Policy Timing under Uncertainty: Ex Ante versus Ex Post Merger Control

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Abstract

This paper analyzes the optimal combination of ex ante and ex post enforcement of government policies with particular reference to merger control. While more information about the competitive effect of a merger often becomes available ex post, undoing a merger (either totally or partially through some divestiture of assets) is typically more costly once the firms have already begun commingling their assets and operations. We characterize when a competition authority prefers to commit to ex ante merger review without the option to reconsider the competitive effect of the merger ex post. We identify when the case for ex post review is strengthened if the firm is able to signal its private information about the consequences of the merger through its market conduct.

Keywords: Competition policy, regulation, merger review, learning, signaling.

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1 Introduction

Prior to the passage of the Hart Scott Rodino (HSR) Act in 1976, the government was required to challenge mergers after they had been consummated, since there was no way for the government to detect a merger before it closed. Although, during this time the government was often successful in these challenges, the cases often took years and finding effective remedies after the fact was difficult (Leibeskind 2004). After the passage of HSR, merging firms must report mergers to the government (as long as they are of sufficient size). This reporting gives the government sufficient opportunity to challenge and, if successful, block the merger before it is closed. As a result, since 1976 merger regulation has predominantly occurred prior to, rather than after, a merger has been consummated. A recent speech by former Federal Trade Commission (FTC) Chairman Timothy Muris, however, has suggested a renewed interest in government enforcement of mergers after the fact.[1]

The FTC's unanimous decision not to challenge in advance Synopsys, Inc. acquisition of Avant! Corporation 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 Anthony "efficiencies will be sufficient to outweigh any potential harm to competition."[2] Commissioner Anthony emphasized that in this particular case, there was a great deal of uncertainty regarding the answer to this question. 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 Leary (2002) put it:[3]

> The Hart-Scott-Rodino process has made it both possible and mandatory to review the vast majority of significant mergers in advance and, at times,

[1] See 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.

[2] See Statement of Commisioner Sheila F. Anthony, Synopsys Inc./Avant! Corporation, FTC File No. 021-0049.

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

> that burden has overwhelmed both antitrust agencies. Moreover, history has demonstrated that it can be difficult to obtain effective post-merger relief. For these reasons, 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 Synopsys decision and the Muris speech 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 although the HSR statute makes ex ante merger enforcement possible, it does not proscribe the government from choosing ex post enforcement if the conditions suggest it is likely to be superior. In particular, as Leibeskind has noted, because antitrust jurisprudence and recent industrial organization scholarship have both moved away from strong structural presumptions about what makes a merger anti-competitive, there is a stronger need for solid evidence of anti-competitive effects. Because these can be hard to prove ex ante, this explains the recent renewed interest in ex post merger enforcement.

Our model can both explain, at a theoretical level, why a mix of ex ante and ex post merger enforcement is optimal and provide a useful framework for determining how to optimally choose between the two types of enforcement in any particular case. As Commissioner Anthony noted in her Synopsis statement, the degree of uncertainty about potential anti-competitive effects and efficiencies is an important factor.[4] 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, since the longer lasting these effects are the more important it is to make an accurate decision. Lastly, if the new information that is revealed with ex post enforcement is only revealed through the actions of the merged firm, this can also suggest ex post enforcement may be desirable since it may

[4]The importance of ex-ante uncertainty about the effect of mergers is also stressed by Pricewaterhouse-Coopers (2005) and Competition Commission (2008) in their evaluation reports of merger control policy in the UK.

create a signaling equilibrium in which the signaling distortion actually increases efficiency without any loss of information.

The paper proceeds as follows. Section 2 illustrates the working of our model in the context of a simple example with only two possible states of the world. Section 3 formulates our baseline model with symmetric learning about the consequences of the merger. Section 4 analyzes the main tradeoff between flexibility and commitment. Section 5 extends the model to allow the firm to observe privately the merger consequences. Section 6 discusses our contribution in relation to the literature. Finally, section 7 discusses our main findings and concludes.

2 Illustration

In period 0, a firm is contemplating an acquisition. If it does the acquisition, its profit will depend on both on how much market power the acquisition generates and on how great the efficiencies from the merger are. Assume for the moment that the efficiencies from the deal are common knowledge to both the firm and the antitrust regulator and that these increase profits and consumer surplus.[5] The market power the acquisition generates could be either small so that the level of competition in the market is high, in which case the net payoff from the deal for the firm is π_H and the social payoff is $\theta_H > 0$. This event occurs with probability q. With probability $1-q$, the deal generates a lot of market power so there is little competition in the market, in which case the payoff to the firm from the acquisition is π_L while the social payoff is $\theta_L < 0$. (Notice that L and H represent low and high social payoffs, not private payoffs.) These are per period payoffs that occur in each of $n+1$ periods starting in period 1. Thus, if the antitrust authority decides whether or not to approve the deal in period 0, it will do so if and only if

$$q\theta_H + (1-q)\theta_L > 0.$$

Then, expected social welfare will be $Max\{(n+1)(q\theta_H + (1-q)\theta_L), 0\}$. We proceed under the assumption that the merger generates positive expected profits for the firm, $q\pi_H + (1-q)\pi_L > 0$.

