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Lower Sanctions, Greater Antitrust Compliance? Cartel Conduct with Imperfect Information about Enforcement Risk

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This article provides a model of two risk-neutral firms that may cooperate to achieve a goal that is potentially illegal. The model assumes enforcement risk and firms that are imperfectly informed about antitrust law enforcement. It is shown that compliance training, which educates the agents about law enforcement, may prevent hardcore cartels. Compliance training programs may also promote forms of cooperation that are beneficial for customers. The article shows that a competition authority can sometimes spur the implementation of compliance programs by imposing lower sanctions on wrongdoers.

(*JEL* K21, K42, L41)

Introduction

When firms consider whether or not to agree to cooperation that may have antitrust law implications, they sometimes make poor economic decisions that create the worst of both worlds. Illegal hardcore cartels that fail to raise prices considerably (Connor 2014) are one example of this. They harm customers by charging prices that are too high, and they harm firms by generating excess profits that are too low to cover the value of antitrust fines, damages, and litigation expenses. ThyssenKrupp, the German steel and industrial technologies group, had to face the consequences of

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such poor decision making. In March 2014, it decided to discontinue its railway equipment division, which had been fined for participating in the German rail cartel.[1] The antitrust fines levied had undermined the division's profitability and had become a significant financial burden on the entire group. Equally poor economic decisions are made every time firms refrain from engaging in legal, profitable cooperation agreements of a horizontal or vertical kind (Cooper and Ross 2009) that would in fact generate efficiency gains for customers. Although efficiency-enhancing cooperation agreements that have been shelved are less well documented than hardcore cartels, they are no less harmful: Customers forego efficiency gains, and firms lose profits. Two potential culprits in these poor economic decisions are enforcement risk and imperfect information.

This article presents a formal model to analyze firms' decisions when they seek to cooperate under a given antitrust law regime. The model explicitly incorporates enforcement risk and imperfect information, and it factors in how firms acquire information about antitrust law enforcement when they implement relevant training programs. It is shown that in some cases lower sanctions imposed on anticompetitive conduct can actually raise firms' incentives to implement antitrust law compliance programs. The article explores under what conditions this is the case and explains why this result is counterintuitive only at first sight. The article thus relates to the literature on enforcement risk, imperfect information and information acquisition, as well as antitrust law compliance programs.

Enforcement risk creates situations in which some legal cooperation agreements between firms are mistakenly sanctioned whereas some illegal ones are mistakenly acquitted. Both the nature and the effects of enforcement risk have been extensively discussed by Calfee and Craswell (1984), Pistor and Xu (2003), Heyer (2005), Schinkel and Tuinstra (2006), Dari-Mattiacci and Deffains (2007), Polinsky and Shavell (2007), and Katsoulacos and Ulph (2013, 2014). By assuming

1 ThyssenKrupp (2014). “Materials Services stops disposal process for Railway/Construction activities.” Press Release, March 11, 2014. http://goo.gl/96B3Mf (accessed on November 6, 2014)

enforcement risk, the model presented in this article is embedded in a similar setting as models of the optimal burden of proof (Kaplow 2011a, 2011b, 2012). The present model complements this strand of research by focusing on the optimal actions of firms (i.e., acquiring information) rather than on those of competition authorities (i.e., choosing an effort level or burden of proof).

In the context of inter-firm cooperation, enforcement risk takes a variety of forms. One of them is cartel offenders' ability to take advantage of settlement procedures or leniency programs. This makes it difficult for firms to predict the exact value of fines they might have to pay if their cooperation were considered illegal. Another one is that additional damage claims on cartel offenders are merely possible rather than certain, which precludes firms from anticipating the exact value of damages. A third form of enforcement risk is found in the fact that some cartel offenders may not be prosecuted at all because statutory limitations apply. This happened in the case of BASF, the German chemicals group, which was ultimately not fined for its participation in the heat stabilizers cartel because the limitation period had expired (European Commission 2011). Yet another form of enforcement risk results from possible disagreements over whether a given cooperation agreement's efficiency gains truly outweigh its anticompetitive effects. This is particularly relevant when efficiency effects are considered under a rule of reason approach or when certain types of conduct have not yet been subject to decisions of a competition authority or the courts.

Whether in these or in other forms, enforcement risk not only reduces the deterrence effect of sanctions on potential cartel offenders. It also imposes a burden on those firms whose cooperation would actually generate efficiency gains. These firms may well refrain from cooperating, fearing possible sanctions or substantial costs associated with demonstrating efficiency gains. For these reasons, many competition authorities are currently making efforts to lower enforcement risk. Reducing enforcement risk alone, however, may not eliminate all poor economic decisions made by

firms. Instead, decision errors may persist to the extent that firms have imperfect information about enforcement risk and thus do not believe that it has been eliminated altogether (Sah 1991, Bebchuk and Kaplow 1992).

Imperfect information may be caused by managerial ignorance and hubris. For example, 49% of those German firms that have implemented an antitrust law compliance program believe that their purchasing or sales staff have only poor or mediocre knowledge of antitrust law (Bussmann et al. 2013). At the same time, top executives who engage in cartels typically tend to "view themselves as too smart to be caught" (Murphy and Kolasky 2012:63). Even in the absence of enforcement risk, such effects may still cause firms to enter into cartels that harm both their customers and themselves. Conversely, managerial dithering – perhaps characterized by over-cautious decision makers who mistakenly believe that a proposed cooperation agreement will be investigated or even prohibited despite its efficiency effects (Harrington 2014) – may cause firms to refrain from legal, beneficial forms of cooperation, again harming both customers and themselves. Such chilling effects on desirable behavior have been researched by Kaplow (2011a), for example, and they may be particularly relevant for multinational cooperation agreements where legal standards differ between countries. A related model, in which firms have private information about the probability of conviction, has been proposed by Harrington (2013) to analyze corporate leniency programs.

The model presented in this article assumes that a firm can acquire information about enforcement risk. Its information acquisition eliminates the additional errors that result from imperfect information and thus complements competition authorities' efforts to reduce enforcement risk. Information acquisition has also been researched by Kaplow (1995). In his model, an agent is uncertain about the true level of harmfulness of her conduct. Whereas his model focuses on a single agent and does not discuss the effects created by agents' strategic interaction (i.e., their need for cooperation), the present model specifically analyzes such group decisions (Zeckhauser 2014).

Information acquisition is an important element of antitrust compliance programs (see Wils 2013 for an overview), which often seek to educate managers about antitrust law (OFT 2011, Geradin 2013). In Germany, Austria, and Switzerland, for example, about 97% of such programs provide firms' employees with information about antitrust law (in the form of brochures, etc.), and 93% of them feature formal compliance training (Goetz et al. 2014). For this reason, the terms *compliance program* and *compliance training* are used interchangeably in this article.

The present article makes three contributions. First, it provides a formal-analytic model (see also Beckenstein and Gabel 1986) that is consistent with and complements the literature on antitrust law compliance programs. This may be an important methodological contribution because most of this literature has so far been qualitative or empirical (see Beckenstein and Gabel 1982, Sokol 2012, Abrantes-Metz and Sokol 2013, and the cartel project of Melbourne Law School[2]). Second, and as a central contribution, this article describes an effect that, to the best of my knowledge, has not been identified before: Competition authorities can sometimes raise firms' incentives to engage in compliance training by lowering the overall level of the sanction imposed on cartel offenders. This helps to avoid the decision errors described above. Third, the analytic model presented here provides a basis for additional, data-driven work. More specifically, the model is numerically calibrated to assess how strongly lower sanctions may affect firms' incentives to engage in compliance training.

The article proceeds as follows. Section 1 presents the model and discusses the effects of enforcement risk and imperfect information. Section 2 discusses firms' private incentives to acquire information about enforcement risk. Section 3 then shows that firms' private incentives to acquire information can sometimes be raised by lowering the sanction that is imposed on offenders. Section 4 analyzes the probability and the order of magnitude of this effect. Section 5 concludes. An example of the model with specific functional forms is provided in the appendix.

2 http://www.law.unimelb.edu.au/cartel, accessed on October 15, 2014

1 The Model Without Information Acquisition

Subsection 1.1 presents the general setup of the model. Subsections 1.2 to 1.4 discuss the nature of cooperation opportunities, enforcement risk, and imperfect information in more detail. The equilibria of the game are presented in 1.5.

1.1 The Game

This article models a static game with two risk-neutral, symmetric firms $i \in \{1,2\}$ that have an action set $A_i=\{a_c,a_{nc}\}$. The objective is to analyze firms' individual decisions on whether to cooperate (a_c) or not (a_{nc}) in situations with enforcement risk and/or imperfect information. If both firms decide on the cooperative strategy a_c, each firm receives a positive payoff, i.e., it earns additional profits over not cooperating. This cooperation agreement may subsequently be investigated and sanctioned by a competition authority. If at least one firm decides to compete, both firms receive a payoff of zero. The profitability of cooperation depends on the probability that a cooperation agreement will be investigated and possibly sanctioned by a competition authority (enforcement risk). The firms are assumed to have imperfect information about the value of this probability, which means that they can assess the profitability of cooperation only imperfectly. Each firm has complete information about the type of the other firm (i.e., that firm's profitability assessment).

