

Three Essays on Leniency Policies

by

Michel Cloutier

A thesis submitted to the
Department of Economics
in conformity with the requirements for
the degree of Doctor of Philosophy

Queen's University
Kingston, Ontario, Canada

August 2014

Copyright © **Michel Cloutier**, 2014

Abstract

This thesis presents three papers in Competition Economics. The unifying theme is leniency policies from an international perspective; that is, I investigate theoretically and empirically the design and effectiveness of leniency policies in major jurisdictions: U.S. Department of Justice's Antitrust Section, European Commission's DG-COMP and Canada's Competition Bureau. A corporation (or an individual) may be granted a lenient treatment in terms of financial fine and/or jail time by confessing its (his/her) information about the collusive activity. Such policies aim at deterring and forcing desistance of this illegal practice. According to some metrics, leniency policies are very effective tools. Other metrics result in more nuanced conclusions, as tested. Using a standard method in industrial organization research with firm-level data, I estimate the effect on corporations' behavior from the amendment in 1993 of the U.S. Corporate Leniency Program. One key element for understanding the mechanisms driving a corporation's application for leniency lies in the nature of the information transferred from the applicant to the competition agency. I claim that by making the lenient fine conditional on this information, a competition agency will receive higher quality information and promote a higher welfare standard. The accrued savings in prosecution resources justifies the benefit of this conditioning. Another key element is the interaction of corporate and individual leniency policies. I claim that a competition agency should align its resources with the leniency policies in place based on two variables: the degree to which collusion affects the worker and the profit margin of collusion over the competitive level.

Acknowledgments

The end of this PhD thesis is the beginning of a new life. Completing this thesis was quite an emotionally charged roller coaster and, definitely, harder than expected when I started the PhD program years ago. But, here I am, still alive, and wonderfully thrilled about the end of this ride. As anything in life, it would have been hell on earth without the help of some people.

First, I thank my advisor Ján Zábajník for his guidance and patience. Ján, you have this spark, this epsilon, this gift that defines you as a researcher and as an advisor from which I had the privilege to learn from. I will remember the clouds when exiting your office just before the upcoming shiny morning when I implement your (correct) “wild guess”. Thank you. My work has also hugely benefited from comments and insights of numerous people. I am grateful to Susumu Imai, Ruqu Wang, Veikko Thiele, Jean-Étienne De Bettignies, Natalia Mishagina, and Kerry Hatzipantos for their expertise and support. I also thank Roger Ware and Marissa Ginn for the career advice about the world of economic consulting.

A special thanks to my department buddies most especially to the original French connection Jean-Denis G., Nicolas-G. M.M, Louis M.P. and Jean-François R., to my badminton partner Gao R., and to my office mate Derek S.. Without you, I would have fallen in a confusing meander.

Le fruit de mes efforts n'est rien comparé à l'amour et l'appui reçus de mes parents, mon frère, mon oncle Dan., ainsi que mon amoureuse. Merci.

Dedication

À Sophie, l'amour de ma vie: nous y voilà, enfin!

À Eva et Eli, un jour je vous raconterai cette histoire!

Contents

Abstract	i
Acknowledgments	ii
Dedication	iii
Contents	iv
List of Tables	vi
List of Figures	vii
Chapter 1: Introduction	1
1.1 Motivation	1
1.2 Summary	3
Chapter 2: Leniency Policy and Quality of Information	7
2.1 Introduction	7
2.1.1 Literature Review	10
2.2 Model	12
2.2.1 Environment	12
2.2.2 Timing	14
2.2.3 Strategy	15
2.2.4 Equilibrium	16
2.2.5 Subgame Perfect Equilibria	25
2.3 Comparative Statics	30
2.4 Antitrust Agency	32
2.5 Comparison with Motta and Polo (2003)	39
2.6 Policy Implications	42
2.7 Conclusion	44
Chapter 3: An Empirical Investigation of the U.S. Corporate Leniency Program	48
3.1 Introduction	48
3.2 Corporate Leniency Program	51

3.3	Literature Review	52
3.4	Data	55
3.5	Estimation Methodologies	58
3.6	Results	61
3.7	Policy Analysis	64
3.8	Caveat	64
3.9	Conclusion	65
Chapter 4: Managerial Hierarchy and Leniency Policies		72
4.1	Introduction	72
4.2	Literature	76
4.3	Model	77
4.4	A Simple Model: One Firm	79
	4.4.1 Worker	79
	4.4.2 Owner	81
	4.4.3 Equilibrium	82
	4.4.4 Antitrust Agency	84
4.5	Policy Analysis	88
4.6	Conclusion	89
Chapter A: Appendix		93

List of Tables

3.1	Summary Statistics	56
3.2	Number of Corporations in Sample per North American Industry Classification System (NAICS) Code	57
3.3	Difference-in-Difference Regression Results	66
3.4	Regression Results Without Endogenous Variables	67
3.5	Regression Results Including Lags	68
3.6	Quantile OLS Regression Results	69

List of Figures

2.1	Timeline of the Game	15
2.2	Existence of the Equilibrium Collude and Reveal Information	23
2.3	Existence of the Equilibrium Collude and No Leniency	26
2.4	Subgame Perfect Nash Equilibrium	29
2.5	Proposition 4. The AA implements CRI whenever firms play the dominant equilibrium CRI and the welfare obtained from this equilibrium is higher than the alternatives. It then selects the optimal policy given these restrictions yielding (α^*, p^*)	36
2.6	Proposition 5 (i). The AA implements CNL whenever firms play the dominant equilibrium CNL and the welfare obtained from this equilibrium is higher than the alternatives. It then selects the optimal policy given these restrictions yielding (α^*, p^*) . The figure depicts a corner solution.	37
2.7	Proposition 5 (ii). The AA implements CNL whenever firms play the dominant equilibrium CNL and the welfare obtained from this equilibrium is higher than the alternatives. It then selects the optimal policy given these restrictions yielding (α^*, p^*) . The figure depicts an interior solution.	38
3.1	Structural Break in 1993-1995	58
3.2	Justification for Using Difference-in-Difference Approach	59
4.1	Possible Outcomes	84

Chapter 1

Introduction

1.1 Motivation

Competition authorities prohibit collusive practices. Cartelistic behavior is a criminal offense and falls under per se treatment¹ in most jurisdictions. The canonical collusive outcome is characterized by an agreement in both price and allocation of supply across cartel members. As a result, cartels set an overcharge on the competitive price and pocket artificially high levels of profits. Typical overcharges vary greatly (from 0% to 2500%) and contemporaneous empirical analysis finds a median long-run markup overcharge of 25% (Connor, 2007). This impacts on social welfare and directly harms consumers.

The face of collusion has greatly evolved over the last decades mainly caused by tough anti-cartel enforcements. The 1990s were a great laboratory for competition agencies. The main enforcement tools developed and/or refined are corporate and individual penalties, the creation and extension of current international organizations, and transparency for leniency applicants. Such higher devotion to fighting the burden associated with this illegal conduct is essentially an attempt at inducing fear amongst cartel members.

For example, the Antitrust Section of U.S. Department of Justice has cleverly increased

¹An illegal per se conduct is without any beneficial effects and only with harmful effects. In court, only the existence of price fixing needs to be proven, opposed to proving the intent of the misconduct. See Viscusi et al. (2005) for more information on per se rule in Antitrust.

the corporate maximum statutory fine from \$10 million to \$100 million and the individual counterpart maximum statutory fine from \$350,000 to \$1 million,² and the maximum jail time from 3 to 10 years (Connor, 2007). Other jurisdictions have followed the U.S. example, notably the European Commission's DG-COMP and Canada's Competition Bureau.

Cooperation between agencies is now part of day-to-day counter-collusion tactical methods. The successful prosecution of the global lysine cartel in 1996 dynamized incentives for international cooperation.³ Since 1994, over 60 cartels have been revealed and were triggered by information shared by global institutions, such as the International Competition Network (Hammond, 2010).

The complementary measures associated with fine levels and international agency cooperation on deterrence and desistance explain a great deal of the contemporary fierce fight against collusion. Since 1993, companies have been fined billions of dollars for antitrust crimes (Hammond, 2010). In the U.S. over 90 percent of the total amount paid in fines are triggered by leniency applications. Also, the number of applications for leniency has unprecedentedly spiked at an average of 20 cases per year from a low one case per year. Harrington (2008, p.215) advocates that

[o]ne of the most important policy developments in U.S. antitrust policy in recent decades is [the] 1993 revision of the Corporate Leniency Program by the Department of Justice.

A corporation (or an individual) may be granted a lenient treatment in terms of financial fine and/or jail time by confessing its (his or her) information about the collusive illegal activity. Other technical conditions must also be satisfied. The first leniency policy was enacted under the U.S. Corporate Leniency Program (Department of Justice, 1993) and dates back to 1978. The current 1993 amended version primarily distinguishes itself on

²With extraordinary large firm, this maximum can reach \$25 US million.

³The securitization of documents was actually performed during a raid by the Federal Bureau of Investigation. This is another example of enhanced tools at competition agencies' disposition.

three regards: leniency is automatic to the first applicant, leniency is still available while an investigation has already begun, and managerial staff can come forward on their own (Hammond, 2010). The key change here is enhanced transparency. Following the U.S. example, other jurisdictions, notably Europe and Canada, have passed their version of the Corporate Leniency Program. Nowadays, over 50 jurisdictions have leniency policies leading to massive detection numbers and a worldwide unprecedented high level of fines.

This thesis studies, theoretically and empirically, the design and effectiveness of leniency policies. My hope is to contribute to a better understanding of the mechanisms by which leniency policies influence firm behavior and, ultimately, positively and normatively influence competition authority policy design. Each chapter highlights the contributions to both academic and practical worlds.

A detailed summary of the next three chapters, also forming three standalone papers, is provided below.

1.2 Summary

Chapter 2 is entitled “Leniency Policy and Quality of Information” and rests on the assumption that leniency policies are effective. I claim that this effectiveness can be enhanced by conditioning the lenient fine on the quality of the evidence. In exchange for a lower fine, a leniency applicant shares a firm’s privileged information on the cartel functioning (e.g., dates of meeting and pricing algorithm) with the antitrust agency. I examine the obtainable gain should an antitrust agency condition the lenient fine to be paid on the evidence turned in. This is directly in line with the European Commission Leniency Policy which dictates that “[c]ompanies [...] may benefit from a reduction of fines if they provide evidence that represents significant added value to that already in the Commission’s possession”.⁴ The analysis accounts for an important characteristic of leniency procedures in allowing firms to

⁴Available online, June 30, 2012, at <http://ec.europa.eu/competition/cartels/leniency/leniency.html>.

collect evidence of colluding practices. The main contribution of this chapter lies in this collection of evidence where previous literature assumed it exogenously provided. The main result demonstrates the effect of the quality of evidence on the sustainability of collusion; a more lenient antitrust agency induces firms to give away higher quality information, while at the same time creating greater incentives for firms to use the existent leniency policy. I also compare the impact of a competition agency respectively making or not making the lenient fine conditional on the turned evidence. The former situation dominates the latter in terms of welfare. The methodology used for the analysis is repeated game theory (Subgame Perfect Nash Equilibrium).

Chapter 3 is entitled “An Empirical Investigation of the U.S. Corporate Leniency Program”, and questions the effectiveness of the U.S. Corporate Leniency Program. The claimed success of leniency policies hinges on two measurable variables: the number of leniency applicants and the total monetary fine paid. Ultimately, the measure of success of such a policy should be accounted for in terms of the ratio of “the number of successfully prosecuted cartels using leniency policies” over “the number of active cartel members”, then and only then can a discussion regarding effectiveness of deterrence and desistance be accurate. To circumvent this difficulty, the current literature deals with a population of discovered cartels. Obviously, this leaves aside all other firms colluding. Thus, the literature remains silent on current cartel behavior. An alternative avenue is experimental economics. The promising avenue is still indirectly inflicted by empirical limitation since it, eventually, relies on parameterizations of the environment developed in empirical studies. I propose a solution that does not rely on a biased population of discovered cartels. I measure the impact of the amendment to the U.S. Corporate Leniency Program in 1993 on U.S. public companies. Results show that in the short run it is impossible to disentangle the effect of the policy on industries’ competitiveness (proxied by markup) while in the long run firms adjust their pricing to the policy, that is firms decrease their markup several years after the policy enactment. Results suggest

that the policy will become more effective in the years to come. The methodology used for this estimation is standard policy analysis technique in industrial organization (Quasi Difference-in-Difference estimation).

Chapter 4 is entitled “Managerial Hierarchy and Leniency Policies” and assumes that leniency policies are effective. The United States Corporate Leniency Program addresses both inter and intra firm incentives for an application to leniency. Horizontal concerns address corporations’ pricing strategy, punishment schemes and other means restricting competition. Several motives that may trigger an application for leniency based on horizontal concerns have been extensively studied in the literature. Vertical concerns, on the other hand, address workers’ incentives to whistle-blow on owners’ illegal conduct under the United States Leniency Policy for Individuals. Then, why would a worker apply for leniency in the first place? Again, several theories attempt to answer this question. All theories assume that companies are sufficiently wealthy and will always find a way to provide workers with a payment transfer that he or she will find convincing and, ultimately, lead him or her not to apply for leniency. This assumption is flawed and contradicted by real-life examples of workers actually coming forward to authorities. This study explores the mechanisms at play when each managerial level (vertical and horizontal motives) has a different incentive to apply for leniency in a private information economy. The competition agency, given a leniency policy, influences agents by means of a signal (message) about the likelihood of an investigation opening. Competition agencies demonstrate their intent to fight collusion, for example, by subsidizing workshops and in-house training on leniency policies. The underlying hypothesis is that a stronger signal sent by the agency will result in higher deterrence of colluding practices. I claim that a competition agency should align its resources with the leniency policies in place based on two variables: the degree to which collusion affects the worker and the profit margin of collusion over the competitive level. The methodology used for the analysis is Bayesian Equilibrium.

Bibliography

Connor, J. M. (2007). *Global Price Fixing*. Springer. Second Edition.

Department of Justice, U. S. (1993). Corporate Leniency Policy. The Antitrust Division, Available online, March 15, 2012, at <http://www.justice.gov/atr/public/guidelines/0091.htm>.

Hammond, S. D. (2010). The Evolution of Criminal Antitrust Enforcement Over the Last Two Decades. National Institute on White Collar Crime, Miami, Florida, February, Available online, March 15, 2012, at <http://www.justice.gov/atr/public/speeches/255515.htm>.

Harrington, J. (2008). Optimal Corporate Leniency Programs. *Journal of Industrial Economics* 56(2), 215–246.

Viscusi, W. K., J. M. Vernon, and J. E. Harrington (2005). *Economics of Regulation and Antitrust*. The MIT Press; fourth edition.

Chapter 2

Leniency Policy and Quality of Information

2.1 Introduction

Leniency policies are effective tools for identifying and prosecuting colluding firms. In exchange for a lower fine, a leniency applicant shares privileged information on the functioning of the cartel with the antitrust agency.¹ The significant increase in the number of cases heard by competition courts and the concurrent increase in subsequent convictions spurred by leniency applicants giving away “smoking gun” evidence on the colluding practices emphasize the effectiveness of leniency policies (Hammond, 2009). The recent success of these policies beginning with the 1993 revision of the Corporate Leniency Program in the United States inspired a decade of research that still tries to understand the complex mechanisms behind the apparent simple idea of a leniency policy. Some key features of leniency policies remain without theoretical foundation.

This paper examines the potential obtainable gains should an antitrust agency make the lenient fine to be paid conditional on the evidence proffered by an applicant being granted leniency. I build on Motta and Polo (2003) and consider an important characteristic of leniency procedures in allowing firms to collect evidence of colluding practices. Using repeated game theory, I show that the following three strategies are subgame perfect equilibria: firms

¹For example: the existence of a cartel, participants, dates, meetings and pricing algorithm.

choose (i) not to collude, (ii) to collude without the use of the leniency policy or (iii) to collude with the use of the leniency policy. My main result demonstrates the effect of the quality of the evidence on the sustainability of collusion. That is, a more lenient antitrust agency induces firms to disclose higher quality information, while at the same time creating a greater incentive for firms to apply for the leniency policy. I also solve for the optimal leniency policy set by the antitrust agency and show that an antitrust agency make the lenient fine conditional on the quality of the evidence dominates the unconditional alternative in terms of welfare.

This paper contributes to the economics literature on collusion, and, more specifically, to the leniency policy literature. I first link the quality of the evidence submitted with the behavior of colluding firms. Second, I relax current assumptions on strict leniency (100% fine discount) and on a 100% rate of conviction by focusing on moderate leniency (less than 100% fine discount) in allowing for an uncertain conviction. Finally, I set the environment to match current European and Canadian practices, as opposed to previous works that focus on the U.S. (Feess and Walzl, 2010) Before discussing the contributions in greater depth, I introduce the relevant institutions to highlight the distinctions from previous works.

Divided into three sections, the U. S. Corporate Leniency Program lists conditions for granting leniency to the first firm that reports the illegal activity. Section A focuses on leniency before an investigation is undertaken, Section B is interested in alternative requirements for granting leniency when an investigation is already underway and, finally, Section C discusses the fate of corporate directors, officers and employees when the firm has been granted leniency. This study focuses on leniency that is granted after an investigation has begun.² During an ongoing investigation, leniency will be granted to the first applicant that satisfies a set of predetermined criteria. Granting leniency to a corporation under Section B of the Corporate Leniency Program provides complete immunity from financial sanction

²An alternative would have been to focus on the period “before an investigation has started”.

and prosecution. This complete immunity is also known as strict leniency.

Elsewhere in the world, antitrust agencies proceed somewhat differently. For example, the European Commission Leniency Policy³ stipulates that once an investigation has begun, “companies [...] may benefit from a reduction of fines if they provide evidence that represents significant added value”. This reduction in fine is also known as *moderate* or *partial leniency*. The main distinction between the European policy and that of the U.S. derives from the plurality in the number of leniency beneficiaries and the conditionality on corporation “added value” to determine the extent to which leniency will be granted (expressed as a percentage of the full fine otherwise charged). In Canada, the Competition Bureau - Leniency Program is comparable to that of the European Union with regard to the treatment that firms receive once an investigation has begun.⁴

The quality of the evidence (“added value”) submitted is best illustrated by reviewing the now famous 2001 carbonless paper case (COMP/E-1/36.212). Carbonless paper, also known as self-copying paper, is used for the duplication of documents. The Official Journal of the European Union⁵ documents the decision of the European Commission on the case by giving precise details of the collusion agreements. Briefly, the case involved a continuing agreement resulting in price fixing between Sappi Limited and ten other companies over the period 1992-1995.⁶ As described in the Commission’s ruling, Sappi “submitted [...] information about the cartel [...] before the Commission had undertaken any investigation (p.69)”. Evidence provided by Sappi documents executives at cartel meetings and the algorithm for price fixing. In the end, Sappi received total immunity from the fine it would have paid had it not cooperated with the Commission. Following the opening of the investigation,

³Available online, March 1, 2012, at <http://ec.europa.eu/competition/cartels/leniency/leniency.html>

⁴Available online, March 1, 2012, at <http://www.competitionbureau.gc.ca/eic/site/cb-bc.nsf/eng/03288.html>

⁵Available online, March 1, 2012, at <http://eur-lex.europa.eu/JOIndex.do>

⁶The companies are Arjo Wiggins Appelton Limited, Bolloré SA, Carrs Paper Ltd, Distribuidora Vizcaina de Papeles S.L., Mitsubishi HiTech Paper Bielefeld GmbH, Papelera Guipuzcoana de Zicunaga SA, Papeteries Mougeot SA, Papierfabrik August Koehler AG, Torraspapel SA and Zanders Feinpapiere AG.

other corporations decided to take advantage of the Leniency Program. Depending on their level of cooperation with the European Commission and the quality of their evidence, these firms received moderate leniency somewhere between a 10 and 50 percent reduction in their penalties for sharing details on meetings, agreements, participating companies and executive responsibilities.

In the present framework, the quality of evidence plays a dual role. It entitles firms to benefit from an accrued benefit compared to a non-evidence based discount by inducing firms to pay a lower fraction of the full fine paid if not applying for leniency. This feature leads these firms to apply for leniency more often. However, a higher quality of evidence implies that the antitrust agency is more likely to apprehend cartel members, which now occurs at a lower cost compared to a lower quality of evidence. More details are provided below.

2.1.1 Literature Review

The scholarly literature on the effectiveness of leniency policies is based on two assumptions.⁷⁸ First, the incriminating evidence transferred from the leniency applicant to the antitrust agency leads to strict leniency (100 percent fine discount) regardless of the quality of the evidence provided. Second, from the moment a firm applies for leniency, other cartel members are convicted with certainty (100 percent rate of conviction). These two assumptions, however, raise many questions when considering the applicability in real life. For example, such assumptions may provoke strategic manipulation of evidence (e.g., falsification), as the fine is determined independently of the accuracy of the information. Leniency programs draw a clear line between leniency application occurring “before” and leniency application occurring “during” an investigation. Hence, by limiting the analysis to strict leniency granted before as well as during an undergoing investigation, these theories do not fit well in moderate leniency jurisdictions such as Canada and the E.U. Finally, a context in

⁷Two good surveys are OECD (2005) and Spagnolo (2008).

⁸Exceptions are Feess and Walzl (2010) and Sibye (2010), discussed later.

which cartel members are convicted with certainty once a firm has applied for leniency fails to consider the possibility that the case may be dropped or may take longer than usual before a conviction is obtained. This situation implies that the leniency applicant can, potentially, face retaliation from fellow cartel members or, worse, face higher scrutiny from the antitrust agency if the case is dropped, thereby counter-acting the goal of the leniency policy in the first place.⁹ It is important to understand the impact of leniency policies in an environment where these two assumptions (strict leniency and 100 percent conviction rate) are relaxed. Moderate leniency distinguishes the present study from others by restricting leniency to the period “once an investigation has started” and by considering discounted fines. Regarding the 100 percent rate of conviction assumption, the evidence submitted by the applicant will allow for an additional probability ($w(e)$) of catching convicted cartel members. Only in a special case will a conviction occur for certain.¹⁰

Recent academic research on leniency policies, such as Motta and Polo (2003), Harrington (2008), Motchenkova (2009), Brenner (2009), and Miller (2009), have helped shape the understanding of the mechanisms at work from both positive and normative perspectives. Most of these earlier studies lack a systematic treatment regarding the quality of information. Only a limited number of papers address this issue.

Feess and Walzl (2010) analyze the impact of strict leniency granted to the first applicant before an investigation has begun in a context identical to the E.U. program in the period pre-2002.¹¹ These authors discuss the pros and cons of allowing the antitrust agency to accept different amounts of evidence (low or high) and demonstrate the suboptimality of offering leniency to the low evidence provider and the optimality of granting leniency to the high evidence provider. A high evidence provider makes leniency application necessary for obtaining a conviction and provides a justification for granting strict leniency to the high

⁹I do not model retaliation per se.

¹⁰This will be the case if the applicant has collected all available evidence.

¹¹Since 2002, in the European Union, firms are only granted strict leniency before an investigation has begun.

evidence provider.

Similarly, Sibye (2010) investigates the relationship between moderate leniency and the asymmetry in the information submitted by firms to the competition agency. By excluding low evidence firms from leniency programs, the author concludes that a firm should be granted leniency only if the firm adds significant value to the competition agency's case in a manner that is directly consistent with the current European Commission program.