[5] Later in this illustration when we discuss signaling, we will consider a case in which the market power effect of the merger is known but the level of efficiencies are unknown in period 0.

Alternatively, say the antitrust authority can allow the deal in period 0, but then potentially review it after seeing what happens in period 1. We assume at this point that after seeing what happens for one period, the amount of market power the deal generates becomes known to all. In case the antitrust authority decides to undo the merger after one period, however, assume there is both a private and social cost of k of "unscrambling the eggs." Then, in period 1, the antitrust authority will undo the merger in state L if and only if $-n\theta_L > k$. It will never undo the merger in state H. If $-n\theta_L > k$, then expected social welfare from ex post action is $q(n+1)\theta_H + (1-q)(\theta_L - k)$. Note, we are assuming the firm stays merged even in state H since the costs of the merger are sunk and it does not want to pay k. If $-n\theta_L \leq k$, then there is never any ex post scrutiny of the deal.

Clearly, if $-n\theta_L > k$, ex post review is optimal if $q\theta_H + (1-q)\theta_L > 0$. The interesting issue is whether to prohibit the deal ex ante or wait for ex post review if $q\theta_H + (1-q)\theta_L < 0$. Prohibiting the deal leads to expected social welfare of zero. We can rewrite the social welfare from ex post review as follows

$$(n+1)\{q\theta_H + (1-q)\theta_L\} + (1-q)\Delta.$$

Here, $\Delta = -n\theta_L - k > 0$ is the social welfare gain from prohibiting a merger that generates a lot of market power. The term in curly braces is negative since we are considering the case in which the expected social welfare from the deal is less than zero. The second term is positive. This term represents the option value from waiting to learn more about the actual effects of the merger.

Not surprisingly, this option value is increasing in the savings that can be achieved from undoing a socially harmful merger, represented by $\Delta = -n\theta_L - k$. It is also larger the smaller is q, that is, the smaller is the probability of the good state. Of course, larger q also means the first term is not so negative. That said, if we hold constant the expected social loss from the merger, ex post review is more likely to be superior when the bad state is more likely, low q, and more socially harmful, large magnitude θ_L and therefore large Δ. That is, for any given (negative) mean effect of the deal, we are more likely to want to wait for ex post review if the merger is very likely to be bad and very harmful when it is, but when it is good, the social welfare gain is quite large compared to a situation where there is less variance in the effect of the deal.

One potential concern about ex post review, however, might occur in situations in which the deal would be approved ex ante, that is when $q\theta_H + (1-q)\theta_L > 0$. The possibility of ex post review might discourage mergers such as this that are, in expectation socially desirable. To see this, notice that the firm's expected profit for a merger that passes the ex ante review is simply $(n+1)\{(1-q)\pi_L + q\pi_H\}$. Under ex post review, instead, expected profit for the firm is $(1-q)(\pi_L - k) + q(n+1)\pi_H$. Thus, if $(1-q)(\pi_L - k) + q(n+1)\pi_H < 0$, the firm would never merge under ex post review, resulting in a expected social welfare of 0. The firm would merge if instead the regulator were to commit not to review the merger ex post, resulting in expected social welfare of $q\theta_H + (1-q)\theta_L > 0$.

In this illustration, this situation is particularly likely if $\pi_L > 0 > \pi_H$, that is, the merger is profitable for the firm if the market is not very competitive after the merger but is not profitable if the market is quite competitive post-merger. In this case, under ex post review the antitrust authority will approve the merger only in the state in which the firm wishes it had not merged. Given this, the firm may not find it profitable to merge. If, however, the social welfare gain in this state is large enough to compensate for the social losses when the merger does reduce competition, social welfare may be lower in expectation because of the possibility of ex ante review.[6]

Lastly, we want to consider the effect of relaxing the assumption that after period 1 both the antitrust authority and the firm learn the true state of the world. Instead, imagine that the firm learns whether it is in state H or L, but the antitrust authority must infer this from the pricing of the firm. In this signaling game, there could be either a pooling equilibrium in which the firm charges the same prices in either state, so the antitrust authority learns no information. Or, there could be a separating equilibrium in which in state H the firm charges a low enough price that the firm in state L would not want to mimic this even if that were necessary for ex post approval. In the pooling case, ex post review has no information advantages. In the separating case, however, the antitrust authority learns the same information as it does if it could observe the state directly. That said, this situation makes ex post review more desirable because the pricing

[6] One example of this might be a merger which enables two firms to improve the quality of their product. If other firms in the market can also improve their quality, then this merger will not generate market power and may even reduce profits if it reduces product differentiation or increases production costs. If the other firms cannot improve their products very much, this added market power will increase profits but might reduce social welfare more than the gain from a better product. This merger could easily be socially beneficial on the average, but ex post review might deter the firms from undertaking it.

in period 1 is lower than it would otherwise be as the firm in state H must make sure that the state L firm would not want to mimic its price. If there is still some market power in state H, this lower price increases social welfare.