Unlike prior literature on collusion, which usually assumes repeated games, the present model assumes a static game. This assumption is made primarily to keep the model lean and focused on identifying potentially new effects of enforcement risk and imperfect information on firms' incentives to establish a collusive agreement. In particular, it eliminates any effects related to the sustainability of cooperation, which have already been addressed in the literature (see below). To ensure consistency with this literature on the sustainability of collusion and with the analysis of dynamic games, several additional assumptions are made.

The present model assumes that the discount factor of the firms is sufficiently high to prevent

deviations from a cooperation agreement. To see the relevance of this assumption, consider that a collusive agreement can only be stabilized when firms' incentive to deviate from it is mitigated by the threat of future punishments (e.g., Friedman 1971, Abreu 1986). Only if firms use a high enough discount factor do they value the future punishment sufficiently highly to adhere to the agreement.

It has also been shown in prior literature (e.g., Rotemberg and Saloner 1986, Haltiwanger and Harrington 1991) that the stability of collusive agreements varies over time when firms' payoffs change across periods. In line with other literature (e.g., Aubert et al. 2006), the present model thus assumes both that the payoffs and other parameters of the model do not change over time and that current payoffs are not contingent on past behavior. In particular, evidence of cooperation is assumed to last for one period. This "simplifies the analysis, since only current behavior can be 'punished' by the antitrust authority" (Aubert et al. 2006:1246).

1.2 Cooperation Opportunities

The assumptions on the different types of cooperation opportunities are summarized in columns (1)-(4) of Table 1. Columns (5)-(8) are explained in Section 1.4 below. At the beginning of the period, two types of cooperation opportunities emerge exogenously. Cooperation can be harmful or beneficial (indicated by H or B) for a third party, e.g., customers. If the firms cooperate, each earns a gross gain g_H (or g_B, depending on the type of cooperation). The different types of cooperation are not mutually exclusive, i.e., cooperation opportunities of type H and of type B emerge at the same time.

A cooperation agreement of type H is unprofitable (denoted as type $\underline{H}$) if the gross gain g_H is weakly lower than the expected costs of cooperating g_H^*, i.e., $g_H \leq g_H^*$. As shown in Subsection 1.3, the costs g_H^* are determined endogenously (e.g., by the sanction that is imposed on a firm by the competition authority). A harmful cooperation agreement is profitable (denoted as type $\overline{H}$) when inequality $g_H > g_H^*$ applies. Two indicator functions, $\Theta_H(g_H^*)$ and $\Theta_B(g_B^*)$, take a value of 1 if

cooperation is unprofitable and a value of zero otherwise.

$$\Theta_H(g_H^*)=\begin{cases}1 & \text{if } g_H \le g_H^* \\ 0 & \text{otherwise}\end{cases} \quad (1)$$

$$\Theta_B(g_B^*)=\begin{cases}1 & \text{if } g_B \le g_B^* \\ 0 & \text{otherwise}\end{cases} \quad (2)$$

(1) true type	(2) Profitable for the firms?	(3) Effect on consumers?	(4) indicator function	(5) info I_i about type	(6) prob	(7) info J_i of both firms	(8) prob
$\underline{H}$	no $g_H \le g_H^*$	harmful	$\Theta_H(g_H^*)=1$	$\underline{h}$	$\Phi_A(e_{A,i}^*)$	$(\underline{h},\underline{h})$	$1-(1-\Phi_A(e_{A,i}^*))^2$
						$(\underline{h},\overline{h})$, $(\overline{h},\underline{h})$	
				$\overline{h}$	$1-\Phi_A(e_{A,i}^*)$	$(\overline{h},\overline{h})$	$(1-\Phi_A(e_{A,i}^*))^2$
$\overline{H}$	yes $g_H > g_H^*$	harmful	$\Theta_H(g_H^*)=0$	$\underline{h}$	$\Phi_A(e_{A,i}^*)$	$(\underline{h},\underline{h})$	$1-(1-\Phi_A(e_{A,i}^*))^2$
						$(\underline{h},\overline{h})$, $(\overline{h},\underline{h})$	
				$\overline{h}$	$1-\Phi_A(e_{A,i}^*)$	$(\overline{h},\overline{h})$	$(1-\Phi_A(e_{A,i}^*))^2$
$\underline{B}$	no $g_B \le g_B^*$	beneficial	$\Theta_B(g_B^*)=1$	$\underline{b}$	$1-\Phi_C(e_{C,i}^*)$	$(\underline{b},\underline{b})$	$1-\Phi_C(e_{C,i}^*)^2$
						$(\underline{b},\overline{b})$, $(\overline{b},\underline{b})$	
				$\overline{b}$	$\Phi_C(e_{C,i}^*)$	$(\overline{b},\overline{b})$	$\Phi_C(e_{C,i}^*)^2$
$\overline{B}$	yes $g_B > g_B^*$	beneficial	$\Theta_B(g_B^*)=0$	$\underline{b}$	$1-\Phi_C(e_{C,i}^*)$	$(\underline{b},\underline{b})$	$1-\Phi_C(e_{C,i}^*)^2$
						$(\underline{b},\overline{b})$, $(\overline{b},\underline{b})$	
				$\overline{b}$	$\Phi_C(e_{C,i}^*)$	$(\overline{b},\overline{b})$	$\Phi_C(e_{C,i}^*)^2$

Table 1: Classification of cooperation

1.3 Profitability of Cooperation: Enforcement Risk

To determine functional forms of the thresholds g_H^* and g_B^*, assume for the moment that both firms have already decided to cooperate and have earned the gross gain g_H or g_B. After earning this gross gain, a cooperation agreement may be investigated by a competition authority with probability ρ_H or ρ_B. The size of this detection probability depends on the type of the cooperation agreement (H or B).

An investigation provides the competition authority with information about the type (H or B) and the profitability (g_H or g_B) of the cooperation agreement. The competition authority is assumed to pursue a consumer surplus standard such that a sanction f_H shall be imposed on every firm that cooperates to the detriment of customers. The sanction may be thought of as the sum of the fines imposed by the competition authority (public enforcement) plus payments for damages (private

enforcement). Cooperation agreements of the beneficial type *B* shall not be sanctioned.

An investigation inflicts a litigation cost l_H or l_B on each firm. The litigation cost parameters l_H and l_B capture the firms' costs of handling the case. These include monetary litigation costs as well as the time and attention that managers and in-house counsel devote to the case (Bussmann et al. 2013). The litigation costs l_H or l_B are incurred by the firms even if no sanction is subsequently imposed on them. Assuming litigation costs does not change the qualitative conclusions inferred from the model. It does, however, facilitate the numerical calibration of the model to situations in the real world (see Section 4).

Enforcement is subject to risk resulting from, e.g., the existence of limitation periods, incomplete legal provisions, or discretion when setting the fine. Therefore, let ε_A be the probability of mistaken acquittal. In this case, a cooperation agreement of type *H* is not sanctioned (type II error, false negative), i.e., the competition authority had a *weak case* (Harrington 2013:15). The variable ε_C denotes the probability of mistaken conviction, i.e., a sanction $f_B>0$ is mistakenly imposed on firms whose cooperation is of type *B* (type I error, false positive). Given these parameters, the expected costs (g_H*, g_B*) of cooperating are defined by (3) and (4).

$$g_H^* = \rho_H l_H - \rho_H (1-\epsilon_A) f_H \tag{3}$$

$$g_B^* = \rho_B l_B - \rho_B \epsilon_C f_B \tag{4}$$

Note that the present model assumes enforcement risk in the conviction probability. In modeling terms, this is equivalent to discretion in determining the value of the sanction f_H or f_B. In practice, enforcement risk might also concern the detection probabilities ρ_H or ρ_B (as was assumed in earlier versions of the model). However, making such an assumption would merely complicate the model in mathematical terms without yielding additional qualitative insights.

1.4 Profitability of Cooperation: Imperfect Information

The firms are not able to assess the exact values of g_H* and g_B* because they have imperfect

information about the true size of the error probabilities ε_A and ε_C. Let $e_{A,i}$ and $e_{C,i}$ denote the expectations of firm i's managers regarding the true error probabilities of a false acquittal (ε_A) or a false conviction (ε_C). For every cooperation opportunity and every firm, the parameters $e_{A,i}$ and $e_{C,i}$ are drawn from the cumulative distribution functions $\Phi_A(e_{A,i})$ and $\Phi_C(e_{C,i})$ with $e_{A,i} \in (0,\varepsilon_{A,max})$ and $e_{C,i} \in (0,\varepsilon_{C,max})$ given $\varepsilon_{A,max} \leq 1$ and $\varepsilon_{C,max} \leq 1$.[3] These individual draws ensure that the model captures the diversity of both firms and cooperation opportunities that can be observed in reality. Given these assumptions, harmful cooperation is considered profitable by firm i when condition (5) (or (6) in case of beneficial cooperation) applies.

$$g_H > E(g_H^*) \quad \text{with} \quad E(g_H^*) = \rho_H l_H + \rho_H (1 - e_{A,i}) f_H \tag{5}$$

$$g_B > E(g_B^*) \quad \text{with} \quad E(g_B^*) = \rho_B l_B + \rho_B e_{C,i} f_B \tag{6}$$

Let $I_i \in \{\underline{h}, \overline{h}, \underline{b}, \overline{b}\}$ denote the information that each firm i has about the profitability of a cooperation opportunity. For $I_i = \overline{h}$, for example, firm i reasons that the harmful cooperation opportunity is of the profitable type $\overline{H}$ (i.e., $E(g_H^*) < g_H$; see column (5) in Table 1). However, this assessment need not be correct because the cooperation could be of type $\underline{H}$ (i.e., $g_H \leq g_H^*$). The perceived profitability of a cooperation agreement may thus either differ from or coincide with its true profitability. To determine the probabilities of firms' correct or incorrect profitability assessments (see column (6) in Table 1), consider the following.

