium for R ex post. As we discuss below, it is possible that the regulator would want to commit to an even lower level of \hat{a} .

generate the semi-separating equilibrium most favorable to R (ex post).

This equilibrium, however, is not unique. There also exist equilibria in which \hat{a} is slightly above \hat{a}^* . In these equilibria, if R observes \hat{a} in period 1, then it will believe that $\theta \in (\theta_1, \theta_2]$ where $\theta_1 < -k/n < \theta_2$. If θ_1 is close enough to $-k/n$, because \hat{a} is close enough to \hat{a}^* , then R will still find it ex post optimal not to undo A . The next proposition describes the possible equilibria in this signaling game. Define first the functions $\theta_1(a)$ and $\theta_2(a)$ as in Lemma 1, that is, such that $\pi(a, \theta_1) + (n-1)\tilde{\pi}(\theta_1) = -k$ and $\bar{a}(\theta_2) = a$. Note that both $\theta_1(a)$ and $\theta_2(a)$ are decreasing in a by the assumption that $\pi_{12} < 0$.

Proposition 5 *Let \hat{a}' be implicitly defined by $\frac{n}{G(\theta_2(\hat{a}')) - G(\theta_1(\hat{a}'))} \int_{\theta_1(\hat{a}')}^{\theta_2(\hat{a}')} \theta g(\theta) d\theta = -k$. For any $\hat{a} \in [\hat{a}^*, \hat{a}']$, if $\pi_2(a, \theta) > 0$ and $n > 1$ then the regulator undoes activity A in period 1 if and only if $a > \hat{a}$ and the firm chooses \hat{a} for $\theta \in (\theta_1(\hat{a}), \theta_2(\hat{a})]$ and chooses $\bar{a}(\theta)$ for $\theta \in [\underline{\theta}, \theta_1(\hat{a})]$ and $\theta \in (\theta_2(\hat{a}), \bar{\theta}]$. The regulator believes that $\theta \in [\underline{\theta}, \theta_1(\hat{a})]$ if $a > \hat{a}$.*

This proposition indicates that there is a continuum of equilibria when the regulator cannot commit to a policy of when to undo activity A . One of these equilibria, the one in which $\hat{a} = \hat{a}^*$, maximizes ex post social welfare by replicating the full information outcome of undoing activity A if and only if the state is such that undoing activity A generates less of a welfare loss than allowing it to continue. In every other equilibria, activity A is allowed to continue in some states in which undoing it would increase social welfare. This occurs because there is partial pooling across states for which allowing A to continue increases social welfare with states for which doing so decreases social welfare.²²

In a signaling equilibrium, the firm's action in period 1 is the same as in the full-information case except when $\theta \in (\theta_1, \theta_2]$. In the welfare-maximizing equilibrium, the regulator's ex post decision is also the same as in the full information case. Thus, the effect of ex post asymmetric information (at least in the welfare-maximizing equilibrium) relative to full-information depends on the welfare effect of the firm's choosing \hat{a}^* rather than $\bar{a}(\theta)$. If $\omega_1(a, \theta) < 0$ for $a \in [\hat{a}, \bar{a}(\theta)]$, then ex post asymmetric information in the welfare maximizing equilibrium will lead to greater social welfare than in the full-information case. In the merger context, where a represents price, since $\hat{a}^* \leq \bar{a}(\theta)$ for $\theta \in (\theta_1, \theta_2]$ (with equality only at $\theta = \theta_2$), in most situations $\omega_1(a, \theta) < 0$ should hold for $a \in [\hat{a}, \bar{a}(\theta)]$ whenever \hat{a}^* exceeds marginal cost at θ_1 , so that ex post asymmetric

²²Of course, it is possible that the regulator can ensure the play of the welfare-maximizing equilibrium.

information simply brings price closer to marginal cost. This is possible as long as the firm has some market power after the merger, so that its profit-maximizing price exceeds marginal cost. In this case, the signaling distortion that reduces profit for the firm is a social benefit, making the case for ex post review stronger when there is ex post asymmetric information. Of course, if the signaling equilibrium is something other than the welfare-maximizing one, then not only will the pooling action be larger, but the regulator's decision will be imperfect, making the case for ex post review weaker.

5.3 Commitment

Lastly, note that even relative to the ex post welfare-maximizing equilibrium, there are circumstances in which the regulator could benefit from the ability to commit to a different standard from \hat{a}^* . If social welfare is greater in the ex post welfare-maximizing equilibrium reported in the previous section than in the case with symmetric information, it is because having the firm choose \hat{a}^* rather than $\bar{a}(\theta)$ for $\theta \in (\theta_1, \theta_2]$ increases social welfare. This means that a reduction in the action a in this region might further increase social welfare, which will be the case provided that $\omega_1(a, \theta) < 0$ at $a = \hat{a}^*$. If R can commit to choosing $\hat{a} < \hat{a}^*$, the boundaries θ_1 and θ_2 will be affected along with the action a that F will choose in this region. Explicitly writing θ_1 and θ_2 as a function of \hat{a} , we can analyze the effect of a small reduction in \hat{a} from \hat{a}^* to \hat{a}^{**} .