To formalize this argument, we introduce a price choice, p, so that the firm's profit is given by $\pi_j(p)$ in state j. We assume that $\pi_L(p) > \pi_H(p)$ for all p (for any given price, a firm earns more profit if competition is less) and that $\pi'_j(p) > 0$ for $p < p^j$ while $\pi'_j(p) < 0$ for $p > p^j$. Furthermore, $p^L > p^H$ and $\pi'_L(p) > \pi'_H(p)$ (the lower the level of competition the higher the optimal price and the greater the marginal benefit from increasing price). Lastly, $\pi''_j(p) < 0$ for $p < p^j$. These assumptions are all consistent with standard models of differentiated Bertrand competition. For the firm in state H to be able to signal the state by charging a price of p_H, the following conditions must hold:

$$\begin{aligned} \pi_H(p_H) + n\pi_H(p^H) &\geq \pi_H(p^H) - k \\ \pi_L(p_H) + n\pi_L(p^L) &\leq \pi_L(p^L) - k \end{aligned} \tag{1}$$

The first condition guarantees that the type H firm prefers to charge a price of p_H and have its merger approved ex post (garnering profits of $\pi_H(p_H)$ for period 1 and $n\pi_H(p^H)$ thereafter) than to charge its profit-maximizing price of p^H but to have the merger rejected (garnering profits of $\pi_H(p^H)$ in period 1 but losing k thereafter due to having to undo the merger). The second condition ensures that the type L firm does not want to mimic the type H firm. If these two conditions are satisfied, then the antitrust authority will approve a merger if it observes a price of p_H (or smaller) and reject it otherwise.

Notice that the way we have currently interpreted the two states, these two conditions cannot be simultaneously satisfied unless $n < 1$. While $n < 1$ is not unreasonable (it reflects a situation where the length of time between the ex ante and the ex post review is long relative to the life of the firm after ex post review), it is certainly the exception rather than the rule. That said, if we reinterpret the two states as representing different levels of efficiency gains from the merger, a signaling equilibrium becomes much easier to achieve. Since state H now represents a high level of efficiencies from the merger (rather than a high level of competition), we would now have $\pi_H(p) > \pi_L(p)$ (the merged firm's profit is greater for any given price if the merger generates a high level of efficiencies rather than a low level). We would still have $p^L > p^H$ and $\pi'_L(p) > \pi'_H(p)$ however since the less efficient firm would have a higher profit-maximizing price and would have a greater

increase in profit from raising price.

Under these conditions on the profit functions, to see that (1) can always be satisfied for $n \geq 1$, rewrite the signalling conditions as follows:

$$\begin{aligned} \pi_H(p_H) + (n-1)\pi_H(p^H) &\geq -k \\ \pi_L(p_H) + (n-1)\pi_L(p^L) &\leq -k \end{aligned} \tag{2}$$

If p_H is small enough, then the second condition can be met. Let the p_H for which this holds at equality be $\hat{p}_H$. Then we have that $\pi_H(\hat{p}_H)+(n-1)\pi_H(p^H) > \pi_L(\hat{p}_H)+(n-1)\pi_H(p^H) \geq \pi_L(\hat{p}_H) + (n-1)\pi_L(p^L) = -k$. Thus, there always exists a period one price $\hat{p}_H$ for which the type H firm will choose if doing so is necessary and sufficient to ensure the merger is not undone but the type L firm prefers to choose p^L even if that means the merger will be undone. Given this pricing behavior, and the assumption that $-nu_L > k$, the antitrust authority will undo the merger if and only if the firm prices at or below $\hat{p}_H$ in period 1.

Of course, even though a separating equilibrium exists, there may also be a pooling equilibrium that satisfies the intuitive criterion (Cho and Kreps 1987). This will occur if $\pi_L(p^H) + (n-1)\pi_L(p^L) \geq -k$. This condition says that a type L firm prefers to charge a type H firm's one-period profit-maximizing price rather than charge its own one-period profit-maximizing price if doing so is necessary to make sure the merger is not undone. In this case, there can be a pooling equilibrium that satisfies the intuitive criterion in which the firm charges p^H in period one regardless of the state.

If $\pi_L(p^H)+(n-1)\pi_L(p^L) < -k$, then there is no pooling equilibrium which satisfies the intuitive criterion. In this case, however, ex post asymmetric information has no effect. The unique separating equilibrium that satisfies the intuitive criterion has both firms charging their one-period profit-maximizing price—which is the full information prices as well.

