Policing the collusion sounds very much like the subtle and complex problem presented in a good detective story.

George J. Stigler (1964, p. 48)

3.1 Introduction

Fines are the main, and sometimes the only, sanction available to antitrust authorities. According to the economic theory of law enforcement, a fine should in principle be set such that the expected fine equals the net harm done to other parties.\(^1\) The optimal fine induces firms to engage only in efficient collusion, and typically fully deters this form of anticompetitive behavior. This insight seems to be well understood by antitrust authorities. To illustrate, the European Commission’s Guidelines state that fines should be set to “punish the firms involved and to deter (emphasis added) others from practices that infringe the competition rules”.\(^2\)

Antitrust authorities may not be able to adhere to this normative principle. European antitrust enforcement, for instance, is constrained by a cap on fines of 10 percent of the firm’s annual turnover. A more fundamental issue is that antitrust authorities may not be able to commit to fines that deter collusion. After the antitrust authority has established the existence of a cartel and must decide on the

\(^1\) See for instance Becker (1968), Landes (1983), or Polinsky and Shavell (2000).
appropriate fine, it has good reasons (and the authority) to lower it. Since the social welfare loss associated with a cartel is sunk, the optimal fine \textit{ex post} is zero. As a result, without the ability to commit itself, the antitrust authority may be unable to deter collusion.

This chapter studies optimal antitrust enforcement when the government cannot commit to an antitrust policy.\footnote{An antitrust policy is a complete description of the actions of the antitrust authority, at all possible information sets.} The government, aiming to maximize social welfare, tackles this commitment problem by delegating enforcement to an antitrust authority with a biased objective function. The antitrust authority’s objective function is biased in the sense that it may give consumer welfare and firm profits unequal weights. It is shown that it is optimal to delegate antitrust enforcement to an antitrust authority whose objective function is biased toward consumer welfare. This may explain why some antitrust authorities pursue to maximize consumer welfare, instead of social welfare, as some commentators argue.\footnote{Alternatively, one may argue that national antitrust authorities of small open economies \textit{de facto} maximize consumer surplus given that the price-fixing firms are mostly multinational.} For instance, Neven and Röller (2005) observe that “[i]t is striking that some of the major antitrust agencies appear to operate with objectives that differ from welfare maximization. In particular, both the U.S. as well as European merger control can be interpreted as maximizing consumer surplus rather than aggregate welfare.” Recently, European Commissioner Kroes said that “We all agree that the overall aim of competition policy, including the application of Article 82 and Section 2 of the Sherman Act, is to protect consumer welfare.”\footnote{N. Kroes, “Exclusionary abuses of dominance – the European Commission’s enforcement priorities”, speech addressed at \textit{Fordham University Symposium}, September 25, 2008.}

The analysis in this chapter naturally relates to the literature on antitrust enforcement. A crucial issue in these models is how one should model the behavior of the antitrust authority. The early contributions (see for instance Block, Nold and Sidak, 1981) assume that the probability of detection of a cartel by the antitrust authority is exogenous. Besanko and Spulber (1989) propose a model with incomplete information in which this probability is endogenous. They find that, even if the antitrust authority can perfectly establish the existence of a cartel and commit to any antitrust policy, it is optimal to allow some degree of collusion. The assumption of perfect commitment is typically discarded in subsequent work. In its place, theorists assume that the antitrust authority commits \textit{ex ante} to some probability of investigation (e.g Motta and Polo, 2003) or that the antitrust authority investigates according to an arbitrary rule of thumb (Harrington, 2005). The model in this
chapter builds on Besanko and Spulber (1989). Their framework is useful because it captures two crucial ingredients of actual antitrust enforcement, namely asymmetric information about the firms’ marginal costs and asymmetric information about their conduct (cooperative or non-cooperative). The main difference between this chapter and their work is that this chapter considers antitrust policy when the antitrust authority is unable to commit itself. In this chapter, the antitrust authority responds strategically to the behavior of the firms. Martini and Rovesti (2004) also consider antitrust enforcement in the absence of commitment. They assess the effectiveness of a consumer welfare standard with a social welfare standard. However, they suppose that an antitrust authority’s investigation retroactively dictates non-cooperative behavior, which is tantamount to assuming the commitment problem away. This condition is not imposed in the analysis below. Moreover, the model in this chapter allows for a more general antitrust objective function, of which consumer welfare and social welfare are special cases.

This chapter also builds on the literature of strategic delegation. In an influential paper, Rogoff (1985) shows, in the context of monetary policy, that it may be optimal to delegate authority to a central banker with a greater distaste of inflation than the median voter. Besanko and Spulber (1993) and Neven and Röller (2005) analyze optimal standards for the antitrust authority in the context of merger analysis. See Carlton (2007) for a recent general discussion of the appropriate objective for antitrust authorities.