A harmful cooperation opportunity is unprofitable when inequality $g_H \leq g_H^*$ applies, but it is perceived as profitable by firm i when inequality $E(g_H^*) < g_H$ applies. Solving the combined inequality $E(g_H^*) < g_H \leq g_H^*$ for the expected probability of mistaken acquittal ($e_{A,i}$) yields condition (7) below, which can be interpreted as follows: A cartel is unprofitable when the probability of false acquittal is small ($\varepsilon_A \leq e_{A,i}^*$), but it is considered profitable when the expected probability of false

3 It can be shown that the qualitative results of the model are the same for different types of distributions. Examples using a uniform distribution and a truncated normal distribution are provided in the appendix.

acquittal is large ($\varepsilon_{A,i}$*<$e_{A,i}$).

$$\epsilon_A \leq e_{A,i}{}^* < e_{A,i} \quad \text{with} \quad e_{A,i}{}^* = 1 - \frac{(g_H - \rho_H l_H)}{\rho_H f_H} \tag{7}$$

Given that $\Phi_A(e_{A,i})$ denotes the cumulative distribution function of $e_{A,i}$, harmful, unprofitable cooperation ($\underline{H}$) is erroneously considered profitable ($\overline{h}$) by firm i with probability 1-$\Phi_A(e_{A,i}$*). For this to happen, firm i must overestimate the probability of mistaken acquittal (ε_A) to a sufficient degree. A correct assessment is made with the complementary probability $\Phi_A(e_{A,i}$*).

Harmful, profitable cooperation (i.e., type $\overline{H}$; g_H*<g_H) is erroneously considered unprofitable (i.e., I_i=$\underline{h}$; $g_H \leq$E(g_H*)) when condition (8) applies.

$$e_{A,i} \leq e_{A,i}{}^* < \epsilon_A \tag{8}$$

This is the case when firm i underestimates the probability of mistaken acquittal to a sufficient degree. This incorrect assessment is made with probability $\Phi_A(e_{A,i}$*). The correct assessment I_i=$\overline{h}$ is made with probability 1-$\Phi_A(e_{A,i}$*).

Similarly, firm i erroneously considers a profitable, beneficial cooperation opportunity (i.e., type $\overline{B}$; g_B*<g_B) unprofitable (i.e., I_i=$\underline{b}$; $g_B \leq$E(g_B*)) when condition (9) applies.

$$\epsilon_C < e_{C,i}{}^* \leq e_{C,i} \quad \text{with} \quad e_{C,i}{}^* = \frac{(g_B - \rho_B l_B)}{\rho_B f_B} \tag{9}$$

Given that $\Phi_C(e_{C,i})$ denotes the cumulative distribution function of $e_{C,i}$, this is the case with probability 1-$\Phi_C(e_{C,i}$*). Firm i considers profitable cooperation unprofitable when it overestimates the probability of a mistaken conviction (ε_C) to a sufficient degree. Similarly, firm i erroneously considers an unprofitable, beneficial cooperation opportunity (i.e., type $\underline{B}$; $g_B \leq g_B$*) profitable (i.e., I_i=$\overline{b}$; E(g_B*)<g_B) when condition (10) applies.

$$e_{C,i} < e_{C,i}{}^* \leq \epsilon_C \tag{10}$$

This is the case when firm i underestimates the probability of a mistaken conviction to a sufficient

degree, which occurs with probability $\Phi_C(e_{C,i}^*)$.

1.5 Strategic Interaction, Equilibria, and Errors

Let the firms' expectations about the probability of mistaken acquittal and the probability of mistaken conviction (i.e., $e_{A,i}$ and $e_{C,i}$) be common knowledge.[4] Therefore, $J_i \in \{(\underline{h},\underline{h}), (\underline{h},\overline{h}), (\overline{h},\underline{h}), (\overline{h},\overline{h}), (\underline{b},\underline{b}), (\underline{b},\overline{b}), (\overline{b},\underline{b}), (\overline{b},\overline{b})\}$ denotes the information of firm i when also considering the expectations of the other firm. Each information tuple emerges with the probability shown in column (8) of Table 1. The tuples $(\underline{h},\overline{h})$ and $(\overline{h},\underline{h})$ as well as $(\underline{b},\overline{b})$ and $(\overline{b},\underline{b})$ are equivalent because of the symmetry of the firms.

Given this information, each firm individually decides on an action from its action set $A_i=\{a_c,a_{nc}\}$, i.e., each firm chooses whether to cooperate with the other firm (a_c) or not (a_{nc}). The firms' payoffs, however, are determined by their strategic interaction. Only when both firms consider cooperation profitable, and thus decide on a_c, does a cooperation agreement emerge as a Nash equilibrium. This is the case when inequalities (5) or (6), which indicate the *perceived* profitability of cooperation, are satisfied for both firms $i \in \{1,2\}$. These inequalities, however, are not the same as (1) and (2), which indicate the true profitability of cooperation. This divergence results from firms' imperfect information about enforcement risk and causes four types of cooperation errors.

First, when cooperation is of type $\underline{H}$, it is mistakenly considered profitable by both firms $(\overline{h},\overline{h})$ with probability $(1-\Phi_A(e_{A,i}^*))^2$. Engaging in this type of cooperation harms both the firms and their customers. This error occurs only when both firms overestimate the probability of mistaken acquittal to a sufficient degree (see condition (7)).

4 Relaxing this assumption would change the nature of the game from one with just imperfect information about enforcement risk to one where firms also have incomplete information about their types. Such a Bayesian game would call for an analysis of signaling or communication between the firms. Although this analysis would be interesting in other respects, it does not contribute to the points that shall be made in this article on compliance training. Therefore, the assumption of complete information will be retained.

Second, profitable cooperation of type $\overline{H}$ is mistakenly considered unprofitable by one ($\underline{h},\overline{h}$) or both ($\underline{h},\underline{h}$) firms with probability $1-(1-\Phi_A(e_{A,i}^*))^2$. This is the case when at least one firm underestimates the probability of mistaken acquittal ($e_{A,i}<\varepsilon_A$) to a sufficient degree (see condition (8)). Not engaging in this type of cooperation harms the firms but benefits their customers.

Third, unprofitable cooperation of type $\underline{B}$ is considered profitable by both firms ($\overline{b},\overline{b}$) with probability $\Phi_C(e_{C,i}^*)^2$. This is the case when both firms underestimate the probability of mistaken conviction to a sufficient degree (see condition (10)). Engaging in this type of cooperation benefits customers but harms the firms.

Fourth, cooperation of type $\overline{B}$ is mistakenly considered unprofitable by one ($\underline{b},\overline{b}$) or both ($\underline{b},\underline{b}$) firms with probability $1-\Phi_C(e_{C,i}^*)^2$. This occurs when at least one firm overestimates the probability of erroneous conviction to a sufficient degree (see condition (9)). Not engaging in this type of cooperation harms the firms and their customers.

The assumption of strategic interaction between the firms (i.e., their need for cooperation to earn additional profits) affects the prevalence of these errors. On the one hand, firms' strategic interaction reduces the prevalence of errors in which the firms – from their viewpoint – engage in too much cooperation. Two firms are less likely to be mistaken than one firm alone. On the other hand, strategic interaction also raises the prevalence of errors in which the firms – from their viewpoint – engage in too little cooperation. This is because the incorrect information of just one firm suffices to preclude a cooperation agreement.

The above model primarily serves to translate the central issues raised by both practitioners and scholars in this field into the formal language of mathematics. The model thus explicitly specifies how its assumptions and features interact, which may increase the transparency of the underlying argument. Ultimately, this may enable researchers and practitioners to pinpoint and study effects that might be far harder to identify in a purely verbal discussion or analysis.

Section 2 shows that competition authorities' efforts to reduce enforcement risk do not suffice to eliminate all of the above errors. In particular, it is argued that the errors that harm customers the most (i.e., engaging in unprofitable, harmful cooperation or refraining from profitable, beneficial cooperation) can be eliminated only by firms' complementary efforts to acquire better information about law enforcement. Section 3 uses the model to identify a novel effect, which is that competition authorities can sometimes *raise* firms' incentive for information acquisition by *lowering* the sanction they impose on cartel offenders.

