UNIVERSITE DE LAUSANNE
FACULTE DES HAUTES ETUDES COMMERCIALES

# LENIENCY PROGRAMS, ANTITRUST ENFORCEMENT AND MULTIMARKET CONTACT:
# THREE ESSAYS IN INDUSTRIAL ORGANIZATION

THESE

Présentée à la Faculté des HEC
de l'Université de Lausanne

par

**Catherine ROUX**

Licenciée en 2004
de l'Université de Lausanne

Titulaire d'un Master en Economie Industrielle,
Microéconomie et Econométrie
de l'Université Paris 1 Panthéon - Sorbonne

Pour l'obtention du grade de
Docteur en Sciences Economiques mention « Economie Politique »

2010

UNIL | Université de Lausanne
HEC Lausanne
Le Doyen
Bâtiment Internef
CH-1015 Lausanne

# IMPRIMATUR

Sans se prononcer sur les opinions de l'auteur, le Conseil de la Faculté des hautes études commerciales de l'Université de Lausanne autorise l'impression de la thèse de Madame Catherine ROUX, licenciée en Sciences Economiques de l'Université de Lausanne, titulaire d'un master en Economie Industrielle, Microéconomie et Econométrie de l'Université Paris 1 Panthéon-Sorbonne, en vue de l'obtention du grade de docteur en Sciences Economiques, mention "Economie Politique".

La thèse est intitulée :

**LENIENCY PROGRAMS, ANTITRUST ENFORCEMENT AND MULTIMARKET CONTACT: THREE ESSAYS IN INDUSTRIAL ORGANIZATION**

Lausanne, le 20 avril 2010

Le doyen

Daniel Oyon

Tél. ++41 21 692 33 66 | Fax ++41 21 692 34 35 | hecdoctorats@unil.ch

# THESIS COMMITTEE

**Professor Thomas von Ungern-Sternberg**

Supervisor

Professor of Economics

Department of Economics, University of Lausanne, HEC

**Professor Bettina Klaus**

Internal Expert

Professor of Economics

Department of Economics, University of Lausanne, HEC

**Professor Damien Neven**

External Expert

Chief Competition Economist

European Commission, Directorate-General for Competition

**Professor Armin Schmutzler**

External Expert

Professor of Economics

Socioeconomic Institute, University of Zürich

Université de Lausanne
Faculté HEC

Doctorat en Sciences Economiques
mention « Economie Politique »

Par la présente, je certifie avoir examiné la thèse de doctorat de

**Catherine ROUX**

Sa thèse remplit les exigences liées à un travail de doctorat.
Toutes les révisions que les membres du jury et le-la soussigné-e ont demandées durant le colloque de thèse ont été prises en considération et reçoivent ici mon approbation.

Signature : _______________ Date : 26/4/10

Prof. Thomas VON UNGERN-STERNBERG
Directeur de thèse

Université de Lausanne
Faculté HEC

Doctorat en Sciences Economiques,
mention « Economie Politique »

Par la présente, je certifie avoir examiné la thèse de doctorat de

**Catherine ROUX**

Sa thèse remplit les exigences liées à un travail de doctorat.
Toutes les révisions que les membres du jury et le-la soussigné-e ont demandées durant le colloque de thèse ont été prises en considération et reçoivent ici mon approbation.

Signature : B.-E. Klaus Date : 26.04.2010

Prof. Bettina KLAUS
Membre interne du jury

Université de Lausanne
Faculté HEC

Doctorat en Sciences Economiques,
mention « Economie Politique »

Par la présente, je certifie avoir examiné la thèse de doctorat de

**Catherine ROUX**

Sa thèse remplit les exigences liées à un travail de doctorat.
Toutes les révisions que les membres du jury et le-la soussigné-e ont demandées durant le colloque de thèse ont été prises en considération et reçoivent ici mon approbation.

Signature : ____________ Date : 25/4/10.

Prof. Damien NEVEN
Membre externe du jury

Université de Lausanne
Faculté HEC

Doctorat en Sciences Economiques,
mention « Economie Politique »

Par la présente, je certifie avoir examiné la thèse de doctorat de

**Catherine ROUX**

Sa thèse remplit les exigences liées à un travail de doctorat.
Toutes les révisions que les membres du jury et le-la soussigné-e ont demandées durant le colloque de thèse ont été prises en considération et reçoivent ici mon approbation.

Signature : ______________ Date : 19/04/2010

Prof. Armin SCHMUTZLER
Membre externe du jury

# Acknowledgements

This work has benefitted from the support and comments of many. There is only enough space to mention a few.

First of all, I am deeply indebted to my supervisor Thomas von Ungern-Sternberg for his invaluable support and interest in my research. Beyond providing excellent supervision, he was always willing to listen to me, be it for professional or personal matters.

Second, I would like to thank Damien Neven for having hosted me as a visiting fellow in the Chief Economist Team at the European Commission in Brussels.

Moreover, I am very much obliged to my good friend and coauthor Yassine Lefouili for profoundly inspiring research collaborations the result of which can be admired in chapters 2 and 3 of this thesis.

My special thanks go to the jury of experts: Bettina Klaus, Damien Neven and Armin Schmutzler. Their precious comments shaped the form of this work. I would also like to mention my colleagues Frederic Payot and Stefano Puddu with whom I had the pleasure to share office.

Last but not least, I heartily thank my parents Marc and Christiane Roux and my sister Jeannette for their unconditional support and generous encouragement through all these years. Without them, the success of this work would have been unthinkable. I am especially grateful to Tobias Menz who shared with me the good and made me laugh in the bad times.

*Meinen Eltern gewidmet*

# Contents

# List of Figures

# Introduction

## Cartels and Leniency Programs

Cartels are a form of illegal behavior which involves the joint, coordinated effort of several rivaling agents to artificially restrict competition by using collusive practices such as price fixing, market sharing or entry prevention. Successful collusion allows these firms to raise prices above the competitive level and reduces social welfare. Accordingly, most antitrust laws prohibit cartels, and antitrust authorities devote large efforts to fighting collusive practices.

In recent years, many policy reforms have been undertaken with the objective to deter and break up cartel activities more effectively and alleviate lengthy administrative procedures. For example in 2008, the European Commission (EC) adopted a white paper on the issue of using customer damages as a penalty[1] and introduced a settlement procedure for cartels to speed up investigations and to redirect resources towards a more rigorous detection of cartels.[2] On the other side of the Atlantic, in 1991, the United States (US) Sentencing Commission promulgated guidelines governing the imposition of sentences on organizations and allowed for significantly harsher penalties.[3] In 2004, the Senate passed a tough antitrust reform act that increased the statutory limit on corporate penalties from $10 million to $100 million and de-trebled civil damages for amnesty applicants.[4] One particular event shall however dwarf all previous and forthcoming

[1]White Paper on Damages Actions for Breach of the EC antitrust rules, COM(2008) 165, 2.4.2008.

[2]Commission Regulation (EC) No 622/2008 of 30 June 2008 amending Regulation (EC) No 773/2004, as regards the conduct of settlement procedures in cartel cases, Official Journal L 171, 1.7.2008, p.3−5.

[3]U.S. Federal Sentencing Guidelines, Sentencing Guidelines Manual and Appendices (2009).

[4]Antitrust Criminal Penalty Enhancement and Reform Act of 2004, H.R. 1086, 108$^{th}$ Cong., Title II, §201-221 (2004).

policy innovations worldwide: The revision of the *Corporate Leniency Program*, "the greatest investigative tool ever designed to fight cartels" (Hammond, 2004, p.2). [5]

Leniency programs cancel the fine against the first cartel member that reports decisive information to the antitrust authority and goes on collaborating with it during the prosecution. In contrast to individual crimes where the wrongdoer is careful to be incognito or unobserved, cartels are organized crimes that build on the coordination between several agents who automatically acquire information on each other's infringement that they can potentially be induced to reveal. The leniency program - if well designed - can not only disrupt existing cartels by making the confession of the crime attractive but also prevent their formation by undermining trust among potential co-conspirators with the increased likelihood that a cartel member, fearing detection, will turn the others in.

The antitrust division of the US Department of Justice (DoJ) introduced its first leniency policy in 1978. It substantially revised this scheme in 1993 to make it easier and financially more attractive for firms to apply. The revision involved three major modifications: First, complete amnesty is automatic if there is no pre-existing investigation. Second, discretionary amnesty can be granted even if an investigation is already underway. Third, all directors, officers and employees of the first firm that cooperates with the DoJ are protected from criminal prosecution.[6] The revised leniency program caused a surge in amnesty applications. While under the old regime, the DoJ obtained one application per year, the revised program generated more than one application per month.

Inspired by the success stories from overseas, the EC adopted its own leniency program in 1996.[7] This program failed for mainly the same reasons as its early US predecessor. In 2002, the EC substantially revised its leniency program and adopted a policy that closely mimics the DoJ's Corporate Leniency Program of 1993.[8] Under the 2002 *Leniency Notice* the number of leniency applications per year more than quadrupled. Finally, in the latest revision of 2006, the EC adopted a marker system which grants

[5] U.S. Department of Justice, Antitrust Division, Corporate Leniency Program (08/10/1993).

[6] U.S. Department of Justice, Antitrust Division, Individual Leniency Program (08/10/1994).

[7] 1996 Commission notice on the non-imposition or reduction of fines in cartel cases, Official Journal C 207, 18.07.1996, p.4-6.

[8] 2002 Commission notice on immunity from fines and reduction of fines in cartel cases, Official Journal C 45, 19.02.2002, p.3-5.

conditional immunity to the applicant on the basis of only limited information, leaving enough time to gather the necessary evidence.[9]

The leniency programs in the US and the European Union (EU) display four main differences: First, while in the US only the first informant can get leniency, in the EU, firms, that do not qualify for full immunity, can still be eligible for fine discounts of 30-50%, 20-30% and up to 20% respectively for the first, second and subsequent firms which provide the EC with evidence of significant added value with respect to what it already holds. Second, while ringleaders can be eligible for leniency in Europe, they are excluded from the program in the US. Third, while the European antitrust law does not hold individuals liable, the US leniency program can protect them from criminal prosecution. Finally, and in my view, the most important difference is the US treatment of parallel cartel offenses by means of the *Amnesty Plus* and *Penalty Plus* programs, included in the US Corporate Leniency Program in 1999, and the related *Omnibus Question*. Amnesty Plus substantially reduces the fine imposed on a firm, already convicted in one cartel, if this firm is first to report another cartel agreement in which it is involved. In addition to benefitting from a fine discount in the initial infringement, it gets complete immunity in the second offense. Penalty Plus punishes a firm which has failed to use Amnesty Plus and is later caught in a second offense. Moreover, companies' representatives must answer whether they know of any collusion in other markets as part of entering the leniency program. Failure to truthfully answer that so-called Omnibus Question results in a complete loss of amnesty, which, coupled with criminal fines for individual wrongdoers, creates incentives for the individual employee to reveal ongoing collusion in other markets.

## Implications for Antitrust Policies

The main objective of antitrust law enforcement against cartels is, first, to avoid the formation of cartels, that is deterrence, and second, to break up the cartels that have not been deterred, that is desistance. A policy instrument is typically evaluated with respect to its effect on both deterrence and desistance.

[9]2006 Commission notice on immunity from fines and reduction of fines in cartel cases, Official Journal C 298, 8.12.2006, p.17.

A burgeoning theoretical literature is ambiguous regarding the potential effects of leniency and its implications for antitrust policy. A common finding is that leniency may destabilize cartels because conspirators may simultaneously deviate from the cartel and apply for leniency (Harrington, 2008; Chen and Rey, 2007; Spagnolo, 2004). Leniency may also destabilize cartels by increasing the riskiness of collusive equilibria (Spagnolo, 2004), by making it more likely that an investigation is successful and that the cartel is put an end to (Motta and Polo, 2003) or when firms can exploit the policy to raise rivals' costs in subsequent periods (Ellis and Wilson, 2003). Alternatively, leniency may stabilize collusive arrangements (Brisset and Thomas, 2004; Ellis and Wilson, 2003; Spagnolo, 2000) and may encourage new cartels to form when probabilities of detection and successful prosecution stochastically fluctuate over time and firms anticipate reduced fines (Harrington, 2008; Motta and Polo, 2003). The effect of leniency may also depend on market concentration (Ellis and Wilson, 2003), whether programs are courageous or modest (Spagnolo, 2004; Aubert, Kovacic, and Rey, 2006) and whether fines are proportional to accumulated cartel profits (Motchenkova and Van der Laan, 2005).

Primarily due to the difficulty, common to all empirical research on collusion, that active cartels are never observed in the data, empirical studies are scarce. Miller (2009) provides the first empirical evaluation of leniency, as it is applied in the US, and shows that it enhances both deterrence and detection. Brenner (2009) examines the effectiveness of the 1996 version of the EU Leniency Program and finds that it helps information revelation with regard to cartels already under scrutiny, but that it has no statistically significant deterrent effects in the long-run.

Although experiments allow to elegantly capture the unobservable deterrence effects of leniency programs, Hinloopen and Soetevent (2008) is the only experimental study that keeps up with the models in the recent theoretical literature.[10] The findings suggest that the introduction of leniency causes more deterrence, a reduced life-time of cartels that are not deterred and a constant high rate of collusive recidivism.

Although, in virtually all studies, the effects of leniency hinge on specific parameters, the overall conclusion of the literature is that leniency programs, if properly designed, make collusion more difficult.

[10] Apesteguia, Dufwenberg, and Selten (2003) are the first to build an experiment, but they only examine one-shot interactions. Hamaguchi and Kawagoe (2005) initially forces all subjects to collude and can therefore not capture the effect of leniency on deterrence.

## Global Cartels and Multimarket Contact

Nowadays, a large company is typically active in various industries. A single product firm usually operates in several distinct geographic markets. Examining recent cartel scores, a pattern in the time and place cartel activities occur becomes apparent. In many cases, the biggest players in one particular market start colluding, and, after a short time period during which the cartel has proven to be successful, replicate this activity in other markets where they compete. Typical examples where the identities of the conspirators as well as the durations of their participation in the infringements overlap include the cartels in vitamins, lysine and citric acid, which I will discuss in chapters 1 and 2. Another illustrative case is the cartel in mechanical carbon and graphite products. In 2003, the EC imposed fines totalling €101.44 million on SGL, Carbone Lorraine and five other companies for operating a cartel in the market for carbon and graphite products. Between October 1988 and December 1999, these companies, who together control 93% of the European carbon and graphite products market, fixed prices and warded off outside competition by undercutting the few rivals left. During the same period, SGL was the ringleader in two other cartels: The speciality graphites cartel where it fixed prices and exchanged commercially sensitive information with, among others, Carbone Lorraine, Tokai Carbon and GraphTech (formerly UCAR) and the graphite electrode cartel where it fixed prices and shared markets with its partners from speciality graphites, Tokai Carbon and UCAR, and six other companies. Despite SGL's participation in all three infringements, the EC decreased the fine imposed on the company in carbon and graphite products on the grounds that the cartels were contemporaneous and did not qualify for recidivistic behavior. Moreover, SGL already had to pay high fines in the two other cartels and found itself in a precarious financial situation.

## Implications for Antitrust Policies

The idea that multimarket contact may soften competition was first raised by Corwin Edwards when he wrote

> "The interests of great enterprises are likely to touch at many points, and it would be possible for each to mobilize at any of these points a consider-

> able aggregate of resources. The anticipated gain to such a concern from unmitigated competitive attack upon another large enterprise at one point of contact is likely to be slight as compared with the possible loss from retaliatory action by that enterprise at many other points of contact."
> (Edwards, 1955, p.335)

There exists a vast empirical literature supporting this hypothesis (for example Fernandez and Marin (1998), Parker and Roeller (1997), Mason and Phillips (1996), Evans and Kessides (1994), Kim and Singal (1993)), but relatively little has been done on the topic in theory. Bernheim and Whinston (1990) provide a first theoretical formalization which shows that multimarket contact helps to sustain marginal collusion provided that markets are not identical. This result becomes stronger when firms have strictly concave static objective functions (Spagnolo, 1999) but gets weaker when they can only imperfectly observe rivals' actions (Thomas and Willig, 2006; Matsushima, 2001).

Although multimarket contact and its potential effect on collusion are extremely well documented, the question of whether and, if yes, how antitrust policies can take this aspect into account remains unanswered. With the implementation of the Amnesty Plus and Penalty Plus programs, the US DoJ has certainly taken a step in the right direction, but theoretical as well as empirical evaluations of these programs are lacking. My thesis aims at filling this gap in the theoretical literature.

## The Layout of My Thesis

This thesis contains three chapters in Industrial Organization that build on the work outlined above. The first two chapters combine leniency programs with multimarket contact and provide a thorough analysis of the potential effects of Amnesty Plus and Penalty Plus. The third chapter puts the whole discussion on leniency programs into perspective by examining other enforcement tools available to an antitrust authority. The main argument in that last chapter is that a specific instrument can only be as effective as the policy in which it is embedded. It is therefore important for an antitrust authority to know how it best accompanies the introduction or modification of a policy instrument that helps deterrence.

Chapter 1 examines the effect of Amnesty Plus and Penalty Plus on the incentives of firms to report cartel activities. The main question is whether the inclusion of these policies in a leniency program undermine the effectiveness of the latter by discouraging the firms to apply for amnesty. The model is static and focus on the ex post incentives of firms to desist from collusion. The results suggest that, because Amnesty Plus and Penalty Plus encourage the reporting of a second cartel after a first detection, a firm, anticipating this, may be reluctant to seek leniency and to report in the first place. However, the effect may also go in the opposite direction, and Amnesty Plus and Penalty Plus may encourage the simultaneous reporting of two cartels.

Chapter 2 takes this idea further to the stage of cartel formation. This chapter provides a complete characterization of the potential anticompetitive and procompetitive effects of Amnesty Plus in a infinitely repeated game framework when the firms use their multimarket contact to harshen punishment. I suggest a clear-cut policy rule that prevents potential adverse effects and thereby show that, if policy makers follow this rule, a leniency program with Amnesty Plus performs better than one without.

Chapter 3 characterizes the socially optimal enforcement effort of an antitrust authority and shows how this effort changes with the introduction or modification of specific policy instruments. The intuition is that the policy instrument may increase the marginal benefit of conducting investigations. If this effect is strong enough, a more rigorous detection policy becomes socially desirable.

# Chapter 1

# Multimarket Contact Between Leniency Applicants: Amnesty Plus and Penalty Plus

> *"Good experience with citric acid. Next opportunity [vitamin] B2. We think it's worth that we explore all possibilities of cooperation. Let's explore cooperation product-by-product." (Kuno Sommer, Hoffmann-La Roche, quoted in New York Times 10/10/99)*

## 1.1 Introduction

This chapter studies the potential of leniency programs, allowing for *Amnesty Plus* and *Penalty Plus*, to create incentives for companies, which are simultaneously participating in multiple cartel activities, to reveal the entire range of their antitrust offenses.

Recent cartel convictions in the markets for vitamins, citric acid and lysine suggest that companies which have been colluding in one specific product or geographic market are more likely to have engaged in, or at least to know about, cartel activities in other adjacent markets. Consider for example the vitamin case where, during ten years, Hoffmann-La Roche (HLR) was simultaneously active in virtually all cartels affecting the whole extent of bulk vitamin production.[1] The first main group of cartels consisted of price fixing agreements in the markets for vitamin A and E between HLR, BASF and Rhône-Poulenc. The initial success of these arrangements inspired their replication in the other vitamin markets. In these second-wave cartels, firms such as Merck, Takeda and Daiichi, simultaneously colluding in at least one other vitamin, joined the pioneers. While Rhône-Poulenc's disclosure of evidence on collusion in the vitamin A and E markets made the cartel's wall of silence crumble, only BASF's comprehensive collaboration with the US Department of Justice (DoJ) under the Amnesty Plus program accelerated inquiries and finally led to the successful prosecution of all participants. Accordingly, the European Commission (EC) stated that "the simultaneous existence of the collusive arrangements in the various vitamins was not a spontaneous or haphazard development, but was conceived and directed by the same persons at the most senior levels of the companies concerned".[2] Surprisingly, when Rhône-Poulenc plead guilty to its vitamin conspiracies under the US Corporate Leniency Program and applied for leniency also in Europe, it pursued cartel activities in methionine and methylglucamine.[3]

During the vitamin conspiracy, HLR was acting as a co-leader of the citric acid cartel, the world's most widespread acidulent and preservative used in the food and beverage industry, at the side of Archer Daniels Midland (ADM). In 1997, at the time of HLR's conviction under the US antitrust law for its participation in the citric acid cartel, the Division informed the company about the ongoing investigations in the vitamin market and even solicited its cooperation in return for lenient treatment. Instead of assisting the DoJ in its inquiries, not only did HLR's top executives, engaged in the citric acid conspiracy and holding at the same time important responsibilities in the vitamin business, boldly deny any knowledge of, or participation in, a vitamin cartel, but they also sharply increased their efforts to conceal the illegal arrangements. In 1997, shortly after ADM had plead guilty for criminal price fixing in citric acid, HLR and Jungbunzlauer AG (JBL) agreed to plea-bargain and to pay fines totaling $25 million. At the same time, ADM and JBL fixed prices and shared markets in sodium gluconate.[4]

[1] Concerned were the markets for vitamins A, E, B1, B2, B3 (niacin), B4 (choline chloride), B5, B6, B9 (folic acid), B12, C, D3, H (biotin), beta carotene, carotenoids and premixes.