The remainder of this chapter is as follows. First, in section 3.2, the model is introduced. The main results are presented in section 3.3, where the full information benchmark (section 3.3.1) and the equilibrium under asymmetric information (section 3.3.2) are studied. Section 3.4 offers an analysis of alternative commitment devices (in section 3.4.1), internal cartel stability (in section 3.4.4) and leniency programs (section 3.4.5). Conclusion are relegated to section 3.5.

3.2 The model

3.2.1 Firms

There are \( n \geq 2 \) identical risk-neutral firms. Each firm produces a homogeneous good at marginal costs \( \theta \geq 0 \). The marginal costs are the same across firms and are either \( \theta_h \) or \( \theta_l \), where \( \theta_h > \theta_l \geq 0 \). The government and the antitrust authority perceive costs as being \( \theta_l \) with probability \( \alpha \) and \( \theta_h \) with probability \( 1 - \alpha \), where \( \alpha \in (0, 1) \).
The firms face a market demand curve $Q(p)$. $Q(p)$ has a finite choke price $p^c > \theta_h$ above which demand is zero. Prices are publicly observable. The market price $p$ is the minimum of the prices of all firms and $p^c$. Let $p_{-i}$ be the minimum of the prices of all firms and $p^c$ excluding firm $i$. Given that $p_{-i} < p^c$, firm $i$’s gross profit (i.e. net of fines), is

$$\pi(p_i) = \begin{cases} 
0 & \text{if } p_i > p_{-i} \\
\frac{1}{\#\{j:p_j=p_{-i}\}}Q(p_i)(p_i - \theta) & \text{if } p_i = p_{-i} \\
Q(p_i)(p_i - \theta) & \text{if } p_i < p_{-i}
\end{cases}$$

After the firms observe their costs, they may either act non-cooperatively or act cooperatively and form a cartel. In the former case, the firms compete in a Bertrand-Nash fashion, which implies that the equilibrium market price is $\theta$ and each firm earns zero profits. If the firms collude, they agree to charge a price that maximizes their expected joint profits.\footnote{To highlight the antitrust authority’s commitment problem, internal cartel stability issues are ignored here. See, however, section 3.4.4 in which the individual firms’ incentives to adhere to the cartel agreement are explicitly studied.} By assumption, a unique price $p^m(\theta)$ exists that maximizes $\pi = (p - \theta)Q(p)$. Additionally, this optimal price is assumed to be relatively high; $p^m(\theta)$ is strictly larger than $\theta_h$. This implies, inter alia, that a low-cost industry cannot simultaneously mimic a high-cost non-cooperative industry and obtain unconstrained monopoly profits.

After the market stage, the antitrust authority may investigate the industry. An investigation yields legal evidence of the industry’s conduct. Since collusion is strictly illegal \textit{per se}, the antitrust authority may impose a penalty $F \in [0, A]$ on a collusive industry, where $A < \infty$. Fines may be bounded because firms enjoy limited liability.\footnote{In practice, antitrust law imposes restrictions on $F$ as well. The Sherman Act, for instance, specifies a maximum fine of $\$ 10,000,000$ for corporations. Additionally, there seems to be a consensus among antitrust authorities that fines should not lead to a firm’s bankruptcy.} To keep the analysis interesting, suppose that $A$ is relatively large: $\pi^m(\theta_h) \le A$. Otherwise, collusion would be impossible to deter.\footnote{According to some economists, fines are often set too low to effectively deter collusion (see for instance Connor, 2004). If that were true, one would expect much more collusive activity than we currently perceive. Perhaps the maximum fine has a deterrent value for some industries, but not for others. The implication of this presumption is that the analysis in this chapter applies to those industries for which the maximum fine is relatively large.}
3.2.2 The antitrust authority

The antitrust authority is supposed to deter collusion. The antitrust authority may investigate the industry at cost $K > 0$. The cost of investigation is relatively small; $K < aA$. Since the antitrust authority neither observes $\theta$ nor the industry’s conduct, it is without loss of generality to let $\beta(p) \in [0, 1]$ be the probability that the antitrust authority investigates the industry, conditional on the market price.

The antitrust authority cannot commit to any arbitrary antitrust policy. This seems a reasonable assumption. *Ex post*, the antitrust authority has no incentive to impose a fine. Fines are just a transfer and, in the presence of collusion, not a remedy. Although many economists suppose that a convicted cartel reverts to non-cooperative behavior, there is no theoretical or empirical justification for this assumption. Moreover, a high fine conflicts with other objectives of the antitrust authority or the government. For instance, a high fine may induce some firms to exit the market, leaving a higher concentrated industry with a high (non-cooperative) price. High fines may also lead to (temporary) unemployment, conflicting with the government’s social objectives. The inability to commit may also derive from the fact that it is hard to fully describe an antitrust policy. Each industry is different and this makes it more likely that the antitrust authority deals with the industry on a case-by-case basis. Finally, the antitrust authority may not be able to commit when the *ex ante* optimal policy requires the antitrust authority to investigate with some probability. It is hard for outsiders to observe whether the antitrust authority was able to commit when it did not investigate a particular industry.