2 The Model with Information Acquisition

In the following, the game is modified by allowing the firms to acquire perfect information about law enforcement. Information acquisition is seen as equivalent to firms investing in antitrust law compliance programs that educate their managers and other employees about antitrust law enforcement and reduce their imperfect information in this respect. It is assumed that the acquired information brings the expectations about law enforcement in line with the true enforcement probabilities (i.e., $e_{A,i}=\varepsilon_A$ and $e_{C,i}=\varepsilon_C$).[5]

2.1 Timing of the Game and Gains from Information Acquisition

The timing of the game is changed as follows: At the beginning of the period, after each firm's cooperation opportunities (i.e., $\underline{H}$, $\overline{H}$, $\underline{B}$, $\overline{B}$) and individual information states $I_i \in \{\underline{h}, \overline{h}, \underline{b}, \overline{b}\}$ have emerged, the firms decide simultaneously and non-cooperatively about acquiring information on enforcement risk. The strategy $\tau=1$ (with $\tau \in \{0,1\}$) means that firm i acquires this information at a cost t. $\tau=0$ means that no information is acquired. The acquired information is assumed to bring firm

5 Practitioners and academics have raised two concerns regarding this assumption. First, information acquisition may not eliminate imperfect information completely. This is harmless because the qualitative conclusions of the model would remain the same: The gain from information acquisition would simply be lower. Second, badly designed training programs may actually impair rather than improve information quality. This is mainly an empirical question: Although such adverse effects cannot be ruled out, a recent survey of antitrust law compliance programs (Goetz et al. 2014) does not provide case evidence to support this concern.

i's expectation about law enforcement in line with the true enforcement probabilities (i.e., $e_{A,i}=\varepsilon_A$ and $e_{C,i}=\varepsilon_C$). The game subsequently proceeds as described in Section 1.

Firm *i* gains from information acquisition by avoiding the errors described in Section 1. With correct information about enforcement risk ($e_{A,i}=\varepsilon_A$, $e_{C,i}=\varepsilon_C$), firm *i*'s information I_i about the profitability of a cooperation opportunity always equals the true profitability. For example, when a cooperation agreement is of type $\underline{H}$, firm *i*'s information will be $I_i=\underline{h}$ with certainty. The same logic applies to the other error probabilities presented in column (6) of Table 1: All probabilities for incorrect profitability assessments take on a value of zero.

Let $G_i(\tau_i,\tau_{-i})$ denote the expected gain (before incurring the information acquisition costs *t*) that accrues to firm *i* when it and/or its rival -*i* acquires information about enforcement risk. To interpret the first line of (11), when harmful cooperation is unprofitable ($g_H \leq g_H^*$), the indicator function $\Theta_H(g_H^*)$ takes a value of 1. The firms would, however, engage in a cartel agreement with probability $(1-\Phi_A(e_{A,i}^*))^2$. The probability of this coordination error can be reduced to 0 by acquiring information about enforcement risk. This would save firm *i* an amount of $g_H^*-g_H=\rho_H(1-\varepsilon_A)f_H+\rho_H l_H-g_H$. Similar gains are attained by avoiding the other three types of errors (see conditions (11) and (12)).

$$\begin{aligned} G_i(1,0) = {} & \Theta_H(g_H^*) \cdot \left[\left(1-\Phi_A(e_{A,i}^*)\right)^2 - 0\right] \cdot \left[\rho_H l_H+\rho_H(1-\epsilon_A)f_H-g_H\right] + \\ & \left(1-\Theta_H(g_H^*)\right) \cdot \left[1-\left(1-\Phi_A(e_{A,i}^*)\right)^2 - \Phi_A(e_{A,i}^*)\right] \cdot \left[g_H-\rho_H l_H-\rho_H(1-\epsilon_A)f_H\right] + \\ & \Theta_B(g_B^*) \cdot \left[\Phi_C(e_{C,i}^*)^2 - 0\right] \cdot \left[\rho_B l_B+\rho_B\epsilon_C f_B-g_B\right] + \\ & \left(1-\Theta_B(g_B^*)\right) \cdot \left[\left(1-\Phi_C(e_{C,i}^*)^2\right) - \left(1-\Phi_C(e_{C,i}^*)\right)\right] \cdot \left[g_B-\rho_B l_B-\rho_B\epsilon_C f_B\right] \end{aligned} \tag{11}$$

$$\begin{aligned} G_i(1,1) = {} & \Theta_H(g_H^*) \cdot \left[\left(1-\Phi_A(e_{A,i}^*)\right)^2 - 0\right] \cdot \left[\rho_H l_H+\rho_H(1-\epsilon_A)f_H-g_H\right] + \\ & \left(1-\Theta_H(g_H^*)\right) \cdot \left[1-\left(1-\Phi_A(e_{A,i}^*)\right)^2 - 0\right] \cdot \left[g_H-\rho_H l_H-\rho_H(1-\epsilon_A)f_H\right] + \\ & \Theta_B(g_B^*) \cdot \left[\Phi_C(e_{C,i}^*)^2 - 0\right] \cdot \left[\rho_B l_B+\rho_B\epsilon_C f_B-g_B\right] + \\ & \left(1-\Theta_B(g_B^*)\right) \cdot \left[\left(1-\Phi_C(e_{C,i}^*)^2\right) - 0\right] \cdot \left[g_B-\rho_B l_B-\rho_B\epsilon_C f_B\right] \end{aligned} \tag{12}$$

The gains from information acquisition can be ranked $0=G_i(0,0)<G_i(0,1)=G_i(1,0)\leq G_i(1,1)$. Firm *i* gains nothing when neither firm implements a compliance program. It gains most when both firms

implement such a program.

Firm i receives the same gain irrespective of whether it or the other firm $-i$ implements a compliance program ($G_i(0,1)=G_i(1,0)$). To see this, consider that the risk $(1-\Phi_A(e_{A,i}^*))^2$ of erroneously forming an unprofitable cooperation agreement of type $\underline{H}$ drops to zero if just one firm acquires the information and, as a consequence, refrains from cooperating. The same is true for the probability $\Phi_C(e_{C,i}^*)^2$ that the firms erroneously form an unprofitable cooperation agreement of the beneficial type $\underline{B}$. Now, consider the situations in which the uninformed firms refrain from forming a profitable cooperation of type $\overline{H}$ or type $\overline{B}$. This occurs with the probability $1-(1-\Phi_A(e_{A,i}^*))^2$ and $1-\Phi_C(e_{C,i}^*)^2$, respectively. If just one firm acquires information, a probability $\Phi_A(e_{A,i}^*)$ or $1-\Phi_C(e_{C,i}^*)$ remains that the other firm assesses the profitability incorrectly and does not cooperate. This risk is the same for both firms. A correct decision will be made with certainty only if both firms acquire information.

2.2 Equilibria

Table 2 displays the normal form of the information acquisition subgame. There are two reasons why the firms might not acquire information. First, the costs t of information acquisition might simply be too high. None of the two firms will acquire information when the costs t exceed the gain from acquiring information individually (i.e., $G_i(1,0)\leq t$). Given that information acquisition improves decision quality and is unambiguously beneficial for the firms, both firms acquire information when the costs t are sufficiently low. This is the case when t is lower than firm i's additional gain from acquiring information compared to a situation where just the other firm $-i$ acquires information (i.e., $t<G_i(1,1)-G_i(0,1)$).

The second reason why a firm might refrain from information acquisition is more nuanced. The information acquisition subgame may have equilibria in pure strategies where just one firm acquires information. This is the case when the costs are in the intermediate range $G_i(1,1)-$

$G_i(0,1) \leq t < G_i(1,0)$. This particular result emerges because one firm may freeride on the information of the other. The correct information of firm i prevents firm $-i$ from establishing some unprofitable cooperation agreements. The acquisition of information by firm i exerts a positive externality on firm $-i$.

		firm 2	
		$\tau=1$	$\tau=0$
firm 1	$\tau=1$	$G_1(1,1)-t \mid G_2(1,1)-t$	$G_1(1,0)-t \mid G_2(0,1)$
	$\tau=0$	$G_1(0,1) \mid G_2(1,0)-t$	$G_1(0,0)-t \mid G_2(0,0)-t$

Table 2: Normal form - information acquisition subgame

It is well known that the existence of positive externalities implies an underprovision of the underlying activity (in this case, information acquisition). An intervention by policymakers and public authorities may thus be required to promote information acquisition of each firm individually. This idea is explored in more detail in Section 3.

3 Theoretical Results on Information Acquisition and Public Policy

Section 2 has shown that information acquisition would always be beneficial for the firms if it were costless ($t=0$). When information acquisition is costly ($t>0$), however, there may be equilibria where no or just one firm acquires information about law enforcement. This may be suboptimal from a social point of view because information acquisition may also benefit customers by deterring harmful cooperation or promoting beneficial cooperation. The following analysis is thus concerned with what public policy can do to promote information acquisition.

Four questions are central to this analysis. First, does compliance training have adverse effects (Wils 2013), and if so, how can these effects be avoided? Second, do competition authorities'

current efforts to reduce enforcement risk suffice to eliminate the errors described in Section 1? Third, what can competition authorities do to promote information acquisition by the firms? Fourth, and most interestingly, why do firms' incentives to acquire information sometimes rise when the value of the sanction is reduced?

3.1 No Adverse Effects Without Enforcement Risk

Information acquisition may have perverse learning effects (Wils 2013:61) and harm customers in two cases. First, assume a situation with profitable, harmful cooperation opportunities ($\overline{H}$) and firms that overestimate the effectiveness of legal enforcement ($e_{A,i}<\varepsilon_A$). When acquiring information about the true, higher probability of mistaken acquittal, the firms will consider cooperation more profitable (see inequality (5)). This may lead to cases in which harmful cooperation is considered unprofitable before information acquisition and profitable thereafter. Second, consider cooperation opportunities that would benefit customers but not the firms ($\underline{B}$). Firms that would otherwise have underestimated the chance of a mistaken conviction ($e_{C,i}<\varepsilon_C$) and learn about its true, higher probability will consider such cooperation less profitable (see condition (6)). This may lead to cases in which beneficial cooperation is considered profitable before information acquisition and unprofitable thereafter.