Both Feess and Walzl (2010) and Sibye (2010) view the information creation as an exogenous process,¹² while as we know, firms are well aware that, following an agreement, they face the choice of retaining certain parts of the discussions. I address this issue by endogenizing the amount of evidence retained by corporations. This methodology allows one to quantify the linkage between leniency discounts and the cost of keeping the incriminating evidence, hence providing a better understanding of a firm's decision and motivation.

The rest of the paper is organized as follows. In Section 2, I describe the model. The antitrust agency is introduced in Section 3, followed by my theoretical findings in Section 4. In Section 5, I compare my results with those of Motta and Polo (2003), and in Section 6, I discuss some policy implications. Section 7 concludes the paper and presents future avenues of research.

2.2 Model

2.2.1 Environment

The game has two firms and an antitrust agency (AA). Firms compete in quantity *à la Cournot* an infinite number of times. During every period, a firm faces a stage game identical to the prisoners' dilemma represented by the matrix below. The following relationship between payoffs hold: $\pi_D > \pi_M > \pi_N > \pi_M^D$, defined, respectively, as the profits resulting from a deviation from collusion, half the monopoly profit, the Cournot Nash equilibrium

¹²The information in hand is independent of firms' behavior. It appears to fall from sky.

profit, and the profit if the other player has deviated from collusion.¹³

	Collusion	No Collusion
Collusion	(π_M, π_M)	(π_M^D, π_D)
No Collusion	(π_D, π_M^D)	(π_N, π_N)

In addition to quantity, firms choose the amount of information, e , revealing the level of their implication in the collusion agreement and, more importantly, their rivals' implication.¹⁴ This collection of information happens at a cost $C(e) = c\frac{e^2}{2}$. Incriminating evidence is collected in the first period and will be used by a firm in exchange for a lenient fine from the antitrust agency. A firm applying for leniency faces a fine $R(e) = sF - er$, where $r, F \geq 0$ and $s \in [0, 1]$. The parameter s denotes the level effect of leniency on the fine; that is, a more lenient agency has a lower s , thus inducing firms to pay a smaller fraction of the full fine F independent of evidence e . The parameter r denotes the marginal effect of the quality of information (e); that is, a more lenient agency has a higher r and is more sensitive to the information revealed by the leniency applicant. I later investigate the effect of variations in s, r and F on firm behavior.

Note that a colluding firm can choose not to accumulate any information ($e = 0$). If so, a firm faces the probability p of being convicted by the AA once the investigation opens, which occurs with probability α . In that event, the firm faces the full fine F .

Firms punish a deviator from collusion using a grim trigger strategy. As is common in applied works in the repeated game literature, my interest is in symmetric equilibria.

Even though I analyze symmetric equilibria, I still must clarify what happens when one firm applies for leniency and the other does not. On the applicant's side, nothing changes, and it pays the lenient fine $R(e)$ once the investigation opens. From the agency's perspective, if it is unable to catch the non-applicant on its own, it can then use the available information

¹³I limit the analysis to firms sustaining the monopoly outcome, as it is a study about collusion. Other quantities can, in fact, be sustained using the appropriate discount factor (Folk Theorem).

¹⁴Following up on the carbonless paper case, examples of information collected are time and frequency of meetings, people at meetings, pricing algorithms, etc.

e and catch the non-applicant with probability $w(e) = e$. Similarly, if two firms apply for leniency at the same time, both pay the lenient fine, and the AA will save prosecution resources (as there are only two firms in the industry).

As for the antitrust agency, it chooses the following policy parameters: the probability of opening an investigation, α ; the probability of leading a successful investigation, p ; the full fine faced by colluding firms, F ; the level leniency parameter, s ; and the marginal leniency parameter, r . The probabilities can be interpreted as resources to fight collusion at the agency's discretion. From the antitrust agency's perspective, the problem is to choose optimally $\{\alpha, p, s, r, F\}$ to maximize societal welfare. The maximization of societal welfare is subject to a budget constraint, $M \geq 0$, determining the optimal combination of p and q and, also, a "political fund", $M_R \geq 0$ determining the minimum value of the leniency fine. These two components are independent from one another.

The following subsection describes the timing of the game.

2.2.2 Timing

At time $t = 0$, the antitrust agency determines the policy parameters $\{\alpha, p, s, r, F\}$.¹⁵ In $t = 1$, firms select a strategy determining the extent of their colluding practices when the investigation opens in period $t = 2$. If colluding, a firm then chooses to collect (apply for leniency) or not (no application for leniency) information in $t = 1$ about colluding arrangements (meetings, people, etc). Period $t = 2$ has the following structure: an investigation opens with probability α and (i) if a firm chooses to collect information in $t = 1$, it gives its incriminating evidence (e) to the AA, pays the lenient fine $R(e)$ and reverts to the Cournot Nash outcome forever; otherwise, (ii) if a firm chooses not to collect information in $t = 1$, with probability p (If the other firm has applied for leniency, this probability becomes $p + (1 - p)w(e)$), it will be fined F , and forced to the Cournot Nash outcome forever. On

¹⁵The optimal policy choice $\{\alpha^*, p^*, s^*, r^*, F^*\}$ will be detailed in Section 4

the other hand, with probability $1 - \alpha$, no investigation opens and firms continue with their previous arrangement (collusion or not). Figure 2.1 summarizes the timeline.

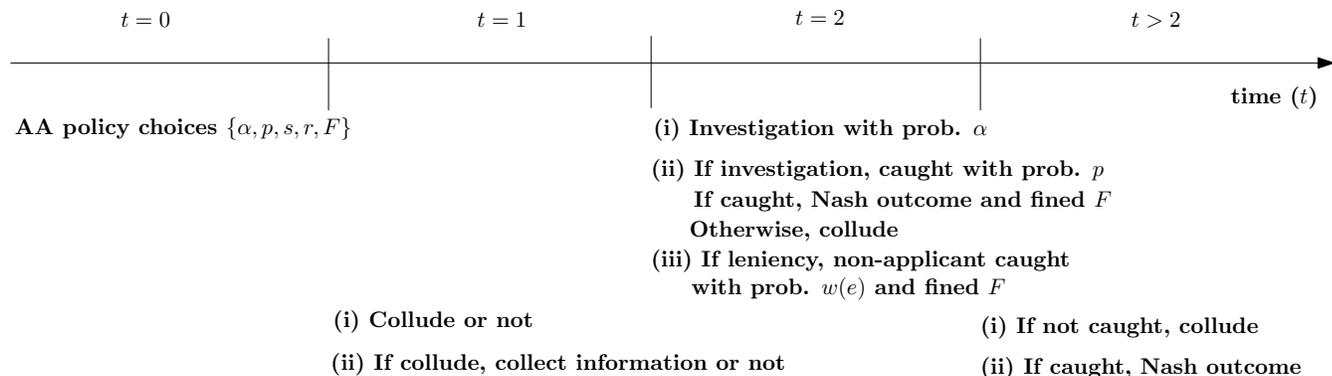


Figure 2.1: Timeline of the Game

2.2.3 Strategy

I introduce the concepts of action, payoff, history, and strategy. The stage game has two players ($i \in \{1, 2\}$), a set of actions ($A_i = \{C, NC\}$), and payoffs ($u_i(a_i) : A_i \rightarrow \mathbb{R}$) given by the prisoner's dilemma matrix depicted above. The set of period $t \in \{1, 2, \dots\}$ histories ($h^t = (a^0, a^1, \dots, a^{t-1})$, where $a^0 = \{\emptyset\}$ and $a^t = (a_1^t, a_2^t)$ denotes a vector of players' actions at t) is a sequence of realized actions from all periods before t .

Now, in the present framework, there is another layer to the simple game described above (and so far identical to a two persons prisoners' dilemma). If colluding, firms can collect information in $t = 1$ with repercussion in $t = 2$ if a firm chooses leniency. So the action space for a colluding firm applying for leniency is slightly different than in a prisoners' dilemma. A firm applying for leniency has an action in $t = 1$ of $a_i^1 = \{C, e\}$, where C stands for collusion and e for the collected information. In $t = 2$, the applicant will simply deliver the information in hand, that is $a_i^2 = \{NC\}$, where NC stands for no-collusion.

I study three possible symmetric equilibria: *no-collusion*, *collude and reveal information* and *collude and no leniency*. Each will be represented by a corresponding strategy, where a

strategy is a mapping from the history set into an action $(\sigma_i(h^t) : H^t \rightarrow A_i, \text{ where } h^t \in H^t)$.

2.2.4 Equilibrium

The equilibrium concept is subgame perfect equilibrium. The following definitions are extracted from Mailath and Samuelson (2006). The first building block is the concept of Nash equilibrium. Intuitively, a Nash equilibrium is a strategy profile in which each player is best responding to the other player strategies, formally:

Definition: Nash Equilibrium. *The strategy profile σ is a Nash equilibrium of the repeated game if for all players i and strategies σ'_i ,*

$$U_i(\sigma) \geq U_i(\sigma'_i, \sigma_{-i}).$$

Then, if for each history the strategy profile is a Nash equilibrium, we say that the strategy profile is a Subgame Perfect Nash Equilibrium:

Definition: Subgame Perfect Nash Equilibrium. *A strategy profile σ is a subgame-perfect equilibrium of the repeated game if for all histories h^t , $\sigma(h^t)$ is a Nash equilibrium of the repeated game.*

To solve for subgame perfection in repeated games with perfect monitoring, I apply the one shot deviation principle and investigate the conditions under which an equilibrium exists and eventually fully characterize the equilibria. First, I define the one-shot deviation principle.

Definition: Profitable One-Shot Deviation. *Fix a profile of opponents' strategies σ_{-i} . A one-shot deviation $\hat{\sigma}_i$ from strategy σ_i is profitable if, at the history h^t for which $\hat{\sigma}_i(h^t) \neq \sigma_i(h^t)$,*

$$U_i(\hat{\sigma}_i(h^t), \sigma_{-i}(h^t)) > U_i(\sigma(h^t)) \equiv U_i(\sigma_i(h^t), \sigma_{-i}(h^t)).$$

I will look for profitable one-shot deviations to find subgame perfect equilibria. A profitable one-shot deviation exists when a player has an incentive to deviate from his or her strategy and obtain a higher expected utility level. I can now introduce the one-shot deviation principle.

Definition: One-shot Deviation Principle. *A strategy profile is subgame perfect if and only if there are no profitable one-shot deviations.*

No Collusion (NC)

A firm playing the strategy *no-collusion* ($\sigma_i^{NC}(h^t)$) will play the Cournot-Nash outcome in every period. Thus, rigorously, the strategy can be written as:

$$\sigma_i^{NC}(h^t) = NC \text{ for all } t \in \{1, 2, \dots\}$$

The expected discounted profit for this strategy is given by $V_{NC} = \frac{\pi_N}{1-\delta}$. It is never a best response for a firm playing the Cournot-Nash outcome to deviate to collusion when the other firm is playing the Nash outcome since it is the only Nash equilibrium of the stage game. Lemma 1 formalizes the result.

Lemma 1. *A subgame perfect equilibrium exists in which firms do not collude.*

Proof. This is a well known result. □

Collude and Reveal Information (CRI)

For this strategy, a firm colludes and collects information at time $t = 1$, and will apply for leniency if an investigation opens in time $t = 2$. If the investigation opens, the firm delivers every bit of information in its possession. If a deviation occurs, firms use Nash punishment forever with profits π_N in every period. The rigorous formulation of the strategy collude and reveal information ($\sigma_i^{CRI}(h^t)$) can be written as follows:

$$\sigma_i^{CRI}(h^t) = \begin{cases} C \text{ and } e & \text{if } t = 1 \text{ and will apply for leniency in } t = 2 \\ C & \text{if } a^\tau = (C, C), \tau \in \{1, 2, \dots, t-1\} \text{ and no investigation (or unsuccessful)} \\ NC & \text{Otherwise} \end{cases}$$

The expected discounted profit, V_{CRI} , of this strategy is the following:

$$V_{CRI} = \pi_M - C(e) + \delta \left\{ \alpha \left[\frac{\pi_N}{1-\delta} - R(e) \right] + (1-\alpha) \frac{\pi_M}{1-\delta} \right\}$$

From V_{CRI} , it is straightforward to determine the optimal amount of information (e^*) collected and delivered to the antitrust agency.

Choice of Quality of Information

Firms playing the strategy *collude and reveal information* have to choose the quality of information collected that will later be given to the agency. This choice of quality is defined over the support¹⁶ $e \in [0, 1]$ and limited by a cost on the acquisition of information $C(e)$. The choice of quality is performed by selecting the highest return on “investment” in quality given by the following:

$$\max_{e \in [0,1]} V_{CRI}(e)$$

The optimal information quality level, e^* , satisfies the following first-order condition:

$$-[C'(e) + \alpha\delta R'(e)] = 0 \tag{2.1}$$

I formalize this result in Lemma 2.

Lemma 2. *Higher quality of information (higher e) follows from a lower cost of accumulating*

¹⁶I assume that c is big enough such that $0 \leq \frac{\alpha\delta r}{c} \leq 1$

information (lower c), a higher value of the future (higher δ), a more lenient authority (higher r), and a higher probability of facing an investigation (higher α).

$$e^* = \frac{\alpha\delta r}{c}$$

Proof. Rewrite equation (2.1) using the functional forms $C(e) = c\frac{e^2}{2}$ and $R(e) = sF - er$ ¹⁷. □

Lemma 2 lists the factors driving the optimal choice of the quality of information, e . A higher likelihood of an investigation by the AA, α , induces firms to collect better quality evidence. A higher cost, c , of acquiring information dissuades firms from collecting information. A higher discount factor, δ , induces firms to collect more information since the upcoming investigation weighs in a firm current decision. Finally, a more lenient authority, r , induces a firm to share higher quality information.

Collude and No Leniency (CNL)

If firms are not benefiting from leniency because they evaluate the cost of acquiring information as too heavy or because they simply think they will not be successfully prosecuted, they can still collude and play the strategy *collude and no leniency* ($\sigma_i^{CNL}(h^t)$).

$$\sigma_i^{CNL}(h^t) = \begin{cases} C & \text{if } t = 1 \\ C & \text{if } a^\tau = (C, C), \tau \in \{1, 2, \dots, t-1\} \text{ and no investigation (or unsuccessful)} \\ NC & \text{Otherwise} \end{cases}$$

¹⁷Note that the second order derivative with respect to e is negative, implying a maximum:

$$\frac{d^2V_{CRI}(e)}{de^2} = -C''(e) - \alpha\delta R''(e) < 0$$

The expected profit (V_{CNL}) from colluding and not using leniency is the following:

$$V_{CNL} = \pi_M + \delta \left\{ \alpha \left[p \left(\frac{\pi_N}{1-\delta} - F \right) + (1-p) \frac{\pi_M}{1-\delta} \right] + (1-\alpha) \frac{\pi_M}{1-\delta} \right\}$$

Again, in $t = 1$, firms are colluding. In $t = 2$, either an investigation opens or not. If it opens, firms are caught with probability p and are forced to revert to the Cournot-Nash outcome; otherwise, firms continue on colluding forever.

One may be tempted to conclude that the strategy *collude and no leniency* is in fact a subset of the strategy *collude and reveal information* where $e = 0$. A closer look at the strategy *collude and reveal information* reveals that a firm playing the strategy and choosing $e = 0$ will be turning itself to the AA without any evidence implying a fine to be paid of sF for sure. As for a firm playing the strategy *collude and no leniency*, it will pay F with probability p contrasting with the strategy *collude and reveal information*.

In what follows, I solve for subgame perfect Nash equilibria by applying the one-shot deviation principle to the three potential equilibria: *no-collusion*, *collude and reveal information* and, finally, *collude and no leniency*.

Collude and Reveal Information

In the strategy *collude and reveal information*, firms collude and collect incriminating evidence at a cost $C(e)$ and pay a fine $R(e)$ to the AA when the investigation opens.

Recall the ex-ante expected payoff from this strategy:

$$V_{CRI} = \pi_M - C(e) + \delta \left\{ \alpha \left[\frac{\pi_N}{1-\delta} - R(e) \right] + (1-\alpha) \frac{\pi_M}{1-\delta} \right\}$$

Since the game can be divided in three stages: (i) $t = 1$, (ii) $t = 2$ and (iii) $t > 2$; a profitable deviation can then happen in $t = 1$, or in $t = 2$ or somewhere in $t > 2$.

In the first case, in $t = 1$, I define V_D and V_{DNL} as, respectively, the payoffs from a $t=1$

deviation from collusion and from a deviation from applying to leniency, where

$$\begin{aligned}
V_D &= \pi_D + \delta \frac{\pi_N}{1-\delta} \\
V_{DNL} &= \pi_M + \delta \left\{ \alpha \left[p \left(\frac{\pi_N}{1-\delta} - F \right) + (1-p)w(\hat{e}) \left(\frac{\pi_N}{1-\delta} - F \right) + \right. \right. \\
&\quad \left. \left. (1-p)(1-w(\hat{e})) \frac{\pi_M}{1-\delta} \right] + (1-\alpha) \frac{\pi_M}{1-\delta} \right\} \\
\Leftrightarrow V_{DNL} &= \pi_M + \delta \left\{ \alpha (p + (1-p)w(\hat{e})) \left(\frac{\pi_N}{1-\delta} - F \right) + \alpha(1-p)(1-w(\hat{e})) \frac{\pi_M}{1-\delta} + (1-\alpha) \frac{\pi_M}{1-\delta} \right\}.
\end{aligned}$$

In V_D , the deviating firm earns the deviating profit in $t = 1$ (recall that $\pi_D > \pi_M$) and faces the punishment for breaking the cartel agreement as the other firm reverts to the Cournot outcome (π_N) in periods $t > 1$. As for V_{DNL} , the colluding and deviating firm is not collecting any information in $t = 1$, implying no possibility for leniency in $t = 2$ if an investigation opens. In $t = 2$, the deviating firm faces the fine F if the investigation is successful (with probability $p + (1-p)w(\hat{e})$), where $w(\hat{e})$ is the probability of conviction relying solely on the evidence (\hat{e}) handed over by the leniency applicant (i.e., the other firm) to the AA. Alternatively, if no investigation opens, the firm continues colluding forever, free of any investigation.

The inequalities $V_{CRI} \geq \max\{V_D; V_{DNL}\}$ ensure that in period 1 neither firm has an incentive to deviate from the proposed equilibrium.

In the second case, a firm may profitably deviate in $t = 2$. Similarly to V_D in $t = 1$, if no investigation opens in $t = 2$, a firm can deviate from collusion with expected payoff given by V_D .¹⁸ The resulting inequality is identical as the one obtained from the stage $t > 2$ application of the one-shot deviation principle. This is given by the standard argument based on the Folk Theorem, where the inequality $\delta \geq \frac{\pi_D - \pi_M}{\pi_D - \pi_N}$ holds to sustain the collusive outcome.

¹⁸Note that a firm may be tempted to deviate by not revealing its collected evidence to the agency. This action is strictly dominated by revealing the evidence to the AA given the other firm will be revealing its information (symmetric equilibrium).

I can now describe the conditions for the existence of a subgame perfect equilibrium in which firms play the strategy *collude and reveal information* in Lemma 3.

Lemma 3. *For given policy values $\{\alpha, p, r, s, F\}$ a subgame perfect equilibrium in which firms play collude and reveal information¹⁹ exists if*

$$\alpha \leq \alpha_I \equiv \left\{ \alpha : -\frac{\alpha^2 \delta^2 r^2 (1 - \delta)}{2c} + \alpha \delta [\pi_M + sF(1 - \delta) - \pi_N] - [\pi_M - \pi_D(1 - \delta) - \delta \pi_N] = 0 \right\},$$

$$p \geq p_I(\alpha) \equiv 1 - \frac{Fc(1 - s) + \alpha \delta r^2 (1 - \delta)}{2(c - \alpha \delta r) [\pi_M - \pi_N + F(1 - \delta)]},$$

$$\delta \geq \delta_0 \equiv \frac{\pi_D - \pi_M}{\pi_D - \pi_N}.$$

This parameter space is non-empty.

Proof. See Appendix. □

Figure 2.2 illustrates Lemma 3 where small x's show the region where a SPNE exists for CRI. Hence the existence of the strategy CRI being an equilibrium is conditional on α taking small values and p taking high values. I now redo the exercise but this time for the strategy CNL.

Collude and No Leniency

In the strategy *collude and no leniency*, firms collude and do not apply for leniency (implying they collect no information).

Recall the ex-ante expected payoff for this strategy:

$$V_{CNL} = \pi_M + \delta \left\{ \alpha \left[p \left(\frac{\pi_N}{1 - \delta} - F \right) + (1 - p) \frac{\pi_M}{1 - \delta} \right] + (1 - \alpha) \frac{\pi_M}{1 - \delta} \right\}$$

¹⁹Recall that firms playing CRI optimally pick $e^* = \frac{\alpha \delta r}{c}$. In order to make the passage to a graphical analysis, I set $e = e^*$ everywhere, hence under CRI, there will be no e showing in the equation.

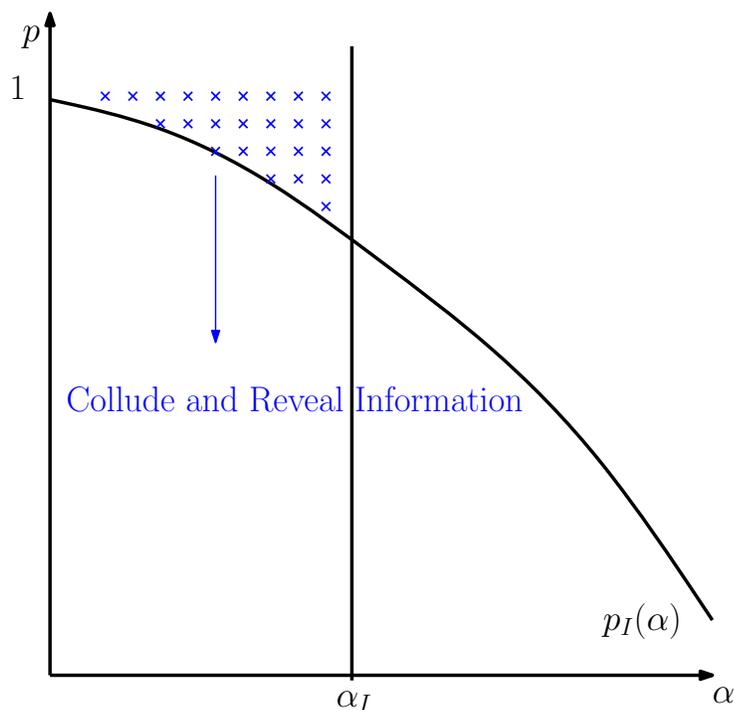


Figure 2.2: Existence of the Equilibrium Collude and Reveal Information

Similarly to the strategy *collude and reveal information*, a deviation may happen in one of the three stages: in $t = 1$, in $t = 2$, or in $t > 2$.