Proposition 6 *Suppose that $\omega_1(a, \theta) < 0$ for $a \in [\hat{a}^*, \bar{a}(\theta)]$ and $\pi_2(a, \theta) > 0$. If the regulator can commit to the set of actions for which it will reverse activity A , then it sets this cutoff at $\hat{a}^{**} < \hat{a}^*$ if $g(\theta_1(\hat{a}^*))$ is sufficiently small.*

A small reduction in \hat{a} shifts up the region of states (i.e., shifts up θ_1 and θ_2) for which the firm lowers its action in order to signal a higher state. (In the merger context, the efficiencies have to be slightly larger for the firm to charge the newly lowered price necessary to signal large enough efficiencies so as to avoid reversal of the deal.) Hence, the change in \hat{a} from \hat{a}^* to \hat{a}^{**} brings about three effects on social welfare. First, for states (between θ_1 and θ_2) in which the firm was going to choose its action to just meet the standard, \hat{a} , this action is now reduced from \hat{a}^* to \hat{a}^{**} . This reduction in the action increases social welfare under our working assumption that lower actions increase welfare in this range. Second, because the region of states in which the firm lowers its action to signal a higher state

shifts up, there is a region (between the old θ_2 and the new, higher, θ_2) in which the firm is now lowering its action to signal a higher state when it otherwise would not need to do so. This reduction in the action also increases social welfare. Third, there is now a region of states (between the old θ_1 and the new, higher, θ_1) in which the firm increases its action because it no longer tries to signal that the state is sufficiently high. This increase in the action reduces social welfare. According to Proposition 6, if the probability of being in this third region is sufficiently small, then the regulator would benefit from being able to commit to lowering the cutoff action \hat{a} below the ex post optimal level because doing so would induce a socially desirable change in the firm's period 1 action.

6 Endogenous Reversibility Cost: Manipulation Effect

In this section we relax the assumption that k , the ex post cost of undoing A , is exogenous. Instead, we allow the firm to choose this cost in period 0 after the regulator has decided not to prohibit A ex ante. As we will see, this tends to make ex ante review, and possibly commitment to ex ante review, more desirable. To incorporate endogenous k , we say that first-period profits are given by $\pi(k, \theta)$, where $\pi_1(k, \theta) > (<)0$ for $k < (>)\bar{k}$, $\pi_{11} < 0$, and $\pi_{12}(k, \theta) = 0$. That is, there is a level of k , \bar{k} , that maximizes period 1 profit. For simplicity, we assume this level of reversibility is independent of the state θ . To isolate the manipulation problem from the regulator's concern for ex post social welfare, we further assume there are no direct externalities associated with k . That is, changes in k only affect period 1 social welfare through their effect on profits, though they may also affect social welfare either through their effect on R 's reversal decision or through the cost of undoing A should R decide to do so. Thus, to be consistent with our interpretation of θ as a measure of social welfare, we define social welfare in period 1 by $\tilde{\omega}(k, \theta)$ with $\tilde{\omega}_2 = 1$, $\tilde{\omega}_1 = \pi_1(k, \theta)$, and $\tilde{\omega}(\bar{k}, \theta) = \theta$. This means that social welfare is given by θ if F chooses its profit-maximizing k in period 1, as we assumed in the baseline model. Thus, our description of θ measuring social welfare in the previous sections is consistent with our definition here. Period 2 payoffs are as in the baseline model.²³

Assuming that R cannot commit ex ante, so that its reversal standard remains at

²³When we write π as a function of just one argument, we are referring to profits accrued at period 2. Whereas, if π is a function of two arguments, we are referring to profits at period 1.

$-k/n$, we obtain the following result.

Proposition 7 *Assume that π_{11} is sufficiently negative to guarantee that $\partial^2\Pi/\partial k^2 < 0$.²⁴ If the firm can choose k in period 0 and R chooses whether or not to undo activity A to maximize ex post social welfare, then the firm's choice of k exceeds the socially optimal level.*

Proposition 7 potentially gives another reason for ex ante control. Without the ability to commit to ex ante control, the firm will choose to make it more costly than socially optimal to undo the activity ex post. That said, note that the proposition does not establish that the privately optimal k necessarily exceeds \bar{k} . That is, prior to this section, we implicitly assumed a fixed k . One could think of this as assuming that k is fixed at \bar{k} , that is, the firm has to choose the level of reversibility costs that maximize current profits. If so, relaxing this assumption does not necessarily suggest that ex ante control is more likely to be superior relative to the situation where F has no flexibility to adjust k .

For illustration, note that F 's distortion of k away from \bar{k} , the period 1 profit-maximizing level, is due to both a desire to reduce the probability of reversal (which pushes towards a larger k) and a desire to minimize the losses when reversal occurs (which pushes towards a smaller k). F will choose a k that exceeds the period 1 profit-maximizing level if and only if its expected future gains from a reduced probability of R reversing A exceed the increased loss when A is still reversed. Interestingly, F may be more likely to choose $k > \bar{k}$ if \bar{k} is already quite large so that the probability that the state is low enough to warrant reversal of A is small (because reversals are so socially costly). That said, if very low states are quite unlikely (if, for example, g is single humped and close to zero at θ), then this may not be the case since increasing k from this already high level may not reduce the probability that R reverses A very much.