[2] EC IP/01/1625 November 2001.

[3] EC IP/01/1625 November 2001, EC IP/02/976 July 2002, EC IP/02/1746 November 2002.

[4] EC IP/01/1743 December 2001, IP/01/1355 October 2001.

In 1995, two years before the citric acid cartel was exposed, dawn raids in the headquarters of ADM, the largest US processor of agricultural commodities, produced hard evidence of collusive arrangements in lysine, an essential amino acid. This investigation directly led to the citric acid cartel when authorities found documents and video tapes which contained references to the conspiracy in citric acid. The illegal price fixing and market sharing agreements in lysine were initiated by ADM in 1992 and discovered by the public in 1995 (Connor, 2000).[5] Besides ADM were involved its Asian rivals Ajinomoto, Cheil, Kyowa and Sewon. In 1996, the Asian lysine producers plead guilty and agreed to cooperate with the DoJ and to testify against ADM in return for lenient treatment. Just after the adoption of the 1996 EC Leniency Notice, Ajinomoto decided to inform the EC on the cartel and qualified for a 50% discount in fines. At the time Ajinomoto came forward, it was involved in a conspiracy in the market for nucleotides lasting until mid 1996 when it was unveiled by its accomplice Takeda, itself under investigation for participation in the vitamin cartel case.[6]

In the US, convictions of global cartels in the 1990s suggest that at least a dozen firms have become repeated offenders in related product industries (Connor, 2003). The DoJ has been investigating around 50 alleged international cartels in 2004, and half of them have been detected during inquiries on separate markets (Hammond, 2004). These so-called 'rolling investigations' and 'cartel profiling' techniques are the DoJ's response to companies' recidivism. With the objective of fully exploiting the multimarket contact between colluding firms, the DoJ implemented the Amnesty Plus and Penalty Plus programs in 1999 as part of its Corporate Leniency Policy (Spratling, 1999). According to Hammond, "The Division's Amnesty Plus program creates an attractive inducement for encouraging companies who are *already under investigation* to report the full extent of their antitrust crimes [...]." (Hammond, 2004, p.16).

Leniency programs cancel the fine against the first cartel member that brings decisive evidence to the antitrust authority. Amnesty Plus and Penalty Plus are aimed at attracting amnesty applications by encouraging subjects of ongoing investigations to consider whether they qualify for amnesty in other than currently inspected markets.

[5]EC IP/00/589 June 2000.
[6]EC IP/02/1907 December 2002.

Amnesty Plus offers a firm which plea-bargains an agreement for participation in one cartel, where it cannot obtain guaranteed amnesty, complete immunity in a second cartel affecting another market. Provided that the firm agrees to fully cooperate in the investigation of the conspiracy of which the DoJ was previously not aware, it is automatically granted amnesty for this second offense. Moreover, the company benefits from a substantial additional discount, i.e. the Plus, in the calculation of its fine in any plea agreement for the initial matter under investigation.[7] The counterpart of Amnesty Plus is Penalty Plus, or equivalently "If Amnesty Plus is the carrot, Penalty Plus is the stick." (Jarrett Arp and Spratling, 2003, p.29). If companies that neglect to take advantage of Amnesty Plus are nevertheless caught for a second time, their behavior is more severely fined than it would otherwise merit. The company's knowing failure to report aggravates the punishment, not only increasing the size of the fine but also the length of the jail sentence for its executives.[8]

Under the current EU policy, Amnesty Plus and Penalty Plus do not exist. Although the Organization for Economic Co-operation and Development (OECD) recommended the inclusion of Amnesty Plus as part of the 2002 reforms of the EU Leniency Program, the EC did not seize the opportunity to follow the US example by introducing a similar policy.

This chapter examines the effect of Amnesty Plus and Penalty Plus on the incentives of firms to report a cartel under a leniency program. Amnesty Plus and Penalty Plus encourage the firms to report a second cartel after a first cartel detection. These reporting incentives increase with the size of the fine discount granted under Amnesty Plus. Ex ante, however, Amnesty Plus and Penalty Plus have an ambiguous effect on the effectiveness of leniency programs. On the one hand, the firms may be less willing to report a cartel if they anticipate that this move entails the break down of the other

[7]The size of the additional discount mainly depends on three factors: The strength of the evidence provided by the cooperating company, the potential significance of the revealed case measured in terms of volume of commerce involved, geographic scope and the number of co-conspirators, and the likelihood that the DoJ would have detected the cartel absent self-reporting (Hammond, 2006).

[8]The DoJ does not state an exact percentage for the fine increase but asserts to pursue a fine or jail sentence at the upper end of the Guidelines Range (Hammond, 2006). An example of Penalty Plus is the DoJ's fining decision in monochloracetic acid in 2003. The German company Hoechst AG was fined roughly 130% above the minimum guideline fine due to its failure to report the illegal agreement in monochloracetic acid at the time it was convicted for its participation in the sorbates cartel (Hammond, 2004).

cartel. Amnesty Plus and Penalty Plus may thus help to sustain a cartel which would have been reported under the EU Leniency Program. On the other hand, the firms may also prefer to immediately report both cartels. Amnesty Plus and Penalty Plus may thus lead to the reporting of a cartel that would not have been reported under the EU Leniency Program. This desirable effect occurs if the probability of detection exceeds a certain threshold above which the firms find it too costly to sustain a cartel that has a high probability of being detected just to preserve the other, profitable, cartel. This threshold increases with the fine discount granted under Amnesty Plus. Hence, while Amnesty Plus and Penalty Plus may be good for competition ex post, they may come with an undesirable effect ex ante, especially if the fine discount is large.

The study of the effect of Amnesty Plus and Penalty Plus on firms' incentives to self-report has been left exclusively to legal scholars. Jephcott (2002) is first to highlight the lack of an equivalent to the Amnesty Plus policy in the 2002 EC Leniency Notice. McElwee (2004) argues that Amnesty Plus and Penalty Plus intensify the 'race to the courtroom' dynamics and thus generate distrust among cartel members.[9] Moreover, companies volunteering information on their participation in other cartels during an investigation on a distinct product or geographic market appear to be rare. This seems especially true for antitrust regimes under which the altruism of companies is not substantially rewarded. Even though exceptions may occasionally occur,[10] the author recommends the introduction of a leniency policy similar to Amnesty Plus and Penalty Plus in Europe. In a recent study, Wils (2007) expresses scepticism and argues that Amnesty Plus, by granting a supplementary reduction in fines, offers more than 100% leniency to a cooperating company. He argues that this is debatable in itself and that there should be less need for a positive financial reward, as the probability of detection after a first conviction is higher than normal.

Although the legal literature on the subject is burgeoning, to my knowledge, there is

[9]Under the US Leniency Program, only the first reporting firm is eligible to full immunity from fines. The so-called 'winner-takes-it-all' approach sets up a race among firms competing for being first to denounce the cartel to the antitrust authority.

[10]In the Belgian Beer Brewers' cartel, Interbrew, one of the colluding companies under investigation, spontaneously disclosed a simultaneously existing illegal agreement between Luxembourg brewers though it could not benefit from an additional fine discount in the Belgian Beer market, e.g. for particularly extensive cooperation, as it would have under US Amnesty Plus (EC IP/01/1739 December 2001, EC IP/01/1740 December 2001).

no economic analysis which tries to clarify possible motifs for the EC's non-adoption of Amnesty Plus and Penalty Plus, let alone to model the role of leniency programs when companies commit multiple antitrust offenses. I take the first step towards filling this gap in economic theory on leniency programs.

The remainder of this chapter is organized as follows. Section 1.2 briefly reviews economic literature related to the topic. Section 1.3 sets up the model. Section 1.4 analyzes the second stage of the revelation game. I then examine the first stage of the game in section 1.5. In Section 1.6 I examine rollover investigations. Section 1.7 briefly concludes.

## 1.2 Related Literature

This chapter examines how the design of leniency programs affects cartel stability and therefore relates to the current economic literature on leniency policies. Recent theoretical contributions such as Harrington (2008), Chen and Rey (2007), Aubert, Kovacic, and Rey (2006), Spagnolo (2004) and Motta and Polo (2003) study the trade-off a leniency program generates between less cartel stability through encouraged reporting and more cartel stability through reduced expected fines. It also elaborates on the differences in conception of leniency programs and their impact on the efficacy of antitrust enforcement. The overall conclusion of this literature is that leniency programs, if properly designed, make collusion more difficult.

While in previous work collusion can occur in one market only, I consider firms which simultaneously participate in several collusive agreements. Chen and Rey (2007) and Spagnolo (2004) are the only studies on leniency programs which touch upon recidivism. In Spagnolo (2004), higher sanctions for recurrent antitrust offenders rationalize the use of reduced fine schemes when firms follow an optimal two-phase punishment. Reporting raises fines and reduces expected profits from further collusion, limiting the costs the firms are willing to incur to punish the whistle-blower defecting from the cartel in the first place. Chen and Rey (2007) show that ruling out leniency for repeated offenders renders the leniency program completely ineffective in deterring collusion. Prohibiting leniency for recidivistic firms stabilize subsequent collusion by ensuring that after having reported once, no cartel member has an incentive to report again in the future. While my analysis captures the idea of recidivism by the firms' opportunity, following a successful investigation in one market, to continue price fixing in another market, neither of the above studies considers firms which are simultaneously involved in multiple cartel activities.

Motchenkova and Van der Laan (2005) explicitly acknowledge the importance of firms' multimarket operations within a leniency framework. They use the multimarket context to examine the effectiveness of leniency rules, given that firms, admitting their collusive conduct, incur costs other than fines. These additional costs are modeled as the loss in sales in markets, other than the one involved in illegal behavior, due to negative reputation effects following a cartel conviction. Although the firms operate in several markets, they form a cartel in one market only.

Another noteworthy difference from the above literature is that, in my model, cartels do not take the form of ongoing criminal relationships. This is in line with Feess and Walzl (2004) who develop a static model to compare leniency policies in the US and the EU and Spagnolo (2000) who examines anticompetitive effects of leniency programs in one-shot market interactions.[11]

Finally, most of the leniency literature focuses on the potential of leniency programs to deter collusion ex ante. I however suppose that cartels have already been formed and instead concentrate on the issue of ex post desistance.[12]

My analysis also relates to the literature on multimarket contact. In their seminal paper, Bernheim and Whinston (1990) build on the idea, first raised by Edwards (1955) and further developed in a finite oligopoly games context by Harrington (1987), that multimarket contact across firms may foster anticompetitive outcomes. The authors show that strategically linking markets weakly increases cartel profits because it slackens the incentive constraints that limit firms' ability to sustain collusive behavior in settings of repeated interactions. Their technical result coincides with the intuition that multimarket contact allows for linkage-induced punishment which can deter deviations from collusive behavior.

[11] Feess and Walzl (2004) focus on differences with respect to e.g. the relevance of the amount of evidence provided in the determination of the fine reductions and the number of firms eligible to leniency. They do not address the issue of Amnesty Plus and Penalty Plus.

[12] See Chen and Rey (2007) for a discussion of deterrence versus desistance as the focus of antitrust policy.

Apart from the main idea of the above studies, namely that multimarket contact between firms may influence collusive outcomes, the setup of my model is different in that I abstract from repeated interactions between colluding firms and do not examine the cartel formation stage of the game. Moreover, multimarket contact alone does not affect collusive behavior. It is Amnesty Plus and Penalty Plus which create the link between the firms' reporting decisions in the markets where they collude.

## 1.3 The Model

### 1.3.1 Basic Assumptions

I analyze the interaction between two symmetric firms, F1 and F2, which simultaneously collude in two distinct product markets, $A$ and $B$, in the presence of an antitrust authority (AA). I compare the firms' decisions to report a cartel under the EU and US Leniency Programs whose sole difference here is that the latter allows for Amnesty Plus and Penalty Plus. Amnesty Plus offers a firm which has been caught colluding in one market, either through reporting of its co-conspirator or through the investigation efforts of the AA, a reduction in the fine imposed in this market in return for reporting the remaining cartel in the other market. Penalty Plus increases the fine for a recidivistic firm.

Throughout the analysis, I use the following notation: I refer to variables of a specific market by using the indices $A$ and $B$. When considering any of the two markets I use $k \in \{A, B\}$. For general considerations of the two markets in comparison to each other I introduce the indices $i$ and $j$ where $i, j \in \{A, B\}$ and $i \neq j$.

When colluding, each firm earns the collusive profit $\Pi_k > 0$. The collusive profits are market-specific because markets $A$ and $B$ may differ in size and profitability. When competing, each firm gets 0.

The strictness of the antitrust enforcement policy is summarized by an exogenous market-specific investigation probability $q_k \in [0, 1]$ with which the AA opens an inquiry leading to the conviction of the colluding firms with certainty in market $k$.[13] I assume

[13] To keep the model simple, I identify investigation and conviction with a single probability. However, I could introduce uncertainty with respect to the AA's ability to prove guilty a detected cartel by substituting $qs$ for $q$ where $s$ is the probability with which the investigation succeeds. See Chen and Rey

that the detection probabilities are independent across markets. At the time the firms decide to enter an illegal agreement, they cannot directly observe the prevailing investigation probabilities, but they conjecture the strictness of the AA's enforcement policy based on a market-specific combination of observable variables which determine the current antitrust policy. Their ex ante conjecture of a market specific detection probability $\bar{q}_k$ is the expected value of the ex post realization. As I focus on desistance, I suppose that, before the start of the game, the conjectured detection probabilities are such that the firms find it profitable to form a cartel in each of the markets. However, the conjectured probabilities of being convicted may change over time. Potential reasons could be complaints from consumers, employees revealing information to the AA, a shift in the AA's budget constraint which affects available resources and efforts devoted to antitrust enforcement in the different product markets or simply changes in the way the AA operates. The change in detection probabilities acts as an exogenous shock on the expected profitability of a cartel and may prompt the firms to reconsider their decision to collude. Following an increase in detection probabilities, the firms simultaneously decide whether to self-report ($S$) or not ($NS$). This decision is a function of conviction probabilities, cartel profits and fines.

### 1.3.2 Enforcement Choices

The AA commits to its enforcement policy by setting

- the market-specific full fine $F_k$, imposed on a non-reporting firm in case of a conviction. The size of the fine is exogenously given by law.[14]

- the reduced fine for the self-reporting firm equal to 0. Only the first self-reporting firm is eligible to amnesty. The latecomer pays the full fine. When both firms report simultaneously, each is first with probability 0.5.

- the fine discount $R_k \in ]0, F_k]$ under Amnesty Plus. When both firms simultaneously apply for Amnesty Plus, each is first with probability 0.5.

(2007) for an analysis of optimal leniency rates before any and once an investigation is opened which distinguishes the probability of launching the investigation from the probability with which it succeeds.

[14] Note that $F_k$ may be above as well as below $\Pi_k$. I only assume that the combination of $\bar{q}_k$ and $F_k$ is such that the firms find it profitable to collude in each of the markets.

- the increased fine $\alpha F_k$ where $\alpha > 1$ and $(\alpha - 1)F_k$ reflects the additional charge a firm has to pay when convicted in one market after a prior detection in another market.

### 1.3.3 Timing

The model is static. There is one period that consists of two stages. Before the start of the game, the AA commits to its fining policy. If no cartel is reported, with probability 0.5 the AA first investigates and discovers $A$ with probability $q_A$ before starting an inquiry in $B$ with probability $q_B$. With probability 0.5 the AA investigates first $B$ and then $A$. *Nature* then chooses the order in which a possible investigation takes place, and the firms observe this. When forming a cartel, the firms conjecture a market-specific conviction probability $\bar{q}_k$. I assume that the conjectures are identical for both firms and sufficiently low so as to make the firms collude in both markets. Both firms receive market-specific signals which make them revise their conjectured detection probabilities from $\bar{q}_k$ to $q_k$. The shift in detection probabilities may push the firms to consider whether they wish to spontaneously report one or both cartels to the AA. If $q_k \leq \bar{q}_k$, collusion is still profitable, and the firms have no incentives to desist from cartel activities and to reveal information to the AA. Thus, the only cases relevant to my analysis result from an increase in probabilities such that $q_k > \bar{q}_k$ in at least one of the markets. Figure 1.1 shows the time structure of the game.

**Stage 1: Reporting Decision in Both Markets.** The firms simultaneously decide whether to report one, both or none of the cartels.

- If both cartels are reported, the AA convicts each cartel with certainty. The game does not reach stage 2.

- If only one cartel is reported, the AA convicts this cartel with certainty, and the game moves on to stage 2.

- If the firms do not reveal any information, the AA detects cartel $i$ with probability $q_i$. The firms may then want to reconsider their decision on whether to report cartel $j$. Hence, if the AA convicts cartel $i$, the game moves on to stage 2. With probability $1 - q_i$, the cartel $i$ remains undetected, and the game does not reach stage 2. In this case, the AA investigates and detects the cartel $j$ with probability $q_j$.

**Stage 2: Reporting Decision After One Detection.** The game reaches stage 2 if only cartel $i$ was detected in stage 1, and the cartel $j$ survived that stage. The firms simultaneously decide whether to report the remaining cartel $j$.

- If the firms do not report the remaining cartel $j$, the AA convicts this cartel with probability $q_j$.
- If at least one of the firms reports the remaining cartel $j$, the AA convicts this cartel with certainty.

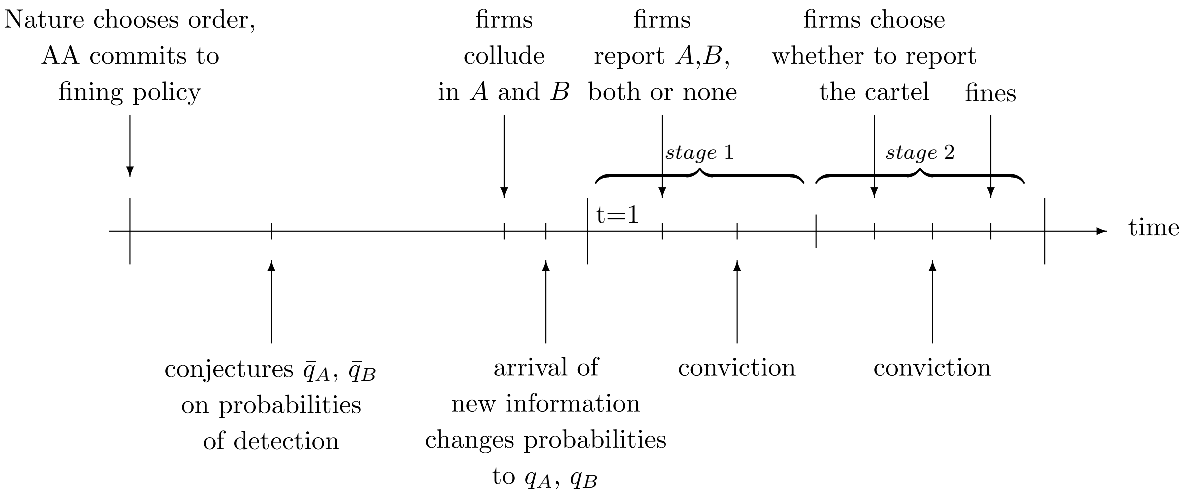


Figure 1.1: Time Line

## 1.4 Reporting Decision in Stage 2

The game reaches stage 2 only after one cartel conviction in stage 1 and thus, there are two different scenarios which lead to this stage. First, no firm reports, but the AA investigates and detects the cartel in market $i$ which happens with probability $q_i$.

Second, both firms report the cartel in $i$ but keep secret the cartel in $j$. I first examine the pure strategy Nash Equilibria of the game in stage 2 under a European policy without Amnesty Plus and Penalty Plus. I then add Amnesty Plus and Penalty Plus and show how these programs affect the parameter range in which these equilibria occur.

### 1.4.1 EU Leniency Program without Amnesty Plus and Penalty Plus

Figure 1.2 presents the normal form of the revelation game played in stage 2 in the absence of Amnesty Plus and Penalty Plus. F1's possible actions are reported vertically, those of F2 horizontally. A firm that reports the cartel in stage 2, while its partner adheres to cooperation, makes zero profits and pays no fine as it is the only firm that applies for leniency. If both firms report, each of them receives immunity from fines with equal chance. If no firm self-reports, cartel $j$ is detected with probability $q_j$ in which case, each firm has to pay the fine $F_j$. Note that the normal form of this game is identical no matter which one of the scenarios leads to stage 2. The reason for this is that each firm, even if it has already used leniency and reported one of the cartels in stage 1, is eligible for leniency in stage 2. The firms thus have equal chances to get leniency in stage 2.

| F1, F2 | S | NS |
|---|---|---|
| S | $-\frac{1}{2}F_j$,$-\frac{1}{2}F_j$ | 0,$-F_j$ |
| NS | $-F_j$,0 | $(1-q_j)\Pi_j - q_jF_j$,$(1-q_j)\Pi_j - q_jF_j$ |

Figure 1.2: Stage 2 Payoff Matrix EU

The outcome in which both firms report the remaining cartel $j$, i.e. $(S_j, S_j)$, is always an equilibrium of this game. There however exists a conviction probability threshold $\frac{\Pi_j}{\Pi_j+F_j} \equiv \widetilde{q}_j$ below which this game exhibits a second equilibrium in which the firms do not report cartel $j$, i.e. $(NS_j, NS_j)$. If the game has two equilibria, I assume that the firms coordinate on the Pareto dominating outcome and therefore do not self-report.[15] For a conviction probability above the threshold $\widetilde{q}_j$, the firms have a dominant strategy in reporting the remaining cartel, and thus, $(S_j, S_j)$ is the only equilibrium.