Analyzing the effect of asymmetric information if $\pi_L(p^H) + (n-1)\pi_L(p^L) \geq -k$ is more complicated. In the pooling equilibrium, the antitrust authority gets no additional information from ex post review. That said, under ex post review prices are lower in state L with the merger than they would be under full information. Thus, if the merger would be approved under ex ante review only ($qu_H+(1-q)u_L > 0$), it will be optimal to threaten ex post review as long as social welfare is greater in state L with prices of p^H than with prices of p^L. This will be the case if the market power in state L is large relative to the

efficiency difference between state H and state L so that inducing the firm to charge p^H is greater than (or even not much smaller than) its marginal costs. In this case, the value of ex post review is not that it generates more information but rather than it (for at least one period) mitigates the anti-competitive effect of the merger in the bad state.

If $\pi_L(p^H) + (n-1)\pi_L(p^L) \geq -k$ and we have a separating equilibrium, then ex post asymmetric information does not reduce the informational advantages of ex post review. The antitrust authority can perfectly infer the state even though it cannot observe it. In this case, ex post asymmetric information may actually make ex post review relatively more attractive. This will occur if social welfare in state H is greater at a price of $\hat{p}_H$ than at a price of p^H. If the firm still has some market power in state H and $\hat{p}_H$ is sufficiently close to p^H, then under ex post review period one prices in state H generate more social welfare if there is ex post asymmetric information than if there is ex post complete information. Intuitively, the need to signal its type prevents the type H firm from fully exercising its market power.

3 Baseline Model with Symmetric Learning

In period 0, a firm, F, is considering taking some action A. This could be a merger, an exclusive contract, building a new plant in an environmentally sensitive area, etc... F's profit if it takes this action is $\pi(\theta)$ in period 1 and $n\pi(\theta)$ in period 2 where θ represents the state of the world and n represents the discounted duration of period 2 relative to period 1.

In period 0, the state θ is unknown. It is distributed according to the distribution function $G(\theta)$ with associated support $\left[\underline{\theta}, \overline{\theta}\right]$ and density function $g(\theta)$. F can only take action A (corresponding to a merger) if it is approved by a benevolent regulator, R. The regulator's payoff from action A, which is also social welfare, is given by θ in period 1 and $n\theta$ in period 2. If this action is not taken, we normalize the firm's profit and social welfare to zero in all periods.

In the baseline version of the model, we assume that θ becomes common knowledge in period 1 only if the firm takes action A in period 0. If the firm does not take action A in period 0, then there is no additional information about θ in period 1. R has the choice of blocking action A in period 0 or waiting until period 1 to learn θ (assuming F choose A in period 0) and then prohibiting A in the future. We assume, however, that once A has

been chosen by F, it is costly to undo that choice. The cost of undoing A in period 1 is k.

4 Flexibility versus Commitment

If the firm takes action A in period 0 and the regulator waits until period 1 to evaluate it, in period 1 R only undoes the action going forward if the future social cost of the action, $-n\theta$, exceeds the social cost of undoing the action, k. Otherwise, R allows the action to continue. The expected social welfare resulting ex ante is

$$\int_{\underline{\theta}}^{\overline{\theta}} \theta g(\theta) d\theta + \int_{\underline{\theta}}^{\overline{\theta}} \max \langle -k, n\theta \rangle \, g(\theta) d\theta = (1+n) \, E[\theta] + \int_{\underline{\theta}}^{\tilde{\theta}} [-n\theta - k] \, g(\theta) d\theta,$$

where $E[\theta] = \int_{\underline{\theta}}^{\overline{\theta}} \theta g(\theta) d\theta$ is the unconditional expected social welfare from action A and $\tilde{\theta} := -k/n$ denotes the *ex post threshold* 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 takes A regardless of R's policy. Abstracting from the possibility that R undoes A in period 1 affects F's willingness to take A in period 0, we obtain the following result:

Proposition 1 *If it is profitable for the firm to take action A in period 0, it is optimal for the regulator to block A ex ante when the cost of undoing A in period 1 is sufficiently high, $k > \hat{k}$. An increase in the length n of the second period and a mean-preserving spread in the distribution of the state θ lead to an increase in the threshold $\hat{k}$.*

Proof. The criterion for F to block A (or not) in period 0 is

$$W[k, n, g(\theta)] := (1+n) \, E[\theta] + \int_{\underline{\theta}}^{\tilde{\theta}} [-n\theta - k] \, g(\theta) d\theta \lesseqgtr 0. \tag{3}$$

Given that $\partial W / \partial k = -G(-k/n) < 0$, we conclude the regulator blocks A whenever $k > \hat{k}[n, g(\theta)]$.