From the point of view of customers, these are adverse effects of information acquisition. They can, however, be prevented to the extent that authorities and policymakers succeed in eliminating enforcement risk. The importance of eliminating enforcement risk must not be underestimated. Given $\varepsilon_A=0$ and $\varepsilon_C=0$, the inequalities $e_{A,i}<\varepsilon_A$ or $e_{C,i}<\varepsilon_C$ cannot apply (see (8) and (9)); the error probabilities $\Phi_A(e_{A,i}^*)$ and $\Phi_C(e_{C,i}^*)$ would drop to zero. Therefore, the two situations that give rise to adverse effects of information acquisition would not occur in the first place. Consequently, in a world without enforcement risk, information acquisition cannot have adverse effects on customers.

3.2 Enforcement Risk and Information Acquisition

In an environment where firms are imperfectly informed about law enforcement, however, reducing enforcement risk may also have unintended, adverse effects. On the one hand, and as intended, eliminating enforcement risk raises the deterrence effect of sanctions on harmful cooperation agreements (see condition (3)) and makes beneficial agreements more profitable (see condition (4)). On the other hand, and this may be rather unintended, in an environment with imperfect information ($e_{A,i} \neq \varepsilon_A$, $e_{C,i} \neq \varepsilon_C$), this will also lead to more cases in which the firms engage in unprofitable, harmful cooperation ($\underline{H}$) or refrain from profitable, beneficial cooperation ($\overline{B}$). These are the cases in which imperfect information about law enforcement harms the firms *and* the customers.

Thus, public authorities' efforts to reduce enforcement risk will not eliminate all errors described in Section 1. Such efforts must rather be accompanied by firms' private efforts to acquire information about the legal consequences of their conduct. Private information acquisition is particularly important in jurisdictions where legal enforcement is highly effective and where firms underestimate this effectiveness. To date, however, many competition authorities remain reluctant to raise firms' incentives for private information acquisition by actively promoting antitrust compliance programs.

3.3 The Costs of Information Acquisition

This raises the question of how private information acquisition can be enhanced by authorities and/or policymakers. In principle, there are two ways to spur information acquisition: first, lowering the costs t and, second, raising the gains G_i.

Regarding the costs t of information acquisition, competition authorities can provide information and, for example, issue guidelines that assist firms in designing effective compliance training to distribute this information among their employees. In practice, such guidelines or related information have already been issued by some competition authorities, such as the British CMA, the

Canadian Competition Bureau, and the Australian ACCC. Reducing t should mainly benefit small to medium-sized firms.[6] This is because their costs t of information acquisition may be assumed to be relatively large (Bussmann et al. 2013, Harrington 2014) compared to their gains G_i. Nonetheless, these firms seem to participate in cartels fairly frequently.

Given some unavoidable compliance expenses, one must expect that t cannot be reduced to levels below some lower threshold. This would call for the second lever to enhance information acquisition, namely raising the gains G_i, which is discussed in the following.

3.4 *Lower Sanctions, Greater Gain from Information Acquisition*

Competition authorities can sometimes raise the gain G_i from information acquisition by reducing the sanction f_H that is imposed on cartel offenders. If the gain G_i from information acquisition is inversely u-shaped in the sanctions f_H or f_B, a higher sanction raises G_i as long as the sanction is low. Once the sanction exceeds a certain threshold and is raised further, however, the gain G_i falls.

To see this effect, consider the case in which the firms engage in harmful, unprofitable cooperation ($\underline{H}$) because they erroneously consider it profitable ($\bar{h},\bar{h}$). Solving (7) for f_H shows that this error occurs only in a certain interval of the sanction f_H.

$$f_H \in \left[\frac{(g_H - \rho_H l_H)}{(1-\epsilon_A)\cdot\rho_H}, \frac{(g_H - \rho_H l_H)}{(1-\epsilon_{A,max})\cdot\rho_H} \right) \tag{13}$$

To interpret this interval, the sanction must, first, be high enough to make collusion unprofitable. Second, it must not be so high that even the worst-informed manager ($e_{A,i}=\varepsilon_{A,max}$) would conjecture

6 Small to medium-sized firms seem to participate in cartels fairly frequently. For example, consider the German cartels in confectionery products, cable bedding compounds, or roof tiles.
Bundeskartellamt (2009). "Fine proceedings against companies in the German clay roof tile sector." B1-200/06, http://goo.gl/jhJSZa, accessed on October 15, 2014
Bundeskartellamt (2012). "Manufacturers of cable bedding compounds fined for forming a cartel." B11-15/09, http://goo.gl/49OO3N, accessed on October 15, 2014
Bundeskartellamt (2013). "Fine proceedings against confectionery manufacturers." B11-11/08, http://goo.gl/lL58bs, accessed on October 15, 2014

that the cartel is unprofitable.

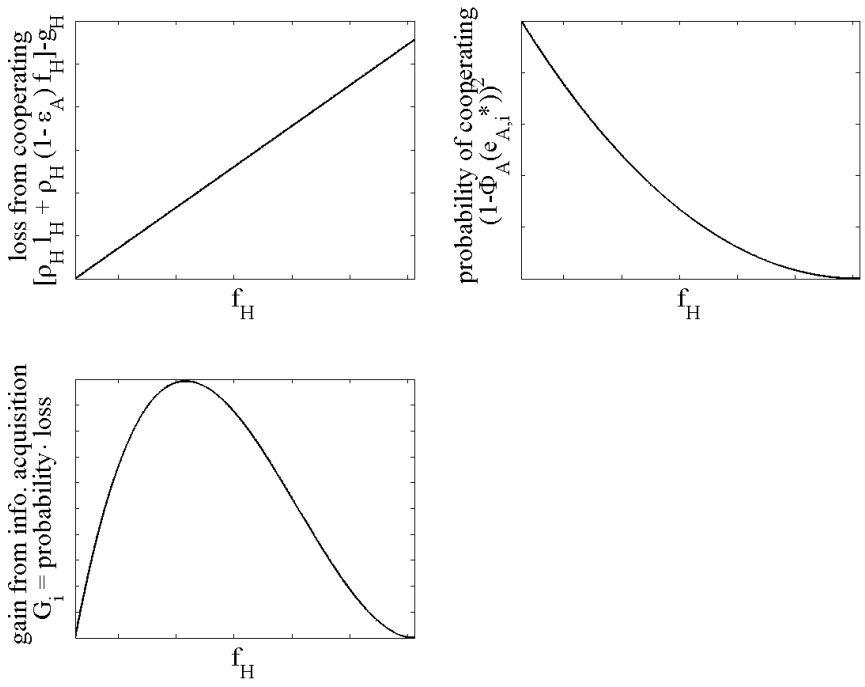

Figure 1: Gain from information acquisition G_i

Starting from the lower threshold and increasing the sanction f_H raises the loss that a firm makes by mistakenly engaging in unprofitable, harmful cooperation ($\underline{H}$; see the upper left panel in Figure 1[7]). Everything else equal, a higher sanction f_H raises the incentive of the firm to implement an antitrust law compliance program and avoid this loss. However, a higher sanction also reduces the probability $(1-\Phi_A(e_{A,i}^*))^2$ that both firms erroneously consider the cooperation profitable ($\bar{h}$). This probability takes a value of 0 at the upper bound for f_H (see the upper right panel in Figure 1). Everything else equal, a higher sanction f_H would lower the incentive of firm i to engage in information acquisition. Taking these two effects together means that the gain G_i from information acquisition is zero at the lower and at the upper bound of f_H and positive within this interval, i.e., G_i is in fact inversely u-shaped in f_H (see the lower left panel in Figure 1).

7 Figure 1 was derived by setting g_H=1, ε_A=0.05, ρ_H=0.2, and l_H=0. Firm i's expectations are assumed to be uniformly distributed in the interval $e_{A,i} \in (0, \varepsilon_{A,max})$ with $\varepsilon_{A,max}$=0.1. Further details are provided in the appendix.

As the above results were derived without assuming a specific functional form of $\Phi_A(e_{A,i})$, they are robust to changes in this cumulative density function. This is illustrated in the appendix, which provides two numerical examples, one with a uniform distribution and one with a censored normal distribution for $\Phi_A(e_{A,i})$. It is also shown in the appendix that a similar inverse u-shape can be found for those cases in which the firms engage in unprofitable, beneficial cooperation ($\underline{B}$) and for those in which they mistakenly refrain from profitable cooperation ($\overline{H}$ or $\overline{B}$) by considering it unprofitable.