[15] That the firms succeed in coordinating on the most collusive equilibrium is a standard assumption in the literature on leniency programs (see e.g. Motta and Polo (2003)).

Both firms reporting the remaining cartel constitutes an equilibrium only if, for given fines and cartel profits, the probability of being convicted in stage 2 exceeds the probability threshold which makes a unilateral deviation from cooperation just unprofitable. Thus, the critical investigation probability is such that the expected profits from the remaining cartel are zero. Figure 1.3 depicts this situation under the EU Leniency Program.

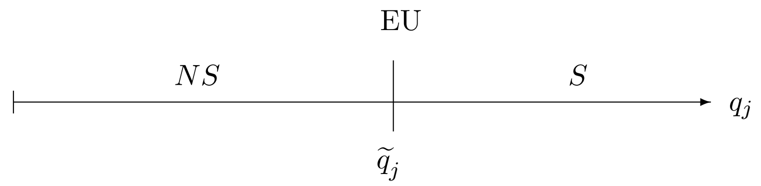


Figure 1.3: Stage 2 Reporting Decisions EU

An increase in the fine a non-reporting firm would have to pay in the case of a conviction in stage 2 decreases the detection probability needed to induce self-reporting. On the contrary, higher cartel profits in stage 2 raise the critical probability thresholds.

### 1.4.2 US Leniency Program with Amnesty Plus

In the presence of Amnesty Plus, the game played in stage 2 depends on the scenario that leads to this stage. First, if there is no reporting in stage 1 but the AA discovers cartel $i$ by its mere efforts, both firms can get a discount in their fine initially imposed. Hence, in stage 2, both firms are eligible to Amnesty Plus. Figure 1.4 shows the payoff matrix that corresponds to this situation.

| F1, F2 | S | NS |
|---|---|---|
| S | $\frac{1}{2}(R_i - F_j)$,$\frac{1}{2}(R_i - F_j)$ | $R_i$,$-F_j$ |
| NS | $-F_j$,$R_i$ | $(1-q_j)\Pi_j - q_jF_j$,$(1-q_j)\Pi_j - q_jF_j$ |

Figure 1.4: Stage 2 Payoff Matrix US, No Reporting in Stage 1, AP

The only difference between the companies' expected payoffs under the EU and the US policy is that, in the presence of Amnesty Plus, a firm which reports the remaining cartel in stage 2 can get a reduction $R_i$ in the fine previously imposed.

Second, if it is the reporting of only cartel $i$ in stage 1 that leads to stage 2, Amnesty Plus creates an asymmetry between the firms in stage 2. Only the firm that has not received leniency in stage 1 is eligible for Amnesty Plus in stage 2. The firm that has already received leniency and therefore has paid zero fines in stage 1 can get leniency in stage 2, but it cannot get Amnesty Plus. The reporting incentives of this firm are thus the same as under the EU policy. Figure 1.5 presents the payoff matrix in stage 2 after F2 has received leniency in stage 1.

| F1, F2 | S | NS |
|---|---|---|
| S | $\frac{1}{2}(R_i - F_j)$,$-\frac{1}{2}F_j$ | $R_i$,$-F_j$ |
| NS | $-F_j$,0 | $(1-q_j)\Pi_j - q_jF_j$,$(1-q_j)\Pi_j - q_jF_j$ |

Figure 1.5: Stage 2 Payoff Matrix US, Reporting in Stage 1, AP

Note that F2 has lower incentives to report in stage 2 than F1 which is eligible for Amnesty Plus. As the non reporting equilibrium can exist only if no firm has an incentive to report, it is the deviation possibility of F1 which is relevant.

As after each scenario in stage 1, there is at least one firm eligible for Amnesty Plus in stage 2, the conviction probability threshold below which this game exhibits two possible equilibria is now $\frac{\Pi_j - R_i}{\Pi_j + F_j} \equiv \widetilde{q}_j^{ap}(R_i)$. Hence, if the conviction probability is low enough, the firms coordinate on the Pareto dominating equilibrium which is both firms not reporting the remaining cartel, i.e. $(NS_j, NS_j)$. For a conviction probability above this threshold, the firms again have a dominant strategy in reporting the cartel and hence, $(S_j, S_j)$ is the only equilibrium.

Comparing the probability thresholds in the EU and the US, it is straightforward that $\widetilde{q}_j^{ap}(R_i) < \widetilde{q}_j$. The reason for this difference is that Amnesty Plus links the two markets. The outcome in market $A$ affects the reporting decisions in market $B$. A firm, once convicted in market $A$, has stronger incentives to denounce the cartel in market $B$ because it can get a reduction in the fine imposed in $A$. Thus, the collusive equilibrium is easier to break than under the EU policy where the actions taken in one of the markets do not affect the firms' decisions in the other market. Figure 1.6 shows the probability thresholds in the US.

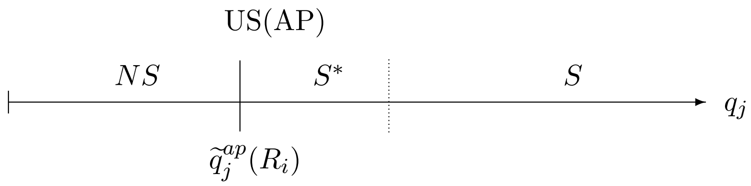


Figure 1.6: Stage 2 Reporting Decisions US, AP

The fine discount under Amnesty Plus decreases the probability threshold and thus, the probability range for which the outcome $(S_j, S_j)$ is the unique equilibrium is larger in the US than in the EU. In the region $S^*$, the equilibrium of the stage game switches. The EU Leniency Program would have sustained the collusive equilibrium whereas in the US, Amnesty Plus offers a profitable deviation to a firm which has been fined in stage 1. Therefore, conditional on conviction in stage 1, Amnesty Plus enhances reporting in stage 2. Note that the probability threshold decreases with the size of the fine discount under Amnesty Plus.

### 1.4.3 US Leniency Program with Amnesty Plus and Penalty Plus

Penalty Plus severely punishes companies which are caught colluding in stage 2 after a cartel conviction in stage 1 by increasing the fine to $\alpha F_j$. As a consequence, expected cartel profits in stage 2 decrease and thus, Penalty Plus reinforces the beneficial effect of Amnesty Plus in this stage. Figures 1.7 and 1.8 show the expected payoffs under the US Leniency Program with Amnesty Plus and Penalty Plus, first after a detection without reporting, and second, after a detection through reporting in stage 1.

| F1, F2 | S | NS |
|---|---|---|
| S | $\frac{1}{2}(R_i - \alpha F_j)$,$\frac{1}{2}(R_i - \alpha F_j)$ | $R_i$,$-\alpha F_j$ |
| NS | $-\alpha F_j$,$R_i$ | $(1-q_j)\Pi_j - q_j \alpha F_j$,$(1-q_j)\Pi_j - q_j \alpha F_j$ |

Figure 1.7: Stage 2 Payoff Matrix US, No Reporting in Stage 1, AP and PP

| F1, F2 | S | NS |
|---|---|---|
| S | $\frac{1}{2}(R_i - \alpha F_j)$,$-\frac{1}{2}\alpha F_j$ | $R_i$,$-\alpha F_j$ |
| NS | $-\alpha F_j$,0 | $(1-q_j)\Pi_j - q_j \alpha F_j$,$(1-q_j)\Pi_j - q_j \alpha F_j$ |

Figure 1.8: Stage 2 Payoff Matrix US, Reporting in Stage 1, AP and PP

The fear of harsher fines further lowers the probability threshold to $\frac{\Pi_j - R_i}{\Pi_j + \alpha F_j} \equiv \widetilde{q}_j^{pp}(R_i, \alpha)$ above which the $(S_j, S_j)$ outcome is the unique equilibrium. Figure 1.9 shows the thresholds after the inclusion of Penalty Plus and compares the situation to the EU and the US with Amnesty Plus only.

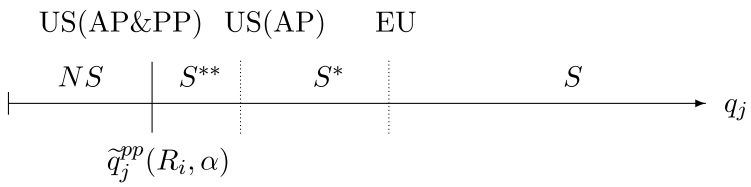


Figure 1.9: Stage 2 Reporting Decisions US, AP and PP

Penalty Plus enlarges the probability range for which the firms report the second infringement in stage 2 by $S^{**}$ at the expense of the zone where $(NS_j, NS_j)$ is the Pareto dominating equilibrium. The probability threshold decreases with the fine increase under Penalty Plus.

## 1.5 Reporting Decision in Stage 1

When the firms decide whether to report a cartel in stage 1, they anticipate the equilibrium outcome in stage 2. First, I compare the firms reporting decisions in stage 1 under the EU and US Leniency Programs in the presence of Amnesty Plus. Second, I show how Penalty Plus affects the outcome of this stage.

### 1.5.1 Amnesty Plus

For $q_j \in ]\widetilde{q}_j^{ap}(R_i), \widetilde{q}_j]$ Amnesty Plus switches the equilibrium in stage 2 from $(NS_j, NS_j)$ to $(S_j, S_j)$. While Amnesty Plus produces the desirable outcome in stage 2 for the detection probabilities in this range, it may have an adverse effect on the reporting incentives in stage 1.

Consider the case where $q_i > \widetilde{q}_i$ and $q_j \in ]\widetilde{q}_j^{ap}(R_i), \widetilde{q}_j]$. Under the EU Leniency Program, the firms report cartel $i$ but not cartel $j$. Nothing links the two markets and reporting cartel $i$ does not affect the firms' reporting incentives in market $j$. Under the US Leniency Program, however, the reporting of only cartel $i$ in stage 1 would trigger the reporting of cartel $j$ in stage 2. The firms now have two possibilities: Either they report none of the cartels in stage 1 and report the remaining cartel in stage 2 only if the AA detects a cartel in stage 1. Or they immediately report both cartels in stage 1. Note that reporting both cartels gives a payoff of zero whereas by reporting cartel $j$ but not cartel $i$ the reporting firm would earn $-\frac{1}{2}F_i$ and by reporting $i$ but not $j$ it would get $-F_i$. If the firms do not report any of the cartels in stage 1, and the AA investigates first market $i$ and only then $j$, two states can occur: First, with probability $q_i$, the AA discovers cartel $i$ and both firms rush to report cartel $j$ in stage 2 in the hope to benefit from Amnesty Plus. Second, with probability $1 - q_i$, the AA does not detect cartel $i$, stage 2 is not reached, and it detects cartel $j$ with $q_j$. Hence, the firms immediately report both cartels in stage 1 if

$$q_i \left( -F_i + \frac{1}{2}(R_i - F_j) \right) + (1 - q_i) \left( \Pi_i + (1 - q_j)\Pi_j - q_j F_j \right) < 0 \tag{1.1}$$

The left hand side (LHS) of the inequality in (1.1) is continuous and decreasing in $q_i$. As this condition is violated for $q_i = 0$ but is satisfied for $q_i = 1$, there must exist a probability threshold $\bar{q}_i^{ap}(R_i) \in ]0, 1]$ such that it holds for $q_i \geq \bar{q}_i^{ap}(R_i)$. This signifies that, if the probability of detection in market $i$ is high enough, the firms find it too costly to sustain the unprofitable cartel $i$ just to preserve the profitable cartel $j$ and therefore report both cartels in stage 1. Note that the threshold $\bar{q}_i^{ap}(R_i)$ increases with $R_i$. The higher the fine reduction $R_i$, the higher is the detection probability $q_i$ needed to reach this desirable outcome. $R_i$ generates a trade-off between cartel desistance ex post and cartel desistance ex ante. A high $R_i$ induces the reporting of cartel $j$ after the detection of cartel $i$ for low values of $q_j$. Hence, after a first detection, the AA would want to set the fine discount at the highest possible level. Ex ante, however, high values of $R_i$ can give the wrong reporting incentives to the firms. Hence, a generous fine discount must be coupled with a high detection probability $q_i$.

### 1.5.2 Penalty Plus

Penalty Plus enlarges the potentially problematic probability range from $]\widetilde{q}_j^{ap}(R_i), \widetilde{q}_j]$ to $]\widetilde{q}_j^{pp}(R_i, \alpha), \widetilde{q}_j]$ where $\widetilde{q}_j^{pp}(R_i, \alpha) < \widetilde{q}_j^{ap}(R_i)$. Penalty Plus also has a direct impact on the firms' reporting incentives in stage 1 by increasing the expected fines when the firms decide not to use Amnesty Plus.[16] The firms immediately report both cartels in stage 1 if

$$q_i \left( -F_i + \frac{1}{2}(R_i - \alpha F_j) \right) + (1 - q_i) \left( \Pi_i + (1 - q_j)\Pi_j - q_j \alpha F_j \right) < 0 \tag{1.2}$$

The inequality in (1.2) is satisfied for $q_i \geq \bar{q}_i^{pp}(R_i, \alpha) \in ]0, 1]$ where $\bar{q}_i^{pp}(R_i, \alpha)$ increases with $R_i$, decreases with $\alpha$ and $\bar{q}_i^{pp}(R_i, 1) = \bar{q}_i^{ap}(R_i)$. Hence, for a given $R_i$, Penalty Plus increases the incentives of firms to report the remaining cartel in stage 2 as well as to report both cartels in stage 1. If however the no reporting outcome occurs in stage 1, it occurs for a higher probability range compared to the policy with only Amnesty Plus.

## 1.6 Rollover Investigations

Rollover investigations, as they occur under the US policy, imply that the probability of detection in market $j$ increases after the detection of cartel $i$. The effect of such investigations depends on whether they make the detection probability in stage 2 switch the range. There is no effect if the detection probability increases only slightly such that the stage 2 equilibrium outcome remains the same or if the initial equilibrium outcome in this stage is $(S_j, S_j)$. If the initial equilibrium outcome in stage 2 is $(NS_j, NS_j)$, and the rollover investigations cause a sufficiently big jump in the detection probability, then

[16] Note that Penalty Plus also increases the fine imposed on a firm that is not eligible for Amnesty Plus in stage 2 because it already reported in stage 1.

the equilibrium may switch from $(NS_j, NS_j)$ to $(S_j, S_j)$ for $q_j \leq \widetilde{q}_j^{ap}(R_i)$. In this case, Amnesty Plus is even more effective in encouraging the firms to report the remaining cartel in stage 2. Hence, in terms of ex post desistance, rollover investigations are clearly beneficial for competition. Ex ante, however, if Amnesty Plus gives the wrong incentives in the first stage, it would do so for a larger range of detection probabilities.

## 1.7 Conclusion

This chapter examines the effect of Amnesty Plus and Penalty Plus on the incentives of firms to report a cartel under a leniency program.

I find that Amnesty Plus and Penalty Plus encourage the firms to report a second cartel after a first cartel detection. The reporting incentives increase with the size of the fine discount granted under Amnesty Plus. Ex ante, however, Amnesty Plus and Penalty Plus have an ambiguous effect on the effectiveness of leniency programs. On the one hand, the firms may be less willing to report a cartel if they anticipate that this move entails the break down of the other cartel. Amnesty Plus and Penalty Plus may thus help to sustain a cartel which would have been reported under the EU Leniency Program. On the other hand, the firms may also prefer to immediately report both cartels. Amnesty Plus and Penalty Plus may thus lead to the reporting of a cartel that would not have been reported under the EU Leniency Program. This desirable effect occurs if the probability of detection exceeds a certain threshold above which the firms find it too costly to sustain a cartel that has a high probability of being detected just to preserve the other, profitable, cartel. This threshold increases with the fine discount granted under Amnesty Plus. Hence, while Amnesty Plus and Penalty Plus may be good for competition ex post, they may come with an adverse effect ex ante, especially if the fine discount is large.

My analysis stresses the trade-off between desistance ex post and desistance ex ante, created by the Amnesty Plus and Penalty Plus programs. Future research should embed this question in a dynamic framework to take into account the ongoing nature of the relationship between cartel members. Moreover, a dynamic analysis may also be well suited to explore the effects of Amnesty Plus and Penalty Plus on the formation of cartels.

# Chapter 2

# Leniency Programs for Multimarket Firms: The Effect of Amnesty Plus on Cartel Formation

joint with Yassine Lefouili

## 2.1 Introduction

Experience garnered over many years has taught antitrust authorities in the United States (US) and the European Union (EU) that companies which have been colluding in one specific product market are more likely to have engaged in cartel activities in adjacent markets.

Due to the high diversity of businesses in multinational firms, cartel activities bear all the marks of contagion within companies. The probably most well-known example for such a cross-linked collusive pattern is the vitamin conspiracy. The striking feature of this complex of infringements is the central role played by Hoffmann-La Roche (HLR) and BASF, the two main vitamin producers, over the course of ten years in virtually every cartel affecting the whole extent of bulk vitamin production.[1] HLR, BASF and Rhône-Poulenc instigated the first group of cartels which consisted of price fixing agreements in the markets for vitamins A and E. The initial success of these arrangements inspired their replication in other vitamin markets. Accordingly, the European Commission (EC) stated that "the simultaneous existence of the collusive arrangements in the various vitamins was not a spontaneous or haphazard development, but was conceived and directed by the same persons at the most senior levels of the companies concerned".[2] Rhône-Poulenc's disclosure of evidence on collusion in the markets for vitamins A and E led to the opening of an investigation. However, only the comprehensive collaboration of BASF with the US Department of Justice (DoJ) under the Amnesty Plus Program led to the successful prosecution of all participants. When Rhône-Poulenc plead guilty to price fixing in vitamins A and E, it did however not provide any information on its participation in the vitamin D3 infringement and even pursued cartel activities in other product markets such as methionine and methylglucamine.[3]

In 1999, the DoJ implemented the Amnesty Plus Program as part of its Corporate Leniency Policy in response to the increasing number of repeat offenders. According to Hammond, "The Division's Amnesty Plus program creates an attractive inducement for encouraging companies who are *already under investigation* to report the full extent of their antitrust crimes [...]" (Hammond, 2004, p.16).

Leniency programs cancel the fine against the first cartel member that brings decisive evidence to the antitrust authority. Amnesty Plus aims at attracting amnesty applications by encouraging subjects of ongoing investigations to consider whether they qualify for amnesty in other than the currently inspected markets. In particular, Amnesty Plus offers a firm, which plea-bargains an agreement for participation in one cartel, where it cannot obtain amnesty, complete immunity in a second cartel affecting another market. Provided that the firm agrees to fully cooperate in the investigation of the conspiracy of which the DoJ was previously not aware, it is automatically granted amnesty for this second offense. Moreover, the company benefits from a "substantial additional discount"

[1] Concerned were the markets for vitamins A, E, B1, B2, B3 (niacin), B4 (choline chloride), B5, B6, B9 (folic acid), B12, C, D3, H (biotin), beta carotene, carotenoids and premixes.

[2] EC IP/01/1625 November 2001, p.2.

[3] EC IP/01/1625 and OJ L 6 of 10.1.2003, p.1-89; EC IP/02/976 and OJ L 255, 08.10.2003, p.1-32; EC IP/02/1746 and OJ L 38, 10.2.2004, p.18-46.

(Hammond, 2006, p.10), i.e. the Plus, in the calculation of its fine in any plea agreement for the initial matter under investigation.

Under the current EC Leniency Notice, Amnesty Plus does not exist. Although the Organization for Economic Co-operation and Development (OECD) recommended the inclusion of Amnesty Plus as part of the 2002 reforms of the EU Leniency Program, the EC did not seize the opportunity to follow the US example by adopting a similar policy. Also in 2006, the EC failed to incorporate Amnesty Plus in the reform package.

The present chapter studies how the Amnesty Plus policy affects firms' incentives to form a cartel. Following a conviction of one cartel, Amnesty Plus may encourage firms to report *another* cartel by granting the first firm which applies for this program a discount on the fine already imposed. Ex ante, however, the opportunity to benefit from Amnesty Plus may decrease the expected fine in one market and make the formation of a cartel - not in this - but in another market, more attractive.

We study two markets in which two identical firms play an infinitely repeated game of collusion. In each period, the firms can choose to form a cartel before interacting in the product market. Collusion generates incriminating evidence which the antitrust authority can discover with some probability. Each firm can also bring this evidence to the authority. When a cartel is detected, each cartel member, except the first reporting firm, pays a fine. Amnesty Plus sets in when the firms decide whether to report the second cartel after having been convicted in the first market.