To investigate the effect of an increase in n, evaluating

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

at $k = \hat{k}$ we have

$$\left.\frac{\partial W}{\partial n}\right|_{k=\hat{k}} = \left.\frac{W\left[k, n, g(\theta)\right]}{n} - E\left[\theta\right] + \int_{\underline{\theta}}^{\tilde{\theta}} kg(\theta)d\theta\right|_{k=\hat{k}} = \left.-E\left[\theta\right] + kG\left(-\frac{k}{n}\right)d\theta\right|_{k=\hat{k}} > 0$$

because

$$E\left[\theta\right] = \frac{W\left[\hat{k}, n, g(\theta)\right]}{(1+n)} + -\frac{\int_{\underline{\theta}}^{-\hat{k}/n}\left[-n\theta - \hat{k}\right]g(\theta)d\theta}{(1+n)} < 0$$

by the definitions of $W\left[k, n, g(\theta)\right]$ and $\hat{k}$ in (3). By the implicit function theorem, we conclude 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

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

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 $E\left[\theta\right]$ unaffected. We conclude that a mean-preserving spread in θ leads to an increase in $\hat{k}$. *Q.E.D.*

Intuitively, an increase in n and a mean preserving spread in θ increase the option value of ex post review, and thus lead to a reduction in the parameter region for which it is optimal for the regulator to block a merger ex ante.

So far we supposed that the firm is willing to take action A even when it is subject to ex post regulation by R. Next, we illustrate cases in which the possibility that 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).

F's expected profit from action A in period 0 is

$$\Pi\left[k, n, g(\theta)\right] := (1+n)\,E\left[\pi\right] + \int_{\underline{\theta}}^{-k/n}\left[-n\pi\left(\theta\right) - k\right]g(\theta)d\theta. \tag{4}$$

When this is negative, the firm is deterred from taking action 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 2 *For ex post review to deter ex ante socially beneficial actions it is necessary that* $E\left[\pi\right] + nE\left[\pi|\theta \geq 0\right] < E\left[\theta\right] + nE\left[\theta|\theta \geq 0\right]$. *For ex post review to deter ex ante socially*

beneficial actions it is sufficient that (i) $-nE[\pi|\theta \geq 0] > E[\pi] > 0$ *and (ii)* $E[\theta] > 0$*, in which case it is optimal for the regulator to commit ex ante to approve A unconditionally when the cost of undoing A belongs to a open subregion of* $[0, \hat{k}]$*.*

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

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

where the first term captures the savings associated to the marginal actions that are now not reversed, while the second term is equal to the increase in reversal cost for the inframarginal actions that are still reversed at the higher k. Given that the second term is equal to $\partial W/\partial k$, Π does not decrease as quickly with k as does W. Thus, if Π lies above W at $k = 0$, or equivalently, if

$$E[\pi] + nE[\pi|\theta \geq 0] \geq E[\theta] + nE[\theta|\theta \geq 0]$$

then then the firm finds optimal to undertake ex ante all the actions that the regulator wants to review ex post. Thus, for ex post review to deter ex ante socially beneficial A it is necessary that $E[\pi] + nE[\pi|\theta \geq 0] < E[\theta] + nE[\theta|\theta \geq 0]$.

To obtain the sufficient condition, note that F's ex ante expected profit Π from action A when A can be undone at no cost ($k = 0$) is negative whenever

$$E[\pi] < -nE[\pi|\theta \geq 0].$$

In this case, by continuity there is an open subregion of $[0, \hat{k}]$ at which the firm would not take action A under ex post review (because $\Pi < 0$), even though A would be socially optimal (because $W > 0$). Under the assumption that $E[\theta] > 0$ the regulator would then want to induce A ex ante—and the firm would be willing to take it (given that $E[\pi] > 0$) provided the regulator commits not to undo it ex post for all states. *Q.E.D.*

Intuitively, the condition $E[\pi|\theta \geq 0] < 0$ is likely to be satisfied when the conflict of interest between R and F is substantial. In this situation, the firm expects to make losses when the action will not be undone by the regulator. More generally, there are situations in which the firm is deterred from the action in the first place by the cost it must bear to undo that action if it turns out to be ex post socially inefficient. When ex ante the action

is socially beneficial, it is optimal for the regulator to forego the option of ex post review and approve the action unconditionally. In the merger context, this is likely when the merger may generate substantial efficiencies, but those efficiencies will mostly be passed onto consumers if the merger will generate little market power. If the merger generates a lot of market power, then the regulator will want to undo the merger. Then, it may be that the merger will not generate enough profits in the states when the regulator will approve it to compensate for the costs of having to undo the merger for the firm. 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.

5 Ex Post Asymmetric Information

Now, we modify the model by assuming that following F's decision to take action A (merge) in period 0, θ becomes known only to F at period 1 (i.e., only after the merger). Furthermore, profit depends on the state θ as well as an action a taken by F, $\pi(a,\theta)$ with $\pi_1(a,\theta) > (<)0$ for $a < (>)\bar{a}(\theta)$ and $\pi_{12}(a,\theta) < 0$. In the merger context, where a is the period 1 price, these assumptions say that profit is increasing in price up to some level and then is decreasing and that increasing price increases profit less (or decreases it more) the larger is θ (the more competitive the market is or the greater the efficiencies from the merger). This action a (but not the state θ) is observable to R. We first establish the conditions for a separating equilibrium to exist. Let $\tilde{\pi}(\theta) = \pi(\bar{a}(\theta),\theta)$ be F's one-period profit in state θ assuming it chooses its one-period profit-maximizing action a. Furthermore, define $\breve{\theta}$ such that $n\tilde{\pi}(\breve{\theta}) = -k$. This is the state for which F is indifferent between voluntarily undoing action A and continuing it.