In the first case, in $t = 1$, I define V_D and V_{DRI} ²⁰ as, respectively, the payoffs from a deviation in $t = 1$ from collusion and from a deviation to applying for leniency (collecting

²⁰Since the deviating firm is the sole applicant to leniency, the optimal collected level of evidence differs from the one calculated for strategy CRI. After optimizing the expected profit from the deviator, the optimal level of e becomes:

$$e_{DRI}^* = \frac{\alpha\delta[r(1-\delta) - (1-p)(\pi_M - \pi_N)]}{c(1-\delta)}.$$

Again, I impose that $e \in [0, 1]$. This implies the additional assumption that

$$r \geq \underline{r} \equiv \frac{\pi_M - \pi_N}{1-\delta}$$

information), where

$$\begin{aligned}
V_D &= \pi_D + \delta \frac{\pi_N}{1 - \delta} \\
V_{DRI} &= \pi_M - C(e) + \delta \left\{ \alpha \left[p \left(\frac{\pi_N}{1 - \delta} - R(e) \right) + (1 - p)w(e) \left(\frac{\pi_N}{1 - \delta} - R(e) \right) \right. \right. \\
&\quad \left. \left. + (1 - p)(1 - w(e)) \left(\frac{\pi_M}{1 - \delta} - R(e) \right) \right] + (1 - \alpha) \frac{\pi_M}{1 - \delta} \right\} \\
\Leftrightarrow V_{DRI} &= \pi_M - C(e) + \delta \left\{ -\alpha R(e) + \alpha p \frac{\pi_N}{1 - \delta} + \alpha(1 - p) \frac{\pi_M}{1 - \delta} \right. \\
&\quad \left. - \alpha(1 - p)w(e) \frac{(\pi_M - \pi_N)}{1 - \delta} + (1 - \alpha) \frac{\pi_M}{1 - \delta} \right\}.
\end{aligned}$$

V_D is identical as before. As for V_{DRI} , the colluding and deviating firm is now collecting information in $t = 1$, implying a lenient fine in $t = 2$ if an investigation opens. Even though the firm shares its incriminating evidence with the AA, the actual conviction of the rival is uncertain. In $t = 2$, since the other firm did not apply for leniency, the deviating firm is the sole beneficiary of leniency, where with probability $p + (1 - p)w(e)$ the rival will be caught. Again, I impose that once the investigation opens, independently of the prosecution results, a firm applying to leniency pays the fine $R(e)$. Alternatively, if no investigation opens or if the investigation is unsuccessful (with probability $\alpha(1 - p)(1 - w(e)) + (1 - \alpha)$), the firms continue on colluding free of any investigation in the future.

The inequalities $V_{CNL} \geq \max\{V_D; V_{DRI}\}$ ensure that in period 1 neither firm has an incentive to deviate from the proposed equilibrium.

In the second case, a firm may deviate in $t = 2$. Similarly to V_D in $t = 1$, V_D denotes the expected profit from a deviation from collusion in $t = 2$. This can happen if an investigation is unsuccessful (with probability $\alpha(1 - p)$) or if no investigation opens (with probability $1 - \alpha$). The resulting inequality is identical to the one obtained when looking at profitable deviations after $t = 2$. This is again given by the standard argument based on the Folk Theorem, where $\delta \geq \frac{\pi_D - \pi_M}{\pi_D - \pi_N}$ should hold to sustain the collusive outcome.

I can now describe the conditions for the existence of a subgame perfect equilibrium in which firms play the strategy *collude and no leniency* in Lemma 4.

Lemma 4. *For given policy values $\{\alpha, p, r, s, F\}$, a subgame perfect equilibrium in which firms collude and use no leniency²¹ exists if*

$$p \leq p_{NL}(\alpha) \equiv \frac{\pi_M - (1 - \delta)\pi_D - \delta\pi_N}{\alpha\delta[\pi_M + F(1 - \delta) - \pi_N]},$$

$$\alpha \leq \alpha_{NL}(p) \equiv \frac{2F(s - p)c(1 - \delta)^2}{\delta \left\{ r(1 - \delta) - (1 - p)(\pi_M - \pi_N) \right\}^2},$$

$$\delta \geq \delta_0.$$

This parameter space is non-empty.

Proof. See the Appendix. □

Figure 2.3 illustrates Lemma 4 where small dots represent the solution region.

2.2.5 Subgame Perfect Equilibria

The equilibrium regions for the different strategies (CRI, CNL and NC) may intersect for some values of α and p depending on the value of r, s, F and c . From Lemma 1, independently of the probabilities α and p , the strategy *no-collusion* is a subgame perfect equilibrium of this game. As Proposition 1 will show, firms can sustain a preferred strategy given the values of the policy parameters. Said otherwise, I will be looking at dominant equilibria from the point of view of the firms. The underlying assumption is that a firm will always pick the equilibrium yielding the maximum expected profit.

To ensure no overlapping between the three existing equilibria, I restrict the analysis to regions where period $t = 1$ discounted payoff is strictly dominant. Recall period 1 discounted

²¹Note that, $e = e_{DRI}^*$ when a firm chooses to deviate from CNL to CRI in period $t = 1$. In Lemma 4, the term, $e_{DRI}^* = \frac{\alpha\delta[r(1-\delta) - (1-p)(\pi_M - \pi_N)]}{c(1-\delta)}$, does not appear since it has already been replaced by its value.

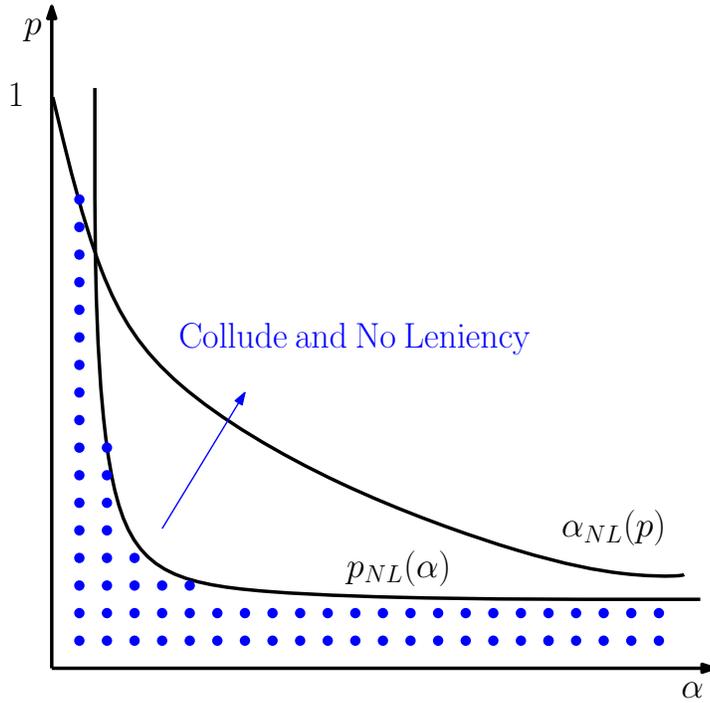


Figure 2.3: Existence of the Equilibrium Collude and No Leniency

payoff for the three equilibria *no collusion*, *collude and reveal information*, and *collude and no leniency*.

$$V_{NC} = \frac{\pi_N}{1 - \delta}$$

$$V_{CRI} = \pi_M - C(e) + \delta \left\{ \alpha \left[\frac{\pi_N}{1 - \delta} - R(e) \right] + (1 - \alpha) \frac{\pi_M}{1 - \delta} \right\}$$

$$V_{CNL} = \pi_M + \delta \left\{ \alpha \left[p \left(\frac{\pi_N}{1 - \delta} - F \right) + (1 - p) \frac{\pi_M}{1 - \delta} \right] + (1 - \alpha) \frac{\pi_M}{1 - \delta} \right\}$$

With these additional inequalities resulting from such a comparison and from Lemmas 1, 3 and 4, I obtain subgame perfection. I describe subgame perfect equilibria in Proposition 1.

Proposition 1. *For given policy values $\{\alpha, p, s, r \geq \underline{r}, F \geq \underline{F}\}$, the dominant Subgame Perfect Nash Equilibria of the repeated game are given by the following:*

$$\begin{aligned}
 \text{Collude and Reveal Information:} & \left\{ \begin{array}{l} \alpha \leq \min \{ \alpha_I; \alpha_{IN} \}, \\ p \geq \max \{ p_I(\alpha); p_{INL}(\alpha) \}, \text{ and} \\ \delta \geq \delta_0. \end{array} \right. \\
 \text{Collude and No Leniency:} & \left\{ \begin{array}{l} p \leq \min \{ p_{NL}(\alpha); p_{INL}(\alpha); p_{NLN}(\alpha) \}, \\ \alpha \leq \alpha_{NL}(p), \text{ and} \\ \delta \geq \delta_0. \end{array} \right. \\
 \text{No Collusion:} & \left\{ \begin{array}{l} \alpha \geq \alpha_{IN}, \text{ and} \\ p \geq p_{NLN}(\alpha). \end{array} \right. \\
 \text{Otherwise:} & \left\{ \text{The unique SPNE is NC} \right.
 \end{aligned}$$

Where:

$$\alpha_{IN} = \left\{ \alpha : -\frac{\alpha^2 \delta^2 r^2 (1 - \delta)}{2c} + \alpha \delta [\pi_M + F(1 - \delta) - \pi_N] - (\pi_M - \pi_N) = 0 \right\},$$

$$p_{NLN}(\alpha) \equiv \frac{\pi_M - \pi_N}{\alpha \delta [\pi_M + F(1 - \delta) - \pi_N]},$$

$$p_{INL}(\alpha) \equiv \frac{\pi_M - \pi_N + (1 - \delta) \left[sF - \frac{\alpha \delta r^2}{2c} \right]}{\pi_M + F(1 - \delta) - \pi_N},$$

$$F_{\Delta 1} = \frac{2r^2(1 - \delta)[\pi_M - \pi_D(1 - \delta) - \delta\pi_N]}{cs^2} - \frac{\pi_M - \pi_N}{s},$$

$$F_{\Delta 2} \equiv \sqrt{\frac{2r^2(\pi_M - \pi_N)}{cs^2(1 - \delta)} - \frac{\pi_M - \pi_N}{s(1 - \delta)}},$$

$$F_{R1} = \frac{\frac{r^2 \delta^2}{2c} - (\pi_D - \pi_M)}{\delta s},$$

$$F_{R2} \equiv \frac{2c(\pi_M - \pi_N) - \delta^2 r^2}{2cs\delta},$$

$$F_{INL} \equiv \frac{r^2 \delta (1 - \delta) - 2c(\pi_M - \pi_N)}{2cs(1 - \delta)},$$

$$F_{NLN} \equiv \frac{\pi_M - \pi_N}{\delta},$$

$$\underline{F} \equiv \max\{F_{\Delta 1}, F_{\Delta 2}, F_{R1}, F_{R2}, F_{INL}, F_{NLN}\},$$

$$\underline{r} = \frac{\pi_M - \pi_N}{1 - \delta}.$$

Proof. See the Appendix. □

Figure 2.4 illustrates the equilibria. From Lemma 1, independently of the probabilities (α, p) , the non-collusive equilibrium always exists. This existence does not necessarily mean dominance. Only dominant equilibria are depicted. As figure 2.4 shows, only when (α, p) are both sufficiently high, that the equilibrium *no-collusion* is dominant over the two other strategies.

Figure 2.4 results make sense. Whenever the gain from collusion is high and the probability of being successfully prosecuted is low, firms will collude. Whenever the likelihood

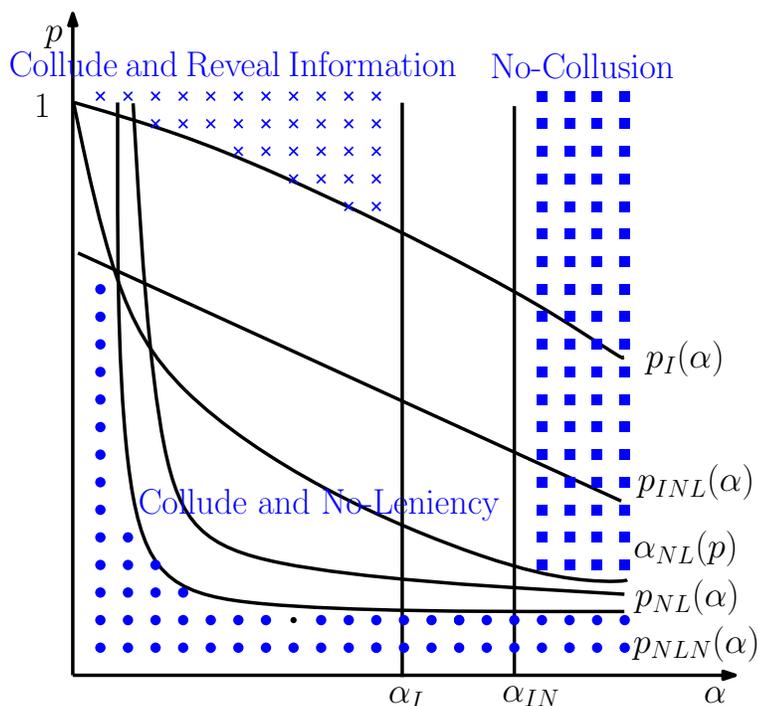


Figure 2.4: Subgame Perfect Nash Equilibrium

of a successful prosecution is too high, firms prefer to apply for leniency. Finally, again, whenever both probabilities are too high, firms prefer not to collude at all and revert to the Cournot-Nash outcome forever.

So far, the only limitations imposed on the parameters are $F \geq \underline{F}$ and $r \geq \underline{r}$. Previous studies using a similar framework (e.g., Motta and Polo (2003) and Motchenkova (2009)) each needed to restrict fine values for feasibility and a representation of the solution in the first quadrant determined by the probabilities (α, p) . This requirement is essential to give rise to a credible and harmful punishment as otherwise the expected fine for collusive behavior will be too low and equilibria CRI and CNL will always exist.

In the next section, I investigate variations in parameters, $\{s, r, F, c\}$, determining the frontlines solution region and extract intuitions on the way. The main purpose of the next section is to build the basics for the optimal policy derivation. In what follows, I focus on

the dominant equilibrium since the treatment is most straightforward.

2.3 Comparative Statics

In this section, I evaluate the impact of an infinitesimal change in the model parameters: $\{s, r, F, c\}$. I look at the effect of s and F on each equilibrium in Lemmas 5 and 6. Again, s represents the level gain from a firm applying for leniency ($R(e) = sF - er$) where F affects both the fine under leniency and the fine under no leniency.

Lemma 5. *An increase in F creates a larger (smaller, smaller) region where the equilibrium no-collusion (CRI, CNL) is a dominant SPNE.*

Proof. See the Appendix. □

This result occurs from the dual impact of F . It enters the strategy *collude and no leniency* as the fine to be paid if an investigation is successful. It also affects the strategy *collude and reveal information* via the fine to be paid. It is somewhat unsurprising that an increase in the fine to be paid will widen the range of parameters (α, p) such that NC is a dominant equilibrium.

Lemma 6 considers a similar scenario, but this time restricting the change to s which only enters the fine to be paid by firms applying to leniency.

Lemma 6. *An increase in s creates a larger (smaller, larger) region where the equilibrium no-collusion (CRI, CNL) is a dominant SPNE.*

Proof. See the Appendix. □

For the expansion of the region where the strategy *no-collusion* is an equilibrium, again, this comes as no surprise as this is a similar situation as Lemma 5 following a variation of F and its impact on the strategy *no-collusion*. The next lemmas look at variations

in parameters affecting the optimal quality of information: the marginal cost of acquiring information c and the marginal effect of r .

Recall Lemma 2, the quality of information is influenced by four variables: the marginal cost c of acquiring information, the discount factor δ , the probability of an investigation opening α and the leniency parameter r . The quality of information is negatively correlated with c , while positively correlated with α , δ , and r . Unfortunately, the effects of α and δ on the equilibria are impossible to sign leaving c and r as the single representatives of the quality of information.

In Lemma 7, I show that a decrease in the cost of acquiring information, c , induces a wider range of parameters (α, p) such that the strategy *collude and reveal information* is an equilibrium. Again, the direct effect of a lower cost, c , is the collection of a higher quality of information passed to the AA.

Lemma 7. *A decrease in c creates a larger region where the strategy collude and reveal information is a dominant SPNE.*

Proof. See the Appendix. □

Another channel influencing the quality of information is to vary the AA's receptiveness (r) to information. Lemma 8 presents the effect of increasing r .

Lemma 8. *An increase in r creates a larger region where the strategy collude and reveal information is a dominant SPNE.*

Proof. Identical to Lemma 7. □

Lemma 8 is interesting on several regards. First, a policy maker with a strong propensity for the implementation of leniency policies will force r to be high to extend the range of applicability of leniency. On one side, the firms prefer leniency for a wider range of (α, p) while at the same time it provides higher quality information to the AA. Similarly, Lemma 9 shows the effect on the solution region NC and CNL.

Lemma 9. *An increase in r , or a decrease in c , creates a smaller (smaller) region where the strategy no-collusion (CNL) is an SPNE.*

Proof. See the Appendix. □

This implies that two of the tools at the AA's disposition (r and s) yield a similar result in terms of leniency applications. Hence, if NC equilibrium is not feasible because, for example, of a financial restriction, both tools should be used together: r will control for the quality of information and s will induce firms to use leniency independently of the quality of information in hand. For example, if F has to be bounded above (as it is the case in most jurisdictions around the world), it is still possible to force firms to apply for leniency with high quality information by setting r to a high value while at the same time allowing a sufficiently high discount on the fine to be paid by setting s sufficient low.

In the next section, I solve for the optimal policy parameters. By doing so, I move to time $t = 0$ and solve for the whole game since the AA is the first player to move in the game.²²

2.4 Antitrust Agency

I investigate in this section the choice of the parameters $\{\alpha, p, s, r, F\}$ by the AA. Similarly to Motta and Polo (2003) and Motchenkova (2009), I argue that an AA always acts under a budget constraint. Its budget constraint is given by $Ap + B\alpha \leq M$, where $A, B > 0$. The coefficients A and B illustrate different impacts of, respectively, leading a successful investigation and opening an investigation, while M denotes the AA's budget for fighting cartels. By expressing the budget constraint in terms of α , I define $p_{BC}(\alpha)$. The AA also has a second, independent, "political" fund to compensate firms that comes forward (also called

²²See Figure 3.1.

courageous leniency). The maximum amount of this courageous fund is set to $M_R \geq 0$.²³

The agency's goal is to maximize welfare under a budget constraint. For example, if the cost of opening an investigation (proxied by α) is relatively high compared to the cost of prosecution (proxied by p), it may be preferable to the AA to settle on inducing firms to apply for leniency instead of the heavy burden of both opening an investigation and leading a successful prosecution.

The welfare function of each equilibrium differs and mainly depends on the probability of successfully avoiding collusion. As it is mathematically simpler to express welfare in terms of saving in deadweight loss (SDWL) rather than deadweight loss itself, the welfare according to the Nash-Cournot outcome (π_N) will be denoted by $SDWL$. Hence, the equilibrium where firms are not colluding is given by $W_{NC} = \frac{SDWL}{1-\delta} \equiv K$, where the agency saves a deadweight loss in every periods.

If firms prefer the symmetric equilibrium *collude and no-leniency*, society incurs savings in deadweight loss only when the cartel is successfully prosecuted (with probability αp) in which case the welfare is given by $W_{CNL} = \frac{\alpha p \delta SDWL}{1-\delta}$. Similarly for the equilibrium *collude and reveal information*, the opening of an investigation (with probability α) is sufficient to catch colluding firms and the welfare function is $W_{CRI} = -2C(e^*) + \frac{\alpha \delta SDWL}{1-\delta}$. The welfare comparison of the equilibrium is such that $W_{NC} \geq W_{CRI}$ and $W_{NC} \geq W_{CNL}$. The relation between W_{CRI} and W_{CNL} is for now ambiguous and will be discussed shortly.

The AA maximizes the welfare function with respect to the budget constraint. Since *no-collusion* is an equilibrium independently of the policy parameters, the question for the AA is simply a matter of budget and domination by firms. Recall that firms with colluding

²³This is a strong assumption that does require justification. First, this assumption simplifies the algebra, and, most importantly, allows for courageous leniency (money in exchange of information). I could have simply shut down the possibility of courageous leniency by forcing $R(e) \geq 0$ and all results will still hold. By restraining from doing so, I get an extra result in terms of comparability with the lenient fine non-conditional on evidence. Only Spagnolo (2004) addresses the issue of courageous leniency and, so far, no jurisdictions have adopted this practice even in the situation before an investigation opening. For practical reason, the "political" fund allows for compensation, but it is assumed to be sufficiently small. Political reasons justify the size of the fund.

possibilities will prefer the dominant Nash outcome only if α and p are sufficiently high.

I break the analysis in four parts. First, in Proposition 2, I derive the optimal fines and, in Propositions 3 to 5 derive, the optimal policies from the point of view of the AA.

Proposition 2. *The optimal policies $\{s^*, r^*, F^*\}$ that implement the equilibria are given by no-collusion ($F^* \rightarrow \infty, s^* = 1, r^* = \underline{r}$), collude and no leniency ($F^* = \underline{F}, s^* = 1, r^* = \underline{r}$), and collude and reveal information ($F^* = \underline{F}, s^* = 0, r^* = \bar{r}$)*

where:

$$\begin{aligned}\underline{F} &= \max\{F_{\Delta 1}, F_{\Delta 2}, F_{R1}, F_{R2}, F_{INL}, F_{NLN}\} \\ \underline{r} &= \frac{\pi_M - \pi_N}{1 - \delta} \\ \bar{r} &\equiv \sqrt{\frac{cM_R}{\alpha^* \delta}}.\end{aligned}$$

Proof. See the Appendix. □

Proposition 2 formalizes the intuition developed so far. If feasible, the AA will seek to implement the NC equilibrium as the welfare extracted from its application is higher than the two alternatives. The optimal policy sets the full fine to the highest feasible level. The equilibrium CNL calls for low values of F and r while a high value for s . On the other hand, the equilibrium CRI requires high values for r , and low values for s and F . As expected, F is the key parameter to address collusive Vs. non-collusive behavior while r and s serves the purpose of creating an incentive for CNL Vs. CRI.

Proposition 3 provides the optimal policies that implement the equilibrium *no-collusion* to be optimal.

Proposition 3. *The antitrust agency chooses to implement the dominant equilibrium no-collusion whenever the relative cost, A and B , and the budget constraint M are such that*

$p_{BC}(\alpha_{IN}) \geq p_{NLN}(\alpha_{IN})$. The optimal policy chosen is then the following:

$$\alpha^* \geq \alpha_{IN} \text{ and } p^* \in \left[p_{NLN}(\alpha^*), p_{BC}(\alpha^*) \right]$$

Proof. See the Appendix. □

This should come as no surprise since the equilibrium *no-collusion* yield the highest welfare. The only condition for its optimality is feasibility under the budget constraint M and the relative cost of opening an investigation, B , and of leading a successful investigation, A .

Similarly, proposition 4 presents the optimal policy when the equilibrium collude and reveal information yields a higher welfare than the two other equilibria.