Our main result is that Amnesty Plus can increase the extent of collusion if the discount on the fine imposed for the initial infringement exceeds the fine the Amnesty Plus applicant would have incurred in the second market. To avoid this adverse effect, the design of the Amnesty Plus policy must respect a discount-setting rule that fixes the discount in the first market equal or below the fine in the second market. A leniency policy with an Amnesty Plus program that sticks to this rule always performs weakly better, in terms of cartel deterrence, than a standard leniency policy without Amnesty Plus. The reason is that Amnesty Plus may induce the reporting of the second cartel after a first detection. Increased desistance from cartel activities in the reporting stage reduces the value of joint collusion provided that the fine discount does not increase the expected collusive value at this stage.

Recent theoretical contributions such as Harrington (2008), Chen and Rey (2007), Aubert, Kovacic, and Rey (2006), Spagnolo (2004) and Motta and Polo (2003) study the trade-off leniency generates between less cartel stability through reporting and more cartel stability through reporting benefits which lower expected fines. The overall conclusion is that leniency programs, if properly designed, make collusion more difficult.[4] Several studies suggest that positive rewards may further strengthen the deterrence power of leniency programs (Aubert, Kovacic, and Rey, 2006; Spagnolo, 2004).

Amnesty Plus is equivalent to a leniency program, coupled with a positive reward for the first informant, that is available in one market - say market 2 - only if the cartel in market 1 is discovered. Amnesty Plus, unlike a standard leniency program, therefore strategically links two markets. The reward can stabilize cartel 2 if cartel 1 is formed and hence increase the extent of collusion. This market linkage also has an important implication for the procompetitive potential of Amnesty Plus. Contrary to a standard leniency program, Amnesty Plus may destabilize a cartel even if the probability of detection in that market is zero. Detection must just be likely enough in the other market. Amnesty Plus may thus be particularly useful when probabilities of detection differ across markets.

Another strand of literature closely linked to our analysis studies the role of multimarket contact between firms in sustaining collusion when there is no antitrust enforcement. In their seminal paper, Bernheim and Whinston (1990) give theoretical support to the informal argument, first raised by Edwards (1955), that multimarket contact may enhance collusion. They show that the firms can pool the incentive constraints of the different markets where they operate in order to transfer slack from a more to a less collusive market. At worst, with identical firms and markets, multimarket contact does not affect the opportunities for cooperation. At best, it facilitates collusion.[5]

In a recent paper, Choi and Gerlach (2009a) examine the sustainability of collusion in two markets linked by demand relationships. They find that successful prosecution in one market may destabilize collusion in the adjacent market if products are substitutes,

[4]See also Miller (2009), Goeree and Helland (2009) and Brenner (2009) for empirical studies and Bigoni, Fridolfsson, Le Coq, and Spagnolo (2009), Hinloopen and Soetevent (2008) and Apesteguia, Dufwenberg, and Selten (2003) for experiments.

[5]Multimarket contact can also lower firms' payoffs if it is combined with imperfect monitoring. See Thomas and Willig (2006).

whereas in the case of complements, successful prosecution in one market may increase cartel stability in the adjacent market. Choi and Gerlach (2009b) focus on substitutes and show that, if there is one local authority per market, free-rider problems, that arise due to positive prosecution externalities in each market, can only be solved by coordinating enforcement efforts across jurisdictions. Although both studies combine multimarket contact with antitrust enforcement, they do not analyze the strategic effects generated by Amnesty Plus or even leniency programs in this context.

The remainder of this chapter is organized as follows. Section 2.2 sets up the model. Sections 2.3 and 2.4 analyze cartel formation. Section 2.5 extends our analysis to the case of heterogenous detection probabilities, partial collusion and more than 2 firms and 2 markets. Section 2.6 concludes.

## 2.2 The Model

### 2.2.1 Set-up

We consider two markets, 1 and 2, in which two identical firms play an infinitely repeated game where, in each period, they can choose to form a cartel before interacting in the product market. Communication is necessary for collusion and generates hard evidence which makes it possible to establish the antitrust offense.[6] Markets 1 and 2 differ in profitability. In particular, market 1 is more profitable than market 2. Firms discount future payoffs by a common discount factor $\delta \in [0, 1[$. We compare the firms' decisions to form cartels under the EU and the US antitrust legislations whose sole difference here is that the latter comprises an Amnesty Plus program.

Throughout the analysis we use the following notation: We refer to variables of a specific market by using the indices 1 and 2. When considering any of the two markets, we use the index $k$, and we refer to the other market by using the index $-k$.

In each period, the fully collusive joint profit in market $k$ is $2\pi_k > 0$, and thus, each firm makes a cartel profit equal to $\pi_k$.[7] If the firms compete, they make zero profits. In

[6]For collusion to be illegal, there must be evidence of an explicit agreement between the firms (McCutcheon, 1997). The view that collusion is self-enforcing but requires communication is common in the literature on leniency programs. See Aubert, Kovacic, and Rey (2006).

[7]We focus on full collusion in the main analysis and examine partial collusion in extension 2.5.4.

case one firm unilaterally deviates from the collusive agreement while the other continues to collude, the deviating firm earns the whole short-term cartel profit $2\pi_k$ alone, whereas the other firm gets nothing. The firms use (grim) trigger strategies. The punishment they agreed upon starts the period following the deviation and lasts forever after.

At the time the firms decide whether to enter a collusive agreement, they observe the exogenous per-period conviction probability $q > 0$ with which the Antitrust Authority (AA) detects a cartel and convicts the colluding firms. Detection is independent across markets and over time.[8] Each convicted firm pays a strictly positive, market specific fine $F_k$ which is reduced under Amnesty Plus to $F_k - R_k$ in return for the disclosure of the second cartel. $R_k \in ]0, F_k]$ represents the fine reduction granted to the first informant. The higher $R_k$ the more generous the Amnesty Plus policy. The successful applicant receives amnesty in the second infringement because it is the first company reporting in that market. If both firms simultaneously apply for Amnesty Plus, each is first with probability $\frac{1}{2}$.

The fines are such that $F_1 \geq F_2$.[9] We assume that the fine-profit ratio is higher for market 2 than for market 1, i.e. $\frac{F_2}{\pi_2} > \frac{F_1}{\pi_1}$. This reflects the idea that the fine rises less than proportionally with the cartel profit. Legislative provisions and fine records support this assumption.[10] Heterogenous fine-profit ratios create heterogenous cartel formation incentives across markets and thereby a parameter range where, in the absence

[8] Detection in one market may increase as well as decrease the probability of detection in the other market. Rollover investigations make a second conviction more likely whereas limited resources of the AA and increased efforts by the firms to conceal the remaining conspiracy make it less likely. Assuming independence across markets is equivalent to saying that both effects are equally strong. By the independence over time assumption we impose stationarity.

[9] We believe that, in the light of $\pi_1 > \pi_2$, the assumption $F_1 \geq F_2$ is plausible. In practice, fines are set according to judicial principles which link them to the gravity of the infringement, and thus, to the nature and importance of the anticompetitive behavior. The latter relates, at least indirectly, to the collusive overcharge which is, with zero competitive profits, equivalent to cartel profits.

[10] The fine-profit ratio decreases with market size if small fines are inflated compared to high fines. The EU fine setting guidelines suggest that this is the case: First, the basic amount of the fine can be increased to ensure a sufficient deterrent effect of the fine. As a fine of a big absolute size is more likely to act as a deterrent (e.g. because of high media coverage), the deterrent uplift for a small fine seems to be relatively bigger than for a high fine. Second, the legal maximum, i.e. 10% of the firm's total turnover in the preceding business year, imposes a cap on large fines. Hence, the fines for large cartels are more likely to be capped than the fines for smaller cartels. Third, the "multiplier" increases the final amount of the fine if the the Commissioner judges that the turnover of the convicted market is too small, and thus, the fine too low, relative to the company's entire turnover. The fine is multiplied by a number, historically between 2 and 5, to increase the financial impact of the penalty. There is also empirical evidence supporting our hypothesis. In particular, see Combe and Monnier (2009) and Connor (2005).

of Amnesty Plus, the firms form only one of the cartels. It is in this range where Amnesty Plus can deploy a negative effect by inducing the formation of the second cartel.[11]

We assume that the evidence of collusion lasts for one period. Thus, after a firm has deviated from a collusive agreement it is held liable for its cartel behavior and can be fined until the end of the period in which the deviation occurred.[12] Each cartel member has the possibility to bring the incriminating evidence to the AA. The first informant receives immunity from fines under a standard leniency program. Again, if both firms simultaneously apply for leniency, each is first with probability $\frac{1}{2}$.

Following a cartel conviction, we assume that the AA closely monitors the previously collusive industry and thus, firms compete, and they never return back to collusion in the same market.

### 2.2.2 Timing

The timing of the game is a version of the time structure used in Chen and Rey (2007), adapted to multimarket contact. In each period, the structure is as follows:

> *Stage 0*: Each firm decides whether to enter a collusive agreement in the market(s) where no cartel has been previously convicted. If at least one firm decides not to collude in market $k$, competition takes place in this market. If this happens in both markets, the firms compete, and the game ends for that period. If both firms choose to collude in market $k$, their communication leaves some hard evidence.
>
> *Stage 1*: Each firm decides whether to stick to, or to deviate from, the collusive agreement(s). Its rival does not observe this decision until the end of stage 2.
>
> *Stage 2*: Each firm decides whether to report the evidence it holds in each cartel to the AA. A cartel is convicted with probability 1 if at least one firm self-reports. The first informant gets complete immunity from fines in this market, whereas the

[11] Note that, instead of heterogenous fine-profit ratios, we could use anything else that creates an asymmetry between the incentives compatibility constraints.

[12] The limitation period of the liability for antitrust offenses is generally a positive number of years. Article 25 of the EC Council Regulation 1/2003 states that the Commission can sue for Administrative Action until five years from the date of the infringement. Moreover, "[...] in the case of continuing or repeated infringements, time shall begin to run on the day on which the infringement ceases".

other firm has to pay the full fine. If each cartel formed in stage 0 is reported in this stage, the game ends for this period; otherwise:

*Stage 3*: Each cartel formed in stage 0 and not reported in stage 2 is detected with probability $q$. If the AA does not detect any cartel, the game ends for that period. If the AA however detects the cartel(s) formed in stage 0 and not reported in stage 2, the colluding firms pay the corresponding fines, and the game ends for that period. If the firms have formed both cartels in stage 0 and not reported them in stage 2, and the AA has detected only one of them, then:

*Stage 4*: Each firm chooses whether to report the remaining cartel.

If Amnesty Plus exists, it is relevant only if the game reaches stage 4. This stage forms the reporting subgame where, after the detection of cartel $k$, the firms decide whether to report the remaining cartel $-k$. Amnesty Plus can alter the equilibria of this subgame and thereby affect the equilibria of the entire game.

Under each leniency policy, we define a set of strategies corresponding to three regimes: collusion in one market only, sequential collusion and joint collusion. We then determine the best collusive (subgame-perfect) symmetric equilibrium of the game without Amnesty Plus, constituted by these strategies, and compare it to its counterpart in the game with Amnesty Plus.

## 2.3 Collusion Under the EU Leniency Program

A strategy is denoted $s$ over a single period and $S$ over all periods. In particular, we denote $s_0$ ($S_0$) the strategy that consists of competing over one period (all periods).

### 2.3.1 Collusion in One Market

To analyze collusion in only one market, we consider the following strategies:
$s_k$: collude in market $k$ only, neither deviate from the collusive agreement nor report.
$S_k$: play $s_k$ in $t = 0$ and in any subsequent period as long as there is neither deviation from the collusive agreement nor reporting nor detection; otherwise play $s_0$ for the remaining periods.

The cartel in market $k$ is *individually stable*, i.e. $(S_k, S_k)$ is an equilibrium, if and only if the gain from any unilateral deviation does not exceed the present discounted expected payoff $V_k(\delta)$ when both firms play $S_k$. $V_k(\delta)$ is recursively defined as

$$V_k(\delta) = q(\pi_k - F_k) + (1-q)(\pi_k + \delta V_k(\delta))$$

which we rewrite as

$$V_k(\delta) = \frac{\pi_k - qF_k}{1 - \delta(1-q)}$$

In the presence of a leniency policy where the first informant pays no fine, the optimal unilateral deviation is to deviate from and to immediately report the collusive agreement. This deviation yields a payoff equal to $2\pi_k$. Both deviating without reporting and reporting without deviating yield lower payoffs, namely $2\pi_k - qF_k$ and 0. $(S_k, S_k)$ is an equilibrium if and only if the following incentive compatibility constraint holds:

$$V_k(\delta) \geq 2\pi_k$$

which we rewrite as

$$\delta \geq \widetilde{\delta}_k \equiv \frac{1 + q\frac{F_k}{\pi_k}}{2(1-q)}$$

The individual stability threshold $\widetilde{\delta}_k$ is increasing in $q$ and $\frac{F_k}{\pi_k}$. Intuitively, the higher the probability of conviction and the higher the fine-profit ratio, the more firms have to value future flows of collusive profits, and thus, the higher the discount factor needed to individually sustain the cartel. Our assumption $\frac{F_2}{\pi_2} > \frac{F_1}{\pi_1}$ implies that $\widetilde{\delta}_2 > \widetilde{\delta}_1$, i.e. a cartel in market 2 is harder to sustain than a cartel in the more profitable market 1. Finally, we assume that $q < \frac{\pi_2}{2\pi_2 + F_2}$. Otherwise, cartel 2 would be individually unstable for any value $\delta \in [0, 1[$.[13]

[13]The probability of detection seems to be quite low also in reality. Bryant and Eckard (1991) estimate the maximum probability of getting caught by the US authorities in any given year at 13% to 17%. Combe, Monnier, and Legal (2008) find around 13% for a European sample.

### 2.3.2 Sequential Collusion

Sequential collusion refers to a situation in which the firms collude in only one market as long as they go undetected. After a detection in this market, they switch to collusion in the other market. We consider the following strategy:
$S_{k\to -k}$: play $s_k$ in $t=0$ and in any subsequent period as long as there is neither deviation from the collusive agreement nor reporting nor detection; if there is detection but no deviation from the collusive agreement in $t$, play $s_{-k}$ in $t+1$ and in any subsequent period as long as there is neither deviation from the collusive agreement nor reporting nor detection; in all other cases, play $s_0$ for the remaining periods.

We focus on the sequential strategy $S_{1\to 2}$.[14] The cartels are *sequentially stable*, i.e. $(S_{1\to 2}, S_{1\to 2})$ is an equilibrium, if and only if no firm has an incentive to deviate both when collusion occurs in market 1 and when it occurs in market 2. Each firm's present discounted expected payoff $V_{1\to 2}(\delta)$ when both firms play $S_{1\to 2}$ is recursively defined as

$$V_{1\to 2}(\delta) = q\left(\pi_1 - F_1 + \delta V_2(\delta)\right) + (1-q)\left(\pi_1 + \delta V_{1\to 2}(\delta)\right)$$

which can be rewritten as

$$V_{1\to 2}(\delta) = V_1(\delta) + q\frac{\delta}{1-\delta(1-q)}V_2(\delta)$$

$(S_{1\to 2}, S_{1\to 2})$ is an equilibrium if and only if the following incentive compatibility constraints hold:

$$V_{1\to 2}(\delta) \geq 2\pi_1$$

$$V_2(\delta) \geq 2\pi_2$$

It is straightforward that the latter constraint implies the former and thus, $(S_{1\to 2}, S_{1\to 2})$ is an equilibrium if and only if cartel 2 is individually stable, i.e. $\delta \geq \widetilde{\delta}_2$.

[14] In appendix 2.A we show that there exists $\widetilde{q} > 0$ such that $(S_{2\to 1}, S_{2\to 1})$ can never be the best collusive equilibrium if $q < \widetilde{q}$. Throughout the chapter we assume that the latter condition holds. This assumption has no qualitative implications for the analysis of the effect of Amnesty Plus but eases the exposition by eliminating $(S_{2\to 1}, S_{2\to 1})$ as a possible candidate for the best collusive equilibrium.

### 2.3.3 Joint Collusion

To study simultaneous collusion in both markets, we consider the following strategies:
$s_{12}$: collude in both markets, neither deviate from any of the collusive agreements nor report.
$S_{12}$: play $s_{12}$ in $t = 0$ and in any subsequent period as long as there is neither deviation from any collusive agreement nor reporting nor detection; if there is detection of cartel $k$ but neither deviation from any collusive agreement nor reporting in $t$, play $s_{-k}$ in $t+1$, and in any subsequent period as long as there is neither deviation from the collusive agreement in market $-k$ nor reporting nor detection, if cartel $-k$ is individually stable; in all other cases, play $s_0$ for the remaining periods.

The two cartels are *jointly stable* under the EU policy, i.e. $(S_{12}, S_{12})$ is an equilibrium, if and only if the gain from any unilateral deviation does not exceed the present discounted expected value $V_{12}(\delta)$ when both firms play $S_{12}$. We denote $V_{12}(\delta)$ the 'value of joint collusion' for the EU. The strategy $S_{12}$ involves multimarket punishment. If one firm unilaterally deviates from the collusive agreement in one of the markets, the co-conspirator reverts to competition in *both* markets. The optimal unilateral deviation is then to deviate from the collusive agreements in both markets simultaneously and report both cartels. This deviation ensures a payoff equal to $2\pi_1 + 2\pi_2$. $(S_{12}, S_{12})$ is an equilibrium if and only if the following incentive compatibility constraint holds:

$$V_{12}(\delta) \geq 2\pi_1 + 2\pi_2$$

The value of joint collusion depends on whether the cartels are individually stable. There are three cases:
a- If cartel 1 is individually stable while cartel 2 is not, i.e. $\widetilde{\delta}_1 \leq \delta < \widetilde{\delta}_2$, the value of joint collusion is recursively defined as

$$\begin{aligned} V_{12}(\delta) &= q^2(\pi_1 + \pi_2 - F_1 - F_2) + q(1-q)(\pi_1 + \pi_2 - F_1) \\ &+ q(1-q)\left(\pi_1 + \pi_2 - F_2 + \delta V_1(\delta)\right) + (1-q)^2\left(\pi_1 + \pi_2 + \delta V_{12}(\delta)\right) \end{aligned}$$

From the independence assumption on the AA's detection technology it follows that the probability of detecting both cartels during a specific period is $q^2$, only cartel 1 (cartel 2) is $q(1-q)$, and none of the cartels $(1-q)^2$. If the AA detects cartel 1, the firms stop forming the individually unstable cartel 2. We rewrite the value of joint collusion as

$$V_{12}(\delta) = \frac{\pi_1 - qF_1}{1-\delta(1-q)} + \frac{\pi_2 - qF_2}{1-\delta(1-q)^2} \tag{2.1}$$

b- If both cartels are individually unstable, i.e. $\delta < \widetilde{\delta}_1$, the value of joint collusion is

$$V_{12}(\delta) = \frac{\pi_1 - qF_1}{1-\delta(1-q)^2} + \frac{\pi_2 - qF_2}{1-\delta(1-q)^2} \tag{2.2}$$

c- If both cartels are individually stable, i.e. $\widetilde{\delta}_2 \leq \delta < 1$, the value of joint collusion is

$$V_{12}(\delta) = \frac{\pi_1 - qF_1}{1-\delta(1-q)} + \frac{\pi_2 - qF_2}{1-\delta(1-q)} \tag{2.3}$$

### 2.3.4 Best Collusive Equilibrium

Proposition 1 characterizes the Pareto dominant equilibrium under the EU antitrust policy.

**Proposition 1** *There exists a joint stability threshold* $\widetilde{\delta}_{12} \in ]\widetilde{\delta}_1, \widetilde{\delta}_2]$ *such that:*
*- If* $\delta < \widetilde{\delta}_1$*, the competitive equilibrium* $(S_0, S_0)$ *is the only equilibrium.*
*- If* $\widetilde{\delta}_1 \leq \delta < \widetilde{\delta}_{12}$*, the individual collusion equilibrium* $(S_1, S_1)$ *is the best collusive equilibrium.*
*- If* $\widetilde{\delta}_{12} \leq \delta < 1$*, the joint collusion equilibrium* $(S_{12}, S_{12})$ *is the best collusive equilibrium.*

**Proof** See appendix 2.C.

Over the interval $[\widetilde{\delta}_{12}, 1[$, the expected lifespan of cartel 2 depends on the size of $\delta$. For $\delta \in [\widetilde{\delta}_{12}, \widetilde{\delta}_2[$, cartel 2 is sustained only as long as the AA does not detect any of the cartels, whereas for $\delta \in [\widetilde{\delta}_2, 1[$, cartel 2 is sustained up to its own detection.

By linking the punishment across markets, the firms can potentially transfer slack enforcement power from market 1 to market 2 and sustain collusion in both markets for values of $\delta < \widetilde{\delta}_2$, i.e. even when cartel 2 is individually unstable. Multimarket contact has this procollusive effect if and only if $\widetilde{\delta}_{12} < \widetilde{\delta}_2$. In appendix 2.B, we provide a necessary and sufficient condition for the latter inequality to hold and discuss how the possibility of cartel detection affects the procollusive potential of multimarket contact.