Lemma 1 *Assume R undoes action A in period one 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 $\pi_2(a,\theta) > 0$, $n > 1$, and $\breve{\theta} < \theta_1$, then F chooses $\hat{a}$ for $\theta \in (\theta_1,\theta_2]$ and chooses $\bar{a}(\theta)$ for $\theta \in [\underline{\theta},\theta_1]$ and $\theta \in (\theta_2,\overline{\theta}]$.*

Proof. Since F has the option to voluntarily undo the merger, in period 1 if $\theta \in (\theta_2,\overline{\theta}]$, then F can maximize its period 1 payoff and still retain the option to stay merged by choosing $\bar{a}(\theta)$. If $\theta \in [\underline{\theta},\theta_1]$, then $\bar{a}(\theta) > \hat{a}$. As a result, F will either choose $\bar{a}(\theta)$, its profit-maximizing choice for period 1, or $a \leq \hat{a}$ to prevent R from undoing the merger.

F's payoff after period 1 is identical for any $a \leq \hat{a}$, so it will choose $\hat{a}$ since this generates the largest period 1 profit of any $a \leq \hat{a}$ (since $\pi_1(a,\theta) > 0$ and $\bar{a}(\theta) > \hat{a}$). Thus, F will choose $\hat{a}$ if and only if $\pi(\hat{a},\theta) + n\tilde{\pi}(\theta) > \tilde{\pi}(\hat{\theta}) - k$. Since $\theta \leq \theta_1$, however, we know that $\pi(\hat{a},\theta) + (n-1)\tilde{\pi}(\theta) \leq \pi(\hat{a},\theta_1) + (n-1)\tilde{\pi}(\theta_1) = -k$ (since $\pi_2(a,\theta) > 0$). For $\theta \in (\theta_1, \theta_2]$, we still have that $\bar{a}(\theta) > \hat{a}$. As before, F will chooses between $\bar{a}(\theta)$ and $\hat{a}$ since this generates the largest period 1 profit of any $a \leq \hat{a}$ (since $\pi_1(a,\theta) > 0$ and $\bar{a}(\theta) \geq \hat{a}$). Thus, F will choose $\hat{a}$ if and only if $\pi(\hat{a},\theta) + n\tilde{\pi}(\theta) > \tilde{\pi}(\hat{\theta}) - k$. Since $\theta > \theta_1$, however, we know that $\pi(\hat{a},\theta) + (n-1)\tilde{\pi}(\theta) > \pi(\hat{a},\theta_1) + (n-1)\tilde{\pi}(\theta_1) = -k$ (since $\pi_2(a,\theta) > 0$). It remains to show that $\theta_1 \leq \theta_2$ (the lemma does not guarantee that the other regions at the extreme are non-empty). This follows from the assumption that $\breve{\theta} < \theta_1$. *Q.E.D.*

The lemma describes the firm's best response function for a given ex post regulatory policy of R. It 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. For a middle range of states, however, the firm chooses the maximum action for which the regulator will not undo action 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 action A. 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, but does not hold if θ represents the amount of competition after a merger, because then low θ types (corresponding to high market power created by the merger) have a larger benefit from ex post approval, so more reason to distort to be approved ex post. In the environmental context, 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. So, if θ represents the ability of the 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.

Given the firm's best response, we now examine the regulator's optimal strategy. If the regulator cannot commit to a level of $\hat{a}$, then in the best equilibrium for R, it would set $\hat{a}$ so that $\theta_1 = \tilde{\theta}$, the state for which the social loss from allowing A to continue exactly equals the social cost of undoing the action ($n\tilde{\theta} = -k$). That is, R sets $\hat{a} = \hat{a}^*$ where $\hat{a}^*$ satisfies $\pi(\hat{a}^*, \tilde{\theta}) + (n-1)\tilde{\pi}(\tilde{\theta}) = -k$. This will generate the semi-separating equilibrium most favorable to R (ex post). This equilibrium, however, is not unique. If F believes that $\hat{a}$ is slightly above $\hat{a}^*$, then if R observes $\hat{a}$ in period 1, it will believe that $\theta \in (\theta_1, \theta_2]$ where $\theta_1 < \tilde{\theta} < \theta_2$. If θ_1 is close enough to $\tilde{\theta}$, because $\hat{a}$ is close enough to $\hat{a}^*$, then R will still find it ex post optimal to not undo A. The next proposition describes the possible equilibria in this signaling game.