Proposition 4. *The antitrust agency chooses to implement the dominant equilibrium collude and reveal information whenever A, B and M are such that $W_{CRI} \geq W_{CNL}$ and $p_{BC}(\alpha_{IN}) \leq p_{NLN}(\alpha_{IN})$. The optimal policy chosen by the AA is then*

$$\alpha^* = \left\{ \alpha : p_{BC}(\alpha) = \max \{ p_I(\alpha); p_{INL}(\alpha) \} \leq p_W, \alpha \leq \min \{ \alpha_I; \alpha_{IN} \} \right\} \text{ and } p^* = p_{BC}(\alpha^*)$$

where

$$p_W \equiv 1 - \frac{M_R}{2K}.$$

Proof. See the Appendix. □

Figure 2.5 illustrates Proposition 4. Again, the crosses represent the region where the equilibrium *collude and reveal information* dominates the two alternatives. For the equilibrium CRI to be implemented by the agency means that, first, NC is not feasible for the AA given its budget constraint and, second, that CRI induces a higher welfare than CNL. In the figure, the budget constraint does not cross the dominant *no-collusion* equilibrium under the specific values of A, B and M ($p_{BC}(\alpha_{IN}) < p_{NLN}(\alpha_{IN})$). The solution region

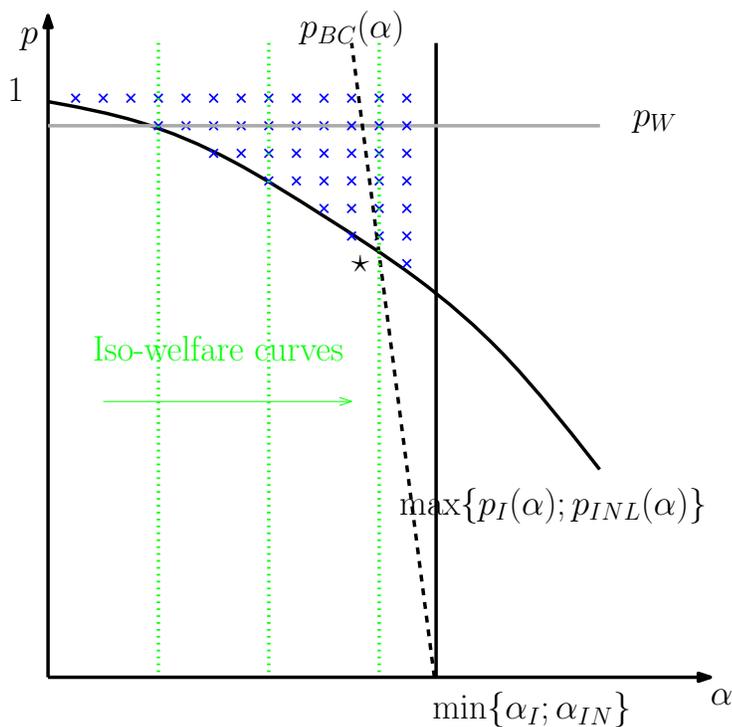


Figure 2.5: Proposition 4. The AA implements CRI whenever firms play the dominant equilibrium CRI and the welfare obtained from this equilibrium is higher than the alternatives. It then selects the optimal policy given these restrictions yielding (α^*, p^*) .

where CRI is an equilibrium bounded by four curves: incentive compatibility constraints ($\max\{p_I(\alpha); p_{INL}(\alpha)\}$, and $\min\{\alpha_I; \alpha_{IN}\}$), budget constraint $p_{BC}(\alpha)$ and p_W , where $p \leq p_W$ delimitates the region where CRI induces a higher welfare than CNL ($W_{CRI} \geq W_{CNL}$). Once this region has been identified, the AA selects the optimal policy (α, p) that yields the highest possible welfare. The iso-welfare curves are depicted and the resulting optimal policy is given by the point marked by a star symbol.

I conduct similar analysis in Proposition 5, but this time for the equilibrium *collude and no leniency*.

Proposition 5. *The antitrust agency chooses to implement the dominant equilibrium collude and no leniency whenever A, B and M are such that $W_{CNL} \geq W_{CRI}$ and $p_{BC}(\alpha_{IN}) \leq$*

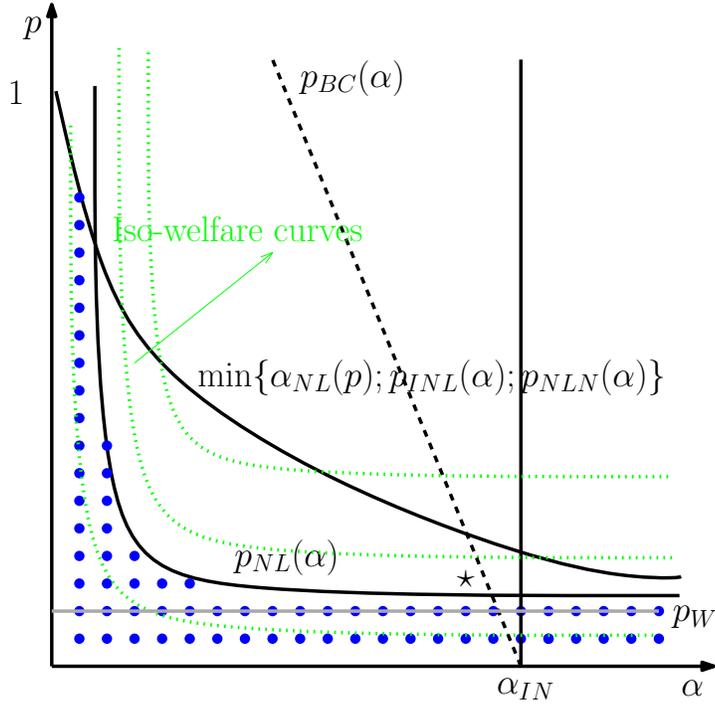


Figure 2.6: Proposition 5 (i). The AA implements CNL whenever firms play the dominant equilibrium CNL and the welfare obtained from this equilibrium is higher than the alternatives. It then selects the optimal policy given these restrictions yielding (α^*, p^*) . The figure depicts a corner solution.

$p_{NLN}(\alpha_{IN})$. The optimal policy chosen is either of the form (i) or of the form (ii):

$$(i) \alpha^* = \left\{ \alpha : p_{BC}(\alpha) = p_{NL}(\alpha) \geq p_W \right\} \text{ and } p^* = p_{BC}(\alpha^*)$$

$$(ii) \alpha^* = \left\{ \alpha : p'_{BC}(\alpha) = p'_{W_{CNL}}(\alpha), p_{BC}(\alpha) \geq p_W \right\} \text{ and } p^* = p_{BC}(\alpha^*)$$

Proof. See the Appendix. □

The two cases of Proposition 5 are depicted in Figures 2.6 and 2.7. Again, blue dots represent the region where *collude and no-leniency* dominates the alternatives. Stars identify the optimal policies and green curves represent iso-welfare curves. The curve $p_{NL}(\alpha)$ has the property of being one of the iso-welfare curves. Thus, this curve represents the frontier of

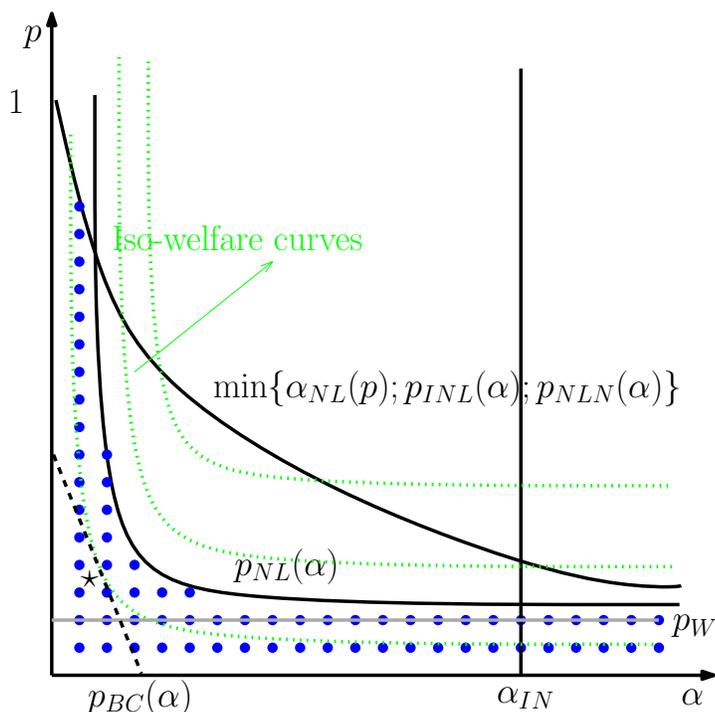


Figure 2.7: Proposition 5 (ii). The AA implements CNL whenever firms play the dominant equilibrium CNL and the welfare obtained from this equilibrium is higher than the alternatives. It then selects the optimal policy given these restrictions yielding (α^*, p^*) . The figure depicts an interior solution.

the highest attainable welfare. As presented in the discussion of Proposition 4, the region delimited by $p \leq p_W$ is such that if CRI dominates CNL then $p \geq p_W$ is the region where CNL dominates CRI.

Figure 2.6 demonstrates the case (i). Note that the equilibrium *no-collusion* will never be selected by the AA in that specific situation since the budget constraint does not have the necessary resources to sustain it. Now, whenever $p_{NL}(\alpha)$ crosses the budget constraint, $p_{BC}(\alpha)$ at a point (α^*, p^*) where $p^* \leq \min \left\{ p_{INL}(\alpha); p_{NLN}(\alpha) \right\}$ and $\alpha^* \leq \alpha_{NL}(p)$, it must be the case that the AA has attained the highest possible welfare.

A similar discussion applies for the case (ii) except that, this time, the budget constraint is below the curve $p_{NL}(\alpha)$. The optimal policy is then obtained by selecting the tangency

point between the budget constraint and an iso-welfare curve.

Additional insights can be derived from a comparison between my framework where the fine under leniency is conditional on the quality of information and the framework of Motta and Polo (2003). Such properties are discussed in the next section.

2.5 Comparison with Motta and Polo (2003)

The present framework builds on Motta and Polo (2003). The main point of departure is that I account for an important characteristic of leniency procedures in allowing firms to collect incriminating evidence. By setting a leniency based on the level of evidence, the AA incentivizes higher quality of information and, also, complements its own prosecution resources. The model in Motta and Polo (2003) is a special case of my framework. To obtain the authors' model, I set $e = 0$ and replace sF by R , where R is now the leniency fine. To resume, in the present framework $R(e) = R - er$ (conditional case) and in Motta and Polo (2003) the lenient fine is simply R (unconditional case).

In this section, I investigate the optimality of making the fine conditional on the evidence. Results show that both firms and AA gain from this addition. Proposition 6 describes the conditions under which firms prefer applying for leniency when the AA makes the fine conditional on the evidence turned in. As a reminder, the “political” fund (M_R), is an independent fund usable by the AA, if needed, that bound the maximum amount at the AA's disposition.

Proposition 6. *Making the fine conditional on the evidence induces firms to apply more often for leniency whenever the “political” fund is big enough, compared to not making the fine conditional on the evidence.*

Proof. See the Appendix. □

From Proposition 6, the additional tool at the AA's disposition (of making the fine

conditional on the quality of information once an investigation opens) widens the region where the equilibrium *collude and reveal information* is preferred by firms. This feature is explainable by one reason. The additional tool is favored by firms since it decreases the amount to be paid under leniency.

In Propositions 7 and 8, I perform similar analyses but this time for the other two equilibria.

Proposition 7. *Making the fine conditional on the evidence induces firms to prefer less to collude and not use leniency, compared to not making the fine conditional on the evidence.*

Proof. See the Appendix. □

Proposition 8. *Making the fine conditional on the evidence induces firms to prefer less the non-collusive outcome, compared to not making the fine conditional on the evidence.*

Proof. The only curve relevant to this Proposition is α_{IN} . The proof of Proposition 6 already contains the discussion demonstrating Proposition 8. □

Proposition 8 is an undesirable feature of the model. Firms will prefer to collude and reveal information to not colluding simply because it pays more to collude and reveal information while facing a lower lenient fine.

On a slightly different topic, one can notice that for the equilibrium CRI in Motta and Polo (2003) the optimal policy is to set $R = 0$, while in my framework $R(e^*) < 0$, hence we might be tempted to inquire about the optimality of setting $R < 0$ in the author's framework. Paying firms to come forward is called courageous leniency. Proposition 9 discusses such a possibility. Courageous leniency was first introduced by Spagnolo (2004) in a related context. The author defines the concept in an environment where the leniency program is self-financed by the cartel members caught as a result of leniency applications. Optimally, only the first applicant receives courageous leniency and the (negative) fine equals the sum of the collectively received fines. To my knowledge, Spagnolo (2004) and the present study,

in different settings, constitute the only two papers obtaining as an equilibrium that the AA should remunerate leniency applicants.

Proposition 9. *Courageous leniency is optimal under unconditional leniency only when $R \geq -R_1$, while always optimal under conditional leniency.*

Where:

$$R_1 \equiv \frac{\pi_M - \pi_N}{1 - \delta}.$$

Proof. See Appendix. □

Proposition 9 exposes a mathematical result that simply occurs because of the additional component in the fine. This conditionality on the evidence renders possible the usage of the “political fund”. No jurisdictions around the world use courageous leniency. As one can imagine, in practice, it is far from trivial to justify its usage as it is already so costly to lead a successful investigation even with direct insider evidence. Proposition 9 only hold if the political fund exists.

After discussing the additional benefit on the firms’ side and some induced differences between Motta and Polo (2003) and the present framework, I address the most relevant question: “Should the AA make the fine conditional on the quality of the evidence?”

Leniency policies were designed to deter and force desistance of colluding practices. Deterrence in the present framework implies an accrued welfare from sustaining the *non-collusive* equilibrium when conditioning on the evidence. As a corollary of Proposition 8, the additional variable “evidence” of the fine shrinks the region where the equilibrium no-collusion is preferred by firms. Hence, for the same budget constraint the AA has a lower possibility to choose from to sustain the equilibrium. Corollary 1 formally states this result.

Corollary 1. *If the goal of the antitrust agency is to deter colluding practices, making the fine conditional on the quality of the evidence destroys possibilities of reaching this goal, hence decreases welfare.*

Proof. Follows from the above discussion. □

Fortunately, the situation is different in terms of desistance. Forcing desistance of the colluding practices in the present framework implies an accrued welfare from sustaining the *leniency* equilibrium when conditioning on the evidence. Proposition 6 showed that the leniency equilibrium region is wider when making the fine conditional on the evidence. The AA has then a wider range of policy choices, in terms of α and p , to maximize societal welfare W_{CRI} . At the same time, the AA, when making the fine conditional on the evidence, faces the additional societal cost coming from the collection of the evidence $C(e)$. Hence, with a sufficiently low marginal cost of collecting the evidence, society ultimately benefit from the conditionality on the evidence. Corollary 2 summarizes the reasoning.

Corollary 2. *If the goal of the antitrust agency is to force desistance of colluding practices, making the fine conditional on the quality of the evidence increases welfare when the marginal cost of collecting the evidence tends to zero.*

Proof. Follows from the above discussion. □

I discuss the model policy implications in the next section.

2.6 Policy Implications

Several lessons can be learned from the above discussions. Most importantly, I provide justification for the use of leniency fines based on the quality of the evidence provided by firms. An AA providing the proper incentive for high quality evidence will benefit from the arrangement. Making the fine conditional on the quality of evidence has two effects: it favors an application for leniency (extended equilibrium region) and results in free prosecution resources for the AA ($w(e)$).

Under reasonable assumptions, I also reinforce the benefit of courageous leniency (i.e.,

money in exchange for information). Again, this result is striking and relies on the disentanglement of the two parts of the lenient fine: a level effect (sF) and a marginal effect (r). This division allows the agency to optimally shut down the level effect and solely rely on the marginal effect (the quality of the information) when sustaining the dominant equilibrium, *collude and reveal information*.

Returning to the definitions of those parameters allows for an alternate interpretation of the results. Recall that the level effect represents all non-evidence based factors considered when setting the optimal fine. In the European Commission Leniency Policy, the leniency percentage discount applicable depends mainly on three components: the evidence (“significant added value”), the timing and the level of cooperation. I have made the implicit assumption that these three components are not correlated. Hence, by optimally shutting down the level effect (non-direct-evidence based factors, such as the timing and the level of cooperation of an applicant) and by setting the marginal effect to the highest feasible value, I assign a weight to each of these three components. Both evidence and non-evidence based factors should be considered when determining the optimal lenient fine. In the current framework, only evidence based fine should be used to induce colluding firms to reveal information to the AA.

As a corollary to this last point, I address an interesting puzzle of competition economics: “Why do colluding firms keep incriminating evidence?”²⁴ According to the reality of the model, firms benefit more from collecting evidence with respect to fine reduction than from the alternatives (e.g., being the first applicant or the level of cooperation). Similar to the theory of contract in economics, when an AA increases its sensitivity to the evidence submitted, it encourages firms to collect higher quality information.

²⁴See Brenner (2009).

2.7 Conclusion

I study the impact of the quality of evidence given by firms to the AA when taking advantage of leniency programs. The discussion is set in an environment corresponding with the current European Commission (E.U.) and the Competition Bureau (Canada) in allowing firms to benefit from leniency based on the quality of the evidence provided once an investigation has ensued. Analytically, I use repeated game theory in a game similar to the prisoners' dilemma where colluding firms can be detected and may collect information about illegal activities to reduce the full fine otherwise paid.

Although simple, my framework elucidates the main motivation for a firm to offer higher quality information to receive a higher reward. The results show that when an AA is more sensitive to the evidence, firms will more often take advantage of the leniency program and, at the same time, submit higher quality information. As a corollary, I show that by making the fine conditional on the quality of the evidence, firms will more often apply for leniency than they would in the unconditional case. I also provide justification for the use of courageous leniency (i.e., paying firms to come forward).

The present chapter also raises questions about the use of moderate leniency (i.e., a reduction of fine). Future research should aim to address the issues of the timing of the applicant and the heterogeneity of firms and should empirically investigate the effect of the information revealed on firm deterrence.

The model is a rather static one even given the plurality of periods in the sense that the information given to the AA is completely independent of the collected information of rivals. Typically, once a *Race to the Courthouse* is underway, all firms want to benefit from leniency. Cooperation, timing and the information available ultimately dictate how lenient the agency will be (Harrington, 2008). In the present chapter, I have addressed the latter situation, thus leaving for future work the degree of cooperation and the timing of applications. The most promising avenue is perhaps the one of timing issues, as firms have a new incentive to act

according to the information held by the other firms.

With respect to firm heterogeneity, an interesting avenue of research would be to consider the effect of a leading firm that holds more information than smaller colluding firms, which hold less information. The big firm can either manipulate the information or use it to manipulate the colluding firms. At the same time, the leading firm can react using its more accurate information by issuing side payments to its smaller rivals, thus more efficiently sustaining the collusion agreement. This information then acts to counterbalance the effects of the leniency policy.

Finally, it will be informative to empirically estimate the impact of incriminating evidence on firm behavior and on the leniency of the fine granted. Brenner (2009) addresses a similar issue. The author tests and finds support for the hypothesis that under leniency, the total amount of the fine paid by prosecuted firms is higher than the total amount in the pre-leniency era. The total amount of the fine acts as a proxy for the information revealed, as better documented cases (with the help of leniency) lead to higher financial penalties from colluding firms (on average, a difference of €31 million). Certainly, it can be argued that this proxy is inadequate, as firms with more available information may more efficiently “game” the system by stabilizing the cartel agreement. More research regarding moderate leniency remains to be conducted, while at the same time, more empirical work on the topic, in general, should be a priority if we are to understand the impact of leniency policies.²⁵

²⁵I document the effectiveness of the Corporate Leniency Program in Cloutier (2013).

Bibliography

- Brenner, S. (2009). An Empirical Study of the European Corporate Leniency Program. *International Journal of Industrial Organization* 27(6), 639–645.
- Cloutier, M. (2013). An Empirical Investigation of the U.S. Corporate Leniency Program. Mimeo, Department of Economics, Queen’s University.
- Feess, E. and M. Walzl (2010). Evidence Dependence of Fine Reductions in Corporate Leniency Programs. *Journal of Institutional and Theoretical Economics* 166(4), 573–590.
- Hammond, S. D. (2009). Recent Developments Relating to the Antitrust Divisions’s Corporate Leniency Program. National Institute on White Collar Crime, San Francisco CA, March 5, Available online, March 15, 2012, at <http://www.justice.gov/atr/public/speeches/244840.htm>.
- Harrington, J. (2008). Optimal Corporate Leniency Programs. *Journal of Industrial Economics* 56(2), 215–246.
- Mailath, J. and L. Samuelson (2006). *Repeated Games and Reputations: Long-Run Relationships*. Oxford University Press.
- Miller, H. N. (2009). Strategic Leniency and Cartel Enforcement. *American Economic Review* 99(3), 750–768.
- Motchenkova, E. (2009). Effects of leniency programs on cartel stability: A timing game

- approach. Tilburg Law and Economic Center, Tilburg University, CentER Discussion paper 2004-98.
- Motta, M. and M. Polo (2003). Leniency Programs and Cartel Prosecution. *International Journal of Industrial Organization* 21(3), 347–379.
- OECD (2005). Hard Core Cartels Third report on the Implementation of the 1998 Council Recommendation. Available online, March 15, 2012, at: <http://www.oecd.org/dataoecd/58/1/35863307.pdf>.
- Sibye, F. (2010). Asymmetric Evidence and Optimal Leniency Programs. in Topics in Competition Policy: Cartels, Leniency, and Price Discrimination, PhD Thesis, University of Copenhagen.
- Spagnolo, G. (2004). Divide et Impera: Optimal Leniency Programs. University of Rome, Stockholm School of Economics, CEPR Discussion Paper No.4840.
- Spagnolo, G. (2008). Leniency and Whistleblowers in Antitrust. Chapter 7 in Buccirosi P. Handbook of Antitrust Economics, MIT Press, Cambridge, Massachusetts, U.S.A.

Chapter 3

An Empirical Investigation of the U.S. Corporate Leniency Program

3.1 Introduction

Measuring empirically the effectiveness of leniency policies on firm behavior is a major challenge for antitrust agencies. Leniency programs are designed to encourage colluding firms to denunciate one another and eventually break down price fixation or market sharing agreements. The main advantage of implementing a leniency policy is the small cost assigned to finding and successfully prosecuting colluding firms. As suggested by the recent increase in the number of successfully prosecuted cases, this type of policy ought to increase deterrence and desistance. But, does it really?

Antitrust agencies with leniency policies offer a degree of immunity and amnesty of prosecution in exchange for valuable incriminating evidence. Treatments differ depending on the jurisdiction and the timing of the leniency application. This may be the source of the success of the program as well as... the source of its failure. Harrington (2008) documents the three main forces at stake fighting each other to influence a firm's binary choice of applying or not for leniency. An application for leniency may be triggered by a cartel member cheating on the cartel. Elaborate schemes for punishing deviators include applying for leniency and delivering on a silver platter the cheating firm to the authority (Deviator Amnesty Effect).

An application for leniency may also be prompted by a shift in leniency policies escalating a firm's risk of being caught. In this scenario, a firm will rush to the antitrust agency to diminish the extent to which it will be punished (Race to the Courthouse Effect). So far, the two forces presented (i.e., Deviator Amnesty and Race to the Courthouse) relate to the effectiveness of the leniency policy. The third force (Cartel Amnesty Effect) lies in the fact that firms may simply use leniency to reduce the size of the penalty if caught colluding. The present study establishes which force is dominant.

This paper broadens the understanding of leniency policies by examining the role of the U.S. Department of Justice (DOJ) amendment of the Corporate Leniency Program in 1993 in destabilizing undetected (as well as detected) cartels. Using data from the Compustat database, I perform a linear difference-in-difference (DID) estimation to estimate the effect of the Corporate Leniency Program on the price markup in numerous industries.