## 2.4 Collusion Under the US Leniency Program

We now introduce Amnesty Plus and examine its effect, first, on the equilibrium of the reporting subgame in stage 4 and, second, on the best collusive equilibrium of the entire game.

### 2.4.1 Reporting Subgame

In the absence of Amnesty Plus, the subgame exhibits two possible equilibria if cartel $k$ is detected in the previous stage: Both firms reporting and both firms not reporting the remaining cartel. The Pareto dominant equilibrium is to not report the remaining cartel $-k$ because each firm's expected payoff is $-\frac{1}{2}F_{-k}$ if both firms report compared to zero (when cartel $-k$ is individually unstable) and $\delta V_{-k}$ (when cartel $-k$ is individually stable) if none reports. As the firms do not report in the Pareto dominant equilibrium, they only desist from cartel $-k$ if it is individually unstable. Figures 2.1 and 2.2 show the payoff matrices of this subgame.

| F1, F2 | R | NR |
|---|---|---|
| R | $-\frac{1}{2}F_k$,$-\frac{1}{2}F_k$ | 0,$-F_k$ |
| NR | $-F_k$,0 | 0,0 |

Figure 2.1: Cartel $k$ unstable

| F1, F2 | R | NR |
|---|---|---|
| R | $-\frac{1}{2}F_k$,$-\frac{1}{2}F_k$ | 0,$-F_k$ |
| NR | $-F_k$,0 | $\delta V_k$,$\delta V_k$ |

Figure 2.2: Cartel $k$ stable

Amnesty Plus may alter the firms' reporting decisions by creating a prisoners' dilemma where reporting cartel $-k$ forms an equilibrium in dominant strategies. If a firm anticipates that its partner reports, it always prefers reporting. If a firm anticipates that its co-conspirator does not report, it prefers to report *for any fine reduction* $R_k$ if cartel $-k$ is individually unstable (Figure 2.3) because it gets a strictly positive $R_k$ from reporting versus zero from not reporting. If cartel $-k$ is individually stable, a firm, which anticipates that its partner does not report, finds it (strictly) optimal to report if and only if $R_k > \delta V_{-k}(\delta)$ (Figure 2.4). Not reporting would imply the renewed formation of the cartel in the next period and is therefore dominated by reporting only if the fine reduction exceeds the present discounted expected payoff a firm gets from this cartel. It is in these two cases where the problem of Amnesty Plus becomes apparent: While Amnesty Plus induces the firms to make the desired reporting decision, it may increase each firm's equilibrium payoff $X = \frac{1}{2}(R_k - F_{-k})$ above the equilibrium payoff in the subgame under the EU policy. Amnesty Plus may therefore raise the value of collusion over the entire game.

| F1, F2 | R | NR |
|---|---|---|
| R | $X$,$X$ | $R_{-k}$,$-F_k$ |
| NR | $-F_k$,$R_{-k}$ | 0,0 |

Figure 2.3: Cartel $k$ unstable

| F1, F2 | R | NR |
|---|---|---|
| R | $X$,$X$ | $R_{-k}$,$-F_k$ |
| NR | $-F_k$,$R_{-k}$ | $\delta V_k$,$\delta V_k$ |

Figure 2.4: Cartel $k$ stable

Amnesty Plus does not affect the firms' decisions to not report an individually stable cartel if $R_k \leq \delta V_{-k}(\delta)$. The subgame exhibits again two possible equilibria, but not reporting Pareto dominates reporting because $\frac{1}{2}(R_k - F_{-k}) < R_k \leq \delta V_{-k}(\delta)$. Notice that we can rewrite $R_k \leq \delta V_{-k}(\delta)$ as

$$\delta \geq \widehat{\delta}_{-k}(R_k) \equiv \frac{R_k}{\pi_{-k} - qF_{-k} + (1-q)R_k}$$

where $\widehat{\delta}_{-k}(R_k)$ defines a robustness threshold for an individually stable cartel $-k$ such that, above this threshold, it is *robust* to, and thus, survives the detection of cartel $k$.

### 2.4.2 Joint Collusion

Amnesty Plus cannot alter strategy profiles that do not involve simultaneous collusive interaction in the two markets. Hence, the strategies $s_0$, $s_k$, $S_0$, $S_k$ and $S_{1\to2}$ are identical with and without Amnesty Plus. The strategy profile for joint collusion is now given by:

$s_{12}^{AP}$: collude in both markets, neither deviate from any of the collusive agreements nor report; if there is detection of one cartel, do not report the remaining cartel under Amnesty Plus if it is individually stable and robust, otherwise report.

$S_{12}^{AP}$: play $s_{12}^{AP}$ in $t = 0$ and in any subsequent period as long as there is neither deviation from any of the collusive agreements nor reporting nor detection; if there is detection of cartel $k$ but neither deviation from any collusive agreement nor reporting in $t$, play

$s_{-k}$ in $t+1$, and in any subsequent period as long as there is neither deviation from the collusive agreement in market $-k$ nor reporting nor detection, if cartel $-k$ is individually stable and robust; in all other cases, play $s_0$ for the remaining periods.

The two cartels are *jointly stable* under the US policy, i.e. $(S_{12}^{AP}, S_{12}^{AP})$ is an equilibrium, if and only if the gain from any unilateral deviation does not exceed the present discounted expected value $V_{12}^{AP}(\delta, R_1, R_2)$ when both firms play $S_{12}^{AP}$. We denote $V_{12}(\delta)$ the 'value of joint collusion' for the US. Here again, the optimal unilateral deviation is to deviate from the collusive agreements in both markets and report both cartels. $(S_{12}^{AP}, S_{12}^{AP})$ is an equilibrium if and only if the following incentive compatibility constraint holds:

$$V_{12}^{AP}(\delta, R_1, R_2) \geq 2\pi_1 + 2\pi_2$$

The value of joint collusion depends on the outcome of the reporting subgame in stage 4. There are four different cases:

a- If cartel 1 is stable and robust while cartel 2 is either unstable or stable but not robust, i.e. $\max(\tilde{\delta}_1, \hat{\delta}_1(R_2)) \leq \delta < \max(\tilde{\delta}_2, \hat{\delta}_2(R_1))$, both firms report cartel 2 but not cartel 1 in the reporting subgame. $V_{12}^{AP}(\delta, R_1, R_2)$ is thus recursively defined as

$$\begin{aligned} V_{12}^{AP}(\delta, R_1, R_2) &= q^2(\pi_1 + \pi_2 - F_1 - F_2) + q(1-q)\left(\pi_1 + \pi_2 - F_1 + \frac{1}{2}(R_1 - F_2)\right) \\ &+ q(1-q)\left(\pi_1 + \pi_2 - F_2 + \delta V_1\right) + (1-q)^2\left(\pi_1 + \pi_2 + \delta V_{12}^{AP}(\delta, R_1, R_2)\right) \end{aligned}$$

which we rewrite as

$$V_{12}^{AP}(\delta, R_1, R_2) = \frac{\pi_1 - qF_1}{1 - \delta(1-q)} + \frac{\pi_2 - qF_2}{1 - \delta(1-q)^2} + \frac{q(1-q)(R_1 - F_2)}{2\left(1 - \delta(1-q)^2\right)} \tag{2.4}$$

b- If cartel 2 is stable and robust and cartel 1 is stable but not robust, i.e. $\max(\tilde{\delta}_2, \hat{\delta}_2(R_1)) \leq \delta < \max(\tilde{\delta}_1, \hat{\delta}_1(R_2))$, the value of joint collusion is

$$V_{12}^{AP}(\delta, R_1, R_2) = \frac{\pi_1 - qF_1}{1 - \delta(1-q)^2} + \frac{\pi_2 - qF_2}{1 - \delta(1-q)} + \frac{q(1-q)(R_2 - F_1)}{2\left(1 - \delta(1-q)^2\right)} \tag{2.5}$$

c- If both cartels are either individually unstable or individually stable but not robust, i.e. $\delta < (\tilde{\delta}_k, \hat{\delta}_k(R_{-k}))$ for both $k = 1, 2$, Amnesty Plus induces the firms to report and the value of joint collusion is

$$V_{12}^{AP}(\delta,R_1,R_2)=\frac{\pi_1-qF_1}{1-\delta(1-q)^2}+\frac{\pi_2-qF_2}{1-\delta(1-q)^2}+\frac{q(1-q)(R_1+R_2-F_1-F_2)}{2\left(1-\delta(1-q)^2\right)} \quad (2.6)$$

d- If both cartels are individually stable and robust, i.e. $\delta \geq (\tilde{\delta}_k, \hat{\delta}_k(R_{-k}))$ for both $k=1,2$, the firms do not report these cartels, and the value of joint collusion is

$$V_{12}^{AP}(\delta,R_1,R_2)=\frac{\pi_1-qF_1}{1-\delta(1-q)}+\frac{\pi_2-qF_2}{1-\delta(1-q)} \quad (2.7)$$

### 2.4.3 Best Collusive Equilibrium

Amnesty Plus may enhance desistance through reporting and is therefore beneficial for competition after a first cartel conviction. It may however generate potentially conflicting effects at the stage of cartel formation: First, the *desistance effect* which occurs if Amnesty Plus induces the firms to report, and thus terminate, an individually stable collusive agreement after a first detection. This effect is either negative, i.e. it reduces the value of joint collusion, or zero. Second, the *reporting effect* which captures the expected *equilibrium* benefits from reporting under Amnesty Plus. This effect is either negative or zero or positive. We explore the net effect of Amnesty Plus in detail in the subsequent analysis.

#### Neutrality of Amnesty Plus on Global Competition

Consider the interval $[0,\widetilde{\delta}_1[$. Amnesty Plus is neutral, and the only equilibrium is $(S_0,S_0)$. To see this, note that if Amnesty Plus were to have an effect, it would have to make either individual or joint collusion sustainable, i.e. make either $(S_1,S_1)$ or $(S_{12}^{AP},S_{12}^{AP})$ an equilibrium. The former is clearly impossible because Amnesty Plus is irrelevant when firms collude in one market only. The latter cannot occur as well because, from the expressions in (2.2) and (2.6), we see that Amnesty Plus weakly decreases the value of jointly colluding over this interval:

$$V_{12}^{AP}(\delta,R_1,R_2)=V_{12}(\delta)+\frac{q(1-q)(R_1+R_2-F_1-F_2)}{2\left(1-\delta(1-q)^2\right)}\leq V_{12}(\delta)$$

for all $\delta\in\ [0,\widetilde{\delta}_1[$.

### The Anticompetitive Effect of Amnesty Plus

Consider the interval $[\widetilde{\delta}_1, \widetilde{\delta}_{12}[$ where $(S_1, S_1)$ is the best collusive equilibrium in the EU. Amnesty Plus is anticompetitive if it induces the formation of cartel 2, i.e. it makes $(S_{12}^{AP}, S_{12}^{AP})$ the best collusive equilibrium, for discount factor values in this interval. This can happen only if Amnesty Plus increases the value of joint collusion.

**Lemma 1** *Amnesty Plus increases the value of joint collusion for $\delta$ in the interval $[\widetilde{\delta}_1, \widetilde{\delta}_{12}[$ if and only if cartel 1 is robust and the fine discount granted in market 1 in return for the disclosure of cartel 2 exceeds the fine that would have otherwise been imposed for the reported cartel 2:*

$$V_{12}^{AP}(\delta, R_1, R_2) > V_{12}(\delta) \iff \delta \geq \widehat{\delta}_1(R_2) \text{ and } R_1 > F_2$$

**Proof** See appendix 2.C.

The net effect of Amnesty Plus is equal to $V_{12}^{AP}(\delta, R_1, R_2) - V_{12}(\delta)$. If this difference is positive, Amnesty Plus is potentially anticompetitive. If cartel 1 is robust, the value of joint collusion is given by equation (2.4) for the US and by equation (2.1) for the EU. We can separate the difference of these two expressions into the desistance $(\Delta_D)$ and the reporting $(\Delta_R)$ effects of Amnesty Plus:

$$\begin{aligned} \Delta_D &= \frac{\pi_1 - qF_1}{1-\delta(1-q)} + \frac{\pi_2 - qF_2}{1-\delta(1-q)^2} - \frac{\pi_1 - qF_1}{1-\delta(1-q)} - \frac{\pi_2 - qF_2}{1-\delta(1-q)^2} = 0 \qquad (2.8) \\ \Delta_R &= \frac{q(1-q)(R_1 - F_2)}{2\left(1-\delta(1-q)^2\right)} <>= 0 \end{aligned}$$

The desistance effect is zero because Amnesty Plus does not induce the reporting of the individually stable cartel 1 in this case. However, if $R_1 > F_2$, the reporting effect is strictly positive and Amnesty Plus increases the value of joint collusion.

**Proposition 2** $(S_{12}^{AP}, S_{12}^{AP})$ *is the best collusive equilibrium for a non-empty range of values of $\delta$ in the interval $[\widetilde{\delta}_1, \widetilde{\delta}_{12}[$ if and only if*

$$R_2 < \bar{R}_2 \equiv \frac{\widetilde{\delta}_{12}(\pi_1 - qF_1)}{1 - \widetilde{\delta}_{12}(1-q)} \qquad (2.9)$$

$$R_1 > \underline{R}_1 \equiv F_2 + \frac{2\left(1-\widetilde{\delta}_{12}(1-q)^2\right)}{q(1-q)}\left[2\pi_1 + 2\pi_2 - V_{12}(\widetilde{\delta}_{12}^-)\right] \tag{2.10}$$

**Proof** See Appendix 2.C.

Proposition 2 is central to this chapter. It suggests that situations occur in which Amnesty Plus stabilizes the previously unstable cartel 2 and thereby increases the extent of collusion. If the fine in market 2 is small such that $F_2 < \bar{R}_2$, condition (2.9) always holds because of our assumption that $R_k \leq F_k$.[15] Amnesty Plus is then anticompetitive if the AA over-rewards applicants by granting a reduction $R_1$ in return for the reporting of cartel 2 that is too high. Condition (2.10) boils down to $R_1 > F_2$ if multimarket contact is procollusive, i.e. $\widetilde{\delta}_{12} < \widetilde{\delta}_2$.[16] An agency that acts optimally would not agree to such a large discount. However, an agency that maximizes the number of convicted cartels rather than minimizing the number of cartels formed definitely has incentives to over-reward. As the number of cartels deterred is unobservable, an antitrust authority can only be assessed based on observable measures of performance such as the number of successfully prosecuted cartels. Maximal deterrence, though socially desirable, may therefore not be the primary objective of an antitrust authority (Harrington, 2010).

**Corollary 1** *Amnesty Plus has no anticompetitive effect on cartel formation if the fine discount granted in market $k$ in return for the disclosure of cartel $-k$ does not exceed the fine that would have otherwise been imposed for the reported cartel $-k$, i.e. $R_k \leq F_{-k}$.*

**Proof** The second term of the right hand side in condition (2.10) of Proposition 2 is weakly positive. A fine reduction $R_k \leq F_{-k}$ violates this condition.

Corollary 1 suggests that the AA can avoid a procollusive effect of Amnesty Plus by fixing fine discounts such that $R_k \leq F_{-k}$. This result is crucial because it gives us a clear-cut policy rule which relies only on parameters set by the authority itself. The discount-setting rule is therefore easy to implement.

[15] If we suppose that there exists an increasing and continuous function g(.), verifying g(0)=0, such that $F_k \leq g(\pi_k)$, condition (2.9) always holds for a sufficiently small market 2.

[16] If $\widetilde{\delta}_{12} < \widetilde{\delta}_2$ then $V_{12}(\widetilde{\delta}_{12}^-) = 2\pi_1 + 2\pi_2$ while, if $\widetilde{\delta}_{12} = \widetilde{\delta}_2$, this may not be true because it may happen that $V_{12}(\widetilde{\delta}_{12}^-) < 2\pi_1 + 2\pi_2 \leq V_{12}(\widetilde{\delta}_{12})$.

**The Procompetitive Effect of Amnesty Plus**

Consider now the interval $[\widetilde{\delta}_{12}, 1[$ where $(S_{12}, S_{12})$ is the best collusive equilibrium in the EU. Amnesty Plus is procompetitive if it either prevents or defers the formation of cartel 2, i.e. if it makes either $(S_1, S_1)$ or $(S_{1\rightarrow 2}, S_{1\rightarrow 2})$ the best collusive equilibrium. We divide this interval into two sub-intervals. We first examine $[\widetilde{\delta}_{12}, \widetilde{\delta}_2[$ where only cartel 1 is individually stable and Amnesty Plus can completely deter the formation of cartel 2, and second $[\widetilde{\delta}_2, 1[$ where both cartels are individually stable and Amnesty Plus can only defer the formation of cartel 2. We focus on a situation where multimarket contact is procollusive such that $\widetilde{\delta}_{12} < \widetilde{\delta}_2$.

Amnesty Plus prevents the formation of cartel 2, i.e. it makes $(S_1, S_1)$ the best collusive equilibrium, for at least some values of $\delta$ in the interval $[\widetilde{\delta}_{12}, \widetilde{\delta}_2[$ if and only if it lowers the value of joint collusion such that forming both cartels is no longer incentive compatible. Note that Amnesty Plus neutralizes the procollusive effect of multimarket contact in this case.

**Proposition 3** *Amnesty Plus prevents the formation of cartel* 2 *for a non-empty range of values of* $\delta$ *in the interval* $[\widetilde{\delta}_{12}, \widetilde{\delta}_2[$ *if and only if* $R_2 > \bar{R}_2$ *or* $R_1 < F_2$*:*
*- If* $R_2 > \bar{R}_2$*,* $(S_1, S_1)$ *is the best collusive equilibrium for a non-empty range of values of* $\delta$ *in the interval* $[\widetilde{\delta}_{12}, \widetilde{\delta}_2[$ *for any* $R_1 > 0$*.*
*- If* $R_2 \leq \bar{R}_2$*,* $(S_1, S_1)$ *is the best collusive equilibrium for a non-empty range of values of* $\delta$ *in the interval* $[\widetilde{\delta}_{12}, \widetilde{\delta}_2[$ *if and only if* $R_1 < F_2$*.*

**Proof** See appendix 2.C.

Proposition 3 suggests that, for a high enough fine discount $R_2$, Amnesty Plus causes desistance and thereby lowers the value of joint collusion such that forming both cartels is no longer incentive compatible for some values of $\delta$. If, however, $R_2$ is too low to induce desistance, the reporting effect in market 2 must be strictly negative to break joint collusion. In the first case, cartel 1 is not robust for values of $\delta$ close enough to $\widetilde{\delta}_{12}$. The value of joint collusion is given in (2.6) for the US and in (2.1) for the EU. Separating the difference of these expressions into the desistance and reporting effects, we get

$$\begin{aligned}\Delta_D &= \frac{\pi_1 - qF_1}{1-\delta(1-q)^2} - \frac{\pi_1 - qF_1}{1-\delta(1-q)} < 0 \\ \Delta_R &= \frac{q(1-q)(R_1+R_2-F_1-F_2)}{2\,(1-\delta(1-q)^2)} \leq 0\end{aligned} \tag{2.11}$$

Amnesty Plus induces reporting in stage 4. Each firm's expected reporting benefits are $(R_1+R_2-F_1-F_2)/2$ which must be weakly negative because $R_k \leq F_k$. Desistance from the stable cartel 1 after the detection of cartel 2 strictly lowers the value of joint collusion. Amnesty Plus therefore prevents the formation of cartel 2 for any fine discount $R_1$ if $\delta$ is close enough to $\widetilde{\delta}_{12}$. In the second case, cartel 1 is robust for all $\delta$ in this interval. The desistance and reporting effects are given by the expressions in (2.8). Amnesty Plus can induce the reporting of only the unstable cartel 2 and therefore has no effect on desistance. However, if $R_1 < F_2$, Amnesty Plus lowers the value of joint collusion and may prevent the formation of cartel 2.

Amnesty Plus defers the formation of cartel 2, i.e. it makes $(S_{1\to 2}, S_{1\to 2})$ the best collusive equilibrium, for at least some values of $\delta$ in the interval $[\widetilde{\delta}_2, 1[$ if and only if it lowers the value of jointly colluding such that either joint collusion is no more incentive compatible *or* is Pareto dominated by sequential collusion. We give here the intuitive arguments and provide the detailed formal analysis in appendix 2.D.

Let us first sketch under what conditions joint collusion is no more incentive compatible. Loosely speaking, $(S_{12}^{AP}, S_{12}^{AP})$ is not an equilibrium for a non-empty range of values of $\delta$ in the interval $[\widetilde{\delta}_2, 1[$ if $R_1$ and $R_2$ take intermediate values. On the one hand, at least one of the fine reductions must be high enough such that both firms report the remaining stable cartel in the reporting subgame of stage 4. On the other hand, the same fine reduction that induces the reporting must be low enough such that the decrease in the expected fine does not compensate the firms for the enhanced desistance. If $(S_{12}^{AP}, S_{12}^{AP})$ is not an equilibrium, $(S_{1\to 2}, S_{1\to 2})$ is the best collusive equilibrium in this interval.