3.2.3 The government

The government aims to maximize social welfare, and views $F$ as a pure transfer from firms to consumers. Then, social welfare $W$ can be written as

$$W = E \left[ \int_{p}^{p'} Q(t) dt + Q(p)(p - \theta) - \beta(p)K \right].$$

(3.1)

Just as the antitrust authority, the government cannot commit to an antitrust policy. However, the government can instruct the antitrust authority to maximize a biased social welfare function. More precisely, the government can choose the relative

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9 Thompson and Kaserman (2001) show that 85% of indicted firms regain their pre-indictment stock price within a year, suggesting that many price-fixers recommence their collusive activities. Bosch and Eckard (1991) estimate that of all firms indicted by the U.S. Department of Justice between 1962 and 1980, 14% were recidivists.
weight that the antitrust authority places on consumer welfare. One way to think about this is that the government delegates the task of antitrust enforcement to an agent with preferences that are biased from the government’s. Let \( \lambda \in [0,1] \) be the relative weight of consumer welfare in the antitrust authority’s objective function. Then, the antitrust authority maximizes

\[
\tilde{W} = E \left[ \lambda \left( \int_p^p Q(t) dt + F \right) + (1 - \lambda) \left( Q(p)(p - \theta) - F \right) - \beta(p)K \right]. 
\] (3.2)

### 3.2.4 Timing

The timing is as follows. First, the government chooses the objective function of the antitrust authority. Then, the firms privately learn their costs. They may commit to form a cartel. The firms subsequently set prices. Given these prices, the antitrust authority may investigate the firms. If it finds evidence of collusive behavior, it can impose a fine. Figure 3.1 depicts the game in extensive form.

### 3.3 The equilibrium

#### 3.3.1 The full information benchmark

Consider antitrust policy when the antitrust authority simply knows the industry’s marginal costs and perfectly observes the mode of behavior. This game can be solved by backward induction. The antitrust authority investigates a collusive industry if and only if \( \lambda F - (1 - \lambda)F - K > 0 \). Clearly, if \( \lambda < 1/2 \), the antitrust authority sets the lowest possible fine. In this case, the antitrust authority never investigates and collusion cannot be deterred. If \( \lambda \geq 1/2 \), the antitrust authority sets \( F = A \) and investigates if and only if

\[
\lambda \geq \frac{A + K}{2A} .
\] (3.3)

Let \( V(p, \theta) = \int_p^p Q(t) dt + Q(p)(p - \theta) \). Then, social welfare is \( E[V(\theta, \theta)] \) if (3.3) holds and \( E[V(p^m(\theta), \theta)] \) otherwise. Social welfare is maximized if the antitrust authority induces non-cooperative behavior without actually investigating the industry. The government can achieve this by choosing a bias such that inequality (3.3) is satisfied. Therefore, with full information, the government selects a biased antitrust authority and collusion does not occur.
3.3.2 Equilibrium antitrust policy

It turns out that this no-collusion result no longer holds when the antitrust authority cannot observe the industry’s marginal costs or conduct. Before deriving the equilibrium, it may be useful to introduce some additional functions. Let $\gamma(\theta; \lambda) : \{\theta_l, \theta_h\} \rightarrow [0, 1]$ be the probability that firms collude given their cost parameter $\theta$ and $\lambda$. Additionally, let $\beta(p; \lambda) : [\theta_l, p^c] \rightarrow [0, 1]$ be the probability that the antitrust authority investigates the industry after observing price $p$. In equilibrium, firms maximize expected profits by choosing $\gamma$ and prices, the antitrust authority maximizes $\tilde{W}$ by setting $\beta$ and the government optimally selects $\lambda$. For all players must hold that their strategies are optimal given their beliefs about their information and the other players’ strategies. Players must update their beliefs according Bayes’ rule whenever applicable.

Suppose first the government chooses a relatively low bias. Then it is straightfor-
ward to show the following.

**Lemma 3.1.** Let $\lambda \in [0, \frac{A+K}{2A}]$. Then, the subgame between the industry and the antitrust authority has a unique (pooling) equilibrium in which both types collude by setting $p^m(\theta)$ and the antitrust authority never investigates. Hence, $\gamma(\theta; \lambda) = 1$ for $\theta \in \{\theta_l, \theta_h\}$ and $\beta(p, \lambda) = 0$ for any $p \in [\theta_l, p^c]$. The government’s payoff is $W_1 = E[V(p^m(\theta), \theta)]$.

**Proof.** Given the value of $\lambda$, it is not rational for the antitrust authority to investigate the industry, irrespective of its beliefs. The firms anticipate this and collude for both realizations of the cost parameter. $\blacksquare$

The government may also select an intermediate bias. This reduces the likelihood of collusion, as the next lemma states.