The Corporate Leniency Program ought to affect firms on many levels. Ultimately, the measure of success of such a policy should be accounted for in terms of the ratio of “the number of successfully prosecuted cartels triggered by a leniency application” over “the number of active cartels”: then and only then can a discussion regarding effectiveness of deterrence and desistance be accurate. Obviously, the denominator of this ratio can at best be estimated without any real idea of its value. To overcome this difficulty, researchers¹ have instead focused on the numerator by characterizing the conditions to firms applying for leniency (more precisely, on firms that have been successfully prosecuted). This avenue has yielded interesting conclusions which will be discussed in the next section. Other avenues inspired by experimental economics recreate an environment where subjects play a game mimicking firms blowing the whistle on each other. Finally, the current approach considers a population of both colluding and not colluding firms, and investigates the impact of the amendment on firm-level data. Using firm-level data allows to investigate the effect of leniency policies on

¹With the exception of Klein (2011)

the variable of interest to the policy maker, which is not directly the number of active cars, but the market outcome. I investigate the most important component of the outcome measure: markup.

The difficulty of this outcome-based measurement is to disentangle the different possibilities of inception of the variation in markups. More specifically, it raises issues about finding the right predictors of a change in markups, that is, if it is due to the effect of a policy change or to other factors that may have influenced markups at the same time as the leniency policy. To deal with this issue, I follow the standard industrial organization literature and use industry concentration as the proxy for the level of competition in the industry. A concentrated industry will be deemed non-competitive and vice-versa for a non-concentrated industry. Following this line of thought, leniency policies are most likely to affect highly concentrated industries since collusion is more likely to be sustainable. Assuming parallelism across industries, that is, assuming that even though there may have been aggregate changes the year of the policy enactment, and there were no changes that affected only the concentrated industries, then, quasi DID can be used. A low concentration industry will act as a control group and a high concentration industry as a treatment group. The effect of a change in leniency policy will be measured by the differential change in markups between concentrated and non-concentrated industries.

In this paper, I evaluate the effect of the Corporate Leniency Program amendment in 1993. I find a non-significant effect on price markups on the short run while I find a significant effect in the longer run.

The paper is organized as follows: Section 2 provides a brief review of the literature, while Section 3 introduces the data. Section 4 presents the estimation strategy and Section 5 provides results of the analysis. Sections 6 and 7, respectively, discuss the results and possible extensions while Section 8 concludes.

3.2 Corporate Leniency Program

The original version of the Department of Justice (DOJ) Corporate Leniency Program dates from 1978. The program aims at deterring and forcing desistance of colluding practices. On paper, this first version had all the right elements in providing complete protection from criminal prosecution to trigger leniency applications. Unfortunately, the success of the program was mitigated as shown by the small number of leniency applications per year (an average of one case per year) and in no successful prosecution of international cartels. In 1993, the program was amended to deal with the various issues in the original program.

The major criticism of the 1978 Leniency Program was its lack of transparency. That is, a leniency applicant satisfying a set of pre-determined criteria was granted protection from criminal prosecution, but the actual outcome of the application was only awarded after the DOJ considered the issue case by case. This uncertainty seems to have prevented firms from applying.

The amendment of the Corporate Leniency Program in 1993 provided clearer guidelines regarding the outcome of an application and, also, increased the amount of compensation from cooperation. The new guidelines for leniency can be summarized as follows (Hammond, 2004). First, if there is no pre-existing investigation, the DOJ will grant leniency automatically to the first applicant. Second, even when an investigation is ongoing, the first applicant may be granted leniency. Hence, a firm may now apply before as well as during an under-going investigation. Finally, individual staff members (directors, officers and employees) can also apply for leniency.

On paper, the amendment was a big success: over \$5 billion in fines have been collected since 1996 from which 90 percent have been brought forward by leniency applicants, and recently over 50 international cartels were under investigation where, in more than half of them, firms have been granted leniency (Hammond, 2009). Following this “success”, other countries have adopted policies that are similar to the Corporate Leniency Program. Over

50 jurisdictions in the world have similar programs. Examples of them include Australia, Brazil, Canada, Japan, Korea, and the European Union (E.U.).

This paper takes a step back and inquires about another measure of success: firm behavior. The main motivation behind the present approach is the unobservable feature of the colluding firms' pool and the incapacity of past approaches to answer questions such as "What is the impact of the amendment of the Corporate Leniency Program in 1993 on firms' behavior?" I try to make a more formal assessment of the leniency program. The difficulty of this exercise lies in the fact that: the direct measure of success, the number of cartels before and after the program implementation, is unobservable. This problem is avoided by looking at an indirect measure of the outcome: the markup. Thus my approach does not require the knowledge of the number of cartels.

The next Section discusses the relevant literature.

3.3 Literature Review

The empirical literature on the effectiveness of leniency policies is divided into two literature strands: experimental economics and empirical studies. I briefly discuss the former, while discuss in detail the latter, which is closer to the present framework.

The growing literature in experimental economics, such as Bigoni et al. (2009), Hamaguchi et al. (2009), and Hinloopen and Soetevent (2008), build on the limitations of observable variables (e.g., number and duration of cartels) and indirect methods (e.g., pricing algorithm²) to conclude on the existence of collusion. For example, in laboratory, Hinloopen and Soetevent (2008) recreate the conditions for collusion by allowing subjects to engage in discussions ultimately leading to price fixing. Results are clear and show the accrued value of implementing leniency programs by means of higher deterrence, desistance, and harsher climate for sustaining pricing agreements compared to the status quo. This is definitely an

²See Harrington and Chang (2009) and Miller (2009).

avenue worth pursuing. At the same time, it is important to point out that rigorous empirical studies are still necessary for understanding these experiments. In the lab, parameters of the experimental environment need to be estimated for researchers conducting experimental studies. For experiments to be relevant in understanding the actual effect of leniency programs, parameters should mimic the actual environment of industries as close as possible. Such parameters can only be recovered following empirical studies based on real world data. This completes an overview of the literature on experimental economics applied to leniency policies. In what follows, I focus on empirical studies.

Miller (2009) tries to overcome the unobservability of cartels by structurally estimating a theoretical model and by using the data on filed violations of Section 1 of the Sherman Act over the period 1985-2005 to infer the discovery rate of cartels. The theoretical model and its empirical analogue show that the Corporate Leniency Program amendment in 1993 succeeded in enhancing both DOJ capabilities of detection and deterrence. Even though Miller (2009) found a way to avoid dealing exclusively with detected cartels, in the end, he still limits the analysis to public cases of prosecuted firms.

Brenner (2009) advocates that the benefit of leniency programs is mainly on the cost reduction of opening an investigation and leading a successful prosecution, by means of additional information revealed to the agency as well as on the shorter time between the detection and verdict period. Results are obtained using 61 cartel cases investigated and prosecuted by the European Commission between 1990 and 2003. The author concludes that leniency policies failed to deter colluding agreement, which is similar to the results obtained here. This paper also suffers from a reliance on a “prosecuted” population.

The closest work to mine is the one of Klein (2011). The author studies the impact of leniency policies over a 20 year period in a population of 23 E.U. countries. Instead of focusing on cartel detection, the author measures the effect of leniency policies on markups. After building industry specific price cost margins separately for each E.U. country, the author then

estimates whether a country specific leniency policy has an impact on an industry's price cost margin. Even though the approach does not suffer from the typical identification problem of limiting the analysis to public colluding agreements, it faces a potential endogeneity problem.

The change in price cost margin could be due to a country's specific policy changes or factors, other than the introduction of the said leniency policies. To deal with this endogeneity issue, Klein (2011) proposes several instruments, which he argues are correlated with a country's leniency policy but uncorrelated with any other policy or shocks that affect markups. One of the instruments used is other countries' leniency policy enactments. The E.U. is a much integrated economy where many large firms operate across member countries; another country's leniency policy could be directly related to a home country's cartel, and thus may change the profit margin. The second instrument is the agenda of political parties of the country. Obviously, a political party should simultaneously influence many other policies that could directly or indirectly affect firms' markups.

I complement Klein (2011) on several points. First, the present analysis uses data on the U.S. corporate population. The empirical analysis of the U.S. leniency policy, which is different from those of the E.U., would provide additional insights on the understanding of the leniency policy.³ More importantly, the present study uses firm level data from Compustat. This database tracks publicly traded firms. This is in contrast with Klein (2011) who calculates markup at the industry level data. Also, using firm level data instead of industry level data allows me to use richer and more relevant controls such as firm size, type of industry and industry concentration. The estimation makes use of a linear quasi DID model. I essentially consider firms within industries with a low concentration ratio as the control group and those with a high concentration ratio as the treatment group. Therefore, any changes that occur at the same time as the leniency policy would have no effect on the

³For example, the U.S. and E.U. have different treatments for applicants during an undergoing investigation. In the U.S. only the first applicant may receive leniency while, in the EU, all applicants provided they add value to the case, may be granted leniency.

parameter estimates as long as it affects the markup of both low and high concentration industries equally.⁴

In the next section, I describe the Compustat data I used and explain the construction of some of the variables that are used in the estimation.

3.4 Data

I rely on the Compustat database to get annual plant level data of all publicly traded firms in the United States over the period 1991 to 1997. Compustat excludes privately held firms.

The database includes for each firm the following annual variables: current asset, book value per share, capital, dividends, earnings per share, number of employees, inventory, closing price, gross profit, cost of goods sold, total revenues, operating expenses, geographic location, NAICS code, SIC code as well as CUSIPs.⁵

I present the summary statistics in Table 3.1. The gross profits span from -\$179M to \$39.2B for 2523 firms over the period 1991 to 1997. Note that negative values indicate losses. In Table 3.2, I show firm demographics for each industry. In the Compustat database, manufacturing firms (NAICS 31-33) have the highest intensity in terms of firm populations (1348 firms) while warehousing and storage (NAICS 49) as well as educational services (NAICS 61) have the lowest (6 firms).

I construct the dependent variable, price-cost margin (PCM), by subtracting the cost of goods sold from the total revenue and dividing by total revenue. I also construct industry level variables, such as market shares and HHI, by aggregating the data at the industry level

⁴Since I have detailed information on each publicly traded firm, I could have used different measures for classifying firms into treatment group and control group, other than the concentration ratio. For example, I could have used the measures of past markup or the highest market share firms only to do the DID analysis, since it is the high market share firms that are more likely to benefit from collusion. On the other hand, with industry level data, there are limits to the analysis one can conduct.

⁵For more information on variable descriptions, see Compustat help files online at <https://wrds-web.wharton.upenn.edu/wrds/>, accessed November, 1 2013

based on the three digit SIC industry code.⁶ Market shares and HHI are calculated using annual sales. Market shares are defined as the ratio of a firm's sales over industry total sales, while HHI is the sum of market shares squared of every firm for a given industry.

Next, I discuss how the treatment variable is constructed. One way to do this is to follow the standard DID framework and assign industries with high concentration ratio to be the potential treatment group and those with low concentration ratio to be the control group. This uses the idea that cartels can be formed and sustained more easily in industries with higher concentration ratios compared to industries with low concentration ratios. Therefore, the probability of a cartel existing is higher in highly concentrated industries, and thus anti-cartel policies such as leniency policies should be more effective. In this study, I adopt a quasi DID approach where the concentration ratio itself is used in the estimation as the continuous policy variation.

Table 3.1: Summary Statistics

	Unit	N	Mean	SD	Min	Max	P25	Med	P75
Gross Profit	\$M	17661	402	1589	-179	39279	9	43	199
Book-Value/Share	\$	-	8	10	-85	268	2	6	12
Capital	\$M	-	95	383	-1	8309	1	6	39
Dividends	\$M	-	30	147	0	4032	0	0	6
Earnings/Share	\$	-	0.6	2.5	-63.5	144.2	0	0.5	1.4
#Employees	K	-	7.4	28.0	0	825.0	0.2	1.0	4.2
Inventory	\$M	-	129	507	0	16497	2	12	66
Price Close	\$	-	18	19	0	487	5	12	26
Current Asset	\$M	-	401	1512	0	41338	15	56	232
Cost Goods Sold	\$M	-	857	3385	0	94127	19	91	425
Revenue	\$M	-	1259	4728	0	120279	31	143	645
Operating Expenses	\$M	-	1071	4111	0	111112	29	125	546

In Figure 3.1, I plot the evolution of the average PCM for U.S. public firms over time. We can see that the average markup declined immediately in year 1993 from 0.343 in 1992

⁶An alternative would have been to use two digits SICs. Three digits NAICS codes were also an option but industries were too disaggregated. Different specifications have been tried, with similar results.

Table 3.2: Number of Corporations in Sample per North American Industry Classification System (NAICS) Code

NAICS Sector	Description	Population in Sample
11	Agriculture, Forestry, Fishing and Hunting	9
21	Mining	104
22	Utilities	122
23	Construction	18
31	Manufacturing	144
32	Manufacturing	360
33	Manufacturing	844
42	Wholesale Trade	113
44	Retail Trade	100
45	Retail Trade	53
48	Transportation and Warehousing	63
49	Transportation and Warehousing	6
51	Information	187
52	Finance and Insurance	45
53	Real Estate and Rental and Leasing	30
54	Professional, Scientific, and Technical Services	108
55	Management of Companies and Enterprises	0
56	Administrative/Support/Waste/Remediation Services	55
61	Education Services	6
62	Health Care and Social Assistance	44
71	Arts, Entertainment, and Recreation	7
72	Accommodation and Food Services	68
81	Other Services (except Public Administration)	13
92	Public Administration	24
-	Total	2523

to 0.340, and declined further to 0.338 in 1994. But surprisingly, in 1995 the average markup went up to 0.344, the highest level since 1991, and thereafter remains relatively constant for the last three years of the sample period. It is important to note that the sharp decline in markup was temporary, even though the leniency policy was effective after that.

In Figure 3.2, I plot the change in industry level average from 1991 to 1997. The HHI concentration ratio is on the horizontal axis and the industry level change in markup is on the vertical axis. From the figure, I do not see any clear relationship between variable HHI

and the change in markup. We can see that both Figures 3.1 and 3.2 do not show any patterns in favor of the leniency policy. Later, I will make a formal econometric assessment of the policy effect, where I include time dummies and other variables that control for firm profitability.

I describe the estimation methodologies in the next section.

3.5 Estimation Methodologies

The first model is a simple OLS estimation, while the second one is a fixed effect estimation controlling for firm level fixed effects. The first equation to be estimated is given by (1):

$$PCM_{it} = b_0 + b_X X_{it} + \sum_{y=1992}^{1997} b_y D_y(t) + b_h HHI_{it} + \delta [HHI_{it} \times D_y(t \geq 1994)] + \epsilon_{it} \quad (3.1)$$

The dependent variable is the markup PCM_{it} . The independent variables include X_{it} ,

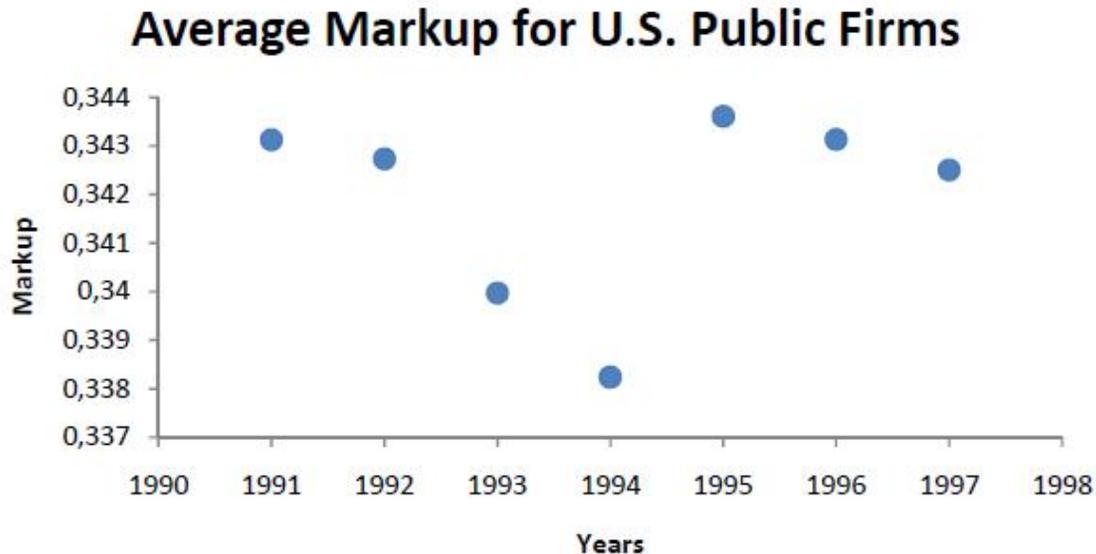
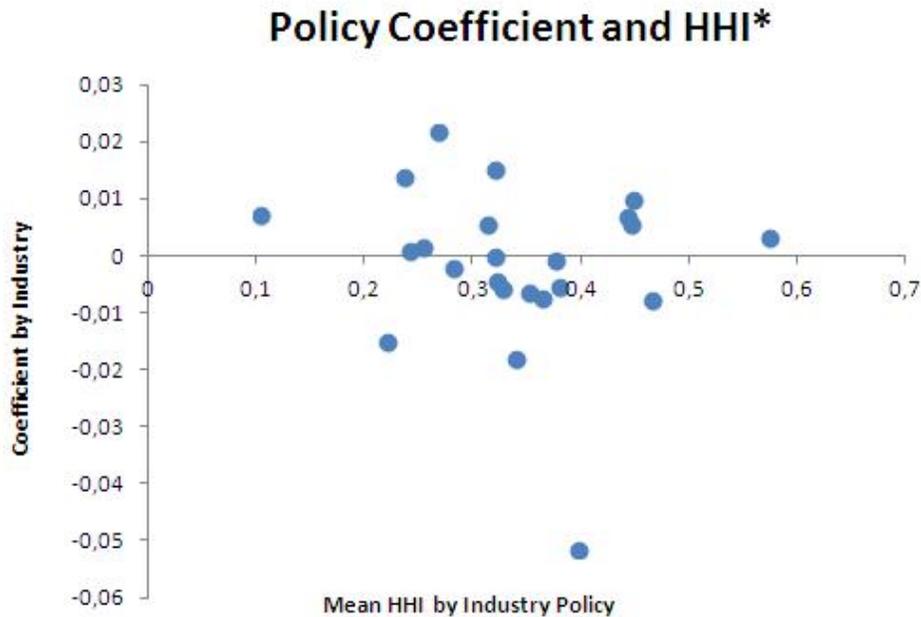


Figure 3.1: Structural Break in 1993-1995

Herfindahl-Hirshman index, HHI_{it} ; year dummies $D_y(t)$ which equals 1 if $t = y$ and 0 otherwise, and the interaction term of HHI and the dummy which equals 1 if the year is 1994 or later. The coefficient of the interaction term measures the policy effect. X_{it} is the vector of additional controls, which include market-share, the number of employees to control for the size of the firm, net income, gross profit, closing price, inventories, earnings per share, and book value per share.

The interaction term, $HHI_{it} \times D_{it}(t \geq 1994)$, between the policy dummy and the HHI is the DID variable of interest. Meyer (1995) points out that by including an interaction between the treatment indicator ($D_{it}[t \geq 1994]$) and covariates (HHI_{it}) it may help to control for heterogeneity in the dynamics induced by the different industries.



* The policy coefficient is calculated by regressing the markup over the annual difference in the policy. I also include controls without a control group. As for the mean HHI by industry, I take the mean by industry over the time period 1991-1997.

Figure 3.2: Justification for Using Difference-in-Difference Approach

A successful leniency policy implies that the coefficient should be estimated to be negative, that is, $\hat{\delta} < 0$, where firms are strongly reacting to the amendment of the Corporate Leniency Program by reducing their cartel activities or not entering any cartels. If I define the treatment group to be the industries whose HHI exceeds some threshold \bar{H} and the control group with the index below the threshold \bar{H} , and use $I_{it}(HHI_{it} \geq \bar{H})$ instead of HHI_{it} in the OLS, then, I would have the standard DID framework, where the policy effect is identified as follows:

$$\hat{\delta} = \left\{ \mathbf{E}[PCM_{it}|treatment, t \geq 1994, X_{it} = X] - \mathbf{E}[PCM_{it}|treatment, t < 1994, X_{it} = X] \right\} - \left\{ \mathbf{E}[PCM_{it}|control, t \geq 1994, X_{it} = X] - \mathbf{E}[PCM_{it}|control, t < 1994, X_{it} = X] \right\}$$

In the present study, instead of the treatment being either effective or not effective, I model the effectiveness of the treatment to depend on the industry structure. The underlying hypothesis is that highly concentrated industry have an accrued probability of sustaining collusion compared to lower concentrated industries. Hence, a leniency policy should have more effect in reducing the markup in highly concentrated industries, that is, those with a higher HHI. Of course, there is some exceptions to this claim, notably the U.S. 1930s cartel in the beer industry including over 700 firms (Levenstein and Suslow, 2006).

Similar results are obtained for international cartels in Levenstein and Suslow (2004).⁷

I also estimate the specification that includes firm specific fixed effects (η_i). The fixed effect estimation model is given by equation (3.2).

$$PCM_{it} = b_0 + b_X X_{it} + \sum_{y=1992}^{1997} b_y D_y(t) + b_h HHI_{it} + \delta [HHI_{it} \times D_y(t \geq 1994)] + \eta_i + \epsilon_{it} \quad (3.2)$$

⁷Notably the famous fine art cartel where two giants (Sotheby and Christie's) were holding a massive 95% of the world market.

In both OLS and fixed effect specifications, I cluster standard errors by firm.

Results are presented in the next section.

3.6 Results

Results are presented in Table 3.3. In Column 2 (OLS 1), I present the OLS coefficient estimates. Market share (estimate [standard error] = -21.8 [10.6]) has a negative and significant effect on markup. This is not consistent with the classical Cournot framework results as the correlation should be positive as higher market share induces higher market power, hence higher markup. However, Berry et al. (1995), in a seminal paper, when estimating the markup in the automobile industry, also obtained a negative relationship between markup and market share. They argue that the “high end” luxury automobiles, the ones with high markups, have smaller market share, and the popular brands, the ones with higher market share, tend to have lower markups. It is intriguing that the book value per share (-4.00 [0.43]) has a negative and significant effect on markup, whereas the coefficient on earnings per share (4.36 [1.32]) and gross profits (0.08 [0.008]) are significantly positive. It is reasonable that higher markup firms tend to be more profitable, hence higher earnings per share and higher gross profit. The coefficients on number of employees (-0.71 [0.32]), current asset (-0.04 [0.006]), and operating expenses (-0.02 [0.003]) are all negative and significant. That is, all coefficient estimates of variables related to cost are all negative and significant. I also see that the coefficient on the HHI is positive but insignificant, which is reasonable since it implies that industries that are highly concentrated have high markups. The coefficient on the interaction term of HHI and the dummy for the policy period, which measures the policy effect, is negative but insignificant. Thus, I do not see any significant policy effect.

In Column 3 (OLS 2), I report the OLS results where industry dummies are included as additional controls. Most coefficient estimates are very similar to those of the OLS without industry dummies, with some exceptions. The market share coefficient is negative, but

its value is only two thirds of that of the OLS without industry dummies. Similarly, the coefficient on the HHI is positive, but half of that of the basic OLS specification. On the other hand, the policy effect is still insignificant but is estimated to be five times as large as that of the basic specification.

A potential problem with the analysis is the possibility of endogeneity bias, where the firm specific unobserved characteristics would be correlated with controls that are themselves correlated with the dependent variable, especially with the control HHI that, ultimately, determines the treatment effect. It is important to note that the endogeneity bias of the control variable coefficients also results in a bias in the estimation of the policy effect if the HHI in the interaction between HHI and the policy dummy, and other controls are correlated with the error term. To deal with the endogeneity issue of cross sectional correlation between the control variables and the error term, I also conduct the fixed effects estimation (FE[3]). There, the coefficient estimates have the same sign as the OLS ones, except for the fixed effect coefficient for HHI (-68.4 [40.7]), which is negative and significant at 10 percent level. Except for the coefficients for the policy effects and the dividends, the coefficients have much smaller values than those of the basic OLS and the OLS with industry dummies. The dividend coefficient has larger value than the OLS estimates and is significant. The policy effect is similar to the one estimated from the OLS with industry dummy and insignificant.