Let us now intuitively explain why the sequential equilibrium may Pareto dominate the joint equilibrium if the firms' discount factor is sufficiently close to 1. Amnesty Plus, if it induces both firms to report, erases future collusive profits in the remaining market. This is however not the case when firms collude sequentially. If the firms highly value *current* collusive profits and care less about the future, i.e. their $\delta$ is relatively low, they prefer to collude in both markets today and to incur the risk of being forced to globally compete in the future. If, however, the firms highly value *future* profits, they may be willing to sacrifice cartel profits today in return for a longer expected duration of collusion. $(S_{1\to2}, S_{1\to2})$ is then the best collusive equilibrium in this interval.

## 2.5 Extensions

### 2.5.1 Heterogenous Detection Probabilities

Amnesty Plus strategically links two markets. The direct consequence of this linkage is that Amnesty Plus may deploy its effects for parameter values where a standard leniency program cannot influence collusion at all. To see this, suppose that $q_1 > 0$ and $q_2 = 0$. Possible reasons for this difference may be e.g. that the AA concentrates on the discovery of big cartels or that consumers are more sensible to prices of a product with an important sales' volume and thus are more likely to complain to the authority about the prices in market 1. With $q_2 = 0$ a standard leniency program has no effect in market 2. This is however not true for Amnesty Plus. Amnesty Plus induces the reporting of the stable cartel 2 after the detection of cartel 1 if the size of the fine discount granted in market 1 is greater than the continuation value from colluding in market 2, which may happen even if $q_2 = 0$. Hence, provided that detection in market 1 occurs with a sufficiently high probability, Amnesty Plus may deter the formation of cartel 2 even for $q_2 = 0$.

### 2.5.2 More than two Firms

Consider $n$ identical firms active on markets 1 and 2. Assume that if all the firms report the remaining cartel simultaneously in stage 4, each firm is first with probability $\frac{1}{n}$. As only the first informant is eligible for the fine discount under Amnesty Plus, a firm's expected payoff from reporting cartel $-k$, when everyone else does, is $\frac{1}{n}R_k - \frac{n-1}{n}F_{-k}$. We have $\frac{1}{n}[R_k - (n-1)F_{-k}] \leq 0$ if and only if $R_k \leq (n-1)F_{-k}$. Hence, to avoid a potential anticompetitive effect of Amnesty Plus, the AA would have to set the fine reductions such that $R_k \leq (n-1)F_{-k}$.[17] This constraint becomes slacker as the number of firms increases. Collusion however tends to be more important in highly concentrated markets, due to eased coordination and monitoring, than in markets where many small firms operate (Tirole, 1988). Moreover, if the AA wants to include a discount-setting rule in its amnesty plus policy that depends only on variables set by itself then it should set up this rule to avoid the anticompetitive effect for *any* possible number of firms. As the worst case scenario occurs for $n = 2$, the authority should adopt the rule $R_k \leq F_{-k}$.

### 2.5.3 More than two Markets

Consider a set $M$ of markets in which two identical firms interact. Denote $|M| = m \geq 2$ the number of markets. For a subset of markets $K \subseteq M$ denote $\Pi_K$ the total profit each firm earns from collusion and $F_K$ the total fine each firm pays if the AA detects the cartels in the subset $K$.[18] For a subset of markets $L \subseteq M \setminus K$ let $R_K^L$ be the fine discount the first firm gets under Amnesty Plus in return for reporting the cartels in subset $L$. Assume that $R_K^L \leq R_K^{L'}$ if $L \subseteq L'$.

Let us first define the strategies we consider under a leniency policy without Amnesty Plus. For any subset of markets $I \subseteq M$ denote $s_I$ the following strategy over one period: collude in the subset $I$, neither deviate from the collusive agreements nor report. In particular, $s_\varnothing$ consists of competing in all markets. We recursively define the strategies $S_{I,t}$ over the subgame starting from period $t$ and denote $V_I(\delta)$ as each firm's expected payoff discounted to period $t$ when both firms play $S_{I,t}$.[19]

$S_{\varnothing,t}$: play $s_\varnothing$ in period $t$ and all subsequent periods.

If $|I| = 1$ then $S_{I,t}$ is the following strategy: play $s_I$ in period $t$ and any subsequent

[17] Consider the case of collusive agreements not involving the same set of firms in both markets. Denote $n_k$ the number of firms in cartel $k$ and $s$ the number of firms partipating in both cartels. If $s = 0$, Amnesty Plus has no effect. If $s \geq 1$, Amnesty Plus can increase the value of collusion for firms involved in both cartels, but whenever this happens it will also decrease the expected cartel profits for firms colluding in one market only. To avoid any increase in the expected profit of *every* firm, it must hold that $R_k \leq (s-1)F_{-k}$, which can be satisfied for strictly positive discounts only if $s > 1$. However, if we consider the weaker (and more relevant) requirement that Amnesty Plus should not increase the *total* value of each cartel then the discount-setting rule $R_k \leq (n_{-k} - 1)F_{-k}$ is sufficient.

[18] In this extension, we allow for substitutability and complementarity between markets, and thus, $\Pi_K$ need not equal the sum of the profits in each of the markets in subset $K$. For an analysis of multimarket collusion with demand linkages see Choi and Gerlach (2009a).

[19] We use $|I|$ as a recursive variable: the definition of the collusive strategies over $I \neq \varnothing$ builds on the definitions of the collusive strategies over the sets whose cardinality is strictly less than $|I|$.

period as long as there is neither deviation from the collusive agreement nor reporting nor detection; if either deviation or reporting or detection occurs in period $t' \geq t$, play $S_{\varnothing,t'+1}$.
If $|I| \geq 2$ then $S_{I,t}$ is the following strategy: play $s_I$ in period $t$ and any subsequent period as long as there is neither deviation from the collusive agreements nor reporting nor detection; if detection of a subset of markets $J \subsetneq I$ occurs in some period $t' \geq t$ but neither deviation from any collusive agreement nor reporting, play $S_{L(I,J),t'+1}$ where $L(I,J) \subseteq I \setminus J$ is such that $V_{L(I,J)}(\delta) \geq V_L(\delta)$ for any $L \subseteq I \setminus J$ if the set $R(I,J) = \{L \subseteq I \setminus J \ / \ V_L(\delta) \geq 2\Pi_L\}$ is not empty and $L(I,J) = \varnothing$ otherwise; if in some period $t'' \geq t$ reporting or deviation occurs, or all the cartels are detected, play $S_{\varnothing,t''+1}$.

Let us now define the strategies under a leniency policy with Amnesty Plus. For any subset of markets $I \subseteq M$ we recursively define the strategy $s_I^{AP}$ over one period and the strategies $S_{I,t}^{AP}$ over the subgame starting from period $t$ and note $V_I^{AP}(\delta)$ as each firm's expected payoff discounted to period $t$ when both firms play $S_{I,t}^{AP}$. For any subset $I$ such that $|I| \leq 1$, we define $s_I^{AP}$ and $S_{I,t}^{AP}$ exactly as $s_I$ and $S_{I,t}$. For any subset $I$ such that $|I| \geq 2$ we define the strategies $s_I^{AP}$ and $S_{I,t}^{AP}$ as follows:
$s_I^{AP}$: collude in the subset $I$, neither deviate from the collusive agreements nor report; if detection of a subset of markets $J \subsetneq I$ occurs but neither deviation nor reporting, then report all the remaining cartels under Amnesty Plus if the set $R^{AP}(I,J) = \{L \subseteq I \setminus J \ / \ V_L^{AP}(\delta) \geq \max(2\Pi_L, \frac{R_J^{I \setminus J}}{\delta})\}$ is empty; otherwise, do not report any of the remaining cartels under Amnesty Plus.
$S_{I,t}^{AP}$: play $s_I^{AP}$ in period $t$ and in any subsequent period as long as there is neither deviation from the collusive agreements nor detection; if in some period $t' \geq t$ detection of a subset $J \subsetneq I$ occurs but neither deviation nor reporting then play $S_{L(I,J),t'+1}^{AP}$ where $L^{AP}(I,J) \subseteq I \setminus J$ is such that $V_{L^{AP}(I,J)}^{AP}(\delta) \geq V_L^{AP}(\delta)$ for any $L \subseteq I \setminus J$ if the set $R^{AP}(I,J)$ is not empty and $L^{AP}(I,J) = \varnothing$ otherwise; if in some period $t'' \geq t$ reporting or deviation occurs, or all the cartels are detected, play $S_{\varnothing,t''+1}^{AP}$.

The following proposition gives the natural extension of the discount-setting rule we suggest in Corollary 1 for $m = 2$ to the general case with $m \geq 2$ markets.

**Proposition 4** *If for all $K \subsetneq M$ and $L \subseteq M \setminus K$ it holds that:*

$$R_K^L \leq F_L$$

*then for any $I \subseteq M$*

$$V_I^{AP}(\delta) \leq V_I(\delta)$$

*which rules out any anticompetitive effect of Amnesty Plus on cartel formation.*

**Proof** See appendix 2.C.

### 2.5.4 Partial Collusion

In our analysis, we have assumed that the firms collude at the monopoly price. Indeed, in our model, if collusion is incentive compatible in both markets, the firms have no incentives to collude at a price lower than this because both cartel stability and expected collusive profits increase in industry profits. Partial collusion may however be optimal if $\delta \in [\widetilde{\delta}_1, \widetilde{\delta}_2[$. To see this, suppose that, if the firms collude, they can fix a price $p_k \in ]c_k, p_k^m]$ where $c_k$ is the marginal cost of production and $p_k^m$ the monopoly price. We assume that a firm's profit function $\pi_k(p_k)$, when both firms choose $p_k$, is continuous, quasi-concave and reaches its maximum at $p_k^m < +\infty$. Furthermore, we denote $\bar{p}_k \in ]c_k, p_k^m[$ the unique solution to the equation $\pi_k(p_k) - qF_k = 0$

Consider first the situation for $\delta \in [\widetilde{\delta}_1, \widetilde{\delta}_2[$ under the EU Leniency Program. If both firms collude and fix a price $p_1 \in ]c_1, p_1^m]$ in market 1 and $p_2 \in ]c_2, p_2^m]$ in market 2, each firm's discounted expected total profit is

$$V_{12}(p_1, p_2, \delta) = \frac{\pi_1(p_1) - qF_1}{1 - \delta(1-q)} + \frac{\pi_2(p_2) - qF_2}{1 - \delta(1-q)^2}$$

Joint collusion at prices $(p_1, p_2)$ is sustainable if and only if the participation constraint

$p_k \geq \bar{p}_k$ holds for $k = 1, 2$ and $V_{12}(p_1, p_2, \delta) \geq 2\pi_1 + 2\pi_2$ which is equivalent to

$$\pi_1(p_1)\left(\frac{1}{1-\delta(1-q)} - 2\right) - \frac{qF_1}{1-\delta(1-q)} + + \pi_2(p_2)\left(\frac{1}{1-\delta(1-q)^2} - 2\right) - \frac{qF_2}{1-\delta(1-q)^2} \geq 0 \quad (2.12)$$

Optimal joint collusion at prices $(p_1, p_2) \in [\bar{p}_1, p_1^m] \times [\bar{p}_2, p_2^m]$ maximizes $V_{12}(p_1, p_2, \delta)$ subject to the incentive compatibility constraint given by (2.12). For all $\delta \in [\widetilde{\delta}_1, \widetilde{\delta}_2[$ the expression $(\frac{1}{1-\delta(1-q)} - 2)$ is positive because $\widetilde{\delta}_1 > \frac{1}{2(1-q)}$. The left hand side (LHS) of (2.12) therefore increases in $p_1$ which implies that full collusion in market 1, i.e. $p_1 = p_1^m$, is always optimal when jointly colluding. This, however, need not be true for market 2 because the LHS of the inequality in (2.12) decreases in $p_2$ if $\delta < \bar{\delta} = \frac{1}{2(1-q)^2}$. We distinguish three cases:

a- If $\bar{\delta} \leq \widetilde{\delta}_1$, equivalently $\frac{F_1}{\pi_1^m} \geq \frac{1}{1-q}$, the joint stability of the cartels increases with $p_2$. Full collusion in market 2 is thus optimal when jointly colluding, and Proposition 1 remains valid.

b- If $\widetilde{\delta}_1 < \bar{\delta} < \widetilde{\delta}_2$, equivalently $\frac{F_1}{\pi_1^m} < \frac{1}{1-q} < \frac{F_2}{\pi_2^m}$, the joint stability of the cartels strictly decreases in $p_2$ for $\delta \in ]\widetilde{\delta}_1, \bar{\delta}[$, is independent of $p_2$ for $\delta = \bar{\delta}$, and strictly increases in $p_2$ for $\delta \in ]\bar{\delta}, \widetilde{\delta}_2[$. Partial collusion arises (for some values of $\delta$) in optimal joint collusion if the condition in (2.12) holds for $(p_1, p_2, \delta) = (p_1^m, \bar{p}_2, \bar{\delta})$ or, equivalently, if $F_2 \leq \frac{\pi_1^m - (1-q)F_1}{1-2q}$. If this inequality does not hold, full collusion is optimal, and Proposition 1 remains valid. If it holds, we can show that two thresholds $\delta_{12,p}$ and $\delta_{12,f}$ exist which satisfy $\widetilde{\delta}_1 < \delta_{12,p} < \delta_{12,f} < \widetilde{\delta}_2$ such that the price pair $(p_1(\delta), p_2(\delta))$ corresponding to optimal collusion contains $p_1(\delta) = p_1^m$ for all $\delta \in ]\widetilde{\delta}_1, \widetilde{\delta}_2[$ and $p_2(\delta)$ as a function over $]\widetilde{\delta}_1, \widetilde{\delta}_2[$ such that: $p_2(\delta) = c_2$ for all $\delta \in ]\widetilde{\delta}_1, \delta_{12,p}]$ (no collusion in market 2), $p_2(\delta) \in ]\bar{p}_2, p_2^m[$ strictly increasing over $]\delta_{12,p}, \delta_{12,f}[$ (partial collusion in market 2) and $p_2(\delta) = p_2^m$ for all $\delta \in [\delta_{12,f}, \widetilde{\delta}_2[$ (full collusion in market 2). Note that multimarket contact makes collusion easier by inducing either partial *or* full collusion in market 2.

c- If $\bar{\delta} \geq \widetilde{\delta}_2$, equivalently $\frac{F_2}{\pi_2^m} \geq \frac{1}{1-q}$, the joint stability of the cartels strictly decreases in $p_2$ for all $\delta \in [\widetilde{\delta}_1, \widetilde{\delta}_2[$. We have two situations: either joint collusion is not incentive compatible, and the firms compete in market 2, or collusion in market 2, partial at worst and full at best, is incentive compatible together with full collusion in market 1.

Consider now the situation under the US Leniency Program. For the ease of exposition, we illustrate how the possibility for partial collusion affects our results by examining the case where $\widetilde{\delta}_1 < \bar{\delta} < \widetilde{\delta}_2$ and $F_2 \leq \frac{\pi_1^m-(1-q)F_1}{1-2q}$ such that partial collusion may arise in equilibrium. Suppose that $R_2$ is small enough such that cartel 1 is robust to a detection of cartel 2 over the entire interval. We can show that two thresholds $\delta_{12,p}^{AP}$ and $\delta_{12,f}^{AP}$ exist which satisfy $\widetilde{\delta}_1 \leq \delta_{12,p}^{AP} \leq \delta_{12,f}^{AP} \leq \widetilde{\delta}_2$ such that the price pair $(p_1^{AP}(\delta), p_2^{AP}(\delta))$ corresponding to optimal collusion contains $p_1^{AP}(\delta) = p_1^m$ for all $\delta \in ]\widetilde{\delta}_1, \widetilde{\delta}_2[$ and $p_2^{AP}(\delta)$ as a function over $]\widetilde{\delta}_1, \widetilde{\delta}_2[$ such that: $p_2^{AP}(\delta) = c_2$ for all $\delta \in ]\widetilde{\delta}_1, \delta_{12,p}^{AP}]$ (no collusion in market 2), $p_2^{AP}(\delta) \in ]\bar{p}_2, p_2^m[$ strictly increasing over $]\delta_{12,p}^{AP}, \delta_{12,f}^{AP}[$ (partial collusion in market 2) and $p_2^{AP}(\delta) = p_2^m$ for all $\delta \in [\delta_{12,f}^{AP}, \widetilde{\delta}_2[$ (full collusion in market 2).[20] Furthermore, we can establish that for all $p_2 \in ]\bar{p}_2, p_2^m]$, we have $V_{12}(p_1, p_2, \delta) < V_{12}^{AP}(p_1, p_2, \delta, R_1, R_2)$ if and only if $R_1 > F_2$. Using the former result, it can be shown that, if $R_1 > F_2$, Amnesty Plus is anticompetitive in the sense that $\delta_{12,p}^{AP} < \delta_{12,p}$, $\delta_{12,f}^{AP} < \delta_{12,f}$ and for all $\delta \in ]\widetilde{\delta}_1, \widetilde{\delta}_2[$ $p_2^{AP}(\delta) \geq p_2(\delta)$. If $R_1 < F_2$, the reverse is true, and Amnesty Plus is procompetitive.

## 2.6 Conclusion

This chapter examines the effect of Amnesty Plus on the firms' incentives to form cartels. The firms repeatedly interact in two markets of different size and can use their multimarket contact to sustain collusion. While US success stories suggest that Amnesty Plus weakens cartel stability, our analysis shows that this is not correct in general.

We find that Amnesty Plus may increase cartel deterrence provided that the procollusive effect is avoided. The central implication of our analysis is that an antitrust authority can easily prevent this effect by adhering to the following rule: Set the absolute size of the fine discount granted in one market equal or below the fine the successful Amnesty Plus applicant would have incurred in the other market. We argue that this rule must be explicitly incorporated in the Amnesty Plus policy. One important reason is that, on top of pursuing a social welfare objective, an antitrust authority cares about performance. If performance is measured by the number of cartels dismantled, the antitrust authority may want to offer high discounts ex post, which may come with undesirable effects on deterrence ex ante.

[20] We cannot exclude that one or even two of these intervals are empty.

## 2.A The Sequential Equilibrium

We show that $(S_{2\to1}, S_{2\to1})$ can never be the best collusive equilibrium if $q$ is sufficiently small. We proceed in 2 steps. In step 1, we show under which conditions $(S_{2\to1}, S_{2\to1})$ is an equilibrium. In step 2, we demonstrate that, when $(S_{2\to1}, S_{2\to1})$ is an equilibrium, there is always another equilibrium that Pareto dominates the latter if $q$ is sufficiently small.

*Step 1.* The expected payoff associated with $(S_{2\to1}, S_{2\to1})$ is

$$V_{2\to1}(\delta) = V_2(\delta) + q\frac{\delta}{1-\delta(1-q)}V_1(\delta)$$

$(S_{2\to1}, S_{2\to1})$ is an equilibrium if and only if cartel 1 is individually stable, i.e. $\delta \geq \widetilde{\delta}_1$, and $V_{2\to1}(\delta) \geq 2\pi_2$. These two conditions hold if and only if $\delta \geq \max(\widetilde{\delta}_1, \widetilde{\delta}_{2\to1})$ where $\widetilde{\delta}_{2\to1}$ is such that $V_{2\to1}(\widetilde{\delta}_{2\to1}) = 2\pi_2$.

*Step 2.* Note first that for $\delta \geq \widetilde{\delta}_2$, $V_{1\to2}(\delta) > V_{2\to1}(\delta)$ if and only if $V_1(\delta) > V_2(\delta)$ which always holds because of our assumptions $\pi_1 > \pi_2$ and $\frac{F_2}{\pi_2} > \frac{F_1}{\pi_1}$. Hence, $(S_{1\to2}, S_{1\to2})$ always strictly Pareto dominates $(S_{2\to1}, S_{2\to1})$ for any $\delta$ in this range. Consider now the interval $[\max(\widetilde{\delta}_1, \widetilde{\delta}_{2\to1}), \widetilde{\delta}_2[$. The equilibrium $(S_1, S_1)$ strictly Pareto dominates $(S_{2\to1}, S_{2\to1})$ if and only if $V_1(\delta) > V_{2\to1}(\delta)$. We can write this inequality as

$$\frac{\pi_2 - qF_2}{\pi_1 - qF_1} < \frac{1-\delta}{1-\delta(1-q)}$$

As the right hand side (RHS) of the above inequality is decreasing in $\delta$, this condition holds for all $\delta \in [\max(\widetilde{\delta}_1, \widetilde{\delta}_{2\to1}), \widetilde{\delta}_2[$ if and only if it holds for $\delta = \widetilde{\delta}_2$, i.e.

$$\frac{(1-q)(\pi_2 - qF_2)^2}{(\pi_1 - qF_1)\,(\pi_2(1-2q) - qF_2)} < 1$$

As the LHS of the above inequality is continuous in $q$ and tends to $\frac{\pi_2}{\pi_1} < 1$ when $q \to 0$, there exists a threshold $\widetilde{q} > 0$ such that $V_1(\delta) > V_{2\to1}(\delta)$ for all $q \in ]0, \widetilde{q}[$ and all $\delta \in [\max(\widetilde{\delta}_1, \widetilde{\delta}_{2\to1}), \widetilde{\delta}_2[$. Hence, if $q < \widetilde{q}$, $(S_1, S_1)$ always strictly Pareto dominates $(S_{2\to1}, S_{2\to1})$ for any $\delta$ in this range.