**Lemma 3.2.** Let $\lambda \in \left(\frac{A+K}{2A}, \frac{A+K/\alpha}{2A}\right]$. Then, the subgame between the industry and the antitrust authority has a unique (separating) equilibrium in which the low type colludes and the high type acts non-cooperatively. Both types set a price $\theta_h$ and the antitrust authority does not investigate collusion. In the equilibrium of this subgame, $\gamma(\theta_l; \lambda) = 1$, $\gamma(\theta_h; \lambda) = 0$, $\beta(\theta_h; \lambda) = 0$ and $\beta(p; \lambda) = 1$ for any $p \neq \{\theta_l, \theta_h\}$. The government’s payoff is $W_2 = \alpha V(\theta_h, \theta_l) + (1-\alpha)V(\theta_h, \theta_h)$.

**Proof.** Suppose that the antitrust authority observes $p = p^m(\theta_h)$. It rationally expects that this price originates from a collusive high type. Given its relatively high bias, it is inclined to investigate the industry and impose a fine. A high-cost industry anticipates this behavior and will not set such a price. The high type might consider a price $p \neq p^m(\theta_h)$. However, the antitrust authority knows that exclusively $\theta_l$ and $\theta_h$ will be observed in a non-cooperative equilibrium. Since setting price below costs is not profitable, high types will not collude in this subgame.

For the same reasons, a low type will not choose $p = p^m(\theta_l)$. Suppose it colludes with certainty and sets $p = \theta_h$. Then, the antitrust authority believes that it faces a collusive low type with probability $\alpha$ and a non-cooperative high type with probability $1 - \alpha$. Given this belief, investigation will not be worthwhile as the expected payoff of an investigation is

$$\alpha(\lambda A - (1-\lambda)A - K + (1-\alpha)0 < 0$$

for $\lambda$ in the assumed interval. $\blacksquare$

Finally, the government may select a relatively high bias. This gives an additional decrease in the probability of collusion.
Lemma 3.3. Let \( \lambda \in \left( \frac{A + K}{2A}, 1 \right) \). Then, the subgame between the industry and the antitrust authority has a unique (semi-separating) equilibrium in which the low type colludes with probability

\[
\beta(\theta_i; \lambda) = \frac{(\theta_h - \theta_l)Q(\theta_l)}{A}
\]

and the high type acts non-cooperatively. The antitrust authority investigates \( p = \theta_h \) with probability

\[
\gamma(\theta_h; \lambda) = \frac{K - \alpha K}{2\alpha \lambda A - \alpha A - \alpha K}
\]

and \( \gamma(p; \lambda) = 1 \) for \( p \neq \{\theta_l, \theta_h\} \). Expected social welfare becomes

\[
W_3 = \alpha (1 - \gamma(\theta_h; \lambda))V(\theta_l, \theta_l) + \alpha \gamma(\theta_h; \lambda)V(\theta_h, \theta_l) + (1 - \alpha)V(\theta_h, \theta_h) - \beta(\theta_l; \lambda)(1 - \alpha + \alpha \gamma(\theta_h; \lambda))K.
\]

Proof. As in the subgame with an intermediate bias, the high type will not form a cartel. Suppose the low type forms a cartel with certainty in equilibrium. Then, given the high bias, it will be optimal for the antitrust authority to investigate \( p = \theta_h \) with certainty. As a result, this subgame will not feature an equilibrium in which the low type always colludes. Suppose the low type never colludes in equilibrium. Then, the antitrust authority interprets \( p = \theta_h \) as a signal that costs are high and will not investigate. But then it is optimal for the low type to collude! Hence, the equilibrium in this subgame must be in mixed strategies. The low type is indifferent between collusion and competition if and only if

\[
(\theta_h - \theta_l)Q(\theta_h) - \beta(\theta_l; \lambda)A = 0.
\]

The antitrust authority is indifferent between investigating upon observing \( p = \theta_h \) if and only if

\[
\frac{\alpha \gamma(\theta_h; \lambda)}{1 - \alpha + \alpha \gamma(\theta_h; \lambda)}(A\lambda - (1 - \lambda)A) - K = 0.
\]

Solving these equations gives the equilibrium probabilities \( \beta \) and \( \gamma \).

Using the above insights, it is straightforward to show that

Proposition 3.1. The government delegates enforcement to an antitrust authority with
an objective function that is biased toward consumer welfare. For \( \alpha \leq \alpha^* \) the game has a separating equilibrium, where

\[
\alpha^* = \frac{K \int_{\theta_l}^{\theta_h} Q(t) dt + (A - K)Q(\theta_h)(\theta_h - \theta_l)}{A \int_{\theta_l}^{\theta_h} Q(t) dt} \in (0, 1).
\]

In this case, the optimal bias is any \( \lambda \) in \((A + K/A, 1)\). For \( \alpha > \alpha^* \) the equilibrium has a semi-separating equilibrium in which the low-cost type pools with some probability with the high-cost type and the optimal bias \( \lambda \) is 1.