The central finding of this article is that, in an environment where firms are imperfectly informed about law enforcement, lower sanctions can improve the deterrence of (harmful) cooperation between firms. This is because lower sanctions sometimes raise firms' incentives for information acquisition. These results are novel and challenge the common notion that higher sanctions improve deterrence. Interestingly, these results do not turn the traditional ideas of deterrence upside down but rather complement them. First, when considering harmful, unprofitable cooperation agreements, the inverse u-shape only appears when the sanction is high enough to make cooperation unprofitable. Second, setting a sanction that is high enough to deter even the worst-informed decision maker from cooperating would also ensure deterrence. This is consistent with classical deterrence theory. However, it is sometimes impractical or even impossible to set such high sanctions: In many jurisdictions, for example, antitrust laws stipulate that fines must not exceed 10% of a firm's revenues. In such situations, lower sanctions may actually improve deterrence.

This implies that competition authorities, both when setting fines and when revising their fining guidelines, should not only pay attention to allocative efficiency (i.e., deterring hardcore cartels) and dynamic efficiency (i.e., not fining cartel offenders out of the market). To carefully fine-tune and balance these effects, they should also consider firms' incentives to acquire information (i.e., to conduct compliance training).

4 Numerical Results and Policy Implications

Section 3 establishes new effects based on theoretical reasoning. Deriving these effects from a formal-analytic model provides an important advantage over purely verbal models: The formal-analytic model can be numerically calibrated to indicate the expected order of magnitude of certain effects. The present section provides an example of such a numerical calibration.

Subsection 4.1 argues that, even in jurisdictions with non-negligible enforcement risk, perverse learning effects of compliance training may be quite rare. Section 4.2 shows that the error in which uninformed managers form an unprofitable cartel is not unlikely under plausible assumptions. Given recent trends in the enforcement of antitrust laws, it might even be observed more frequently in the future. Section 4.3 argues that, when firms' information about antitrust law enforcement is sufficiently imperfect, the risk that managers refrain from beneficial cooperation is not remote even for relatively moderate sanctions. Thus, promoting firms' information acquisition may generate considerable benefits for customers.

4.1 Enforcement Risk and Perverse Learning Effects

Section 3 argues that antitrust law compliance programs may have perverse learning effects (i.e., promoting harmful cartels and reducing beneficial cooperation; Wils 2013) only when there is considerable enforcement risk ($\varepsilon_A>0$, $\varepsilon_C>0$). Note that measuring enforcement risk is a difficult exercise (Dari-Mattiacci and Deffains 2007), and there does not seem to be any study that provides precise estimates of ε_A or ε_C. Over the last decades, however, competition authorities have increasingly used microeconomic reasoning and empirical analyses (Heyer 2005) to reduce ε_A and ε_C. Moreover, competition authorities attempt to create legal certainty by issuing guidelines, regulations, etc. They are often seen as vigilant watchdogs rather than toothless tigers.[8] This

8 For example, in a speech given on November 13, 2013, former competition commissioner Almunia emphasized the goal of strengthening legal certainty regarding leniency applications and actions to claim damages (http://goo.gl/tyil4i, accessed on October 15, 2014).

contributes to lowering ε_A and ε_C so that enforcement risk is presumably low in countries with an established antitrust law tradition, such as the US, the EU, and EU member states.

Even in jurisdictions with non-negligible enforcement risk, however, perverse learning effects may still be fairly rare. To see this, assume an environment with frequent enforcement errors (ε_C=20%), a high detection probability (ρ_B=80%), and litigation costs l_B that amount to no less than l_B/g_B=25% of the gain g_B. Even under these strong assumptions, efficiency-enhancing cooperation of type *B* would be unprofitable ($g_B^* \leq g_B$) only if the (erroneously imposed) sanction f_B were more than five times larger than the gain g_B, as can be seen from (14).

$$f_B \geq \frac{g_B - \rho_B l_H}{\rho_H \epsilon_C} \tag{14}$$

Such situations may be considered the exception rather than the rule.

4.2 Imperfect Information: Too Many Harmful Cartels

This subsection shows under what conditions managers can be expected to engage in unprofitable hardcore cartels. A numerical example will determine in which range of the sanction this error occurs and what sanction would maximize the private incentive for information acquisition.

Hardcore cartels are unprofitable when the gain g_H is small, when cartels are detected with a high probability ρ_H, when they are punished by strong sanctions f_H, or when litigation costs l_H are high. The gain g_H is presumably small when, first, a cartel is established by salespeople or lower-level managers rather than general management; second, the conspiracy is made in a declining market; third, it concerns a product or region that contributes little to the firms' revenues and profits. In antitrust law practice, one can observe an increase in fines[9], a more important role of follow-on damages suits[10], and an increasing number of cases prosecuted over the last years (see also

Also see Reuters (2014). "Antitrust watchdog clears Fresenius purchase of Rhoen hospitals." http://goo.gl/GuxVF3, accessed on October 15, 2014

9 For example, see the cartel statistics provided on the website of the European Directorate General of Competition: http://goo.gl/IZshkg, accessed on October 15, 2014

10 For example, see the information provided on the website of the European Directorate General of Competition:

Katsoulacos and Ulph 2013, Harrington 2014). Extrapolating the trend of rising fines, higher detection probabilities, and a growing importance of private damages claims, one may conclude that this type of error (i.e., engaging in unprofitable cartels) might also become more important.

In line with traditional deterrence theory, Section 3 suggests that cartels formed by mistake can, in principle, be avoided by raising the sanction f_H and the detection probability ρ_H to levels where even uninformed managers consider cartel conduct unprofitable. However, increasing the probability-weighted sanction may not always be easy or even feasible. First, raising the detection probability is costly. Second, fines are often capped (e.g., consider the 10%-of-revenue cap in Europe). Third, the sanctions f_H that are imposed on hardcore cartel conduct and the sanctions f_B that are (erroneously) imposed on beneficial cooperation agreements (f_B) might be correlated (i.e., $\partial f_B/\partial f_H>0$). Raising the sanction that is imposed on hardcore cartels would therefore also deter beneficial cooperation.

In these cases, firms' incentives to conduct compliance training, and to avoid the formation of unprofitable cartels in this way, can sometimes be enhanced by lowering the overall level of sanctions. Let $f_{\underline{H}}^*$ denote the sanction that maximizes the gain G_i from engaging in compliance training and avoiding the erroneous formation of unprofitable cartels. To assess the value of this sanction, assume a detection probability ρ_H=20% (European Commission 2008:fn.29), an error probability ε_A=5%, a maximum expected error probability $\varepsilon_{A,max}$=10%, and litigation costs that amount to l_H/g_H=5% of the collusive gain. Assuming that $e_{A,i}$ is uniformly distributed in the interval $(0,\varepsilon_{A,max})$, one finds that the incentive to implement an antitrust law compliance program is maximal for a sanction $f_{\underline{H}}^*$ that equals 530% of the gain g_H (see equation (A7) in the appendix).Whether the actual sanction in particular jurisdictions is higher or lower than $f_{\underline{H}}^*$ is ultimately an empirical question that might usefully be explored by future research.

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http://goo.gl/21876n, accessed on October 15, 2014

4.3 Imperfect Information: Too Little Beneficial Cooperation

This section is concerned with cooperation agreements that would benefit both the customers and the firms, but are not formed because managers overestimate the risk of being mistakenly sanctioned. Such errors may well occur under plausible assumptions on the values of the model's parameters.

This error occurs when the sanction f_B is within the bounds provided by the interval shown in (15), which was determined by solving inequality (9) for f_B.

$$f_B \in \left[\frac{g_B - \rho_B l_B}{\epsilon_{C,max} \cdot \rho_B}, \frac{g_B - \rho_B l_B}{\epsilon_C \cdot \rho_B} \right) \tag{15}$$

Given the parameter values (i.e., ε_C=20%, ρ_B=80%, and l_B/g_B=25%) and the reasoning from subsection 4.1, it is unlikely that the sanction exceeds the upper bound $f_B \leq 5g_B$. Concentrating on the lower bound $(g_B-\rho_B l_B)/(\varepsilon_{C,max}\rho_B)$ instead, it can be argued that the error of not engaging in efficiency-enhancing cooperation given the risk of being mistakenly sanctioned may indeed occur in reality. For $\varepsilon_{C,max}$=40%, one would find a lower bound $f_B>2.5g;$, for $\varepsilon_{C,max}$=60%, the lower bound would be $f_B>1.67g_B$.

Thus, for high enough values of $\varepsilon_{C,max}$ (i.e., for a sufficient degree of imperfect information), a relatively low sanction would suffice to let firm *i* refrain from efficiency-enhancing cooperation. This is particularly relevant because efficiency-enhancing cooperation agreements are often assessed under a rule of reason approach. This may make it hard to predict the outcome of an investigation *ex ante*, and, accordingly, imperfect information about enforcement risk may be considered fairly high. In comparison, hardcore cartels are prohibited *per se*, which helps to keep firms' imperfect information about enforcement low.

As a sanction, one need not even impose a fine when firms are found to cooperate without generating efficiency gains. In the present model, the sanction also includes the foregone gains if a

competition authority stops the cooperation before the gain g_B has been realized. Hence, the sanction f_B would simply amount to the gains forgone plus, perhaps, sunk costs of investments that might already have been made. A further deterrence effect may result from the case-handling costs l_B.

This reasoning suggests that imperfect information about antitrust law enforcement may well lead to a decision error that harms both customers *and* firms. Managers may mistakenly refrain from profitable, efficiency-enhancing cooperation agreements. Information acquisition (e.g., compliance training programs) can help to avoid these errors.