²⁴Note that

$$\frac{\partial^2\Pi}{\partial k^2} = \pi_{11}(k, \theta) + \frac{1}{n} \left\{ \left[2 - \pi' \left(-\frac{k}{n} \right) \right] g \left(-\frac{k}{n} \right) - \left[\pi \left(-\frac{k}{n} \right) + \frac{k}{n} \right] g' \left(-\frac{k}{n} \right) \right\}.$$

If g is single humped, then ensuring $\partial^2\Pi/\partial k^2 < 0$ is most difficult at $g'(-k/n) = 0$. Thus, the density of the distribution cannot be too large at its peak relative to the concavity of profit in k . Of course, for a sufficiently large n , this condition should be relatively easy to satisfy.

7 Conclusion

Our analysis of the tradeoffs inherent in ex ante and ex post regulation provides some insight into how regulators should use the option of ex post enforcement along with ex ante enforcement. We show that the option to prohibit some activity after the regulator becomes better informed about its consequences should often induce the regulator to become more lenient in its ex ante decision. The magnitude of this leniency is greater the smaller is the cost of undoing an activity after it has been undertaken (the cost of “unscrambling the eggs” in the merger context), the more uncertain are the effects of the merger, and the longer the activity will continue to have effects in the market after the ex post decision.

Our analysis also uncovers the benefits of allowing the regulator to commit not to undertake ex post review when there is sufficient conflict of interest between the regulator and the firm proposing the activity. This commitment is valuable in situations in which the activity is socially beneficial in expectation, but the states in which it increases social welfare are also (largely) the states in which it reduces firm profit. The firm may then be discouraged to take on such a welfare-increasing activity when the regulator is unable to commit not to review the activity ex post. In these circumstances, the regulator also benefits from committing to a more lenient ex post standard.

We also demonstrate that the presence of ex post asymmetric information (according to which the firm learns the true effect of the activity but the regulator does not) often does not reduce the benefit of ex post review and may actually increase it. In the merger context, if the nature of the uncertainty concerns the efficiencies the merger will generate, then if the firm has private information regarding these effects after merging, it will want to signal that the efficiencies are large by charging low prices. If prices exceed marginal cost because of market power, this signaling distortion may actually increase social welfare.

Ex post review, however, might create a perverse incentive for the firm to increase strategically the cost of reversing the activity so as to essentially force the regulator not to undo the activity. Note that all three effects identified here (chilling, discipline, and manipulation) result in a reduction of the number of ex post reversals, consistent with the rare occurrence of reversals in the application to merger control.

Outside of merger review, our analysis applies to other areas of competition policy,

such as in the regulation of cooperation agreements among competitors as well as vertical or exclusive dealing contracts where there are potentially both pro- and anti-competitive effects.²⁵ More broadly, the tradeoffs uncovered in our simple model arise in other areas in which a regulator has to decide whether to allow or prohibit some activity that may or may not be harmful to society and for which uncertainty is reduced if the activity is allowed for some time and its effects are observed. While we applied our model mostly to competition policy, the analysis is relevant also for environmental and health regulation as well as for professional licensing and urban planning. A multi-period extension of the model could be developed to analyze the optimal multi-phase regulatory approval process adopted in those specific contexts. Further research on approval regulation under uncertainty could also shed light on the more general design of organizations to foster learning, with implications for broader principal-agent environments.

²⁵The European Union recently implemented a change in the policy regime for regulating agreements among competitors. Council Regulation (EC) 1/2003 (so called Modernisation Regulation) replaced an old ex ante control system (originally established by Regulation 17/62) based on mandatory notification of agreements among competitors with a new regime of ex post control, mostly implemented by competition authorities at the state level. See Loss et al. (2008) for more details.

Appendix A: Proofs

Proof of Proposition 2. Using (1), we have

$$\frac{\partial W}{\partial n} = E[\theta] - \int_{\underline{\theta}}^{-k/n} \theta g(\theta) d\theta = \frac{W[k, n, g(\theta)]}{n} - \frac{E[\theta]}{n} + \int_{\underline{\theta}}^{-k/n} \frac{k}{n} g(\theta) d\theta.$$

Evaluating this derivative at $k = \hat{k}$ and using $W[\hat{k}, n, g(\theta)] = 0$, we find that

$$\left. \frac{\partial W}{\partial n} \right|_{k=\hat{k}} = -\frac{E[\theta]}{n} + \frac{\hat{k}}{n} G\left(-\frac{\hat{k}}{n}\right) > 0$$

under the assumption that $E[\theta] < 0$. Given (2), we conclude by the implicit function theorem that an increase in n leads to an increase in \hat{k} .