**Proof.** The government is the first to move in the game and will select the value of \( \lambda \) that maximizes expected social welfare. It is straightforward to show that \( W_1 \), the expected level of social welfare as found in lemma 3.1, is strictly dominated by \( W_2 \). Substituting the equilibrium values of \( \gamma(\theta_h; \lambda) \) and \( \beta(\theta_l; \lambda) \) for the subgame with \( \lambda \in (\frac{A + K}{2A}, 1) \) into \( W_3 \), one can show that \( W_3 \) is strictly increasing and concave in \( \lambda \). Furthermore,

\[
W_2 - W_3|_{\lambda=\frac{A+K}{2A}} = \frac{KQ(\theta_h)(\theta_h - \theta_l) + A(1 - \alpha)Q(\theta_h)(\theta_h - \theta_l)}{A - K}.
\]

Hence, social welfare strictly decreases as \( \lambda \) moves from the second interval to the third interval. The government’s choice is therefore between \( W_2 \) and \( W_3 \) for \( \lambda = 1 \). The difference between these levels is

\[
\frac{(K - \alpha A) \int_{\theta_l}^{\theta_h} Q(t) dt + (A - K)Q(\theta_h)(\theta_h - \theta_l)}{A - K}
\]

and this is positive if \( \alpha < \alpha^* \).

### 3.3.3 Discussion of the equilibrium

Figure 3.2 depicts social welfare as a function of \( \lambda \).

Social welfare is non-monotonic in \( \lambda \). A relatively low bias does not deter collusion because the antitrust authority has no incentive to investigate. Increasing the bias induces the high type to act non-cooperatively and the low type to collude by mimicking the high type. This yields a strict increase in social welfare as both firms lower their price, and the antitrust authority does not investigate. By increasing the bias even further, the third scenario is entered in which the low-cost type and the antitrust authority randomize their actions. Although this initially reduces social welfare, social welfare is strictly increasing in \( \lambda \) in this interval. It may even be op-
Antitrust enforcement without commitment

Figure 3.2. Social welfare with a biased antitrust authority.

It is optimal to delegate enforcement to an antitrust authority who maximizes consumer welfare if the ex ante probability that firms have low costs if sufficiently high.

Observe that, even if $\lambda$ is chosen optimally, collusion cannot be perfectly deterred. In each of the three cases, the firms collude to some extent. The lowest ‘degree of collusion’ can be found in the third case, in which only the low type colludes with some probability. This probability is still positive for $\lambda = 1$.

The degree of collusion decreases in $K$ and $\lambda$. Hence, a more efficient antitrust authority obtains a higher level of social welfare. In principle, collusion could be perfectly deterred by letting $\lambda \to \infty$. This requires the antitrust authority to minimize the industry’s profits, and seems politically infeasible. A better way to reduce the incidence of collusion is to increase the maximum fine $A$. In the limit, as $A \to \infty$, this perfectly deters collusion as well.

In equilibrium, the government chooses a positive bias to overcome the commitment problem. This may explain why actual antitrust authorities maximize consumer welfare, instead of social welfare. However, this result should not be interpreted as a policy prescription. Although the optimal bias is positive, it is easy to find alternative parameter configurations for which this result fails. For instance, if $\pi^m(\theta) > A$, it is optimal to select $\lambda = 1/2$, because otherwise the antitrust authority engages in ineffective and costly investigations. The optimal bias depends on institutional variables ($A, K$) and industry characteristics ($\alpha, \pi$), and a one-size-
fits-all solution seems therefore unavailable. A more fundamental reason is that the normative policy prescription from the economic analysis of law enforcement still applies. Fines should be set such inefficient harmful acts are deterred. Antitrust authorities should commit to this principle by, e.g., building a reputation of tough law enforcers.

The idea of appointing an agent with biased preferences to solve the commitment problem is borrowed from the central banking literature. It is striking to observe that our model recommends to choose an agent with what one could describe as ‘left-wing’ preferences, whereas the central banking literature advises to hire an agent with ‘right-wing’ preferences.

3.4 Extensions

3.4.1 Building a reputation

It may be difficult in practice to determine the optimal bias. If so, the inability to commit (to the optimal antitrust policy) implies that each industry type engages in unconstrained collusion. As noted above, the antitrust authority may preclude this by building a reputation. However, the notion of reputation is rather vague. The aim of this section is to clarify how antitrust authorities may build and maintain a reputation of a vigilant cartel fighter.

In common parlance, an agent is usually said to have a reputation if he or she is able to forgo short-run gains to secure high long-run gains. In game-theoretical parlance, there may be two types of reputation; the ‘equilibrium’ interpretation and the ‘adverse selection’ interpretation (Samuelson, 2006). In the former approach, one considers an infinitely repeated game, and selects a particular equilibrium that has the desired ‘reputation-like’ features. In the latter approach, the agent is privately informed about its type and may mimic the behavior of a strong type if he or she is weak.