5 Conclusion

This article provides a formal model that analyzes the effects of antitrust law compliance programs on cooperation between firms whose decisions are subject to enforcement risk and imperfect information about law enforcement. The model shows that eliminating enforcement risk alone does not suffice to eliminate firms' decision errors altogether. As long as firms continue to believe that enforcement might be subject to risk, they tend to engage in some hardcore cartels that – in addition to harming customers – are unprofitable for them due to the value of sanctions. Similarly, imperfect information about antitrust laws may prevent firms from engaging in some horizontal cooperation agreements that would actually benefit customers.

These errors, which harm both firms *and* customers, can be prevented by compliance programs that educate managers about antitrust law. Firms, however, do not necessarily adopt such programs due to high costs and a potential freeriding effect. The model shows that reducing the sanction imposed on cartel offenders can promote the adoption of antitrust law compliance programs. This is particularly true when the sanction is objectively high enough to deter cartel conduct and merely fails to do so because the managers underestimate the probability of conviction.

These results have implications for both competition policy and future research. To date,

many competition authorities are somewhat reluctant to reduce fines so as to reward firms that have implemented an antitrust law compliance program. The above results suggest that discussions about the appropriate level of fines should not be dismissed out of hand. Clearly, though, the sanction must not be reduced to a level so low that a well-informed firm would consider hardcore cartel conduct profitable after deducting the expected sanction and potential payments for damages.

At this point, it may be apt to recall that the above results are theoretically derived and thus require empirical evidence to refute or support them. Specifically, as Harrington (2014) suggests, more empirical evidence is required concerning the deterrence effects of sanctions on cooperation agreements that have mistakenly been deterred by the fear of being prosecuted. The present article may thus be considered an initial step towards measuring the relevant effects by suggesting a formal theory that can serve as a framework for future empirical work.

To extend the present model, future research could focus on analyzing the optimal level of enforcement risk when its reduction costly. Moreover, it may be interesting to determine the optimal detection probability given that detection efforts are also costly. These issues have so far been investigated in models with perfect information, but they might usefully be analyzed in models with imperfect information. In a similar vein, additional efforts to determine firms' optimal level of information acquisition may be highly pertinent. The present model assumes that firms can acquire perfect information at a fixed cost, but one may surmise that there are situations in which the quality of information increases the more firms spend on information acquisition.

Going somewhat further, one might consider that antitrust law compliance programs generally have a broader scope than merely educating and training managers. Their purpose often includes establishing a compliance culture within the firm. In this context, an intriguing question may be how compliance interacts with the establishment of social norms, such as the stigmatization of illegal conduct (Paha 2013). Finally, given the survey results of Goetz et al. (2014), further

research appears warranted on the potential signaling or reputation function of compliance programs for both shareholders and stakeholders of the firm.

Appendix

This appendix illustrates the statements from the general model by providing an example that assumes specific forms of the cumulative distribution functions $\Phi_A(e_{A,i})$ and $\Phi_C(e_{C,i})$. It also illustrates how changes in the sanctions f_H and f_B affect the gain G_i from acquiring information about enforcement risk.

It follows from (1) and (3) that harmful cooperation is unprofitable ($\underline{H}$; $g_H^* \leq g_H$) under correct expectations ($e_{A,i}=\varepsilon_A$) if inequality (A1) applies and profitable ($\overline{H}$) otherwise.

$$f_H \geq \frac{g_H - \rho_H l_H}{\rho_H (1-\epsilon_A)} \tag{A1}$$

It follows from (2) and (4) that beneficial cooperation is unprofitable ($\underline{B}$; $g_B^* \leq g_B$) under correct expectations ($e_{C,i}=\varepsilon_C$) if inequality (14) applies and profitable ($\overline{B}$) otherwise.

It is assumed that the error probabilities $e_{A,i}$ and $e_{C,i}$ are random variables that are uniformly distributed ($\Phi_A(e_{A,i})$, $\Phi_C(e_{C,i})$) in the intervals $e_{A,i} \in (0,\varepsilon_{A,max})$ and $e_{C,i} \in (0,\varepsilon_{C,max})$ with $\varepsilon_{A,max} \leq 1$ and $\varepsilon_{C,max} \leq 1$. In the following, functional forms are derived for the probabilities $\Phi_A(e_{A,i}^*)$ and $\Phi_C(e_{C,i}^*)$ at the cutoff values $e_{A,i}^*$ and $e_{C,i}^*$. Further below, it is shown that the same qualitative conclusions can be derived using a censored normal distribution.

Given $e_{A,i}^* = 1-(g_H-\rho_H l_H)/(\rho_H f_H)$ (see equation (7)), one can write $\Phi_A(e_{A,i}^*)$ as follows.

$$\Phi_A(e_{A,i}^*) = \frac{e_{A,i}^*}{\epsilon_{A,max}} = \frac{1-(g_H-\rho_H l_H)/(\rho_H f_H)}{\epsilon_{A,max}} \tag{A2}$$

The decision errors of the firms occur in different intervals of the sanction f_H. First, an unprofitable, harmful cooperation agreement ($\underline{H}$) is mistakenly considered profitable ($\overline{h}$) when firm i overestimates the probability of false acquittal to a sufficient degree, as is shown in (7). Solving (7) for f_H while using $max(e_{A,i})=\varepsilon_{A,max}$ yields the interval (13) in which this error occurs. Second, profitable, harmful cooperation ($\overline{H}$) is mistakenly considered unprofitable ($\underline{h}$) when firm i underestimates the probability of false acquittal to a sufficient degree. Solving (8) for f_H while using $min(e_{A,i})=0$ shows that this error occurs in the interval presented in (A3).

$$f_H \in \left[\frac{g_H - \rho_H l_H}{\rho_H}, \frac{g_H - \rho_H l_H}{(1-\epsilon_A)\cdot\rho_H} \right) \tag{A3}$$

For $\varepsilon_A=0$, the interval in (A3) shrinks to a single point that yields $\Phi_A(e_{A,i}^*)=0$. Eliminating the risk of wrongful acquittal eliminates this decision error.

The same logic applies to the errors made when assessing the profitability of beneficial cooperation agreements (type *B*). Given $e_{C,i}^*=(g_B-\rho_B l_B)/(\rho_B f_B)$ (see equation (9)) and the assumption of $e_{C,i}$ being uniformly distributed in the interval $(0,\varepsilon_{C,max})$, one can express $\Phi_C(e_{C,i}^*)$ as shown in (A4).

$$\Phi_C(e_{C,i}^*)=\frac{e_{C,i}^*}{\epsilon_{C,max}}=\frac{(g_B-\rho_B l_B)/(\rho_B f_B)}{\epsilon_{C,max}} \tag{A4}$$

Profitable, beneficial cooperation ($\overline{B}$) is mistakenly considered unprofitable ($\underline{b}$) when firm *i* overestimates the probability $e_{C,i}$ of false conviction to a sufficient degree, as can be inferred from inequality (9). Given $\max(e_{C,i})=\varepsilon_{C,max,}$ this is the case in the interval shown in (15). Unprofitable, beneficial cooperation ($\underline{B}$) is mistakenly considered profitable when (A5) applies, which can be found by solving (9) for f_B given $\min(e_{C,i})=0$.

$$f_B\in\left[\frac{g_B-\rho_B l_B}{\epsilon_C\cdot\rho_B},\infty\right) \tag{A5}$$

Note that for $e_{C,i}\to 0$, the cooperation agreement would even be considered profitable for $f_B\to\infty$.

The gain from compliance G_i can be written as shown in (11) and (12) when one or both firms acquire information about law enforcement. Information acquisition helps the firms both to avoid the losses from not engaging in unprofitable cooperation and to earn the gains that would have been foregone by refraining from profitable cooperation. The following calculation determines the critical values $f_{\underline{H}}^*, f_{\overline{H}}^*, f_{\underline{B}}^*, f_{\overline{B}}^*$ of the sanction for which the gain G_i from acquiring information is maximized within each interval (13), (15), (A3), or (A5) of the fines f_B or f_H.