Proposition 3 *Let θ_1', θ_2', and $\hat{a}'$ be implicitly defined by $\frac{n}{G(\theta_2')-G(\theta_1')}\int_{\theta_1'}^{\theta_2'} \theta g(\theta)d\theta = -k$, $\pi(\hat{a}', \theta_1') + (n-1)\tilde{\pi}(\theta_1') = -k$, and $\bar{a}(\theta_2') = \hat{a}'$. For any $\hat{a} \in [\hat{a}^*, \hat{a}']$, if $\pi_2(a, \theta) > 0$, $n > 1$ and $\breve{\theta} < \theta_1$, then R undoes action A in period 1 if and only if $a > \hat{a}$ and F chooses $\hat{a}$ for $\theta \in (\theta_1, \theta_2]$ and chooses $\bar{a}(\theta)$ for $\theta \in [\underline{\theta}, \theta_1]$ and $\theta \in (\theta_2, \overline{\theta}]$, where θ_1 and θ_2 are defined as in Lemma 1. R believes that $\theta \in [\underline{\theta}, \theta_1]$ if $a > \hat{a}$.*

Proof. If R undoes the action 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 $\frac{n}{G(\theta_2')-G(\theta_1')}\int_{\theta_1}^{\theta_2} \theta g(\theta)d\theta$ if it does not undo action A and by $-k$ if it does undo action A. Since $\hat{a} \in [\hat{a}', \hat{a}^*]$, R's payoff is weakly greater if it allows A. If R observes $a < \hat{a}$, then she infers $\theta \in (\theta_2, \overline{\theta}]$, generating a larger payoff from allowing A. If she observes $a > \hat{a}$, then she believes $\theta \in [\underline{\theta}, \theta_1]$, ensuring that her payoff is larger from undoing A. R's beliefs follow from F's strategy except for $a \in (\bar{a}(\theta_1), \hat{a})$. Believing that $\theta \in [\underline{\theta}, \theta_1]$ given seeing this off-equilibrium action does not violate the intuitive criterion. *Q.E.D.*

This proposition indicates that when the regulator cannot commit to a policy of when to undo action A that there are a continuum of equilibria that are possible. 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 action A if and only if the state is such that undoing action A generates less of a welfare loss than allowing it to continue. In every other equilibria, action 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. Of course, it is possible that cheap talk by the regulator could ensure the play of the welfare-maximizing equilibrium.

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 choosing $\hat{a}^*$ rather than $\bar{a}(\theta)$. 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 $\theta = \theta_2$), a sufficient condition for the existence of ex post asymmetric information to increase social welfare is that $\hat{a}^*$ exceeds marginal cost at θ_1. 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.

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 than $\hat{a}^*$. If social welfare is greater in the ex post welfare-maximizing equilibrium than in the full information case, this 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 further reduction in a in this region might increase social welfare further. If R can commit to an $\hat{a} < \hat{a}^*$, this will change θ_1 and θ_2 and change the 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 $\hat{a}^{**}$. Notice that since $\hat{a}^{**} < \hat{a}^*$, we have $\theta_1(\hat{a}^{**}) > \theta_1(\hat{a}^*)$ and $\theta_2(\ \hat{a}^{**}) > \theta_2(\ \hat{a}^*)$. Thus, for $\theta \in (\theta_1(\hat{a}^{**}), \theta_2(\hat{a}^*)]$, a falls from $\hat{a}^*$ to $\hat{a}^{**}$. For $\theta \in (\theta_2(\hat{a}^*), \theta_2(\hat{a}^{**})]$, a falls from $\bar{a}(\theta)$ to $\hat{a}^{**}$. For $\theta \in (\theta_1(\hat{a}^*), \theta_1(\hat{a}^{**})]$, a increases from $\hat{a}^*$ to $\bar{a}(\theta)$. Lastly, note that reducing $\hat{a}$ means that R will undo A if $\theta \in (\theta_1(\hat{a}^*), \theta_1(\hat{a}^{**})]$ even though this reduces social welfare in the future. This magnitude of this welfare loss is $[G(\theta_1(\hat{a}^{**})) - G(\theta_1(\hat{a}^*))]k + n\int_{\theta_1(\hat{a}^*)}^{\theta_1(\hat{a}^{**})} \theta g(\theta) d\theta > 0$ since $n\theta_1(\hat{a}^*) = -k$ since $\theta_1(\hat{a}^*) = \tilde{\theta}$. If decreasing a increases social welfare and the probability that $\theta \in \theta \in (\theta_1(\hat{a}^*), \theta_1(\hat{a}^{**})]$ is small, then the ability to commit to a small

reduction in $\hat{a}$ from $\hat{a}^*$ to $\hat{a}^{**}$ can increase social welfare. This requires commitment since after observing a, it is too late to influence the period 1 action and reducing $\hat{a}$ below $\hat{a}^*$ only results in undoing action A sometimes when this reduces social welfare.