3.4.2 Equilibrium reputation

As an example of reputation under the ‘equilibrium’ interpretation, consider an infinitely repeated game version of the model. Suppose that the antitrust authority and the firms have a common discount factor \( \delta \in (0, 1) \) and maintain the assumption that \( \pi^m(\theta) \leq A \). The proposed equilibrium features ‘reputation’, in the sense that the antitrust authority investigates any price \( p \neq \theta_i \) and firms do not collu-
de. This equilibrium could be supported by the antitrust authority’s belief that, if it deviates, both cost types collude ‘forever’. The equilibrium exists if the value of investigating conditional on observing $p = \theta_h$ is larger than the value of not investigating. The value of maintaining an equilibrium is

$$-K + \frac{\delta}{1-\delta} \left[ \alpha V(\theta_l, \theta_l) + (1-\alpha)(V(\theta_h, \theta_h) - K) \right].$$

If the antitrust authority refrains from investigating $p = \theta_h$, its value is

$$E \left[ \frac{\delta}{1-\delta} V(p^m(\theta), \theta) \right].$$

It is straightforward to show that the proposed equilibrium exists if and only if

$$\delta \geq \frac{K}{E[V(\theta, \theta) - V(p^m(\theta), \theta)]}.$$ 

So, if the antitrust authority is sufficiently patient, it may maintain a reputation. The proposed equilibrium has reputation-like features, as the antitrust authority loses its reputation when it fails to investigate.

### 3.4.3 Adverse selection reputation

The model can also be adjusted to allow for ‘adverse selection’ reputation. More specifically, assume the model of section 3.2 is repeated twice and players do not discount the future. For simplicity, suppose that the antitrust authority is unbiased, i.e. $\lambda = 1/2$. Firms are incompletely informed about the antitrust authority’s type. The antitrust authority may be strong, and have zero investigation costs, or be weak, and have a positive cost of investigation $K$. Suppose that the firms ex ante belief is that both possibilities are equally likely. In this setting, there may be a pooling equilibrium in which both antitrust authorities (i.e. the strong and the weak type) investigate in the first period and firms act non-cooperatively in both periods.

To see this, note first that a strong antitrust authority has a (weakly) dominant strategy to investigate each price. A weak antitrust authority investigates a price $\theta$ if and only if

$$2E[V(\theta, \theta)] - K \geq E[V(\theta, \theta) + V(p^m(\theta), \theta)],$$
or if

\[ K \leq E[V(\theta, \theta) - V(p^m(\theta), \theta)]. \]

If a weak antitrust authority deviates from the proposed equilibrium, the firms (correctly) believe that the antitrust authority is weak and collude in the second period. Additionally, firms should not find it optimal to collude in the first period. This holds if \( \pi^m(\theta) - \frac{1}{2} A \leq 0. \)

In the proposed pooling equilibrium, a weak antitrust authority builds a reputation by mimicking a strong antitrust authority.

### 3.4.4 Antitrust enforcement and cartel stability

So far, the matter of internal cartel stability is ignored. A cartel agreement is internally stable if no cartel member is tempted to deviate from it. In the one-shot model of section 3.2, an agreement to set a price above marginal costs is unstable. Given that all other firms adhere to the collusive price, a firm could dramatically boost its profit by slightly undercutting this price. Each firm understands this temptation and the market price is driven down to marginal costs. The aim of this section is to include the restriction that cartel agreements should be stable.

To enable the firms to enter into stable agreements, adjust the model in the following way. The game is infinitely repeated and firms discount payoffs with common discount factor \( \delta \in (0, 1) \). Marginal costs are distributed independently across periods.\(^{10}\) Firms observe only their current marginal costs. As is well-known, repeated games typically admit multiple equilibria, or an ‘embarrassment of riches’. One such equilibrium is encountered in section 3.4.1 of the repeated game in which the antitrust authority maintains a reputation. To select a subgame perfect equilibrium, assume that the firms coordinate on the profit-maximizing agreement and the antitrust authority myopically maximizes its objective function.

Before the equilibrium of the adjusted model is derived, note first that defection by a cartel member informs the antitrust authority that a cartel exists. If consumers can observe that a firm undercuts the current market price, then so can the antitrust authority.

Just as in section 3.3.2, the model is solved by considering the equilibria of the

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\(^{10}\) This assumption is clearly restrictive. However, if marginal costs evolve deterministically, plus some additive random term, then the independence assumption can be reinterpreted by viewing the firms’ private information as knowledge of the random term.
subgames for given values of $\lambda$. For

$$
\lambda \in \left[0, \frac{A + K}{2A}\right],
$$

the antitrust authority never investigates and the remaining constraint to consider is the firms’ incentive compatibility condition. This is

$$
\frac{1}{n} \pi^m(\theta_k) + \frac{1}{n} \frac{\delta}{1 - \delta} E[\pi^m(\theta)] \geq \pi^m(\theta_k)
$$

for $k = l, h$. This can be rewritten as

$$
\delta \geq \frac{(n - 1) \pi^m(\theta_k)}{E[\pi^m(\theta)] + (n - 1) \pi^m(\theta_k)}. \quad (3.4)
$$

Collusion is hardest to sustain for $\theta = \theta_l$. Condition (3.4) can therefore be ignored if the firms have high marginal costs.