To investigate the effect of changes in the distribution of θ on \hat{k} , rewrite the expected social welfare when not blocking A ex ante as

$$W[k, n, g(\theta)] = E[\theta] + \int_{\underline{\theta}}^{\bar{\theta}} \max\langle -k, n\theta \rangle g(\theta) d\theta.$$

It is then immediate to derive our last two comparative statics results. First, W increases with a first-order stochastic shift in the distribution of θ because θ and $\max\langle -k, n\theta \rangle$ are both increasing functions of θ . Second, by Rothschild and Stiglitz (1970) we know that a mean-preserving spread in θ increases the expected value of the convex function of θ in the second term, while leaving $E[\theta]$ unaffected. We conclude that a first-order stochastic shift in θ and a mean-preserving spread in θ lead to an increase in \hat{k} . *Q.E.D.*

Example for Proposition 3. We now illustrate the sufficient conditions given in Proposition 3 through a simple numerical example of a situation in which an activity is efficiently taken ex ante only if the regulator commits not to review it ex post. Let $\pi(\theta) = z - b\theta$ for $z, b > 0$ and assume that θ is uniformly distributed. In this case, $E[\theta] > 0$ if and only if $\underline{\theta} + \bar{\theta} > 0$. $E[\pi(\theta)] > 0$ if and only if $z > -b(\underline{\theta} + \bar{\theta})/2$. To ensure that $E[\pi] + n \int_{-k/n}^{\bar{\theta}} \pi(\theta) g(\theta) d\theta - kG(-k/n) < 0$, so that the firm does not want to file for A in the presence of ex post review, z cannot be too large. In this example, this condition is $z < \{b[\bar{\theta}^2 n(1+n) - \underline{\theta}^2 n - k^2] - 2k(k + \underline{\theta}n)\} / \{2n[\bar{\theta}(1+n) - \underline{\theta} + k]\}$. To show that it is possible to satisfy all of these conditions on z simultaneously, let $\underline{\theta} = -1/2, \bar{\theta} = 1, k = 1/2, b = 1/4, n = 2$. Thus, we need $z > 1/16$ for A to be

profitable in expectation when the regulator commits not to reverse it ex post. For ex ante review to deter A we need $z < 29/256$. Since $29/256 > 1/16$, all of the conditions are satisfied.²⁶

Proof of Proposition 4. If $E[\pi] + n \Pr(\theta \geq -k/n) E[\pi | \theta \geq -k/n] < 0$, $E[\pi] > 0$ and $E[\theta] > 0$, then we know from Proposition 1 that the regulator wants the firm to propose A . However, the firm will never undertake activity A since it generates negative profits at the current cost. Thus, R needs to commit to some ex post review policy other than what would be ex post optimal. Approval for $\theta > \theta^c$ will induce the firm to propose A by definition of θ^c . To prove that this is the socially optimal way to meet the zero profit constraint, assume that the regulator chooses to approve the proposal in some region $[\theta_1, \theta_2]$ for $\theta_2 \leq -k/n$. Because approval in $[\theta_1, \theta_2]$ reduces social welfare, this must be done to help meet the zero profit constraint by providing some positive level of profit $\int_{\theta_1}^{\theta_2} [n\pi(\theta) + k] g(\theta) d\theta =: z > 0$, given that $\pi(-k/n) > 0$ and $\pi'(\theta) < 0$. We will show that the socially optimal way to generate z in profits to F is increase θ_1 as much as possible, which will be until $\theta_2 = -k/n$ and, consequently, $\theta_1 = \theta^c$.

To prove this, we begin by totally differentiating $\int_{\theta_1}^{\theta_2} [n\pi(\theta) + k] g(\theta) d\theta = z$ with respect to θ_1 and θ_2 to obtain $\frac{d\theta_2}{d\theta_1} = \frac{n\pi(\theta_1) + k}{n\pi(\theta_2) + k} \frac{g(\theta_1)}{g(\theta_2)}$. The welfare effect of approval in this region is $\int_{\theta_1}^{\theta_2} [n\theta + k] g(\theta) d\theta$. To compute the change in welfare due to a small change in θ_1 , we differentiate the latter expression with respect to θ_1 . Using $\frac{d\theta_2}{d\theta_1} = \frac{n\pi(\theta_1) + k}{n\pi(\theta_2) + k} \frac{g(\theta_1)}{g(\theta_2)}$, we obtain $g(\theta_1) \left[\frac{n\pi(\theta_1) + k}{n\pi(\theta_2) + k} (n\theta_2 + k) - (n\theta_1 + k) \right]$. Using $n\pi(\theta_2) + k > 0$ (otherwise there would be no reason not to overturn A at θ_2 because doing so would reduce profit and social welfare), this expression has the sign of $[n\pi(\theta_1) + k] (n\theta_2 + k) - [n\pi(\theta_2) + k] (n\theta_1 + k)$. Note that $[n\pi(\theta_1) + k] (n\theta_2 + k) - [n\pi(\theta_2) + k] (n\theta_1 + k) = n\{[n\pi(\theta_2) + k] (\theta_2 - \theta_1) + [\pi(\theta_1) - \pi(\theta_2)] (n\theta_2 + k)\}$, where $[n\pi(\theta_2) + k] (\theta_2 - \theta_1) > 0$ and $n\theta_2 + k < 0$.