## 2.B The Effect of Multimarket Contact

Multimarket contact is procollusive, i.e. $\widetilde{\delta}_{12} < \widetilde{\delta}_2$, if and only if

$$V_{12}(\widetilde{\delta}_2^-) > 2\pi_1 + 2\pi_2$$

which we rewrite as:

$$\pi_1 > \frac{F_1}{F_2}\pi_2 + \frac{\left(\frac{\pi_2}{F_2} - q\right)(\pi_2 + qF_2)}{1 + q - q(1-q)\frac{F_2}{\pi_2}} \tag{2.13}$$

The latter holds only if the markets are sufficiently different in terms of profitability. To see this, we use our assumptions on the relative size of the fines and of the fine-profit ratios to write

$$\frac{\pi_2}{\pi_1}F_1 < F_2 \leq F_1$$

If $\pi_2 \to \pi_1$, the above inequality implies that $F_2 \to F_1$, and the RHS of the inequality in (2.13) converges to

$$\pi_1 > \pi_1 + \frac{\left(\frac{\pi_1}{F_1} - q\right)(\pi_1 + qF_1)}{1 + q - q(1-q)\frac{F_1}{\pi_1}} \tag{2.14}$$

Since $(1+q) - q(1-q)\frac{F_1}{\pi_1} > (1+q) - q(1+q)\frac{F_1}{\pi_1} = (1+q)\frac{\pi_1 - qF_1}{\pi_1}$ and $\pi_1 - qF_1 > 0$, the second expression in the RHS of the inequality in (2.14) is strictly positive. Hence, the condition in (2.13) is not satisfied, and multimarket contact cannot help stabilize an individually unstable cartel if markets 1 and 2 are too close in terms of profitability. In this case, multimarket contact is neutral, i.e. $\widetilde{\delta}_{12} = \widetilde{\delta}_2$. However, if market 1 is sufficiently more profitable than market 2, in the sense that the condition in (2.13) holds, then multimarket contact is procollusive, i.e. $\widetilde{\delta}_{12} < \widetilde{\delta}_2$.

This finding contrasts with the irrelevance result in Bernheim and Whinston (1990). In our model, the latter takes the form of the special case $q = 0$ in which multimarket contact cannot affect the firms' ability to collude as the individual stability constraints are identical for both markets. If the presence of an antitrust authority creates an asymmetry between the markets in terms of collusion sustainability, due to e.g. heterogenous detection probabilities or fine-profit ratios, then multimarket contact may ease collusion.

## 2.C Proofs

**Proof of Proposition 1** We proceed in three steps. In step 1, we determine the range of discount factors for which $(S_{12}, S_{12})$ is an equilibrium. In step 2, we show that the sequential collusion equilibrium can never be the best collusive equilibrium of the game. In step 3, we conclude.

*Step 1.* The value of joint collusion $V_{12}(\delta)$ is given by:

$$V_{12}(\delta) = \begin{cases} \frac{\pi_1 - qF_1}{1-\delta(1-q)^2} + \frac{\pi_2 - qF_2}{1-\delta(1-q)^2} & \text{if} \quad \delta < \widetilde{\delta}_1 \\ \frac{\pi_1 - qF_1}{1-\delta(1-q)} + \frac{\pi_2 - qF_2}{1-\delta(1-q)^2} & \text{if} \quad \widetilde{\delta}_1 \leq \delta < \widetilde{\delta}_2 \\ \frac{\pi_1 - qF_1}{1-\delta(1-q)} + \frac{\pi_2 - qF_2}{1-\delta(1-q)} & \text{if} \quad \widetilde{\delta}_2 \leq \delta \end{cases} \tag{2.15}$$

If $\delta < \widetilde{\delta}_1$, $(S_{12}, S_{12})$ is not an equilibrium because $V_{12}(\delta) \leq V_1(\delta) + V_2(\delta) < 2\pi_1 + 2\pi_2$. If $\delta \geq \widetilde{\delta}_2$, $(S_{12}, S_{12})$ is an equilibrium because $V_{12}(\delta) = V_1(\delta) + V_2(\delta) \geq 2\pi_1 + 2\pi_2$. Consider now $\delta \in [\widetilde{\delta}_1, \widetilde{\delta}_2[$. Note first that

$$V_{12}(\widetilde{\delta}_1) = 2\pi_1 + \frac{\pi_2 - qF_2}{1 - \widetilde{\delta}_1(1-q)^2} < 2\pi_1 + V_2(\widetilde{\delta}_1) < 2\pi_1 + 2\pi_2$$

It follows from the continuity and strict monotonicity of $V_{12}(\delta)$ that $V_{12}(\delta) < 2\pi_1 + 2\pi_2$ for any $\delta \in ]\widetilde{\delta}_1, \widetilde{\delta}_2[$ if $V_{12}(\widetilde{\delta}_2^-) \leq 2\pi_1 + 2\pi_1$. However, if $V_{12}(\widetilde{\delta}_2^-) > 2\pi_1 + 2\pi_1$ then there exists a threshold in the interval $]\widetilde{\delta}_1, \widetilde{\delta}_2[$ such that $V_{12}(\delta) \geq 2\pi_1 + 2\pi_2$ for the discount factor values above this threshold and $V_{12}(\delta) < 2\pi_1 + 2\pi_2$ for values below. Thus, there always exists a (unique) threshold $\widetilde{\delta}_{12} \in ]\widetilde{\delta}_1, \widetilde{\delta}_2]$ such that $(S_{12}, S_{12})$ is an equilibrium for $\delta \geq \widetilde{\delta}_{12}$ and $(S_{12}, S_{12})$ is not an equilibrium for $\delta < \widetilde{\delta}_{12}$. If $V_{12}(\widetilde{\delta}_2^-) > 2\pi_1 + 2\pi_1$ then $\widetilde{\delta}_{12} < \widetilde{\delta}_2$. Otherwise $\widetilde{\delta}_{12} = \widetilde{\delta}_2$.

*Step 2.* We show that whenever $(S_{1\to2}, S_{1\to2})$ is an equilibrium, it is strictly dominated by the equilibrium $(S_{12}, S_{12})$ and thus cannot be the best collusive equilibrium. We know that $(S_{1\to2}, S_{1\to2})$ is an equilibrium if and only if $\delta \geq \widetilde{\delta}_2$. However, for $\delta \geq \widetilde{\delta}_2$, the strategy pair $(S_{12}, S_{12})$ constitutes an equilibrium as well and yields a collusive payoff of $V_{12}(\delta) = V_1(\delta) + V_2(\delta)$ (Step 1). Since $V_1(\delta) + V_2(\delta) > V_1(\delta) + q\frac{\delta}{1-\delta(1-q)}V_2(\delta)$, $(S_{1\to2}, S_{1\to2})$ can never be the best collusive equilibrium. Notice that we exclude $\delta = 1$ because $(S_{12}, S_{12})$ and $(S_{1\to2}, S_{1\to2})$ yield the same payoff in that case, and both are best collusive equilibria.

*Step 3.* We conclude that:
- If $\delta < \widetilde{\delta}_1$, neither $(S_1, S_1)$ nor $(S_{1\to 2}, S_{1\to 2})$ nor $(S_{12}, S_{12})$ is an equilibrium.
- If $\widetilde{\delta}_1 \leq \delta < \widetilde{\delta}_{12}$, the only collusive equilibrium is $(S_1, S_1)$.
- If $\delta \geq \widetilde{\delta}_{12}$ then $(S_{12}, S_{12})$ is an equilibrium and yields a higher payoff than $(S_1, S_1)$ and $(S_{1\to 2}, S_{1\to 2})$, whenever it is an equilibrium. ■

**Proof of Lemma 1** Consider first $\delta < \widehat{\delta}_1(R_2)$ where cartel 1 is not robust to a detection of cartel 2. The value of joint collusion is

$$V_{12}^{AP}(\delta, R_1, R_2) = \frac{\pi_1 - qF_1}{1-\delta(1-q)^2} + \frac{\pi_2 - qF_2}{1-\delta(1-q)^2} + \frac{q(1-q)(R_1 + R_2 - F_1 - F_2)}{2\left(1-\delta(1-q)^2\right)}$$

Since $R_k \leq F_k$, we know from (2.15) in Proof of Proposition 1 that $V_{12}^{AP}(\delta, R_1, R_2) \leq V_{12}(\delta)$. Amnesty Plus cannot increase the value of joint collusion.

Consider now $\delta \geq \widehat{\delta}_1(R_2)$. The value of joint collusion is

$$V_{12}^{AP}(\delta, R_1, R_2) = \underbrace{\frac{\pi_1 - qF_1}{1-\delta(1-q)} + \frac{\pi_2 - qF_2}{1-\delta(1-q)^2}}_{V_{12}(\delta)} + \frac{q(1-q)(R_1 - F_2)}{2\left(1-\delta(1-q)^2\right)}$$

Amnesty Plus therefore increases the value of jointly colluding, i.e. $V_{12}^{AP}(\delta, R_1, R_2) > V_{12}(\delta)$, if and only if $R_1 > F_2$. ■

**Proof of Proposition 2** The value of joint collusion $V_{12}^{AP}(\delta, R_1, R_2)$ is strictly increasing and right-continuous in $\delta$ over $[\widetilde{\delta}_1, \widetilde{\delta}_{12}[$. Therefore, a necessary and sufficient condition for $(S_{12}^{AP}, S_{12}^{AP})$ to be the best collusive equilibrium over a non-empty subinterval of $[\widetilde{\delta}_1, \widetilde{\delta}_{12}[$ is that $V_{12}^{AP}(\widetilde{\delta}_{12}^{-}, R_1, R_2) > 2\pi_1 + 2\pi_2$. The Proof of Lemma 1 shows that if $\widetilde{\delta}_{12} \leq \widehat{\delta}_1(R_2)$ then $V_{12}^{AP}(\widetilde{\delta}_{12}^{-}, R_1, R_2) < V_{12}(\widetilde{\delta}_{12}^{-}) \leq V_{12}(\widetilde{\delta}_{12}) = 2\pi_1 + 2\pi_2$. However, if $\widehat{\delta}_1(R_2) < \widetilde{\delta}_{12}$ (equivalent to the condition in (2.9)) then $V_{12}^{AP}(\widetilde{\delta}_{12}^{-}, R_1, R_2) = V_{12}(\widetilde{\delta}_{12}^{-}) + \frac{q(1-q)(R_1-F_2)}{2(1-\widetilde{\delta}_{12}(1-q)^2)} > 2\pi_1 + 2\pi_2$ if and only if the condition in (2.10) holds. ■

**Proof of Proposition 3** Assume first that $R_2 > \bar{R}_2$, which implies that $\widehat{\delta}_1(R_2) > \widetilde{\delta}_{12}$. For $\delta \in [\widetilde{\delta}_{12}, \widehat{\delta}_1(R_2)[$ cartel 1 is not robust and the Proof of Lemma 1 shows that $V_{12}^{AP}(\widetilde{\delta}_{12}, R_1, R_2) < V_{12}(\widetilde{\delta}_{12}) = 2\pi_1 + 2\pi_2$. Hence, for any $\delta \in [\widetilde{\delta}_{12}, \widehat{\delta}_1(R_2)[$ sufficiently close to $\widetilde{\delta}_{12}$, it must hold that $V_{12}^{AP}(\delta, R_1, R_2) < 2\pi_1 + 2\pi_2$ which implies that $(S_{12}, S_{12})$ is not an equilibrium and that $(S_1, S_1)$ is then the best collusive equilibrium.

Assume now that $R_2 \leq \bar{R}_2$, which implies that $\widehat{\delta}_1(R_2) \leq \widetilde{\delta}_{12}$. For any $\delta \in [\widetilde{\delta}_{12}, \widetilde{\delta}_2[$, cartel 1 is then robust, and, consequently,

$$\begin{aligned} V_{12}^{AP}(\delta, R_1, R_2) &= \frac{\pi_1 - qF_1}{1-\delta(1-q)} + \frac{\pi_2 - qF_2}{1-\delta(1-q)^2} + \frac{q(1-q)(R_1 - F_2)}{2\left(1-\delta(1-q)^2\right)} \\ &= V_1(\delta) + \frac{2(\pi_2 - qF_2) + q(1-q)(R_1 - F_2)}{2\left(1-\delta(1-q)^2\right)} \end{aligned}$$

$(S_1, S_1)$ is the best collusive equilibrium for a given $\delta$ if and only if either

$$V_{12}^{AP}(\delta, R_1, R_2) < 2\pi_1 + 2\pi_2 \tag{2.16}$$

or

$$V_{12}^{AP}(\delta, R_1, R_2) < V_1(\delta) \tag{2.17}$$

As we initially assumed that $q \leq \frac{\pi_2}{2\pi_2 + F_2}$ which implies that the numerator of $V_{12}^{AP}(\delta, R_1, R_2) - V_1(\delta) = \frac{2(\pi_2 - qF_2) + q(1-q)(R_1 - F_2)}{2(1-\delta(1-q)^2)}$ is strictly positive, and because $V_1(\delta)$ is increasing in $\delta$, $V_{12}^{AP}(\delta, R_1, R_2)$ is also increasing in $\delta$ over $[\widetilde{\delta}_{12}, \widetilde{\delta}_2[$. Hence, $(S_1, S_1)$ is the best collusive equilibrium for a non-empty range of values of $\delta$ in $[\widetilde{\delta}_{12}, \widetilde{\delta}_2[$ if and only if at least one of the conditions (2.16) and (2.17) holds for $\delta = \widetilde{\delta}_{12}$, i.e.

$$V_{12}^{AP}(\widetilde{\delta}_{12}, R_1, R_2) < \max\left(2\pi_1 + 2\pi_2, V_1\left(\widetilde{\delta}_{12}\right)\right)$$

which amounts to

$$V_{12}(\widetilde{\delta}_{12}) + \frac{q(1-q)(R_1 - F_2)}{2\left(1-\delta(1-q)^2\right)} < \max\left(2\pi_1 + 2\pi_2, V_1\left(\widetilde{\delta}_{12}\right)\right)$$

Since $V_1(\widetilde{\delta}_{12}) < V_{12}(\widetilde{\delta}_{12}) = 2\pi_1 + 2\pi_2$ the latter condition can be rewritten as $\frac{q(1-q)(R_1 - F_2)}{2(1-\delta(1-q)^2)} < 0$ which is the same as $R_1 < F_2$. ∎

**Proof of Proposition 4** Assume that fine discounts under Amnesty Plus are such that $R_K^L \leq F_L$ for all $K \subsetneq M$ and $L \subseteq M \setminus K$.

For every $i \in \{2, 3, ..., m\}$, denote $M_i = \{I \subseteq M$ such that $|I| \leq i\}$. Let us prove by recursive induction on $i$ that, for any $i \in \{2, 3, ..., m\}$, $V_I^{AP}(\delta) \leq V_I(\delta)$ for all $I \in M_i$.

For $i = 2$, the result is readily derived from our main analysis.

Consider now any $i \geq 3$ and assume that $V_I^{AP}(\delta) \leq V_I(\delta)$ for all $I \in M_{i-1}$. We will show that the latter inequality also holds for any $I \in M_i$, which will complete the proof. To do so it is sufficient to establish that the inequality is true for any subset $I$ of $i$ markets, i.e. such that $|I| = i$. Consider such a subset.

$V_I(\delta)$ is recursively defined as:

$$V_I(\delta) = \Pi_I + (1-q)^i \delta V_I(\delta) + \sum_{\substack{J \subsetneq I \\ J \neq \varnothing}} q^{|J|} (1-q)^{i-|J|} \left[-F_J + Y(I,J)\right] - q^i F_I$$

where $Y(I,J) = 0$ if $R(I,J) = \varnothing$ and $Y(I,J) = \delta V_{L(I,J)}(\delta)$ otherwise, which yields:

$$V_I(\delta) = \frac{1}{1-(1-q)^i \delta} \left[\Pi_I + \sum_{\substack{J \subsetneq I \\ J \neq \varnothing}} q^{|J|} (1-q)^{i-|J|} \left[-F_J + Y(I,J)\right] - q^i F_I\right]$$

$V_I^{AP}(\delta)$ is recursively defined as:

$$V_I^{AP}(\delta) = \Pi_I + (1-q)^i \delta V_I^{AP}(\delta) + \sum_{\substack{J \subsetneq I \\ J \neq \varnothing}} q^{|J|} (1-q)^{i-|J|} \left[-F_J + Y^{AP}(I,J)\right] - q^i F_I$$

where $Y^{AP}(I,J) = \frac{1}{2}(R_J^{I \setminus J} - F_J^{I \setminus J})$ if $R^{AP}(I,J) = \varnothing$ and $Y^{AP}(I,J) = \delta V_{L^{AP}(I,J)}^{AP}(\delta)$ otherwise, which yields

$$V_I^{AP}(\delta) = \frac{1}{1-(1-q)^i \delta} \left[\Pi_I + \sum_{\substack{J \subsetneq I \\ J \neq \varnothing}} q^{|J|} (1-q)^{i-|J|} \left[-F_J + Y^{AP}(I,J)\right] - q^i F_I\right]$$

Let us show that for any non-empty set $J \subsetneq I$, it holds that $Y^{AP}(I,J) \leq Y(I,J)$

which is a sufficient condition for the inequality $V_I^{AP}(\delta) \leq V_I(\delta)$ to hold.

Assume first that $J$ is such that $R(I,J) = \varnothing$, i.e. for any $L \subseteq I \setminus J$, it holds that $V_L(\delta) < 2\Pi_L$. Since any $L \subseteq I \setminus J$ belongs to $M_{i-1}$, we have: $V_L^{AP}(\delta) \leq V_L(\delta) < 2\Pi_L \leq \max(2\Pi_L, \frac{R_J^{I\setminus J}}{\delta})$. Therefore, $R^{AP}(I,J) = \varnothing$. Thus, in this case, we get $Y(I,J) = Y^{AP}(I,J) = 0$.

Assume now that $J$ is such that $R(I,J) \neq \varnothing$. If $R^{AP}(I,J) = \varnothing$ then $Y^{AP}(I,J) = \frac{1}{2}(R_J^{I\setminus J} - F_J^{I\setminus J}) \leq 0 \leq \delta V_{L(I,J)}(\delta) = Y(I,J)$. If $R^{AP}(I,J) \neq \varnothing$ then by definition of $L(I,J)$, we have $V_{L^{AP}(I,J)}(\delta) \leq V_{L(I,J)}(\delta)$ and since $L^{AP}(I,J)$ belongs to $M_{i-1}$, we also have $V_{L^{AP}(I,J)}^{AP}(\delta) \leq V_{L^{AP}(I,J)}(\delta)$. Combining the latter two inequalities we obtain $V_{L^{AP}(I,J)}^{AP}(\delta) \leq V_{L(I,J)}(\delta)$, which implies that $Y^{AP}(I,J) \leq Y(I,J)$.Thus, we conclude that $Y^{AP}(I,J) \leq Y(I,J)$ holds for any non-empty set $J \subsetneq I$, which implies that $V_I^{AP}(\delta) \leq V_I(\delta)$. ■

## 2.D The Procompetitive Effect of Amnesty Plus

Amnesty Plus defers the formation of cartel 2, i.e. it makes $(S_{1\to 2}, S_{1\to 2})$ the best collusive equilibrium, for at least some values of $\delta$ in $[\widetilde{\delta}_2, 1[$ if and only if it lowers the value of jointly colluding such that either joint collusion is no more incentive compatible or is Pareto dominated by sequential collusion. First, we show for which specific values of $R_1$ and $R_2$, the strategy pair $(S_{12}^{AP}, S_{12}^{AP})$ cannot be an equilibrium for at least some values in the interval, and, second, we provide conditions under which $(S_{1\to 2}, S_{1\to 2})$ Pareto dominates $(S_{12}^{AP}, S_{12}^{AP})$.