If

$$
\lambda \in \left(\frac{A + K}{2A}, \frac{A + K/\alpha}{2A}\right),
$$

both types set $p = \theta_h$ in the one-shot game. This also holds in the repeated game, because the antitrust authority plays the optimal one-shot Nash response. The incentive compatibility condition is

$$
\frac{1}{n} Q(\theta_h)(\theta_h - \theta_l) + \frac{\alpha}{n} \frac{\delta}{1 - \delta} Q(\theta_h)(\theta_h - \theta_l) \geq Q(\theta_h)(\theta_h - \theta_l) - \frac{A}{n}.
$$

Observe that, if a firm defects, the antitrust authority learns that a cartel exists and imposes a fine $A$ on the industry, which is equally borne by all firms. The incentive constraint can be rewritten as

$$
\delta \geq \frac{(n - 1) Q(\theta_h)(\theta_h - \theta_l) - A}{(n - 1 + \alpha) Q(\theta_h)(\theta_h - \theta_l) - A} \equiv \bar{\delta}. \quad (3.5)
$$

Interestingly, a higher maximum fine may have perverse effects on the firms’ ability to collude.

**Proposition 3.2.** An increase of the maximum fine $A$ fosters collusion if

$$
\lambda \in \left(\frac{A + K}{2A}, \frac{A + K/\alpha}{2A}\right).
$$
Proof. The result simply follows by observing that the critical discount factor $\bar{\delta}$ decreases in $A$. ■

Antitrust policy helps firms to form a cartel because defection is immediately punished by the antitrust authority. As soon as a firm deviates from the cartel agreement, the rational antitrust authority learns that a cartel exists, launches a successful investigation and imposes a fine on all firms, including the defector. This strategic response of the antitrust authority makes defection less attractive, and thereby collusion more stable. Various authors (e.g. Motta and Polo, 2003) have observed similar pro-collusive effects of well-intended antitrust legislation.

Finally, suppose the antitrust authority’s bias is

$$\lambda \in \left( \frac{A + K/\alpha}{2A}, 1 \right).$$

Then, as argued above, the equilibrium of the one-shot game is in mixed strategies. Each firm expects zero profits under the collusive agreement. If the firms have decided to collude and charge $\theta_h$, a firm that contemplates to deviate adheres to the collusive price if and only if

$$\frac{1}{n} ((\theta_h - \theta_l)Q(\theta_h) - \beta A) \geq (\theta_h - \theta_l)Q(\theta_h) - \frac{A}{n}.$$

Given the zero-profit constraint, this incentive compatibility condition boils down to $A \geq Q(\theta_h)(\theta_h - \theta_l)$ which is always satisfied. The analogue of proposition 3.1 is

**Proposition 3.3.** In equilibrium of the modified (repeated-game) model, the government delegates enforcement to an antitrust authority with an objective function that is biased toward consumer welfare. The optimal bias $\lambda$ is 1 if $\alpha > \alpha^*$ and $\delta \geq \bar{\delta}$ hold simultaneously. Otherwise, the optimal bias is any $\lambda$ in $\left( \frac{A + K}{2A}, \frac{A + K/\alpha}{2A} \right]$. Expected social welfare per period attains its maximum $E[V(\theta, \theta)]$ if $\delta < \bar{\delta}$.

Proof. First, suppose that $\delta \geq \bar{\delta}$. Then, a collusive agreement under which the low type mimics the non-cooperative high type can be sustained. Since the implicit assumption of the basic model is that cartels are always stable, proposition 3.1 can be applied directly to find the optimal bias. Second, suppose $\delta < \bar{\delta}$. A collusive agreement in pure strategies is no longer feasible. Given that $\lambda \in \left( \frac{A + K}{2A}, \frac{A + K/\alpha}{2A} \right]$, the firms cannot collude when their costs are low. To see this, suppose that a low type colludes with some probability $\gamma$. Then, the critical discount factor $\bar{\delta}$ increases in $\gamma$. As a result, firms always behave non-cooperatively. Social welfare in this case is $E[V(\theta, \theta)]$ per period, and this cannot be improved. ■
Perhaps the most interesting implication of proposition 3.3 is that an antitrust authority’s bias should be relatively low when firms are unable to profitably collude. By keeping the bias low, the government induces non-cooperative market conduct. It must be emphasized that this result hinges on the assumption that the firms are sufficiently impatient. When, as seems more realistic, firms are sufficiently patient, it may be optimal to increase the antitrust authority’s bias, as the next section illustrates.

3.4.5 Leniency programs

Following the success of the U.S. Antitrust Division’s Corporate Leniency Program, many national antitrust authorities have adopted similar policies, by granting partial or full fine reduction to firms that voluntarily report their cartel. A few recent papers examine the effects of leniency on cartel stability, see for instance Spagnolo (2004) or Aubert, Rey and Kovacic (2006). The general finding that emerges from this literature is that leniency programs help to deter collusion. However, these models typically assume that the antitrust authority does not act strategically, by supposing that the antitrust authority commits to a fixed probability of detection. The premise of the current chapter is that antitrust authorities act strategically and without commitment. It would be very interesting to consider the desirability of a leniency policy in such an environment, and that is exactly the aim of this section.