Next, by the intermediate value theorem, we have $[n\pi(\theta_2) + k] (\theta_2 - \theta_1) + [\pi(\theta_1) - \pi(\theta_2)] (n\theta_2 + k) = [n\pi(\theta_2) + k] (\theta_2 - \theta_1) + \pi'(\theta^*) (\theta_1 - \theta_2) (n\theta_2 + k)$ for some $\theta^* \in [\theta_1, \theta_2]$. This is positive if and only if $[n\pi(\theta_2) + k] - \pi'(\theta^*) (n\theta_2 + k) > 0$. Clearly, $[n\pi(\theta_2) + k] - \pi'(\theta^*) [n\theta_2 + k] > n[\pi(\theta_2) - \pi'(\theta^*) \theta_2]$ by the assumption $\pi' < 0$. By the intermediate

²⁶Note that these conditions can be compatible with the willingness of the firm not to voluntarily undo the action (see footnote 16 for a discussion of this possibility). To guarantee that F never undoes A voluntarily, we need that $z > b\bar{\theta} - k/n$. For the numerical value in the example, we need $z > 0$ to ensure the firm never voluntarily undoes A , a condition that is automatically satisfied by the parameters considered here.

value theorem, we have $\pi(\theta_2) = \pi(0) + \theta_2 \pi'(\theta^{**})$ where $\theta^{**} \in [\theta_2, 0]$. Using this, we obtain $n[\pi(\theta_2) - \pi'(\theta^*)\theta_2] = n\{\pi(0) + \theta_2[\pi'(\theta^{**}) - \pi'(\theta^*)]\}$. Since $\theta_2 < 0$ and $\theta^{**} > \theta^*$, this is positive if $\pi(0) > 0$ and $\pi'' < 0$ for $\theta < 0$.

Thus, increasing θ_1 has a positive effect on social welfare. This shows that it is optimal for R to set $\theta_2 = -k/n$. Next, notice that R will set θ_1 so as to minimize the expected welfare loss, resulting from the activity for $\theta_1 \leq \theta'_1 \leq -k/n$, subject to the zero profit constraint. Hence,

$$\begin{aligned} \min_{\theta_1 \in [\underline{\theta}, -\frac{k}{n}]} & - \int_{\theta_1}^{-\frac{k}{n}} (n\theta + k)g(\theta)d\theta \\ \text{s.t.} & (1+n)E[\pi] + \int_{\underline{\theta}}^{\theta_1} [-n\pi(\theta) - k]g(\theta)d\theta \geq 0. \end{aligned}$$

Given that the constraint as well as the objective function are decreasing in θ_1 , it is indeed optimal to set $\theta_1 = \theta^c$. *Q.E.D.*

Proof of Lemma 1. Define $\mathcal{P}(\theta) := \pi(\hat{a}, \theta) + (n-1)\pi(\bar{a}(\theta), \theta)$ and note that $\mathcal{P}(\theta_1) = -k$ by the definition of θ_1 . Using optimality of $\bar{a}(\cdot)$ and the fact that $\pi_2(a, \theta) > 0$, it follows immediately that \mathcal{P} is increasing in θ . When $\theta > \theta_2$, we have $\bar{a}(\theta) < \hat{a}$ because $\bar{a}(\theta_2) = \hat{a}$ and $\bar{a}(\theta)$ is decreasing in θ by $\pi_{12} < 0$. Thus, in this case the regulator does not undo the activity A and the firm chooses $\bar{a}(\theta)$ in period 1. If instead $\theta < \theta_2$, it is straightforward to see that the firm finds it optimal to prevent R from undoing activity A if and only if $\mathcal{P}(\theta) > -k$, which is equivalent to $\theta > \theta_1$, given that \mathcal{P} is increasing. In conclusion, for $\theta \in [\underline{\theta}, \theta_1]$, F chooses $\bar{a}(\theta)$ and R undoes activity A in period 2; for $\theta \in (\theta_1, \theta_2]$, F chooses \hat{a} in period 1, R does not undo A , and F chooses $\bar{a}(\theta)$ after period 1; for $\theta \in (\theta_2, \bar{\theta}]$, F chooses $\bar{a}(\theta)$ in all periods and R does not undo the activity A after period 1. Clearly, if $\theta_1 > \theta_2$, in the first period the firm chooses the best action $\bar{a}(\theta)$ for all θ . *Q.E.D.*

Proof of Proposition 5. If R undoes the activity if and only if $a > \hat{a}$, then Lemma 1 establishes F will act as stated in the Proposition. If F does play this strategy, then R 's payoff (which is simply social welfare) after seeing $a = \hat{a}$ is given by $\frac{n}{G(\theta_2(\hat{a})) - G(\theta_1(\hat{a}))} \int_{\theta_1(\hat{a})}^{\theta_2(\hat{a})} \theta g(\theta) d\theta$ if it does not undo activity A and by $-k$ if it does undo activity A . Since $\hat{a} < \hat{a}'$, and $\theta_1(a)$ and $\theta_2(a)$ are decreasing in a , we have

$$\frac{n}{G(\theta_2(\hat{a})) - G(\theta_1(\hat{a}))} \int_{\theta_1(\hat{a})}^{\theta_2(\hat{a})} \theta g(\theta) d\theta \geq \frac{n}{G(\theta_2(\hat{a}')) - G(\theta_1(\hat{a}'))} \int_{\theta_1(\hat{a}')}^{\theta_2(\hat{a}')} \theta g(\theta) d\theta = -k.$$

Therefore, R 's payoff is weakly greater if it allows A . When observing $a < \hat{a}$, R infers $\theta \in (\theta_2(\hat{a}), \bar{\theta}]$, generating a larger payoff from allowing A . When observing $a > \hat{a}$, R believes $\theta \in [\underline{\theta}, \theta_1(\hat{a})]$, ensuring a larger payoff from undoing A . R 's beliefs follow from F 's strategy except for $a \in (\hat{a}, \bar{a}(\theta_1(\hat{a})))$. Note that believing that $\theta \in [\underline{\theta}, \theta_1(\hat{a})]$ when seeing this off-equilibrium action does not violate the intuitive criterion (Cho and Kreps 1987). *Q.E.D.*