6 Related Literature

Other papers in the literature compare ex ante and ex post regulation, but focus on very different tradeoffs than we identify here. Shavell (1984) presents a model of ex ante safety regulation and ex post tort liability in which there is also an informational advantage to using ex post tort liability. This advantage, however, stems from the fact that injurers are privately informed ex ante, so that they have the information to take optimal ex ante precautions. In that paper, the only reason ex post regulation does not achieve the first best is that ex post liability is insufficient due to judgement proof injurers and plaintiffs who do not always sue. Kolstad et al. (1990) also analyze the optimal use of ex ante safety regulation and ex post tort liability. In their model, uncertainty about how a court will interpret whether or not the injurer met the standard of due care can lead to inefficiencies in ex post tort liability, which can be corrected with appropriate ex ante regulation.

Daripa and Varotto (2005) contrast ex ante versus ex post regulation of bank capital. Like Shavell's model, the advantage of ex post regulation is that it allows the bank manager to use her private information about the risk faced by her bank. On the other hand, ex post regulation is more vulnerable to unknown managerial risk aversion. Barros (2003) analyzes the European Union's shift from prior notification system for horizontal agreements to a system of ex post control. The focus of the analysis there is purely on the effect this change will have on the restrictiveness of the agreements proposed in a model in which firms can finely adjust the restrictiveness at a cost (which is greater under ex post control).

Loss et al. (2008) also compare the EU's prior notification system to the ex post control system. Their focus is on the effect of each system on the firm's decision to enter into an agreement for which it has private information as to whether or not it is good or bad. In their model, the competition authority's ability to distinguish between good and bad agreements does not differ between the ex ante and the ex post regime. Besanko and Spulber (1993) model the decision to merge by firms with private knowledge of the efficiency consequences of the merger. In their model, however, the government regulator has no independent signal of the state (the efficiency consequences of the merger). Rather,

they model how commitment to a pro-consumer welfare standard can influence the merger filing decision in a way that increases social welfare.

Our model contributes more broadly to the understanding of the option value of delay in strategic environments when uncertainty is resolved over time. While most of the literature on optimal experimentation focuses on non-strategic problems faced by individual decision makers, we contribute a simple model of social experimentation in which two parties (the firm and the regulator) share the authority to make a decision (merger) that generates information (about the social desirability of the merger). The merger decision is delegated to the firm, but it affects the payoff of the regulator who, in turn, decides whether to allow the firm to merge or to force a de-merger (but is unable to force a firm to merge). The firm is biased ex ante toward merging, while the regulator does not know ex ante whether merging is desirable.

Other models of social experimentation, instead, focus either on common value environments (Bolton and Harris 1999) or settings with ex-ante symmetric agents with independent preferences (Strulovici 2007).[7] In our setting, we find that conflicts of interest across agents (firm and regulator) tend to reduce the amount of experimentation and introduce a tradeoff between the flexibility induced by the ex post optimal use of information by the regulator and the willingness of the firm to undertake a merger that is costly to reverse. Thus, we identify conditions for the regulator to benefit from committing to turn a blind eye to an anti-competitive merger.[8]

7 Discussion

The tradeoff between making regulatory decisions ex ante with little information versus waiting to acquire more information is of widespread importance. Recently in the area of competition policy, the US Federal Trade Commission has been wrestling with this tradeoff in the context of merger review. The tradeoff also arises in many other areas in which a regulator has to decide whether to allow or prohibit some action that may or may not be harmful to society and for which the only way to substantially reduce the

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

[8] 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.

uncertainty associated with the impact of this action is to allow it for some time to actually observe its effects. Outside of merger review, this fundamental tradeoff may occur in other areas of competition policy, for example, in various agreements among competitors or in vertical arrangements like exclusive dealing where there are potentially both pro- and anti-competitive effects. This tradeoff also arises in environmental contexts, such as in a decision about whether or not to allow oil drilling in an environmentally sensitive location, or in the decision about whether or not to allow the distribution of a new drug.

Despite its widespread importance, this tradeoff has not yet been rigorously analyzed. In filling this gap, we provide 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 action later after the regulator has better information about its consequences should often lead the regulator to be somewhat more lenient in its ex ante decision. The magnitude of this leniency is greater the smaller is the cost of undoing an action 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 action will continue to have effects in the market after the ex post decision.

We also show that in situations where there is sufficient conflict of interest between the regulator and the firm proposing the action, that there may be benefit to allowing the regulator to commit not to undertake ex post review of an action. This occurs in situations in which the action is, in expectation, socially beneficial, but the states in which it increases social welfare are also (largely) the states in which it reduces firm profit. In the absence of a commitment to purely ex ante review, the firm may not propose such welfare increasing actions. Lastly, we demonstrate that if there is ex post asymmetric information, so that the firm learns the true effect of the action but the regulator does not, this will often 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 of 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 increase social welfare.

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