As above, suppose that the basic game of section 3.2 is infinitely repeated. The government endows the antitrust authority with some bias $\lambda$ and imposes a leniency program. This program gives full immunity to prosecution for any firm that reports a cartel. When a firm informs the antitrust authority of the existence of a cartel, the antitrust authority still needs to investigate this case at some cost. It seems reasonable to suppose that the cost of investigation is lower when one cartel member cooperates. To uncover the pure effect of the leniency program on the incentive to collude, however, it is helpful to make a conservative estimate of the investigation cost. In particular, let this cost be $K$, irrespective of whether a firm collaborates with the authorities.

To see how these assumptions affect the equilibrium, observe that a leniency program has no effect when $\lambda \in \left[0, \frac{A+K}{2A}\right]$, as in that case the antitrust authority does not investigate the industry and a leniency program has no ‘bite’. For $\lambda \in \left(\frac{A+K}{2A}, \frac{A+K/\alpha}{2A}\right]$, a leniency program has a destabilizing effect on cartels. This follows directly from proposition 3.2, which establishes that an increase in the maximum fine lowers the critical discount factor. Granting leniency to a firm that si-
multaneously cheats on the cartel agreement and reports the cartel to the antitrust authority increases the critical discount factor to
\[
\bar{\delta}_{LP} = \frac{(n-1)Q(\theta_h)(\theta_h - \theta_l)}{(n-1+a)Q(\theta_h)(\theta_h - \theta_l)}.
\]

For \(\lambda \in \left(\frac{A+K/A}{2A}, 1\right]\), the effect of a leniency program is even stronger. By simultaneously deviating and reporting, a defector earns \(Q(\theta_h)(\theta_h - \theta_l)\). The value of adhering to the cartel agreement is zero, given the use of mixed strategies. Hence, the cartel’s incentive compatibility condition is \((\theta_h - \theta_l)Q(\theta_h) \leq 0\), which cannot be satisfied.

The observations imply the following result.

**Proposition 3.4.** A consumer welfare standard, combined with a leniency program, is sufficient to induce the non-cooperative equilibrium.

By choosing a consumer welfare standard, i.e., setting \(\lambda = 1\), a collusive industry is restricted to use mixed strategies. The leniency program ensures that this strategy is unstable. So, the antitrust authority’s bias and the leniency program are complementary. If the government chooses to use just one instrument, it would have to tolerate some degree of collusion. Proposition 3.4 rationalizes, or at least sheds more light on actual antitrust enforcement policy.

### 3.5 Concluding remarks

There is no reason to suppose that antitrust authorities have the ability to commit to an antitrust enforcement policy. Even in relatively simple models, optimal enforcement requires a commitment to a set of intricate and industry-specific probabilities of investigation and fine functions. It seems more realistic to suppose that antitrust authorities try to deter collusion on a case-by-case basis. Responding to suspicious pricing behavior, and imposing fines that are optimal ex post, the antitrust authority effectively operates without commitment.

Given that fines are perceived as welfare-neutral transfers, an antitrust authority that cannot commit would refrain from setting a fine, enabling firms to engage in unconstrained collusion. To prevent this from occurring, the government, or a social planner, can appoint an agent with preferences biased toward consumers to head the antitrust authority. This agent does not perceive fines as mere transfers and therefore does not shy away from imposing the maximum fine on firms that
have been found guilty of price-fixing.

Welfare is shown to be non-monotonic in the agent’s bias. Nevertheless, the optimal bias is always positive: the government hires an agent whose preferences are biased toward consumer welfare. This finding may explain why some antitrust authorities seem to maximize consumer welfare, instead of social welfare. A practical constraint of the delegation solution is that it may be difficult to select the optimal bias, especially when the optimal bias lies somewhere in the mysterious realm between the social welfare standard and the consumer welfare standard.

An alternative interpretation of a preference bias is that the government gives the antitrust authority an explicit incentive contract. This contract may stipulate higher wages if the observed degree of collusion is low, or the revenue from fines is high.

Even if the antitrust authority is run by an agent with an optimal bias, firms are still able to collude. This is not caused by the antitrust authority’s inability to commit however. Institutional constraints, such as a limit on the maximum fine, prevent the antitrust authority to fully deter price-fixing. By explicitly modeling the cartel members’ incentive to adhere to the collusive agreement, it can be shown that leniency programs, combined with a consumer welfare standard, induce the non-cooperative equilibrium. This suggests that leniency programs are most successful when the antitrust authority actively investigates potentially colluding industries.

For future research, it would be interesting to relax a few technical assumptions. More specifically, the firms in this chapter have common marginal costs, their private information is binary and that marginal costs are independently distributed across periods. Much realism can be gained by allowing for a continuum of marginal costs or by considering persistent marginal costs.