Consider the case in which unprofitable cooperation of type $\underline{H}$ is mistakenly considered profitable ($\overline{h},\overline{h}$) by both firms, i.e., f_H is in the interval provided by (13). One sees that $\partial G_i(1,0)/\partial f_H=\partial G_i(1,1)/\partial f_H$ applies. The first derivative can be written as shown in (A6).

$$\begin{aligned}\frac{\partial G_i}{\partial f_H} \;=\; \Theta_H(g_H^*)\cdot\Bigg[&\frac{\partial\left(1-\Phi_A(e_{A,i}^*)\right)^2}{\partial f_H}\;\cdot\;\left[\rho_H l_H+\rho_H\left(1-\epsilon_A\right)f_H-g_H\right]\\ &+\left(1-\Phi_A(e_{A,i}^*)\right)^2\;\cdot\;\frac{\partial\left[\rho_H l_H+\rho_H\left(1-\epsilon_A\right)f_H-g_H\right]}{\partial f_H}\Bigg]\end{aligned} \tag{A6}$$

Given (A4), one finds $\partial(1-\Phi_A(e_{A,i}^*))^2/\partial f_H<0$, i.e., a higher sanction f_H reduces the probability of engaging in unprofitable cooperation. The term $\partial\left[\rho_H l_H+\rho_H\left(1-\epsilon_A\right)f_H-g_H\right]/\partial f_H>0$ shows that a higher sanction f_H raises the absolute value of the loss that can be avoided by acquiring information. The opposite signs of $\partial(1-\Phi_A(e_{A,i}^*))^2/\partial f_H<0$ and $\partial\left[\rho_H l_H+\rho_H\left(1-\epsilon_A\right)f_H-g_H\right]/\partial f_H>0$ show that G_i is non-monotonic in the sanction f_H. By substituting the respective

functions in (A6) and solving for $f_{H,}$ one can show that (A7) applies.

$$\frac{\partial G_i}{\partial f_H}\begin{cases}>0 & \text{if} \quad f_H < f_{\underline{H}}^* \equiv \dfrac{g_H-\rho_H l_H}{2\rho_H\cdot(1-\epsilon_{A,max})}\cdot\left[-1+\sqrt{1+8\cdot\dfrac{1-\epsilon_{A,max}}{1-\epsilon_A}}\right] \\ <0 & \text{if} \quad f_H > f_{\underline{H}}^*\end{cases} \tag{A7}$$

As long as the actual sanction f_H is below the critical value $f_{\underline{H}}^*$, a higher fine raises the gain from making correct decisions $\left(\rho_H l_H+\rho_H\left(1-\epsilon_A\right)f_H-g_H\right)$ more strongly than it lowers the probability of making a wrong decision $(1-\Phi_A(e_{A,i}^*))^2$. For $f_H>f_{\underline{H}}^*$, however, this effect is reversed because with such a high fine it is fairly obvious even for an uninformed manager that the cartel is unprofitable.

Again, the same logic applies to the case in which the firms would mistakenly engage in an unprofitable, beneficial cooperation agreement ($\underline{B}$, $(\bar{b},\bar{b})$). It can be shown that in the interval (A5) the conditions $\partial\left[\rho_B l_B+\rho_B\epsilon_C f_B-g_B\right]/\partial f_B>0$, $\partial(1-\Phi_C(e_{C,i}^*))^2/\partial f_{\underline{B}}<0$ and (A8) apply.

$$\frac{\partial G_i}{\partial f_B}\begin{cases}>0 & \text{if} \quad f_{\underline{B}} < f_B^* \equiv \dfrac{2\left(g_B-\rho_B l_B\right)}{\rho_B\epsilon_C} \\ <0 & \text{if} \quad f_{\underline{B}} > f_B^*\end{cases} \tag{A8}$$

Where imperfect information keeps the firms from profitable cooperation of types $\overline{H}$ or $\overline{B}$, it can be shown that there is more to gain for the second firm that acquires information than for the first firm. Therefore, I focus on the gain $G_i(1,1)$ when both firms acquire information. A first-order condition similar to (A6) and (A8) can be found in both cases. Using (A2) and (A4), one finds that higher values of the sanction raise the error probabilities, i.e., $\partial[1-(1-\Phi_A(e_{A,i}^*))^2]/\partial f_H>0$ and $\partial[1-\Phi_C(e_{C,i}^*)^2]/\partial f_B>0$. However, a higher sanction also makes cooperation less profitable, i.e., $\partial\left[g_H-\rho_H l_H-\rho_H\left(1-\epsilon_A\right)f_H\right]/\partial f_H<0$ and $\partial\left[g_B-\rho_B l_B-\rho_B\epsilon_C f_B\right]/\partial f_B<0$. Given the opposite signs of the partial derivatives, one finds that the gain $G_i(1,1)$ from acquiring information is inversely u-shaped in the value of the sanction. The respective gain is at its maximum for $f_{\overline{H}}^*$ and $f_{\overline{B}}^*$.

$$\frac{\partial G_i}{\partial f_H}\begin{cases}>0 & \text{if} \quad f_H < f_{\overline{H}}^* \\ <0 & \text{if} \quad f_H > f_{\overline{H}}^*\end{cases} \tag{A9}$$

$$\frac{\partial G_i}{\partial f_B}\begin{cases}>0 & \text{if} \quad f_B < f_{\overline{B}}^* \\ <0 & \text{if} \quad f_B > f_{\overline{B}}^*\end{cases} \tag{A10}$$

The functional forms of $f_{\overline{H}}^*$ and $f_{\overline{B}}^*$ are quite lengthy and difficult to obtain. Therefore, I use a numerical example to show that these maxima exist and that they fall in the intervals given by (A3) and (15). Assume $g_H=g_B=0$, $l_H=l_B=0$, $\varepsilon_A=0.05$, $\varepsilon_{A,max}=0.1$, $\varepsilon_C=0.05$, and $\varepsilon_{C,max}=0.5$. The parameter value $\rho_H=0.2$ is used in the case of $\underline{H}$, and $\rho_B=0.9$ is used in

the case of $\overline{B}$. Using these values, one finds f_H*= 5.1205 and f_B*= 5.7622, as can be seen in Figure 2 and Figure 3.

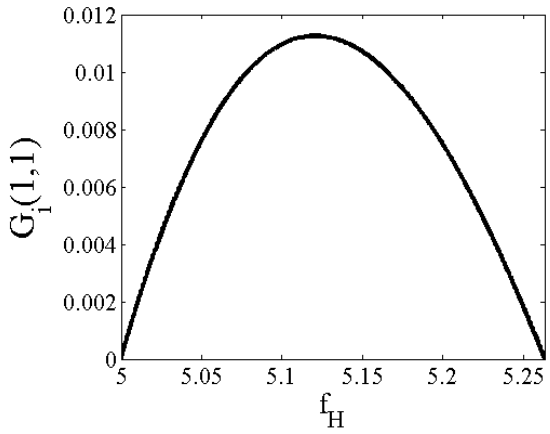

Figure 2: Opt. sanction f_H* (uniform distribution)

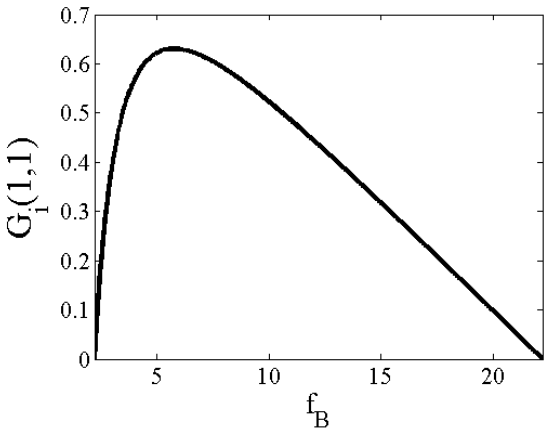

Figure 3: Opt. sanction f_B* (uniform distribution)

The same qualitative conclusions can be derived when using a bell-shaped distribution function. In particular, I assume that the error probability $e_{A,i}$ follows a censored normal distribution with a mean $\mu=\varepsilon_A$ and a standard deviation $\sigma=0.25\varepsilon_A$ in the interval $(0,\varepsilon_{A,max})$, i.e., $e_{A,i}\sim CN(\varepsilon_A,0.25\varepsilon_A,0,\varepsilon_{A,max})$. The probability of a mistaken acquittal is assumed to be distributed accordingly, i.e., $e_{C,i}\sim CN(\varepsilon_C,0.25\varepsilon_C,0,\varepsilon_{C,max})$. Normal distributions have also been used by Craswell and Calfee (1986), for example. Under these assumptions, the equivalents of Figures 2 and 3 are derived. As expected, the exact shape of the resulting functions, which are shown in Figures 4 and 5, is affected by the assumption of a bell-shaped distribution. The inverse u-shape, however, can still be observed.

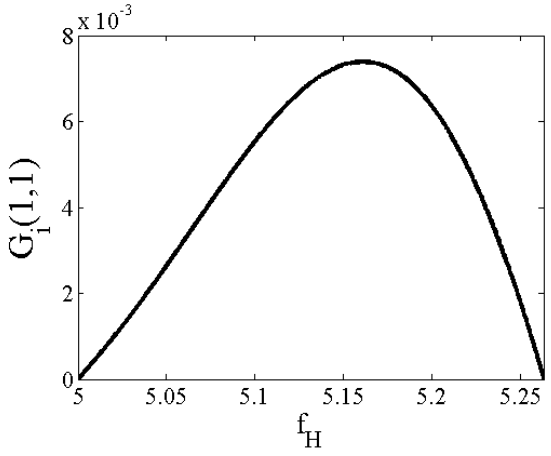

Figure 4: Optimal sanction f_H* (truncated normal)

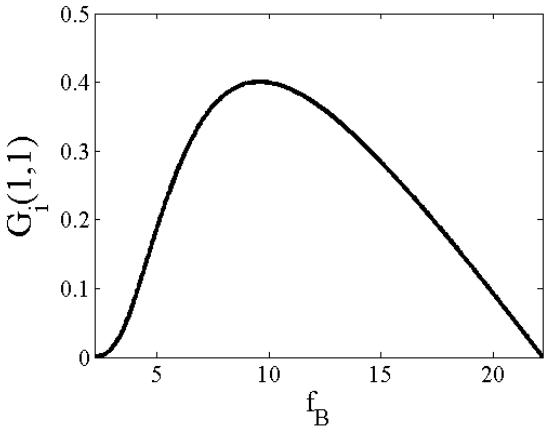

Figure 5: Optimal sanction f_B* (truncated normal)

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