Proof of Proposition 6. By Lemma 1, social welfare given \hat{a} is

$$\int_{\underline{\theta}}^{\theta_1(\hat{a})} [\theta - k]g(\theta)d\theta + \int_{\theta_1(\hat{a})}^{\theta_2(\hat{a})} [\omega(\hat{a}, \theta) + n\theta]g(\theta)d\theta + \int_{\theta_2(\hat{a})}^{\bar{\theta}} (1 + n)\theta g(\theta)d\theta.$$

Differentiating this with respect to \hat{a} yields

$$\begin{aligned} \theta'_1(\hat{a})[\theta_1(\hat{a}) - \omega(\hat{a}, \theta_1(\hat{a})) - k - n\theta_1(\hat{a})]g(\theta_1(\hat{a})) + \int_{\theta_1(\hat{a})}^{\theta_2(\hat{a})} \omega_1(\hat{a}, \theta)g(\theta)d\theta \\ + \theta'_2(\hat{a})[\omega(\hat{a}, \theta_2(\hat{a})) - \theta_2(\hat{a})]g(\theta_2(\hat{a})). \end{aligned}$$

The last term is zero since $\omega(\hat{a}, \theta_2(\hat{a})) = \theta_2(\hat{a})$ by the definition of θ_2 and ω . Thus, the net effect on welfare from a change in \hat{a} is $\theta'_1(\hat{a})[\theta_1(\hat{a}) - \omega(\hat{a}, \theta_1(\hat{a})) - k - n\theta_1(\hat{a})]g(\theta_1(\hat{a})) + \int_{\theta_1(\hat{a})}^{\theta_2(\hat{a})} \omega_1(\hat{a}, \theta)g(\theta)d\theta$. If we evaluate the welfare effect at \hat{a}^* we obtain

$$\theta'_1(\hat{a}^*)[\theta_1(\hat{a}^*) - \omega(\hat{a}^*, \theta_1(\hat{a}^*))]g(\theta_1(\hat{a}^*)) + \int_{\theta_1(\hat{a}^*)}^{\theta_2(\hat{a}^*)} \omega_1(\hat{a}^*, \theta)g(\theta)d\theta, \quad (6)$$

using $-k - n\theta_1(\hat{a}^*) = 0$ by the definition of \hat{a}^* . To determine the sign of the first term, we first determine the sign of $\theta'_1(\hat{a})$. Total differentiation of $\pi(\hat{a}, \theta_1) + (n-1)\tilde{\pi}(\theta_1) = -k$ with respect to θ_1 and \hat{a} gives $\frac{d\theta_1}{d\hat{a}} = \frac{-\pi_1(\hat{a}, \theta_1)}{\pi_2(\hat{a}, \theta_1) + (n-1)\tilde{\pi}'(\theta_1)}$. The denominator is positive since $\pi_2(a, \theta) > 0$. The numerator is negative since $\hat{a}^* < \bar{a}(\theta_1)$ and $\pi_1(a, \theta) > 0$ for $a < \bar{a}(\theta)$. Thus, the first term of (6) is positive since $\theta'_1(\hat{a}^*) < 0$ and $\theta_1(\hat{a}^*) - \omega(\hat{a}^*, \theta_1(\hat{a}^*)) < 0$ by the assumption that $\omega_1(a, \theta) < 0$. The second term is also negative by $\omega_1(a, \theta) < 0$. The overall effect is negative if and only if $g(\theta_1(\hat{a}^*)) < \frac{\int_{\theta_1(\hat{a}^*)}^{\theta_2(\hat{a}^*)} \omega_1(\hat{a}^*, \theta)g(\theta)d\theta}{\omega(\hat{a}^*, \theta_1(\hat{a}^*)) - \theta_1(\hat{a}^*)} \frac{\pi_2(\hat{a}^*, \theta_1(\hat{a}^*)) + (n-1)\tilde{\pi}'(\theta_1(\hat{a}^*))}{\pi_1(\hat{a}^*, \theta_1(\hat{a}^*))}$, as claimed. *Q.E.D.*

Proof of Proposition 7. The expected social welfare is

$$\check{W}[k, n, g(\theta)] := (1 + n) E[\theta] + \pi(k, \theta) - \pi(\bar{k}, \theta) + \int_{\underline{\theta}}^{-k/n} [-n\theta - k]g(\theta)d\theta. \quad (7)$$

Thus, the socially optimal level of k is given implicitly by

$$\frac{\partial \check{W}}{\partial k} = \pi_1(k^*, \theta) - G\left(-\frac{k^*}{n}\right) = 0. \quad (8)$$