To further address the endogeneity issue, I also estimate the version of the model where I dropped all the control variables that could be correlated with the error term: market share, gross profit, operating expenses and number of employees. The results are presented in Table 3.4. Now, the market share coefficient is estimated to be negative, although insignificant. The policy effect is estimated to be slightly smaller for the basic OLS specification, and slightly larger for the OLS with industry dummies and the fixed effects, but they still are insignificant.

Similarly to Klein (2011), I control for a possible delay in firms' reaction to the new

policy in Table 3.5. It is reasonable to assume that firms took a few months, even a few years, to adapt to this new environment with new incentives for deterrence and desistence of colluding practices. Three lags were included to account for a maximum of three years of delay. The regression equation 3.2.⁸ now includes three interaction terms where the three policy variables are set to “1” in 1995 and onward, 1996 and onward, and 1997 and onward, respectively.

For the fixed effect model, the policy coefficient is now negative and significant implying that, in the aggregate, firms are affected by the amendment of 1993, when controlling for a reaction delay. Note that from Table 3.3, firms do not immediately react to the policy. The reaction takes one to two years to materialize. Surprisingly, after 3 years, the policy effect dies out. This may be true, but more likely a by-product of data limitation as the sample spans from 1991 to 1997. Hence, since the policy variable takes the value “1” for 1994 and onward, this means that with a three-year lag, there is only one year of post-policy effect which is rather small.

Finally, conditional quantile regression results are presented in Table 3.6. Linear regression estimates mean values of the response variable for a given levels of predictor while quantile regression focuses on quantiles instead of averages. This is of particular interest in the current study since the base assumption is that the impact of the policy is more likely to affect high markup industry, that is firms in higher quantiles. Interestingly, for the .90 quantile regression we can see a negative and significant policy coefficient (-67.1 [31.3]).

So far, the discussion should have convinced the reader that the proposed econometric model yields interesting predictions that are faithful to intuition in most specifications. That being said, the role played by the leniency policy will be investigated in the next section.

⁸See Subsection 3.5

3.7 Policy Analysis

All model specifications are pointing towards one direction: the amendment in 1993 of the U.S. Corporate Leniency Program did not affect firms' pricing behavior (similarly to Brenner (2009)) on the short term, but the leniency policy started to be effective after 1995 (similarly to Miller (2009) and Klein (2011)). I obviously cannot conclude on the amendment effectiveness solely by the current study as the population studied both includes colluding and non-colluding firms, but if assumed that high concentration industries are most likely to collude, results suggest that (colluding) firms were most likely influenced by the revision of the policy in 1993.

3.8 Caveat

Even though this study does not rely only on prosecuted cartels, it still has numerous limitations. First, I can not know whether the effect comes from the colluding firms that decided to reduce their markups in order to avoid detection, or non-colluding firms that were deterred from forming a cartel.

Also, recent prosecuted cases demonstrate the internationalization of cartels (e.g., the Air Cargo cartel and the vitamin cartel). The required coordination between countries' antitrust agencies complicate the conviction process as well as the interpretation of the present results. Capturing this reality is impossible with Compustat. The underlying difficulty here is that, in Compustat, potentially colluding firms are under represented limiting the effect on the variables.

Finally, Ali et al. (2009) investigate the difficulties with relying exclusively on U.S. publicly-held companies data. It turns out that when building industry level aggregate variables such as HHI and market share, the weight of privately-held companies in the entire population (both public and private firms) is not negligible. Plus, if assuming that big public firms are less efficient than private ones, it means that when I construct market shares with

only public firms, firms have large market shares but very little markups. Hence, omitting privately held firms could bias the estimation results.

3.9 Conclusion

In this project, I measure the impact of the amendment to the U.S. Corporate Leniency Program in 1993 on U.S. publicly held companies. My estimation results imply that the amendment did not change the industry structure, which is proxied by the markup of firms, in the short run while the effect is present one and two years after the program implementation. These are striking results and future work should focus on the persistence of the policy effect. In the sample, the policy effect is still there even when considering two lags, that is estimating the impact of the policy in 1996. Much work remains to be done. The quantile regression results indicate the policy effect among high conditional quantiles. That is, even though the policy may not change the conditional mean of the industry markup, it could be changing the distribution of markups, in particular, increase the competition at high markup firms. In order to fully categorize the changes in the industry structure, privately held firms will have to be included in the analysis, which would be a promising avenue for future work.

Table 3.3: Difference-in-Difference Regression Results

Variables	OLS(1)		OLS(2)		FE(3)	
Policy x HHI	-21.8	*	-13.2		-8.33	
	(10.6)		(10.4)		(9.73)	
HHI	37.8	*	14.6		-68.4	*
	(18.7)		(18.5)		(40.7)	
Marketshare	-95.0	***	-59.5	***	-26.0	
	(18.1)		(17.4)		(31.8)	
Gross Profit	0.08	***	0.08	***	0.05	***
	(0.008)		(0.007)		(0.007)	
Book-Value/Share	-4.00	***	-3.32	***	-0.17	
	(0.43)		(3.82)		(0.20)	
Capital	0.00		-0.00		0.01	
	(0.01)		(0.01)		(0.006)	
Dividends	-0.05		-0.02		-0.12	***
	(0.05)		(0.04)		(0.03)	
Earnings/Share	4.36	***	5.21	***	3.10	***
	(1.32)		(1.43)		(0.93)	
#Employees	-0.71	**	-0.64	**	-0.14	
	(0.32)		(0.29)		(0.14)	
Inventory	0.06	***	0.05	***	0.03	***
	(0.01)		(0.01)		(0.008)	
Price Close	2.65	***	2.42	***	0.75	***
	(0.11)		(0.25)		(0.11)	
Current Asset	-0.04	***	-0.04	***	-0.02	***
	(0.006)		(0.005)		(0.004)	
Operating Expenses	-0.02	***	-0.02	***	-0.01	***
	(0.003)		(0.00)		(0.002)	
Constant	yes		yes		yes	
Year-Dummy	yes		yes		yes	
Industry-Dummy	no		yes		no	
R^2	0.17		0.19		0.08	
#Observations	17661		17661		17661	

Notes: Standard errors are shown in parentheses and ***, **, and * denote statistical significance at level 1%, 5%, and 10% levels, respectively.

Table 3.4: Regression Results Without Endogeneous Variables

Variables	OLS(1)		OLS(2)		FE(3)	
Policy x HHI	-28.8	***	-18.4	*	-12.0	
	(11.0)		(10.7)		(9.92)	
HHI	-10.3		-16.5		-70.0	*
	(15.9)		(16.1)		(40.5)	
Marketshare	-		-		-	
Gross Profit	-		-		-	
Book-Value/Share	-4.77	***	-4.01	***	-0.29	
	(0.56)		(0.49)		(0.20)	
Capital	0.04	***	-0.04	***	0.003	
	(0.01)		(0.01)		(0.004)	
Dividends	0.11	***	0.12	***	0.03	
	(0.04)		(0.03)		(0.03)	
Earnings/Share	5.02	***	5.89	***	3.37	***
	(1.69)		(1.72)		(1.01)	
#Employees	-		-		-	
Inventory	-0.04	***	-0.04	**	0.003	
	(0.02)		(0.01)		(0.007)	
Price Close	2.71	***	2.53	***	0.81	***
	(0.31)		(0.28)		(0.12)	
Current Asset	0.008	*	0.004		-0.004	*
	(0.004)		(0.005)		(0.002)	
Operating Expenses	-		-		-	
Constant	yes		yes		yes	
Year-Dummy	yes		yes		yes	
Industry-Dummy	no		yes		no	
R^2	0.06		0.14		0.02	
#Observations	17661		17661		17661	

Notes: Standard errors are shown in parentheses and ***, **, and * denote statistical significance at level 1%, 5%, and 10%, respectively.

Table 3.5: Regression Results Including Lags

Variables	FE(1)		FE(2)		FE(3)	
One Lag Policy x HHI	-15.7 (9.08)	*	-		-	
Two Lags Policy x HHI	-		-16.1 (9.34)	*	-	
Three Lags Policy x HHI	-		-		-13.8 (9.29)	
HHI	-67.2 (40.3)	*	-68.5 (39.9)	*	-70.1 (39.8)	*
Marketshare	-26.2 (31.8)		-26.4 (31.7)		-26.1 (31.6)	
Gross Profit	0.06 (0.007)	***	0.06 (0.007)	***	0.06 (0.007)	***
Book-Value/Share	-0.17 (0.20)		-0.17 (0.20)		-0.18 (0.20)	
Capital	0.01 (0.006)		-0.01 (0.01)		0.01 (0.007)	
Dividends	-0.12 (0.03)	***	-0.12 (0.03)	***	-0.12 (0.03)	***
Earnings/Share	3.09 (0.93)	***	3.10 (0.93)	***	3.10 (0.93)	***
#Employees	-0.14 (0.14)		-0.14 (0.14)		-0.14 (0.14)	
Inventory	0.03 (0.008)	***	0.03 (0.008)	***	0.03 (0.008)	***
Price Close	0.75 (0.11)	***	0.76 (0.11)	***	0.75 (0.11)	***
Current Asset	-0.02 (0.004)	***	-0.02 (0.004)	***	-0.02 (0.004)	***
Operating Expenses	-0.01 (0.00)	***	-0.01 (0.002)	***	-0.01 (0.002)	***
Constant	yes		yes		yes	
Year-Dummy	yes		yes		yes	
Industry-Dummy	no		no		no	
R^2	0.08		0.08		0.08	
#Observations	17661		17661		17661	

Notes: Standard errors are shown in parentheses and ***, **, and * denote statistical significance at level 1%, 5%, and 10%, respectively.

Table 3.6: Quantile OLS Regression Results

Variables	0.10	0.20	0.50	0.80	0.90	
Policy x HHI	18.0 (15.4)	10.0 (13.7)	-7.06 (12.3)	-26.1 (24.1)	-67.1 (31.3)	**
HHI	24.0 * (12.4)	37.9 *** (11.1)	11.1 (9.91)	12.4 (18.6)	98.8 (24.5)	***
Marketshare	12.8 (9.67)	-32.7 *** (8.84)	-7.53 *** (8.17)	-136 *** (16.7)	98.8 *** (24.5)	***
Gross Profit	0.07 *** (0.005)	0.08 *** (0.004)	0.09 *** (0.003)	0.07 *** (0.007)	0.07 *** (0.009)	***
Book-Value/Share	-0.50 * (0.30)	-1.60 *** (0.24)	-3.74 *** (0.18)	-7.00 *** (0.44)	-6.81 *** (0.70)	***
Capital	0.02 ** (0.09)	0.02 * (0.008)	0.008 (0.007)	-0.004 (0.02)	-0.03 (0.02)	
Dividends	-0.04 ** (0.02)	-0.05 ** (0.02)	-0.08 *** (0.02)	-0.12 *** (0.04)	-0.10 * (0.06)	*
Earnings/Share	7.20 *** (1.21)	6.03 *** (0.85)	4.00 *** (0.56)	2.43 *** (0.90)	-0.20 (1.17)	
#Employees	-0.12 (0.08)	-0.15 ** (0.07)	-0.43 *** (0.07)	-0.85 *** (0.23)	-0.57 (0.36)	
Inventory	0.08 *** (0.008)	0.08 *** (0.007)	0.06 *** (0.006)	0.03 ** (0.01)	0.01 (0.02)	
Price Close	1.84 *** (0.17)	2.12 *** (0.14)	2.48 *** (0.10)	3.53 *** (0.19)	3.31 *** (0.27)	***
Current Asset	-0.05 *** (0.004)	-0.04 *** (0.003)	-0.03 *** (0.003)	-0.03 *** (0.006)	-0.03 *** (0.009)	***
Operating Expenses	-0.02 *** (0.001)	-0.03 *** (0.001)	-0.03 *** (0.001)	-0.01 *** (0.002)	-0.01 *** (0.003)	***
Constant	yes	yes	yes	yes	yes	
Year-Dummy	yes	yes	yes	yes	yes	
Industry-Dummy	no	no	no	no	no	
R^2	0.07	0.07	0.08	0.09	0.08	
#Observations	17661	17661	17661	17661	17661	

Notes: Standard errors are shown in parentheses and ***, **, and * denote statistical significance at level 1%, 5%, and 10%, respectively.

Bibliography

- Ali, A., S. Klasa, and E. Yeung (2009). The Limitation of Industry Concentration Measures Concentrated with Compustat: Implications for Finance Research. *Review of Financial Studies* 22(10), 3839–3871.
- Berry, S., J. Levinsohn, and A. Pakes (1995). Automobiles Prices in Market Equilibrium. *Econometrica* 63(4), 841–890.
- Bigoni, M., F. SO., C. Le Coq, and G. Spagnolo (2009). Fines, Leniency and Rewards in Antitrust Experiments. University of Rome, Stockholm School of Economics, Centre for Economic Policy Research, CEPR Discussion Paper No. DP7417.
- Brenner, S. (2009). An Empirical Study of the European Corporate Leniency Program. *International Journal of Industrial Organization* 27(6), 639–645.
- Hamaguchi, Y., T. Kawagoe, and A. Shibata (2009). Group Size Effects on Cartel Formation and the Enforcement Power of Leniency Programs. *International Journal Industrial Organization* 27, 145–165.
- Hammond, S. D. (2004). Cornerstone of an Effective Leniency Program. ICN Workshop on Leniency Programs, Sydney, Australia, November 22-23, Available online, March 15, 2012, at <http://www.justice.gov/atr/public/speeches/206611.htm>.
- Hammond, S. D. (2009). Recent Developments Relating to the Antitrust Divisions's Corporate Leniency Program. National Institute on White Collar

- Crime, San Francisco CA, March 5, Available online, March 15, 2012, at <http://www.justice.gov/atr/public/speeches/244840.htm>.
- Harrington, J. (2008). Optimal Corporate Leniency Programs. *Journal of Industrial Economics* 56(2), 215–246.
- Harrington, J. E. and M.-H. Chang (2009). Modeling the Birth and Death of Cartels with an Application to Evaluating Competition Policy. *Journal of European Economic Association* 7(6), 1400–1435.
- Hinloopen, J. and A. R. Soetevent (2008). Laboratory Evidence on the Effectiveness of Corporate Leniency Programs. *RAND Journal of Economics* 39(2), 607–616.
- Klein, J. K. (2011). Cartel Destabilization and Leniency Programs - Empirical Evidence. *ZEW - Centre for European Economic Research Discussion Paper No.10-107*.
- Levenstein, M. C. and V. Y. Suslow (2004). Contemporary International Cartels and Developing Countries: Economic Effects and Implications for Competition Policy. *Antitrust Law Journal* 71(3), 801–852.
- Levenstein, M. C. and V. Y. Suslow (2006). What Determines Cartel Success? *Journal of Economic Literature* XLIV, 43–95.
- Meyer, B. D. (1995). Natural and Quasi-Experiments in Economics. *Journal of Business and Economic Statistics* 13(2), 151–162.
- Miller, H. N. (2009). Strategic Leniency and Cartel Enforcement. *American Economic Review* 99(3), 750–768.

Chapter 4

Managerial Hierarchy and Leniency Policies

4.1 Introduction

A cartel is an association of two or more legally independent firms that explicitly agree to coordinate their prices or outputs for the purpose of increasing their collective profits. Colluding firms as well as their owners, then, benefit from the accrued profit and higher growth perspective. Depending on the position stakeholders occupy within an organization's hierarchy, incentives to report the illegal conduct greatly differ. On one side, there are the workers (i.e., non-executive employees) and, on the other, the owners of the firm (i.e., shareholders, executives and board of directors). The nature of the motive behind a report of illegal activity is at the center stage of the United States Leniency Policy for Individuals.¹ The United States Leniency Policy for Individuals essentially grants immunity from criminal sanctions (fine and jail time) to the qualifying applicant. The standard black box view of the firm needs to be broadened for a better understanding of such leniency mechanisms.

Antitrust agencies (AAs) with leniency policies aim at deterring and forcing desistance of colluding practices. Desistance, the most realistic goal, implies that colluding firms will cease their illegal behavior and, this, because of either an application for leniency or the fear of being detected. This fear acts as a powerful device in the hands of the authorities and

¹Available online, May 3, 2012, at <http://www.justice.gov/atr/public/guidelines/0092.htm>.

is, in fact, at the cornerstone of an effective leniency policy (Hammond, 2004). Creating this fear of detection can be attained by using the appropriate leniency discounts and, more importantly, by signaling a true devotion to fighting cartels. AAs demonstrate their intent to fight collusion, for example, by subsidizing workshops² and in-house training on leniency policies.³ Ultimately, this “message” (or signal of intent) sent from a AA to cartels will be interpreted in terms of a likelihood of an investigation opening. Thus this message may trigger a fear of detection within fellow cartel members resulting in a *race to the courthouse* (Harrington, 2008). The underlying hypothesis is that a clearer message (a stronger signal) sent by the agency will result in higher desistance from colluding practices. This message is at the heart of this paper.

Creating this environment of fear motives a constant effort and is a resource consuming goal. According to two metrics,⁴ the number of leniency applications and the total value of the lenient fines paid, AAs have become very efficient in terms of spreading panic. Broadening the understanding of leniency policies from within the firm is directly in line with the United States Leniency Policy for Individuals which is an extension of Section C of the broader Corporate Leniency Program. Such policy forces corporations not only to evaluate the likelihood that a fellow cartel member will reach the courthouse (horizontal concerns) first, but also that leaked information may trigger an application for leniency from its own employees (vertical concerns).

Horizontal concerns address corporations’ pricing strategy, punishment schemes, and other means restricting the scope of competition arrangements. Several motives that may trigger an application for leniency (Corporate Leniency Program) based on horizontal concerns have been extensively studied in the literature (Harrington, 2008). For the current

²The International Competition Network workshop series are an example of such workshops. Available online, July 9, 2012, at <http://www.internationalcompetitionnetwork.org/working-groups/current/cartel.aspx>.

³See Angelucci and Han (2010) for compliance programs.

⁴Since 1996, companies have paid over \$5 billion in antitrust crimes, while over 90 percent of this amount was initiated by leniency application. See Hammond (2010) for details on the success of leniency policies.

study, the motive of horizontal concerns will be the fear of an upcoming detection. This fear will then be translated into a probability of conviction that will dictate a corporation's application for leniency, according to a benefit-cost analysis. This is a standard assumption in Competition Economics literature on leniency policy.

Vertical concerns, on the other hand, address workers' incentives to whistle-blow on owners' illegal conduct under the United States Leniency Policy for Individuals. A special feature of vertical concerns is that workers are not required by law to submit evidence of collusion to the authority. Then, why would a worker apply for leniency in the first place? Again, several theories attempt to answer this question (Spagnolo, 2008). All theories assume that companies are sufficiently wealthy and will always find a way to provide workers with a payment transfer that he or she will find convincing leading him or her not to apply for leniency. This assumption is flawed and contradicted by real-life examples of workers actually coming forward to authorities.⁵ I address this flaw by presenting an approach based on the simple fact that the illegal conduct of a firm does not benefit a typical worker. Even though the share of total equity allocated to non-executive employees (workers) has increased in past years,⁶ it, still, remains relatively low⁷ compared to equity payment to executives and board of directors (owners).⁸ It will then be assumed that workers do not see collusion as a profitable outcome.

Workers have, in fact, no interest at all or minimal interest at best and may even be negatively affected by the illegal conduct. Organizational culture and corporate values are highly regarded by employees (Daulatraum, 2003). Any misconduct by a company will impact on employees' working environment and, most likely, their performance (Gordon

⁵Of course, the identity of whistle-blowers always remains secret. Extrapolating from whistle-blowers policies applied in the corporate world one can infer that such policies are and will continue on being used. See Alford (2002) for more information on the subject.

⁶Core and Guay (2001) report a percentage increase of 22 percent (from 17 to 39 percent) over the years 1993-1999 for large firms granting stock options to at least half of the non-executives.

⁷Over 7 million US employees held equity-based compensation in 2000 (Bergman and Jenter, 2007).

⁸A typical chief executive officer pocketed an impressive 5% of the total value of options (\$141 million) granted by the average firm in the S& P 500 in 2002 (Brian and Murphy, 2003)

and DiTomaso, 1992). A company's behavior encouraging illegal conduct, such as collusion, definitely qualifies as misconduct. The impact of collusion on a worker's behavior as well as his or her lack of financial benefit from the misconduct defines the premise of the current paper. A worker will apply for leniency because of the savings in negative externality from collusion and, also, because of the lump-sum transfer⁹ in exchange for collaboration with a AA.¹⁰

The new insights developed by the present paper stem from the fusion of a three-tier model with the message sent by a AA, and with the novel justification for an individual's application for leniency. As for a AA, its goal is to optimally advertise its intent to fight collusion. It seeks to optimally divide its resources to maximize the effect of the leniency policy. The basic tradeoff exhibited in this model balances out the gain from leniency with the cost of the signals. Factors influencing the decision of the agency are (1) worker's sensitivity to collusion, (2) the relative costs of sending the signals, and (3) the leniency policy in place. A preview of the results goes like this. A sufficiently strong externality from collusion coupled with small profit margins results in leniency granted to workers at a zero cost. Workers are so affected by collusion that they will apply for leniency regardless of the AA's signal. I also find that if the workers' sensitivity to collusion is sufficiently small and profit margins sufficiently large, the owner will be the sole receiver of a signal and be granted leniency. Under such conditions, workers will never apply for leniency and neither would had an owner if he or she had not received a signal from the AA. The AA triggers an application for leniency in this situation.

After reviewing the relevant literature to highlight the contribution of this paper in the next section, I set up the model in Section 3. Section 4 establishes the key findings, while Section 5 discusses policy implications, and Section 6 concludes.

⁹This lump-sum transfer could also be seen as a proxy for the avoidance of any criminal sanction.

¹⁰I leave as an extension the resulting fear of retaliation even though present in real life cases.

4.2 Literature

There is extensive literature on collusion.¹¹ As illustrated by a static one period prisoners' dilemma and its repeated version, theoretically, breaking a cartel is a rather straightforward task to accomplish, given the right incentives. Motta and Polo (2003) discuss some of these incentives in line with leniency policies. Given the limited resources to open an investigation and successfully prosecute firms, leniency policies are an effective tool for desistance of cartelistic practices.¹²

This paper takes as granted the effectiveness of leniency policies and contributes principally to a strand of literature in Competition Economics dealing with internal conflicts within an organization and all underlying effects on collusion.

The scant literature on individual leniency policies starts with the pioneer work of Aubert et al. (2006).¹³ The authors investigate an AA's incentive to grant lenient treatments to both firms and employees. They obtain that positive rewards¹⁴ for leniency applicants have a larger deterring and desisting power than a simple discount on the full fine, since now firms can completely outweigh the risk of continuing their collusive agreements. The authors argue that individual bounties for whistle-blowers can at best act as an additional cost on colluding firms. This cost is actually a bribe to individuals holding incriminating evidence. Hence by bribing (or re-allocating) the workers, owners now collude free of whistle-blowers. A higher bounty results in harsher conditions to sustain collusion. This line of thought assumes that bribe levels may become so high that collusive agreements become endangered. Considering firms' values compared to individual wages, an employee will be lucky to be able to blackmail a firm's owners for an amount big enough such that collusion becomes unsustainable. This

¹¹See, for example, Stigler (1964) and Connor (2007).