Assuming that $\pi_1(0, \theta) - G(0) > 0$, we have an interior solution $0 < k^* < \bar{k}$. As far as the firm is concerned, the modified profit function is

$$\check{\Pi}[k, n, g(\theta)] := \pi(k, \theta) + nE[\pi] + \int_{\underline{\theta}}^{-k/n} [-n\pi(\theta) - k]g(\theta)d\theta, \quad (9)$$

recalling that R cannot commit ex ante. It thus follows that the optimal level of k for the firm solves

$$\frac{\partial \check{\Pi}}{\partial k} = \left[\pi\left(-\frac{k^{**}}{n}\right) + \frac{k^{**}}{n} \right] g\left(-\frac{k^{**}}{n}\right) + \pi_1(k^{**}, \theta) - G\left(-\frac{k^{**}}{n}\right) = 0. \quad (10)$$

Under Condition 1, comparing (8) and (10) we conclude that $k^{**} \geq k^*$. *Q.E.D.*

Appendix B: Merger Application

Focusing on our leading application to merger control, this appendix illustrates how the payoffs functions for F and R can be derived from a fully-fledged industrial organization model. We consider a merger to monopoly between two symmetric firms $n = 1, 2$ offering differentiated products and competing simultaneously in prices. Denoting the price and the quantity of product i by p_i and q_i , assume that demand is given by Shubik and Levitan's (1980) linear demand system, with $q_i =: (2v - 2p_i + \lambda(p_j - p_i)) / 4$ for $i, j \in \{1, 2\}$ with $j \neq i$, where $\lambda \in [0, \infty)$ measures the degree of substitutability between the two products. Before the merger the marginal cost of production for each firm is c . The merger reduces the marginal cost to $c - \gamma$, where $\gamma \in [0, c]$ measures the extent of the synergy created by the merger.

In the Bertrand-Nash equilibrium resulting in the baseline scenario in which the firms do not merge, equilibrium profits for each firm and total surplus at equilibrium are equal to

$$\pi_1 = \pi_2 = \frac{\lambda + 2}{(\lambda + 4)^2} (v - c)^2, \quad TS = \frac{(\lambda + 2)(\lambda + 6)}{2(\lambda + 4)^2} (v - c)^2,$$

where $\pi_i = (p_i - c)q_i$, $CS = (v - p_1)q_1 + (v - p_2)q_2 - [1/(1 + \lambda)] [q_1^2 + q_2^2 + (\lambda/2)q_1q_2]$, and $TS = \pi_1 + \pi_2 + CS$. Once the firms merge, profits and total surplus are equal to

$$\pi_{1\&2}^A = \frac{1}{4} (v - c)^2 + \frac{1}{4} \gamma [2(v - c) + \gamma], \quad TS^A = \frac{2\lambda + 3}{8(\lambda + 1)} (v - c)^2 + \frac{2\lambda + 3}{8(\lambda + 1)} \gamma [2(v - c) + \gamma].$$

We consider two alternative cases, depending on whether the uncertainty is about cost synergy, γ , or product substitutability, λ . First, we show when that the synergy is uncertain, the change in equilibrium profits induced by the merger increases in the change in total surplus achieved in equilibrium. Second, when instead product substitutability is uncertain, the change in equilibrium profits induced by the merger decreases in the change in total surplus.

Uncertain Synergy: Increasing $\pi(\theta)$. For any given level of substitutability, $\lambda \in [0, \infty)$, we now characterize the impact of the synergy, γ , on the change in profits and total surplus generated by the merger. Note that the change in profits for the merging firms, $\pi_{1\&2}^A - \pi_1 - \pi_2$, and the change in total surplus from the merger, $TS^A - TS$, are both increasing functions of γ . This property follows immediately from the observation that

γ affects positively post-merger profits as well as social surplus, but does not affect pre-merger profits and social surplus. Thus, once we define the state as $\theta := TS^A(\gamma) - TS(\gamma)$, the differential profits from the merger, $\pi(\theta) := \pi_{1\&2}^A - \pi_1 - \pi_2$, are increasing in θ .

Uncertain Substitutability: Decreasing $\pi(\theta)$. Next, holding constant the synergy, $\gamma \in [0, c]$, we characterize the impact of the substitutability, λ , on the change in profits and total surplus generated by the merger. The change in total surplus from the merger, $TS^A - TS$, is a decreasing function of λ . To see this, note that the post-merger level of social surplus TS^A decreases in λ in the absence of the synergy, further decreases in λ when the synergy is strictly positive (the more so, the stronger the synergy), and the pre-merger level of social surplus TS^A increases in λ . Intuitively, the more closely substitutable the products, the bigger the deadweight loss resulting from market power when the firms merge and act as a joint monopolist that controls both prices. On the other hand, the more closely substitutable the products, the stronger the competition between the firms when they are separate, and thus the smaller the resulting deadweight loss. By the same logic, the change in profits for the merging firms, $\pi_{1\&2}^A - \pi_1 - \pi_2$, is an increasing function of λ , because $\pi_{1\&2}^A$ is constant in λ while π_1 and $\pi_2 = \pi_1$ decrease in λ . Once we define the state as $\theta := TS^A(\lambda) - TS(\lambda)$, we conclude that $\pi(\theta) := \pi_{1\&2}^A - \pi_1 - \pi_2$ is decreasing in θ . In this case, the preferences of the firm and the regulator go in opposite directions: an increase in the product substitutability between the products enhances the merged firm's ability to leverage its market power, and thus makes the merger more profitable but less socially desirable.