¹²See Miller (2009), Brenner (2009) and Cloutier (2013a) for an empirical investigation of such effectiveness.

¹³A good survey on whistle-blowers and individual leniency is Spagnolo (2008). Other interesting work includes Aubert (2009) and Festerling (2005).

¹⁴Spagnolo (2000) and Cloutier (2013b) obtain a similar result in different settings. An AA uses positive rewards if it remunerates the leniency applicant in exchange for information.

scenario is quite improbable.¹⁵ The present paper builds on this flaw. In fact, the interlinkage of individual and corporate entities is rendered possible via an externality coming from the collusive outcome. The sensitivity to this externality felt by individuals determines to which extent they will blow the whistle on the illegal conduct of owners.

Angelucci and Han (2010) also study internal conflicts in collusive arrangements. This paper, similarly to Aubert et al. (2006), presents an analysis based on bribes from one hierarchical level to the other. The authors advocate that a AA should provide partial leniency to shareholders and that managers should be fined the maximum legal amount. This result relies on the assumption that only shareholders possess evidence that can be passed to a AA. Hence, an AA contributes to a better alignment of the two levels of incentives for no collusion by fixing the managers' fine to its maximum level. The different treatments received by different types of individuals in the firm is the object of interest in the present framework. A problem with Angelucci and Han (2010) comes from the incriminating information flow. It is unclear why sometimes shareholders possess the information while in others managers do. The identity of the holder of information, of course, dictates whom will be granted leniency. In the present study, both workers and owners may apply for leniency implicitly assuming every agent has information about the illegal activity. Instead of restricting leniency to one hierarchical level, I broaden the analysis to encompass this limitation and study the interaction of both forms of leniency: individual and corporate.

4.3 Model

In this colluding industry, there are N firms and a three-tier structure: an AA, N workers, and N owners. Each firm has one owner and one worker. The owner has a preference for collusion over the competitive outcome and has for only choice variable the decision of applying for leniency. Accordingly, a corporate leniency policy exists. A successful leniency

¹⁵Of course, this scenario could become probable if several employees were to apply for leniency at the same time. This situation is not part of the current analysis.

application by an owner is such that he or she will be granted a reward by the AA, $Y > 0$. Collusion yields an industry profit, π'_M , redistributed equally via individual firm profit, $\pi_M \equiv \frac{\pi'_M}{N}$. The individual competitive profit is denoted by π_C , where $\pi_M > \pi_C$. The margin of collusion over the competitive outcome is private information to the owner. A worker has a belief about this margin of collusion according to $\pi_M - \pi_C \equiv \Delta \sim \mathbf{U}[0, 1]$, where $H(\cdot)$ denotes the cumulative density function of a uniform distribution.

A worker knows about the competitive arrangement of the owner and receives a fixed salary, W . Collusion in the industry creates an externality, C , only affecting workers. This externality, also known as a morality parameter, acts as a cost for workers and is private information to the worker. An owner has a belief about this morality parameter according to $C \sim \mathbf{U}[0, 1]$, where $G(\cdot)$ denotes the cumulative density function. The worker has for only choice variable the decision of applying or not for individual leniency. A successful leniency application by a worker is such that he or she will be granted a lump-sum transfer by the CA, $X > 0$. A worker will lose her or his job after a successful leniency application.

In the event of multiple applications to the policy, all applicants will be granted leniency. Under the right conditions, a party will apply for leniency and receive a leniency discount (X or Y). It is then the role of the AA to set the optimal conditions to induce an application for leniency.

In fact, the role of the AA is to affect the competitive environment and deter collusive practices by sending a signal, $q, p \in [0, 1]$, about its intention to open an investigation.¹⁶ A greater signal means a higher likelihood to open an investigation. The AA seeks to end the collusive practices at the lowest cost possible. Workers act upon the signal p of an investigation while owners act upon the signal q . Signals are public, non-additive, and tailored to a party so that each party can not act upon the other party signal. The leniency

¹⁶Owners and workers have differing prior beliefs about the probability the CA will open an investigation. Morris (1995) discusses the benefit (and cost) of economic assessments based on beliefs without the common prior assumption. A recent analysis using similar approach includes Van den Steen (2010).

discounts, respectively Y for owners and X for workers, are not choice variables to the AA and are amounts of money already at the AA's disposition.¹⁷ Finally, the AA has also private information about both the margin of collusion and the externality variables, that is it observes the realizations of both Δ and C .

4.4 A Simple Model: One Firm

As surveyed in Levenstein and Suslow (2006), the number of firms in prosecuted cartels greatly differs. Highly concentrated industries share the benefit of coordination, while larger agreements are possible with the "help" of industry specific associations and even governments in some cases. The number of firms in a cartelized industry definitely matters and contemporaneous cases range from two to a few hundred.

In this paper, I present a simple version of the interaction between a worker and an owner. To do so, I look at one firm in a colluding industry (N firms). A natural extension of this framework will be to investigate the impact of including the entire industry, that is, the other $N - 1$ firms. Alternatively, the model can be applied to any illegal behavior induced by an executive or anyone significantly tied to a company's profit. An example of such a behavior is corporate fraud, and an equivalent to the leniency policy is the False Claims Act. The False Claims Act offers a financial reward for a party disclosing fraud evidence committed against the U.S. government. So assuming the owner commits a fraud, the current framework extends to the False Claims Act, when $N = 1$.¹⁸

4.4.1 Worker

A worker will apply for leniency under specific conditions. After receiving a signal, p , the worker compares the (expected) benefit from continued employment in the colluding firm (and dealing with the externality from collusion, C) and the gain obtainable should he or she

¹⁷Hence, they will not enter be part of the AA's cost.

¹⁸See Carson et al. (2008) for more details on the False Claims Act.

blow the whistle. A continued employment yields $W - C$ when no investigation opens (with probability $1 - p$) and W otherwise. Thus the worker benefits two-fold from an application for leniency. First, he or she saves on the negative externality from the owner's collusion and, second, he or she receives the financial transfer from whistle-blowing on the owner.¹⁹ Recall that $G(\cdot)$ is the cumulative density function associated with the collusion margin of the owners. Note that, variables with a "hat" will denote beliefs. A worker's belief about the cutoff value of the owner collusive margin over the competitive level, Δ , is denoted by $\hat{\Delta}$. Mathematically, a worker applies for individual leniency if the following condition holds:

$$X > pW + (1 - p) \left[G(\hat{\Delta})W + (1 - G(\hat{\Delta}))(W - C) \right]$$

Lemma 1. *When $0 \leq X < W$, an increase in the worker's sensitivity to collusion, C , makes it more likely that the worker applies for leniency. When $X \geq W$, the worker will always apply for leniency.*

Proof. Lemma 1 is straightforward from the simplified incentive compatible inequality of the worker:

$$X > W - (1 - p)(1 - G(\hat{\Delta}))C$$

An increase in C implies a decrease in the right-hand side of the inequality. The worker is now applying for leniency for a wider range of values of p . As for the second part of the Lemma, it is straightforward to see that if $X \geq W$, then the inequality is always satisfied and the worker will then always apply for leniency. \square

Lemma 1 defines the relation between the leniency parameter, X , the worker's salary, W , and the externality, C under both weak leniency ($X < W$) and strong leniency ($X \geq W$) policies. The externality does make a difference on a worker's incentive for leniency; it

¹⁹It is assumed that the a worker loses (or quits) his or her job after obtaining leniency. Since both entities live only for one period, there is no harm in making such an assumption, except for simplifying the model.

determines the solution region where the worker prefers to apply or not for leniency.

Lemma 2 defines the cutoff value, C^* , tipping an application for leniency under weak leniency. Whenever $C \in [C^*, 1]$, a worker will always apply for leniency.

Lemma 2. *The cutoff value tipping an application for leniency by the worker, C^* , is a function of $\{W, X, p\}$ and of the worker's belief about the profit margin of collusion over the competitive level, $\hat{\Delta}$:*

$$C^*(\hat{\Delta}) \equiv \frac{W - X}{(1 - p)(1 - G(\hat{\Delta}))}$$

Proof. Follows from the proof of Lemma 1. □

The next section presents the analysis, but this time from the point of view of an owner.

4.4.2 Owner

An owner will apply for leniency under specific conditions. After receiving a signal, q , the owner compares the (expected) benefit from continuing the illegal conduct and the gain obtainable should he or she apply for leniency. Collusion yields a profit π_M while the competitive outcome yields a profit of π_C . An owner's belief about the cutoff value of the worker externality, C , is denoted by \hat{C} . Mathematically, an owner applies for leniency if the following condition holds:

$$\pi_C + Y \geq q\pi_C + (1 - q) \left[(1 - H(\hat{C}))\pi_C + H(\hat{C})\pi_M \right]$$

Lemma 3. *A more lenient AA (higher Y) makes it more likely that an owner will apply for leniency.*

Proof. It is straightforward after rearranging the owner's leniency application inequality. The inequality becomes

$$Y > (1 - q)H(\hat{C})\Delta.$$

A more lenient AA (increase in Y) results in an increase in the left hand side, hence the difference between the left-hand side and the right-hand side increases. \square

Lemma 3 is a straightforward interpretation of an owner's application for leniency. Also, Lemma 3 links the leniency obtainable should an owner apply for leniency with the investment in the signal sent to the owner by the AA. An increase in leniency (an increase in Y) implies that the owner will now apply for leniency for a wider range of values for the signal. To see this, I define the cutoff value tipping an application for leniency by the owner, Δ^* .

Lemma 4 presents the variables determining the cutoff value tipping an application for leniency by the owner. This cutoff value is a function of $\{Y, q, p\}$ and the owner's belief about the worker's sensitivity to collusion, \hat{C} . Recall that $H(\cdot)$ is the cumulative density function associated with the externality.

Lemma 4. *The cutoff value tipping an application for leniency by the owner, Δ^* , is a function of $\{Y, q, p\}$ and of the owner's belief about the externality, \hat{C} :*

$$\Delta^*(\hat{C}) \equiv \frac{Y}{(1-q)H(\hat{C})}$$

Proof. It is straightforward from the proof of Lemma 3. \square

If $\Delta \in [0, \Delta^*]$, the owner prefers applying to leniency than facing the risk of being caught by the agency (or the worker).

The next section solves for the Nash Bayesian Equilibrium of this game.

4.4.3 Equilibrium

The bayesian equilibrium in this game of private information can be solved using a cut-off strategy. Proposition 1 aggregates the results developed previously.

Lemma 5. *In equilibrium, cutoff values are given by the following equations:*

$$C^* = \frac{W - X}{1 - p} + \frac{Y}{1 - q}$$

$$\Delta^* = \frac{(1 - p)Y}{(1 - q)(W - X) + (1 - p)Y}$$

Proof. In equilibrium, the following equality must hold: $C^* = \widehat{C}$ and $\Delta^* = \widehat{\Delta}$. Lemma 5 follows from the distribution of $H(\cdot)$ and $G(\cdot)$, and Lemmas 2 and 4. The two Lemmas provide the equalities that will be satisfied in equilibrium, that is the expressions related to $C^*(\widehat{\Delta})$ and $\Delta^*(\widehat{C})$. Lemma 5 is then obtained after substituting for the two distributions. \square

Lemma 5 aggregates the results of Lemma 2 and 4. A worker will more likely apply for leniency if wages are low, rewards are high, owner's leniency is small, and both signals are weak. The intuitions for the wages and rewards are related and straightforward: higher payoffs from a relatively poor worker makes leniency more desirable. Interestingly, an increase in the owner's leniency parameter makes the worker less likely to apply for leniency. Recall that an owner applying for leniency means no more collusion and, hence, no need for the worker to apply for leniency in the first place. Consequently, there is no need for a leniency policy to the worker if the signals are relatively strong.²⁰

As for the owner, he or she will more likely apply for leniency if wages are low, rewards are high, his or her signal is strong, worker's leniency is high and signal is weak. A better reward makes leniency more desirable, yet again. The owner is the one benefiting from collusion and faces two opposing parties: the worker and the AA. Variables inducing the worker to apply will help trigger an application for leniency by the worker (e.g., greater leniency, wage, and weaker signal to the worker). Finally, a strong signal by the AA forces the owner to apply for leniency since the benefit of applying is greater than not applying, if almost sure to get caught.

²⁰Of course, the more interesting situations occur when resources are scarce and signals are not too strong.

The next section discusses the AA's optimal signal choices.

4.4.4 Antitrust Agency

The AA optimally divides a signal between the owner and the worker. To do so, it chooses the extent to which the different hierarchical levels are informed about leniency policies, p and q . Given this information, the owner and the worker choose their optimal behavior yielding (or not) an application for leniency.²¹

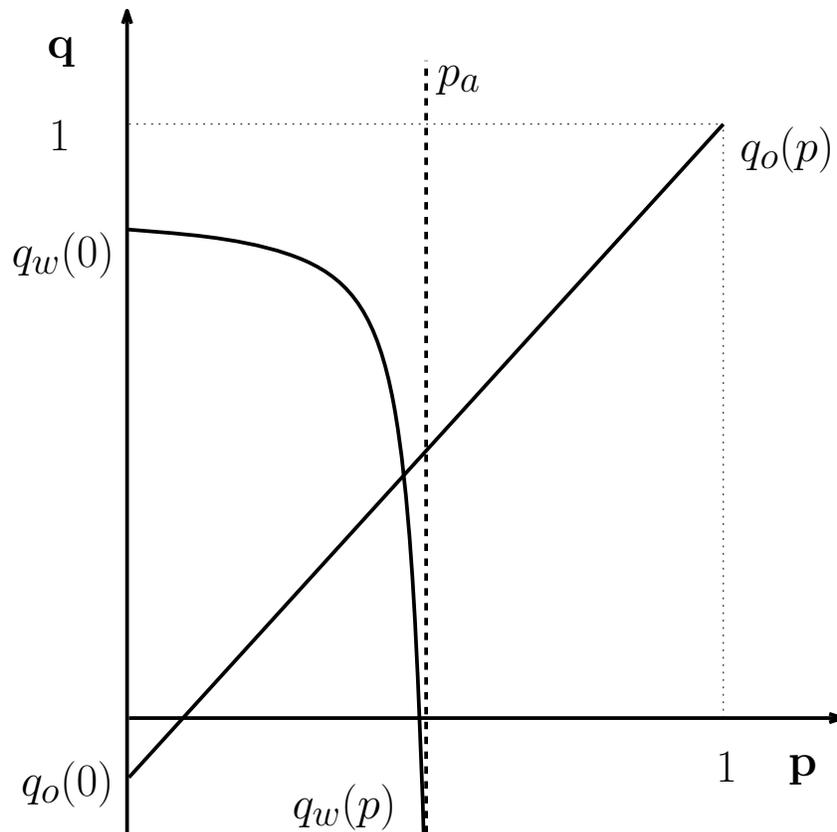


Figure 4.1: Possible Outcomes

There is a simple linear cost function, $Ap + Bq \leq M$, to model the AA's financial constraint, where $M > 0$ denotes the AA's budget limit.²² The tradeoff faced by the agency

²¹Recall that the AA has private information about the owner's collusive margin and the worker's externality.

²²Recall that leniency discounts are not part of the cost function.

is to balance the goal of a collusion-free industry with the cost of informing each party about its intent to fight collusion. The success is then binary: yes, a party applies or no, a party does not apply, given the agency's financial resources. The problem may be framed as follows:

$$\min_{\{p,q\} \in [0,1]} Ap + Bq$$

w.t.

$$(IC_W) C \geq C^* = \frac{W - X}{1 - p} + \frac{Y}{1 - q}$$

AND / OR

$$(IC_O) \Delta \leq \Delta^* = \frac{(1 - p)Y}{(1 - q)(W - X) + (1 - p)Y}$$

Incentive compatibility constraints, IC_W and IC_O , have been derived in Lemma 5.

Many scenarios can occur in this simple economy; leniency can be granted to the owner, to the worker, to both of them, or to none of them. Proposition 1 discusses a AA's optimal decision.

Proposition 1. *To trigger an application for leniency when $N = 1$, the AA chooses the optimal signal (p^*, q^*) as follows:*

Case 1: $(p^*, q^*) = (0, 0)$

\Rightarrow Worker gets leniency if $q_w(0) \geq 0$

\Rightarrow Owner gets leniency if $q_o(0) \leq 0$

Case 2: $(p^*, q^*) = (0, q_o(0)) \Rightarrow$ Owner gets leniency

If $\frac{q_o(0)}{p_a} < \frac{B}{A}$ and $q_w(0) < 0$ and $q_o(0) > 0$

Case 3: $(p^*, q^*) = (p_a, 0) \Rightarrow$ Worker gets leniency

If $\frac{q_o(0)}{p_a} > \frac{B}{A}$ and $q_w(0) < 0$ and $q_o(0) > 0$

Case 4: $(p^*, q^*) = (p, \frac{M - Bq}{A}) \Rightarrow$ Both parties get leniency

If $\frac{q_o(0)}{p_a} = \frac{B}{A}$ and $q_w(0) < 0$ and $q_o(0) > 0$

Where:

$$q_w(p) = 1 - \frac{(1-p)Y}{C - (W - X)}$$

$$q_o(p) = 1 - \frac{(1-\Delta)(1-p)Y}{\Delta(W - X)}$$

$$p_a = \frac{C - (W - X)}{C}$$

Proof. For each case, the solution is obtained by minimizing the cost with respect to the AA's inducing a leniency application. First, if $q_w(0) \geq 0$ then $(p, q) = (0, 0)$ is feasible under the AA's budget constraint and will yield an application for leniency regardless of the signal sent. Similarly, if $q_o(0) \leq 0$, then $(p, q) = (0, 0)$ is feasible and will be selected by the AA. Now, Cases 2 to 4 are essentially the same problem but with different values of A and B . If $q_w(0) < 0$ and $q_o(0) > 0$ then the point $(p, q) = (0, 0)$ yields no application for

leniency and similarly to every combination of (p, q) such that $q < q_o(p)$ and $p < p_a$. On the other hand, the region $q \geq q_o(p)$ and $p \geq p_a$ delimit the possibilities where there will be leniency. Subject to this delimited leniency region, the AA will compare the relative slope of the budget constraint with $\frac{q_o(0)}{p_a}$. This leads to Cases 2 to 4. \square

Figure 4.1 illustrates the possible outcome based on the owner and worker respective incentive constraints (ICs). This comes as a result of aggregating Proposition 1 and Lemmas 1 to 4. Suppose $q_w(0) \geq 0$ and $q_o(0) > 0$, then leniency will be granted to the worker only. The first inequality holds as long as the externality, C , is sufficiently high. The threshold determining this inequality is given by $Y + W - X$. A lower transfer to the owner or a higher transfer to the applicant worker results in a lower threshold. A lower threshold means that it is more likely that the AA will not need to send any signal about the upcoming investigation as high sensitivity to the externality alone does the job of inducing the worker to apply for leniency irrespectively of the values of (p, q) . As for the second inequality, it holds as long as profits are high enough, that is an owner will apply for leniency if the profit margin is relatively small $\frac{\Delta}{1-\Delta} \leq \frac{Y}{W-X}$.

Now, consider the following situation: $q_w(0) < 0$ and $q_o(0) \geq 0$. The owner will apply for leniency in the region delimited by $q \geq q_o(p)$ and the worker in the region $p > p_a$. Depending on the price ratio of the signal, multiple solutions may emerge. The AA will compare the ratio of $\frac{q_o(0)}{p_a}$ with $\frac{B}{A}$. For example, only the owner will apply and obtain leniency if $\frac{q_o(0)}{p_a} < \frac{B}{A}$. This scenario is most likely to happen if leniency to owner is high, margin over the competitive level is small, worker's sensitivity to collusion is high, and leniency to worker is high, that is the left-hand side of the inequality is small. Finally, Cases 3 and 4 occur if the inequality is reversed or replaced by an equality.

4.5 Policy Analysis

In line with the Antitrust Division of U.S. Department of Justice, the discussions and results obtained in this analysis promote the use of individual accountability to enforce leniency policies (Hammond, 2010). The model studied here applies to either feasible forms of punishment: fine or jail.

Vertically driven disruption of collusive conduct plays a key role. This role is to induce “fear” of prosecution at the corporate level (owners) triggered by potential application to leniency from individuals (workers). The interaction between the two levels forces the corporate level to prompt its application to leniency because of vertically driven fear (vertical incentive), while also keeping an eye on other cartel members (horizontal incentive).

The enforcement of leniency policy is more than the simple determination of optimal discount factors. I claim that AAs explicitly send a message about their intent to fight collusion. This message is essentially the sum of all public interventions performed by AAs. Parts of the message targets different receivers and complements the effect of leniency discounts.

A variation in the leniency discounts should always be paired with a realignment of a AA’s message to reinforce the effect of this variation. Consider the following hypothetical scenario. Assume the AA offers some degree of leniency ($X, Y > 0$). Proposition 1 shows that the AA will send no signal and grant leniency to worker if the externality is sufficiently strong while grant leniency to owner if collusive margin is sufficiently low. Also, an owner will be the sole receiver of a signal and be granted leniency if the worker’s sensitivity to collusion is sufficiently small, profit margin is also sufficiently small, and the relative price ratio is favoring the owner.

As advocated in Hammond (2004), it is paramount to never lose sight of the true target: stopping collusive behavior. Individual leniency is desirable only if it helps unravel cartels. This is the case here where both types of applications (individual and corporate) result in desistence of collusion in different situations, justifying the existence of leniency policies for

individuals in the first place.

4.6 Conclusion

United States leniency policies address both the roles of individuals and corporate entities for whistle-blowing. I study their compatibility in an environment where workers (non-executive employees) and owners (executives or board of directors) have private information about the likelihood of an investigation opening. Such uncertainty acts as a powerful device at the AA's disposition to induce fear and trigger a race for leniency that will ultimately result in desistance of colluding practices.

The analysis also provides a novel approach to understanding workers' incentives for whistle-blowing: an ethical negative externality coming from the collusive activity. Workers are not tied directly to firm profits compared to owners and are affected by the burden of working in a firm where profits are illegally boosted to artificially high levels. This negative externality ultimately governs a worker's decision to apply for leniency and leads to desistance of colluding practices when corporate leniency per se would have failed to do so.

Future work should aim at transferring the dual nature of individual leniency with corporate leniency into a dynamic framework. This will render possible a better understanding of the mechanisms at stake. In the present framework, I remain silent about the modeling of these incentives and only assume their presence to justify the study of both levels of staff.

Bibliography

- Alford, C. F. (2002). *Whistleblowers: Broken Lives and Organizational Power*. Cornell University Press.
- Angelucci, C. and A. M. Han (2010). Monitoring Managers Through Corporate Compliance Program. Amsterdam Center for Law and Economics, Working Paper 2010-14.
- Aubert, C. (2009). Managerial Effort Incentives and Market Collusion. Toulouse School of Economics Working Paper No. 09-127.
- Aubert, C., P. Rey, and W. E. Kovacic (2006). The Impact of Leniency and Whistleblowing Programs on Cartels. *International Journal of Industrial Organization* 24(6), 1241–1266.
- Bergman, N. and D. Jenter (2007). Employee Sentiment and Stock Option Compensation. *Journal of Financial Economics* 84, 667–712.
- Brenner, S. (2009). An Empirical Study of the European Corporate Leniency Program. *International Journal of Industrial Organization* 27(6), 639–645.
- Brian, H. and K. Murphy (2003). The Trouble with Stock Options. *Journal of Economic Perspectives* 17(3), 49–70.
- Carson, T. L., V. M.E., and W. R.E. (2008). Whistle-Blowing for Profit: An Ethical Analysis of the Federal False Claims Act. *Journal of Business Ethics* 77, 361–376.