References

- Alonso, Ricardo, and Niko Matouschek. 2008. "Optimal Delegation." *Review of Economic Studies*, 75(1): 259–293.
- Amador, Manuel, George-Marios Angeletos, and Ivan Werning. 2006. "Commitment vs. Flexibility." *Econometrica*, 74(2): 365–396.
- Ando, Amy W. and Madhu Khanna. 2000. "Environmental Costs and Benefits of Genetically Modified Crops." *American Behavioral Scientist*, 44(3): 435–463.
- Armstrong, Mark, and John Vickers. 2008. "A Model of Delegated Project Choice." University College London and University of Oxford mimeo.
- Arrow, Kenneth J., and Anthony C. Fisher. 1974. "Environmental Preservation, Uncertainty, and Irreversibility." *Quarterly Journal of Economics*, 88(2): 312–319.
- Barros, Pedro Pita. 2003. "Looking Behind the Curtain—Effects from Modernization of European Union Competition Policy." *European Economic Review*, 47(4): 613–624.
- Besanko, David, and Daniel Spulber. 1993. "Contested Mergers and Equilibrium Antitrust Policy." *Journal of Law, Economics and Organization*, 9(1): 1–29.
- Bolton, Patrick, and Christopher Harris. 1999. "Strategic Experimentation." *Econometrica*, 67(2): 349–374.
- Cho, In-Koo, and David M. Kreps. 1987. "Signaling Games and Stable Equilibria." *Quarterly Journal of Economics*, 102(2): 179–221.
- Competition Commission. 2008. *Evaluation of the Competition Commission's Past Cases*, United Kingdom.
- Compton, Charles T., and Scott A. Sher. 2003. "If at First You Succeed . . . Counseling for the Close of a Merger Between Competitors." *Mergers and Acquisition Newsletter*, 4(1): 3–8.
- Daripa, Arup, and Simone Varotto. 2005. "Ex Ante versus Ex Post Regulation of Bank Capital." Birkbeck College mimeo.

- Farrell, Joseph, and Michael L. Katz. 2006. "The Economics of Welfare Standards in Antitrust." *Competition Policy International*, 2(2): 3–28.
- Fernandez, Raquel, and Dani Rodrik. 1991. "Resistance to Reform: Status Quo Bias in the Presence of Individual-Specific Uncertainty." *American Economic Review*, 81(5): 1146–1155.
- Henry, Claude. 1974. "Investment Decisions under Uncertainty: The Irreversibility Effect." *American Economic Review*, 64(6): 1006–1012.
- Holmström, Bengt. 1984. "On the Theory of Delegation." In: *Bayesian Models in Economic Theory*, ed. Marcel Boyer and Richard Kihlstrom. Elsevier, Amsterdam.
- Johnson, Ronald N., and Allen M. Parkman. 1991. "Premerger Notification and the Incentive to Merge and Litigate." *Journal of Law, Economics and Organization*, 7(1): 145–162.
- Kolstad, Charles D., Thomas S. Ulen and Gary V. Johnson. 1990. "Ex Post Liability for Harm vs. Ex Ante Safety Regulation: Substitutes or Complements?" *American Economic Review*, 80(4): 888–901.
- Kovacic, William E. 2001. "Evaluating Antitrust Experiments: Using Ex Post Assessments of Government Enforcement Decisions to Inform Competition Policy." *George Mason Law Review*, 9: 843–861.
- Leibeskind, Richard. 2004. "Challenges to Consummated Mergers: Making the Game Worth the Candle." *Mergers and Acquisition Newsletter*, 4(2): 25–32.
- Loss, Frédéric, Estelle Malavolti-Grimal, Thibaud Vergé, and Fabian Bergès-Sennou. 2008. "European Competition Policy Modernization: From Notifications to Legal Exception." *European Economic Review*, 52(1): 77–98.
- Mason, Robin, and Helen Weeds. 2008. "Merger Policy, Entry, and Entrepreneurship." University of Southampton and University of Essex mimeo.
- PricewaterhouseCoopers. 2005. *Ex Post Evaluation of Mergers*. Study for the Competition Commission, the Office of Fair Trading and the Department of Trade and Industry, United Kingdom.

- Rey, Patrick. 2003. "Towards a Theory of Competition Policy." In: Dewatripont, Mathias, Lars Peter Hansen, and Steven J. Turnovsky (Eds.), *Advances in Economics and Econometrics: Theory and Applications* (Eighth World Congress). Cambridge University Press, Cambridge.
- Rothschild, Michael, and Joseph E. Stiglitz. 1970. "Increasing Risk: I. A Definition." *Journal of Economic Theory*, 2: 225–243.
- Shavell, Steven. 1984. "A Model of the Optimal Use of Liability and Safety Regulation." *RAND Journal of Economics*, 5(2): 271–280.
- Shubik, Martin, and Levitan, Richard. 1980. *Market Structure and Behavior*. Harvard University Press, Cambridge, MA.
- Strulovici, Bruno. 2008. "Learning While Voting: Determinants of Collective Experimentation." Northwestern University mimeo.
- Taylor, Curtis, and Huseyin Yildirim. 2008. "Subjective Performance and the Value of Blind Evaluation." Duke University mimeo.
- Weeds, Helen. 2002. "Strategic Delay in a Real Options Model of R&D Competition." *Review of Economic Studies*, 69(3): 729–747.