- Cloutier, M. (2013a). An Empirical Investigation of the U.S. Corporate Leniency Program. Mimeo, Department of Economics, Queen's University.
- Cloutier, M. (2013b). Leniency Programs and Quality of Information. Mimeo, Department of Economics, Queen's University.
- Connor, J. M. (2007). *Global Price Fixing*. Springer. Second Edition.
- Core, J. and W. Guay (2001). Stock Option Plans for Non-Executive. *Journal of Financial Economics* 61, 253–287.
- Daulatraum, B. (2003). Organizational Culture and Job Satisfaction. *Journal of Business and Industrial Marketing* 18(3), 219–236.
- Festerling, P. (2005). Cartel Prosecution and Leniency Programs: Corporate versus Individual Leniency. University of Aarhus Denmark Working Paper 2005-20.
- Gordon, G. and N. DiTomaso (1992). Predicting Corporate Performance from Organizational Culture. *Journal of Management Studies* 29(6), 783–798.
- Hammond, S. D. (2004). Cornerstone of an Effective Leniency Program. ICN Workshop on Leniency Programs, Sydney, Australia, November 22-23, Available online, March 15, 2012, at <http://www.justice.gov/atr/public/speeches/206611.htm>.
- Hammond, S. D. (2010). The Evolution of Criminal Antitrust Enforcement Over the Last Two Decades. National Institute on White Collar Crime, Miami, Florida, February, Available online, March 15, 2012, at <http://www.justice.gov/atr/public/speeches/255515.htm>.
- Harrington, J. (2008). Optimal Corporate Leniency Programs. *Journal of Industrial Economics* 56(2), 215–246.
- Levenstein, M. C. and V. Y. Suslow (2006). What Determines Cartel Success? *Journal of Economic Literature* XLIV, 43–95.

- Miller, H. N. (2009). Strategic Leniency and Cartel Enforcement. *American Economic Review* 99(3), 750–768.
- Morris, S. (1995). The Common Prior Assumption in Economic Theory. *Economics and Philosophy* 11, 227–253.
- Motta, M. and M. Polo (2003). Leniency Programs and Cartel Prosecution. *International Journal of Industrial Organization* 21(3), 347–379.
- Spagnolo, G. (2000). Optimal Leniency Programs. University of Rome, Stockholm School of Economics, CEPR Discussion Paper No.4840, FEEM Working Paper No.42.2000.
- Spagnolo, G. (2008). Leniency and Whistleblowers in Antitrust. Chapter 7 in Buccirosi P. Handbook of Antitrust Economics, MIT Press, Cambridge, Massachusetts, U.S.A.
- Stigler, G. J. (1964). A Theory of Oligopoly. *Journal of Political Economy* 72(1), 44–61.
- Van den Steen, E. (2010). On the Origin of Shared Beliefs (and Corporate Culture). *RAND Journal of Economics* 41(4), 617–648.

Appendix A

Appendix

Proof: Lemma 3

Proof. The condition $\alpha \leq \alpha_I$ comes from eliminating the first possible profitable deviation in $t = 1$, that is $V_{CRI} \geq V_D$. Similarly, the condition $p \geq p_I(\alpha)$, for $t = 1$, is obtained from $V_{CRI} \geq V_{DNL}$. Other possible profitable deviations are constrained by imposing $\delta \geq \delta_0$. The rest of the argument shows that the parameter space is non-empty. I start with α_I . The polynomial describing α_I is of the following form:

$$g(x) = -Ax^2 + Bx - C = 0, \text{ where } A, B, C > 0$$

I investigate the property of $g(x)$. The main concern is that the roots are not in $x \in [0, 1]$. First, $g(x)$ is a concave function ($g''(x) < 0$) with its maximum value in $x > 0$ (at $x^* = \frac{2A}{B} > 0$). Since $g(0) = -C < 0$, I conclude that the roots are in the range $x > 0$. I then impose the determinant ($\Delta = B^2 - 4AC > 0$) to be positive for obtaining two real roots. This is satisfied if the full fine, F , is sufficiently big:

$$F > F_{\Delta 1} \equiv \frac{2r^2(1-\delta)[\pi_M - \pi_D(1-\delta) - \delta\pi_N]}{cs^2} - \frac{\pi_M - \pi_N}{s}$$

Finally, since this polynomial has two roots in the range $x > 0$, one needs to check if they

are in $x \in [0, 1]$. Recall the formula for computing the quadratic polynomial roots:

$$x = \frac{-B \pm \sqrt{\Delta}}{-2A}$$

It is a straightforward exercise to check that a single root can be such that $x < 1$ with a sufficiently high fine F . So, the small root will be this single root if the following inequality holds: $A + C < B$. This implies the following condition:

$$F > F_{R1} \equiv \frac{r^2 \delta^2}{2c} - \frac{(\pi_D - \pi_M)}{\delta s}$$

I can then conclude that $g(x) = 0$ yields a single root in the range $[0, 1]$ with the minimal requirement that $F > \max\{F_\Delta, F_R\}$. The second check for non-emptiness is for $p \geq p_I(\alpha)$. There is no floor value for $p_I(\alpha)$ and a ceiling value of one: $p_I(\alpha) < 1, \forall \alpha \in [0, 1]$. Finally, it is a straightforward exercise to show that $p_I(0) = 1$, $\frac{\partial p_I(\alpha)}{\partial \alpha} < 0$, and $\frac{\partial^2 p_I(\alpha)}{\partial \alpha^2} < 0$, since the inequality $1 - \frac{\alpha \delta r}{c} > 0$ always hold ($e \in [0, 1]$). Hence, $p \geq p_I(\alpha)$ is non-empty. \square

Proof: Lemma 4

Proof. The condition $p \leq p_{NL}(\alpha)$ comes from eliminating the first possible profitable deviation in $t = 1$, that is $V_{CRI} \geq V_D$. Similarly, the condition $\alpha \leq \alpha_{NL}(p)$, for $t = 1$, is obtained from $V_{CNL} \geq V_{DRI}$. Other possible profitable deviations are constrained by imposing $\delta \geq \delta_0$. The rest of the argument shows that the parameter space is non-empty. I start with $p_{NL}(\alpha)$. The only requirement here is that $p_{NL}(\alpha) \geq 0$. This condition is always satisfied once imposed $\delta \geq \delta_0$ implying a non-negative numerator. Similarly for $\alpha_{NL}(p)$, I only need to check that $\alpha_{NL}(p) \geq 0$. This is always satisfied for $p \leq s$ and won't be an issue as the optimal policy will be to set $s^* = 1$ (to come later). Hence, the solution region is non-empty. \square

Proof: Proposition 1

Proof. Follows from Lemmas 1, 3 and 4 with the additional conditions: $V_{NC} \geq V_{CRI}$, $V_{NC} \geq V_{CNL}$, and $V_{CRI} \geq V_{CNL}$ yielding $\alpha \geq \alpha_{IN}$, $p \geq p_{NLN}(\alpha)$, and $p \geq p_{INL}(\alpha)$. The rest of the argument shows that the parameter space is non-empty. For those three curves, conditions have to be imposed for characterizing the dominant equilibria from the point of view of the firms and ensuring that the solution fits in $[0, 1]$. I start with $p_{INL}(\alpha)$. Imposing that $p_{INL}(\alpha) \geq 0$ boils down to the following condition:

$$F \geq F_{INL} \equiv \frac{r^2\delta(1-\delta) - 2c(\pi_M - \pi_N)}{2cs(1-\delta)}$$

On the other side, the condition $p_{INL}(\alpha) \leq 1$ is always satisfied by straightforward algebraic manipulation. The case of α_{IN} follows the analysis performed for α_I . The polynomial describing α_{IN} is of the following form:

$$f(x) = -Ax^2 + Bx - C = 0, \quad , \text{ where } A, B, C > 0$$

I investigate the property of $f(x)$. First, note that $f''(x) < 0$ and $f(0) < 0$. I conclude that the roots are in the range $x > 0$. I then impose a positive determinant ($\Delta = B^2 - 4AC > 0$) for obtaining two real roots. The condition is given by the following:

$$F > F_{\Delta 2} \equiv \sqrt{\frac{2r^2(\pi_M - \pi_N)}{cs^2(1-\delta)}} - \frac{\pi_M - \pi_N}{s(1-\delta)}$$

Finally, since this polynomial has two roots in the range $x > 0$, one needs to check if can be the case that both roots be in $x \in [0, 1]$. Remember that the quadratic formula for computing the roots of $f(x)$ is the following:

$$x = \frac{-B \pm \sqrt{\Delta}}{-2A}$$

It is a straightforward exercise to check that only a single root can be such that $x < 1$ with a sufficiently high fine F . So the small root will be this single root if the following inequality

hold: $A + C < B$, rewritten most precisely as

$$F > F_{R2} \equiv \frac{\frac{r^2\delta^2}{2c} + (\pi_M - \pi_N)}{\delta s}.$$

I can then conclude that $f(x) = 0$ yields a single root in the range $[0, 1]$ with the minimal requirement that $F > \max\{F_{\Delta 2}, F_{R2}\}$. Finally, I study the non-emptiness of $p_{NLN}(\alpha)$. The existence of a solution in $[0, 1]$ is given by

$$F \geq F_{NLN} \equiv \frac{\pi_M - \pi_N}{\delta}.$$

This condition comes from imposing an intersection between $p = 1$ and $p_{NLN}(\alpha)$, where the correspondent α fits in $[0, 1]$. From the above discussion, the proposition only holds if

$$F > \underline{F} \equiv \max\{F_{\Delta 1}, F_{\Delta 2}, F_{R1}, F_{R2}, F_{INL}, F_{NLN}\}$$

□

Proof: Lemma 5

Proof. To conclude on a larger region where the strategy no-collusion is an SPNE, I look at curves delimitating this equilibrium. Two curves are delimitating that region: α_{IN} and $p_{NLN}(\alpha)$.

Starting by α_{IN} , I first write down the simplified polynomial $f(x) = -Ax^2 + Bx - C$, where $A, B, C > 0$. This polynomial function has two zeros: one where $x > 0$ and one where $x < 0$. Since the interest is on the region where the polynomial is negative and such that $x \leq 1$, I look at the property of the function $x = \frac{B - \sqrt{B^2 - 4AC}}{2A}$. From the parametrization of the polynomial, an increase in F is equivalent to an increase in B , implying a root closer to

the y-axis, hence α_{IN} is lower:

$$\frac{\partial x}{\partial B} = \frac{\sqrt{B^2 - 4AC} - B}{2A} < 0$$

For $p_{NLN}(\alpha)$, the computation is straightforward: an increase in F implies a lower area under the curve:

$$\frac{\partial p_{NLN}(\alpha)}{\partial F} = -\frac{(1 - \delta)[\pi_M - \delta\pi_N]}{\alpha\delta[\pi_M + F(1 - \delta) - \pi_N]^2} < 0$$

As for the CRI part, F enters the three following curves delimitating the equilibrium: $p_I(\alpha)$, p_{INL} and α_I . I start with α_I . Recall $g(x)$ from Lemma 3's proof. The root of interest (discriminant given by: $\Delta = B^2 - 4AC$) can be written as follows:

$$x = \frac{B - \sqrt{\Delta}}{2A}$$

The partial derivative of x is negative implying a root closer to the y-axis with higher F :

$$\frac{\partial x}{\partial B} = \frac{\sqrt{B^2 - 4AC} - B}{2A} < 0$$

As for $p_I(\alpha)$ and p_{INL} , it is straightforward to see that $\frac{\partial p_I}{\partial F} > 0$ and $\frac{\partial p_{INL}}{\partial F} > 0$. Hence, an increase in F shrinks the region where the strategy CRI is an equilibrium.

As for the CNL part, F enters the following three curves delimitating the region: $p_{NL}(\alpha)$, $\alpha_{NL}(p)$ and $p_{INL}(\alpha)$. The analysis for the first curve is straightforward and it follows that an increase in F will move the curve downward. As for $\alpha_{NL}(p)$, an increase in F moves the curve upward. This is a counter-intuitive result. From the formulation of $p_{INL}(\alpha)$, an increase in F moves the curve downward. By increasing F , the curve $\alpha_{NL}(p)$ will move upward binding the two other incentive constraints. As we will later see in the AA section, this problem vanishes by noting that $p_{NL}(\alpha)$ is an iso-welfare curve. As long as the curves

$\alpha_{NL}(p)$, $p_{INL}(\alpha)$ and $p_{NL}(\alpha)$ intersect in $[0, 1]^2$, no problem arises. \square

Proof: Lemma 6

Proof. For the NC part of the proposition, s only enters the curve α_{IN} . The proof is identical to Lemma 5. Similarly for CRI, it follows from Lemma 5, where the effect is identical. Finally, for the equilibrium CNL, it follows from the analysis on $\alpha_{NL}(p)$ in Lemma 5. \square

Proof: Lemma 7

Proof. Four curves delimitating the equilibrium CRI are affected by a change in c : $p_I(\alpha)$, p_{INL} , α_{IN} , and α_I . I start with α_I . Again, the root of interest is given by the following:

$$x = \frac{B - \sqrt{\Delta}}{2A}$$

The partial derivative with respect to A is positive.

$$\frac{\partial x}{\partial A} = \frac{\overbrace{B[B - \sqrt{\Delta}] - 2AC}^{>0}}{4A^2} > 0$$

Similarly for α_{IN} where, again, the root of interest is given by the following:

$$x = \frac{B - \sqrt{\Delta}}{2A}$$

From a straightforward calculation and since $A, B, C > 0$, I get that the partial derivative with respect to A is positive:

$$\frac{\partial x}{\partial A} = \frac{B[B - \sqrt{\Delta}] - 2AC}{4A^2\sqrt{\Delta}} > 0$$

As for the curve $p_I(\alpha)$, I get the desired result from the following calculation:

$$\frac{\partial p_I(\alpha)}{\partial c} = -2\alpha r F \delta \overbrace{[2c - \alpha \delta r]}^{>0} - 4\alpha c F^2 \delta (1 - s) < 0$$

Finally, it is straightforward to see that a decrease in c negatively increases the slope of the curve p_{INL} . A decrease in c creates a larger region where CRI is an equilibrium. \square

Proof: Lemma 9

Proof. The only curve determining NC equilibrium and affected by a change in r (or c) is α_{IN} . From Lemma 8, it implies that the NC equilibrium region shrinks as r increases (c decreases).

As for the CNL part, two curves are affected by such a change: $\alpha_{NL}(p)$ and $p_{INL}(\alpha)$. The analysis is similar to Lemma 5. \square

Proof: Proposition 2

Proof. I start with the NC. The optimal value of sF and r follows from Lemmas 5, 6 and 9. As for CNL, it follows from Lemmas 5, 6, and 9. Finally, for CRI, from Lemmas 5, 6, 7, and 8, I set values for $\{s, r, F\}$, where r is bounded above by $R(e^*) \geq -M_R$. Hence, $r^* = \bar{r} \equiv \sqrt{\frac{cM_R}{\alpha^* \delta}}$ \square

Proof: Proposition 3

Proof. The budget constraint (BC) of the AA is given by $Ap + B\alpha \leq M$. Rewriting the BC in terms of α , I get $p \leq p_{BC}(\alpha) \equiv \frac{M - B\alpha}{A}$. I start with NC. Recall that the welfare under that equilibrium is $W_{NC} = \frac{SDWL}{1 - \delta}$, the budget constraint is $p \leq p_{BC}(\alpha)$ and the solution region was established in Proposition 1. The key fact here is the BC. Since the welfare attached to the equilibrium NC for the AA is the highest of the three strategies, the only requirement is feasibility. Hence, if the BC crosses the solution region for NC,

$p_{BC}(\alpha_{IN}) \geq p_{NLN}(\alpha_{IN})$, any feasible point is an optimal policy. So, any point such that $\alpha^* \geq \alpha_{IN}$ and $p^* \in [p_{NLN}(\alpha^*), p_{BC}(\alpha^*)]$ is an optimal policy. \square

Proof: Proposition 4

Proof. For the the AA to prefer the equilibrium CRI over NC, it must be the case that NC is not feasible: $p_{BC}(\alpha_{IN}) < p_{NLN}(\alpha_{IN})$. Similarly, it must be the case that CRI dominates the equilibrium CNL. This is satisfied when $W_{CRI} > W_{CNL}$. As for the optimal policy, this is a little trickier. I first build the iso-welfare curves. I write $W = f(\alpha)$, where

$$f(\alpha) \equiv -2C(e^*(\alpha)) + \alpha\delta K.$$

This implies that $f(0) = 0$, $f''(\alpha) = 0$ and the first derivative $f'(\alpha) > 0$ when $M_R < 2K$. So, whenever $M_R < 2K$, iso-welfare curves are straight lines increasing with α . It turns out that to have CRI dominating CNL, the following inequality has to be satisfied:

$$W_{CRI}(\alpha) > W_{CNL}(\alpha, p) \Leftrightarrow p < p_W \equiv 1 - \frac{M_R}{2K}$$

Hence, if a solution exists, it will satisfy the following:

$$\alpha^* = \left\{ \alpha : p_{BC}(\alpha) = \max \{p_I(\alpha); p_{INL}(\alpha)\} \leq p_W, \alpha \leq \min\{\alpha_I; \alpha_{IN}\} \right\} \text{ and } p^* = p_{BC}(\alpha^*)$$

This solution assumes that p_W intersects with $p_{BC}(\alpha)$ at a higher value in terms of α than $\max\{p_I(\alpha); p_{INL}(\alpha)\}$ intersects with $p_{BC}(\alpha)$. Whenever the intersection of $\max\{p_I(\alpha); p_{INL}(\alpha)\}$ and $p_{BC}(\alpha)$ is such that $\alpha \leq \min\{\alpha_I; \alpha_{IN}\}$, it must be the case that CRI dominates CNL. \square

Proof: Proposition 5

Proof. For the the AA to prefer the equilibrium CRI over NC, it must be the case that NC is not feasible: $p_{BC}(\alpha_{IN}) < p_{NLN}(\alpha_{IN})$. Similarly, it must be the case that CNL dominates

the equilibrium CNL. This is satisfied when $W_{CNL} > W_{CRI}$. As for the optimal policy, I first build the iso-welfare curves: $p = p_{W_{CNL}}(\alpha) \equiv \frac{W}{\alpha\delta K}$. The iso-welfare curves have as an element the curve $p_{NL}(\alpha)$. From the proof of Proposition 4, I have established that CNL is dominated by CRI if $p \leq p_W$, so in the case of interest, I simply inverse the relation to get CRI dominated by CNL when $p \geq p_W$. So two cases might happen, either the budget constraint crosses the upper-contour delimited by $p_{NL}(\alpha)$ or there is a tangent point between an iso-welfare curve and the budget constraint represented by the two solutions:

- (i) $\alpha^* = \{\alpha : p_{BC}(\alpha) = p_{NL}(\alpha) \geq p_W\}$ and $p^* = p_{BC}(\alpha^*)$
- (ii) $\alpha^* = \{\alpha : p'_{BC}(\alpha) = p'_{W_{CNL}}(\alpha), p_{BC}(\alpha) \geq p_W\}$ and $p^* = p_{BC}(\alpha^*)$

In (i), the budget constraint crosses the upper-contour $p_{NL}(\alpha)$ and the intersection happens above $p_W(\alpha)$. Finally, in (ii), there is a tangency between the budget constraint and the iso-welfare and this happens above $p_W(\alpha)$. □

Proof: Proposition 6

Proof. The proof is essentially a comparison of the solution region at optimality under the two regimes: $R(e)$ and R . I compare ?'s result with mine.

The equivalent to α_I is α_I^M . It is straightforward to show that $\alpha_I \geq \alpha_I^M$:

$$\alpha \leq \alpha_I^M \equiv \frac{\pi_M - \pi_D(1 - \delta) - \pi_N}{\delta[\pi_M + R(1 - \delta) - \pi_N]}$$

Rewriting the inequality describing α_I , I get the following:

$$\alpha \leq \alpha_I^M + \left\{ \frac{\alpha^2 \delta^2 r^2 (1 - \delta)}{2c\delta[\pi_M + R(1 - \delta) - \pi_N]} \right\}$$

Hence, α_I is necessarily bigger than or equal to α_I^M .

The equivalent to $p_I(\alpha)$ is the inequality $R \leq F$. It is a straightforward exercise to show that whenever M_R is big enough, the constraint $p \geq p_I(\alpha)$ is identical to $p \geq 0$, which means that the constraint never binds.

The equivalent to $p_{INL}(\alpha)$ is $p_{INL}^M(\alpha)$, where

$$p \geq p_{INL}^M(\alpha) \equiv \frac{\pi_M + R(1 - \delta) - \pi_N}{\pi_M - \pi_N + F(1 - \delta)}.$$

Rewriting $p_{INL}(\alpha)$, I get that

$$p_{INL}(\alpha) = p_{INL}^M(\alpha) - \left\{ \frac{\alpha \delta r^2 (1 - \delta)}{2[\pi_M - \pi_N + F(1 - \delta)]} \right\}.$$

Hence, $p_{INL}(\alpha) \leq p_{INL}^M(\alpha)$.

Finally, the equivalent α_{IN} is α_{IN}^M , where

$$\alpha \leq \alpha_{IN}^M \equiv \frac{\pi_M - \pi_N}{\delta[\pi_M - \pi_N + R(1 - \delta)]}.$$

Rewriting the inequality for α_{IN} , I get that

$$\alpha \leq \alpha_{IN}^M + \left\{ \frac{\alpha^2 \delta^2 r^2 (1 - \delta)}{2c} \right\}.$$

Hence, α_{IN} is necessarily bigger or equal than α_{IN}^M .

□

Proof: Proposition 7

Proof. The two frontlines defining CNL equilibrium are determined by $R(e)$ and subject to the change of regime. The case of $p_{INL}(\alpha)$ has been dealt with in the proof of Corollary 1.

The case of interest here is what happens to the profitable deviation to *collude and reveal information*. In Lemma 4, it has been established that the solution region is bounded by the following:

$$\alpha \leq \alpha_{NL}(p) \equiv \frac{2F(s-p)c(1-\delta)^2}{\delta \left\{ r(1-\delta) - (1-p)(\pi_M - \pi_N) \right\}^2}$$

The parallel is ?'s:

$$p \leq p_{NL}^M(\alpha) \equiv \frac{\pi_M - \pi_N + (1-\delta)R}{\pi_M - \pi_N + (1-\delta)F}$$

The optimal policy as described in ? is to set $R = F$ implying that $p_{NL}^M(\alpha) = 1$. Since $\alpha_{NL}(p)$ decreases in p and either crosses or not the line $p = 1$ at a point $\alpha \leq 1$. I then obtain that either the solution region shrinks or is identical for that curve. Adding to this the effect of $p_{INL}(\alpha)$, I get the desired result. \square

Proof: Proposition 9

Proof. For the non-conditional case, recall $\alpha_I^M(R)$. The global maximum of this function with respect to R happens whenever the denominator is as close to zero as possible. The denominator tends to zero as R tends to $R_1 \equiv \frac{\pi_M - \pi_N}{1-\delta}$.

For the conditioning case, since at optimality $\{s^*, r^*, F^*\} = \{0, \bar{r}, \underline{F}\}$, it implies that $R(e^*) < 0$. \square