The present discounted expected payoff $V_{12}^{AP}(\delta, R_1, R_2)$ each firm gets when they both play the strategy $S_{12}^{AP}$ is right-continuous and strictly increasing in $\delta$ over the interval $[\widetilde{\delta}_2, 1[$. Hence, $(S_{12}^{AP}, S_{12}^{AP})$ is not an equilibrium for a non empty range of values of $\delta$ in $[\widetilde{\delta}_2, 1[$ if and only if

$$V_{12}^{AP}(\widetilde{\delta}_2, R_1, R_2) < 2\pi_1 + 2\pi_2 \tag{2.18}$$

The value $V_{12}^{AP}(\widetilde{\delta}_2, R_1, R_2)$ depends on the equilibrium payoff in the reporting subgame of stage 4. We therefore examine the condition in (2.18) for each of the four possible scenarios that arise from the comparison of the individual stability threshold $\widetilde{\delta}_2$ and the robustness thresholds.

a- If $\widetilde{\delta}_2 \geq \widehat{\delta}_1(R_2)$ and $\widetilde{\delta}_2 \geq \widehat{\delta}_2(R_1)$, both cartels are individually stable and robust for $\delta = \widetilde{\delta}_2$ and the value of joint collusion is equal to

$$V_{12}^{AP}(\widetilde{\delta}_2, R_1, R_2) = \frac{\pi_1 - qF_1}{1 - \widetilde{\delta}_2(1-q)} + \frac{\pi_2 - qF_2}{1 - \widetilde{\delta}_2(1-q)} > 2\pi_1 + 2\pi_2$$

It is straightforward that in this case that the condition in (2.18) cannot hold. The fine reductions $R_1$ and $R_2$ are both too small to trigger reporting in the reporting subgame. Amnesty Plus has no effect and $V_{12}^{AP}(\widetilde{\delta}_2, R_1, R_2) = V_{12}(\widetilde{\delta}_2)$.

b- If $\widetilde{\delta}_2 \geq \widehat{\delta}_1(R_2)$ and $\widetilde{\delta}_2 < \widehat{\delta}_2(R_1)$, cartel 1 is individually stable and robust whereas cartel 2 is stable but not robust for $\delta = \widetilde{\delta}_2$. The value of joint collusion is equal to

$$V_{12}^{AP}(\widetilde{\delta}_2, R_1, R_2) = \frac{\pi_1 - qF_1}{1 - \widetilde{\delta}_2(1-q)} + \frac{\pi_2 - qF_2}{1 - \widetilde{\delta}_2(1-q)^2} + \frac{q(1-q)(R_1 - F_2)}{2\left(1 - \widetilde{\delta}_2(1-q)^2\right)}$$

We can thus rewrite the condition in (2.18) as

$$R_1 < F_2 + \frac{2\left(1 - \widetilde{\delta}_2(1-q)^2\right)}{q(1-q)} \left(2\pi_1 + 2\pi_2 - V_1(\widetilde{\delta}_2) - \frac{\pi_2 - qF_2}{1 - \widetilde{\delta}_2(1-q)^2}\right)$$

which suggests that, if Amnesty Plus can induce the reporting of cartel 2 in the reporting subgame, the fine reduction in market 1 must be sufficiently low. Otherwise, the decrease of the expected fine would compensate the firms for the enhanced desistance, and the procompetitive effect cannot occur.

c- If $\widetilde{\delta}_2 < \widehat{\delta}_1(R_2)$ and $\widetilde{\delta}_2 \geq \widehat{\delta}_2(R_1)$, cartel 2 is individually stable and robust whereas cartel 1 is individually stable but not robust for $\delta = \widetilde{\delta}_2$. The value of joint collusion is equal to

$$V_{12}^{AP}(\widetilde{\delta}_2, R_1, R_2) = \frac{\pi_1 - qF_1}{1 - \widetilde{\delta}_2(1-q)^2} + \frac{\pi_2 - qF_2}{1 - \widetilde{\delta}_2(1-q)} + \frac{q(1-q)(R_2 - F_1)}{2\left(1 - \widetilde{\delta}_2(1-q)^2\right)}$$

The condition in (2.18) becomes

$$R_2 < F_1 + \frac{2\left(1 - \widetilde{\delta}_2(1-q)^2\right)}{q(1-q)} \left(2\pi_1 - \frac{\pi_1 - qF_1}{1 - \widetilde{\delta}_2(1-q)^2}\right)$$

A similar argument as above applies, and the procompetitive effect cannot occur.
d- If $\widetilde{\delta}_2 < \widehat{\delta}_1(R_2)$ and $\widetilde{\delta}_2 < \widehat{\delta}_2(R_1)$, both cartels are stable but not robust for $\delta = \widetilde{\delta}_2$. The value of joint collusion is

$$V_{12}^{AP}(\widetilde{\delta}_2, R_1, R_2) = \frac{\pi_1 - qF_1}{1-\widetilde{\delta}_2(1-q)^2} + \frac{\pi_2 - qF_2}{1-\widetilde{\delta}_2(1-q)^2} + \frac{q(1-q)(R_1+R_2-F_1-F_2)}{2\left(1-\widetilde{\delta}_2(1-q)^2\right)}$$

We rewrite the condition in (2.18) as

$$R_1 + R_2 < (F_1+F_2)\frac{2-q}{1-q} - \frac{4\widetilde{\delta}_2(1-q)(\pi_1+\pi_2)}{q}$$

In this case, Amnesty Plus triggers the reporting in each possible reporting subgame of stage 4. The fine reductions must be sufficiently low such that the expected fines do not decrease too much.

We now provide sufficient conditions under which $(S_{1\to 2}, S_{1\to 2})$ Pareto dominates $(S_{12}^{AP}, S_{12}^{AP})$. Since $V_{1\to 2}(1^-) = V_1(1^-) + V_2(1^-) > 2\pi_1 + 2\pi_2$ and $V_{1\to 2}(\delta)$ is continuous and increasing on $[\widetilde{\delta}_2, 1[$, there exists a threshold $\widetilde{\delta}_{1\to 2} \in [\widetilde{\delta}_2, 1[$ such that for $\delta$ values in this interval, we have $V_{1\to 2}(\delta) \geq 2\pi_1 + 2\pi_2$ if and only if $\delta \geq \widetilde{\delta}_{1\to 2}$. This implies that the comparison of $V_{12}^{AP}(\delta, R_1, R_2)$ to $V_{1\to 2}(\delta)$ is mainly relevant over the interval $[\widetilde{\delta}_{1\to 2}, 1[$. In what follows, we therefore concentrate on sufficiently high values of $\delta$.

Consider the case where $\widehat{\delta}_1(R_2) > 1$. Cartel 1 is then not robust for any value of $\delta$ in this interval. If, moreover, $\widehat{\delta}_2(R_1) > 1$ the value of joint collusion for $\delta = 1^-$ is

$$V_{12}^{AP}(1^-, R_1, R_2) = \frac{\pi_1 - qF_1}{1-(1-q)^2} + \frac{\pi_2 - qF_2}{1-(1-q)^2} + \frac{q(1-q)(R_1+R_2-F_1-F_2)}{2\left(1-(1-q)^2\right)}$$

If, however, $\widehat{\delta}_2(R_1) \leq 1$ we have

$$V_{12}^{AP}(1^-, R_1, R_2) = \frac{\pi_1 - qF_1}{1-(1-q)^2} + \frac{\pi_2 - qF_2}{q} + \frac{q(1-q)(R_2-F_1)}{2\left(1-(1-q)^2\right)}$$

In both cases it is true that $V_{12}^{AP}(1^-, R_1, R_2) < V_1(1^-) + V_2(1^-) = V_{1\to 2}(1^-)$ which implies that $V_{12}^{AP}(\delta, R_1, R_2) < V_{1\to 2}(\delta)$ for a non empty range of values of $\delta$ sufficiently close to 1. Hence, for this range of values, Amnesty Plus defers the formation of cartel 2.

Consider now the case where $\widehat{\delta}_1(R_2) \leq 1$. Amnesty Plus defers the formation of cartel 2 for values of $\delta$ sufficiently close to 1 if

$$\frac{\pi_2 - qF_2}{q} < R_1 < F_2 + \underbrace{2\frac{\pi_2 - qF_2}{q(1-q)}\left(\frac{1-(1-q)^2}{q} - 1\right)}_{>0}$$

The LHS ensures that cartel 2 is not robust, i.e. $\widehat{\delta}_2(R_1) > 1$, and the RHS implies that $V_{12}^{AP}(1^-, R_1, R_2) < V_1(1^-) + V_2(1^-) = V_{1\to 2}(1^-)$ given that $\widehat{\delta}_1(R_2) \leq 1$ and $\widehat{\delta}_2(R_1) > 1$.

# Chapter 3

# Why Effort May Increase With Ability: Complementarity of Antitrust Enforcement and Policy Instruments

joint with Yassine Lefouili

## 3.1 Introduction

There are two main points to this chapter. First, we characterize the optimal cartel detection effort of an antitrust authority.[1] Second, we show that this effort may increase with the use of a policy instrument that assists cartel deterrence.

Recent years have seen several important changes in the antitrust law of the European Union (EU) with respect to cartels, all with the objective of improving deterrence of cartel activities in the Community and some with a view to alleviating lengthy administrative procedures.[2] There have been three policy modifications with particularly

[1]Throughout the chapter, we use detection effort, detection probability and rate of law enforcement interchangeably.

[2]The time span between the starting date of an investigation, i.e. the date of the dawn raid, and the decision has been e.g. more than five years for the copper fittings case, around four years for the

far-reaching implications for the effectiveness of the European antitrust policy as well as for the workload of the competent division in the European Commission (EC), namely the adoption of a settlement procedure, the introduction of damages actions and the 2002 reform of the leniency program.

In 2008, the EC has introduced a settlement procedure for cartels.[3] Settlements are an option for companies which prefer to admit liability, bring an end to the procedure and obtain a 10% reduction in the fine, rather than explore every procedural option available. They speed up cartel investigations and thereby allow the EC to redirect resources, time and energy previously employed in the long process leading to a decision towards the detection of cartels.

Also in 2008, the EC adopted a white paper on the issue of using customer damages as a penalty.[4] Despite the great effort of the EC to promote an effective mechanism for the private enforcement of European competition law, private actions for damages have remained relatively rare. However, if a damage actions system can be made effective and victims of competition law infringement enforce their right for compensation, the level of fines may dramatically rise and thereby increase deterrence substantially.

The EU Leniency Program, especially after its revision in 2002, has been very successful in uncovering large international cartels.[5] The revised program makes it easier and financially more attractive for firms to apply. An effective leniency program produces cartel cases where the applicant delivers information which guides the authority's investigations and thus reduces time and resources spent on establishing the case. Moreover, if properly designed, leniency programs make collusion more difficult and therefore increase deterrence.[6]

This chapter examines the effect of policy instruments, such as settlement procedures, private actions and leniency programs, on the optimal effort the antitrust authority provides to detect cartels. We measure this detection effort by the probability of launching an investigation in a particular industry. The policy instrument and the detection effort

---

Netherlands bitumen case and more than three years for the synthetic rubber case (Motta, 2007).

[3]Commission Regulation (EC) No 622/2008 of 30 June 2008 amending Regulation (EC) No 773/2004, as regards the conduct of settlement procedures in cartel cases, Official Journal L 171, 1.7.2008, p.3−5.

[4]White Paper on Damages Actions for Breach of the EC antitrust rules, COM(2008) 165, 2.4.2008.

[5]Commission Notice on Immunity from Fines and Reduction of Fines in Cartel Cases, 2002/C 45/03, 19 February 2002.

[6]See in particular Harrington (2008), Chen and Rey (2007), Spagnolo (2004).

are complements if the introduction of a new - or the modification of an already existing - instrument, which assists deterrence, is optimally accompanied by a higher enforcement rate. They are substitutes if the authority finds it optimal to lower the enforcement rate when it uses the instrument. The issue of complementarity and substitutability is important for antitrust policy in practice. Guidelines are permanently revised, new legal frameworks are promoted and established ones adapted. The correct redirection of additionally available resources is crucial for the effectiveness of antitrust enforcement and for society as a whole.

A major part of the economic literature on crime and punishment focuses on the trade-off between probability and severity of punishment. In his seminal paper, Becker (1968) suggests that the detection probability and fines are substitutes. Both the size of fines and the rate of investigations positively affect deterrence, but, whereas the former are costless transfers, investigations are costly. Hence, to reach a *given level* of crime deterrence, fines should be in- and the detection probability decreased. It would seem intuitive that, when more deterrence is reached through the mere use of a policy instrument, less resources should be spent on detection. It is however not clear a priori in which direction the optimal level of detection changes if the latter is endogenous.

Our main finding is that the effect of the policy instrument on the optimal detection effort depends on the specific enforcement tool used. Complementarity occurs if the use of the policy instrument increases the marginal benefit of launching investigations. We find this to be the case for instruments that affect the level of fines for convicted cartel members such as settlement procedures and damages actions. If, however, the instrument is an effective leniency program, the optimal rate of law enforcement may increase as well as decrease.

In a recent paper, Chang and Harrington (2008) analyze the impact of a leniency program on the steady-state cartel rate when the antitrust authority's enforcement policy is endogenous. Their striking finding is that the leniency program may raise the cartel rate. To get this result, the authors make the assumption that the authority disposes of limited resources which it uses for handling leniency and non-leniency cases. If part of the resources are used for leniency cases, then fewer resources are available for effectively prosecuting non-leniency cases. In response to having a leniency policy, the antitrust authority adjusts its optimal enforcement policy downwards and thus prosecutes a smaller fraction of cartels discovered outside the leniency program. Hence, in those industries where the leniency program cannot deter cartel formation, weaker cartel enforcement increases the life span of the cartels. There are three main differences between our study and Chang and Harrington (2008). First, in their model, while the antitrust authority can choose the fraction of non-leniency cases it pursues, the probability of detecting a cartel is fixed. We however examine whether the authority should increase or decrease this detection probability with the introduction of a leniency program. Second, while Chang and Harrington (2008) consider an authority that maximizes the mass of cartels successfully prosecuted, we examine an authority that maximizes the mass of cartels deterred. Third, while the authors are only concerned with leniency programs, we analyze the authority's optimal response to different instruments.

The remainder of the chapter is organized as follows. Section 3.2 discusses the basic model without monitoring. In section 3.3, we introduce two different policy instruments and examine whether we have complementarity or substitutability. We introduce monitoring in section 3.4. Finally, section 3.5 briefly concludes. All proofs can be found in the appendix.

## 3.2 Basic Model

### 3.2.1 Set-up

Consider an economy that consists of a continuum of industries the mass of which is constant over time. In each industry, there are $n$ firms that discount future payoffs by a common discount factor $\delta$. Inter-industry heterogeneity exists with respect to $\delta$ which is distributed across industries with a strictly increasing $F(\delta)$ over $[0, 1]$.[7] We consider an infinitely repeated game where, in each period, the firms can choose to collude before interacting on the product market. Communication is necessary for collusion and generates hard evidence which makes it possible to establish the antitrust offense. There is no intra-industry heterogeneity, and the firms in the same industry either all collude

[7] Inter-industry heterogeneity with respect to $\delta$ implies that the industries differ only in their discount factors and not in size or collusive profits. Whereas $\delta$ captures various sources of heterogeneity, the reverse assumption, namely that industries differ only in size or profits, seems more restrictive to us.

or compete. At the time the firms decide whether to enter a collusive agreement, they observe the Antitrust Authority's (AA) enforcement policy which is summarized by the probability of detection and, if applicable, other policy instruments such as fines and self-reporting benefits.

In each period, there is a probability $q \in [0, 1]$, invariant across time and industries, with which the AA launches an investigation. This probability represents the AA's detection effort. Once an investigation is opened, the probability to convict the cartel is 1. Each convicted firm must pay a strictly positive fine $f$.

To keep the analysis simple, we suppose that the evidence of collusion lasts for one period which implies that a cartel cannot be prosecuted for its past activity. Thus, a firm which has deviated from a collusive agreement is held liable for its cartel behavior and can be fined until the end of the period in which the deviation occurred. Following a cartel conviction, we assume that the AA does not monitor the industry and thus, each period, the firms may return back to collusion. We relax this 'no monitoring' assumption further in the analysis.

For each detection probability $q$, an increasing threshold function $\widetilde{\delta}(q)$ exists. Collusion in a particular industry is sustainable if and only if $\delta \geq \widetilde{\delta}(q)$. The proportion of industries which are collusive at a specific detection probability $q$ is then $1-F(\widetilde{\delta}(q))$. We denote this proportion the *collusion rate* of the economy and assume that $q \to F(\widetilde{\delta}(q))$ is concave. Given the 'no monitoring' assumption, the collusion rate is stationary and equal to $1 - F(\widetilde{\delta}(q))$ each period.

The objective of the AA is to maximize the present discounted sum of welfare generated each period over all industries. A competitive industry generates a per-period welfare of $W$. Cartels are homogenous, and thus, each collusive industry generates the same per-period deadweight loss $D$. $W - D$ is then the per-period welfare generated by a collusive industry, and $[1 - F(\widetilde{\delta}(q))]D$ is the per-period social cost of collusion. To guarantee detection and conviction at a probability $q$ each period, the AA incurs a present discounted cost of $C(q, \delta_s)$. We assume that $C(0, \delta_s) = 0$, $\frac{\partial}{\partial q}C(0, \delta_s) = 0$, $\frac{\partial}{\partial q}C(q, \delta_s) > 0$ and $\frac{\partial^2}{\partial q^2}C(q, \delta_s) \geq 0$. $\delta_s$ is the AA's discount factor.

### 3.2.2 Timing

We use the timing of Chen and Rey (2007). In each period, the time structure of the game is as follows:

*Stage 0*: Each firm decides whether to enter a collusive agreement. If at least one firm chooses not to collude, competition takes place in this particular industry, and the game ends for that period. If all the firms in an industry choose to collude, they communicate and leave some hard evidence.

*Stage 1*: Each firm decides whether to deviate from the collusive agreement. Their rivals do not observe this decision until the end of the period.

*Stage 2*: Each cartel formed in stage 0 is detected with probability $q$ in which case all firms pay $f$, and the game ends for that period.

### 3.2.3 Antitrust Authority

**Optimal Law Enforcement**

The AA maximizes the present discounted sum of welfare generated each period over all industries:

$$U(q) = \frac{W}{1-\delta_s} - \frac{D\left(1 - F\left(\widetilde{\delta}(q)\right)\right)}{1-\delta_s} - C(q, \delta_s)$$

Since $U(q)$ is strictly concave in $q$, we have a unique maximizing solution $q^*$ characterized by the First Order Condition:[8]

$$\frac{\partial}{\partial q} S(q^*, \delta_s) = \frac{\partial}{\partial q} C(q^*, \delta_s)$$

where $S(q, \delta_s) = -\frac{D(1-F(\widetilde{\delta}(q)))}{1-\delta_s}$ is the present discounted sum of per-period welfare losses due to collusion. The above equation implies that the optimal rate of law enforcement $q^*$ equalizes marginal benefits in terms of cartel deterrence and marginal costs of conducting investigations.

[8]We assume that the unique solution to the AA's maximization program is interior.

**Policy Instrument**

To better combat collusion, the AA decides an exogenous change in the legal framework $R > 0$. $R$ represents the modification or the introduction of a policy instrument. We assume that this modification is costless, or equivalently, that its cost is independent of $q$. In a particular industry, collusion is now sustainable if and only if $\delta \geq \widetilde{\delta}(q, R)$ where $\widetilde{\delta}(q, R)$ increases in $R$ and $\widetilde{\delta}(q, 0) = \widetilde{\delta}(q)$. $R$ affects the AA's objective and, thereby, the optimal detection probability $q^*(R)$ which is now characterized by

$$\frac{\partial}{\partial q} S(q^*, R, \delta_s) = \frac{\partial}{\partial q} C(q^*, \delta_s)$$

where $S(q, R, \delta_s) = -\frac{D(1-F(\widetilde{\delta}(q,R)))}{1-\delta_s}$.

**Lemma 2** *(a) If $\frac{\partial^2}{\partial q \partial R} S(q, R, \delta_s) > 0$, then $q^*(R)$ increases with R; the policy instrument R and the optimal law enforcement are complements.*

*(b) If $\frac{\partial^2}{\partial q \partial R} S(q, R, \delta_s) < 0$, then $q^*(R)$ decreases with R; the policy instrument R and the optimal law enforcement are substitutes.*

**Proof** Follows directly from the differentiation of both sides of the optimality condition with respect to $R$.

Lemma 2 implies that, if the policy instrument raises the marginal benefit of $q$ in terms of social loss reduction, it is optimal to increase $q$ until the marginal benefit equals the marginal cost. Using Lemma 2 we get the following Proposition:

**Proposition 5** *Without monitoring, the impact of the policy instrument R on the optimal detection probability $q^*(R)$ solely depends on whether R increases or decreases the marginal efficiency of q in deterring collusion.*

*(a) If $\frac{\partial^2}{\partial q \partial R} F(\widetilde{\delta}(q, R)) > 0$, then $q^*(R)$ increases with R; the policy instrument R and the optimal law enforcement are complements.*

*(b) If $\frac{\partial^2}{\partial q \partial R} F(\widetilde{\delta}(q, R)) < 0$, then $q^*(R)$ decreases with R; the policy instrument R and the optimal law enforcement are substitutes.*

**Proof** Follows directly from Lemma 2.

Proposition 5 suggests that, if, by means of the policy instrument, an additional investigation can prevent collusion more effectively than before, the AA should optimally tighten its enforcement policy and spend more resources on detection. If, however, the instrument decreases the marginal efficiency of $q$, less enforcement is optimal. A priori, there is no reason why the latter rather than the former scenario should occur. Whether we have complementarity or substitutability depends on the nature of the policy instrument. Proposition 5 implies:

**Corollary 2** *If $F(.)$ is weakly convex, at least over $[\widetilde{\delta}(0,0),1]$, a sufficient condition for the policy instrument and the optimal law enforcement to be complements is $\frac{\partial^2}{\partial q \partial R}\widetilde{\delta}(q,R) > 0$.*

**Proof** See Appendix 3.A.

### 3.2.4 Cartel Stability

Consider a particular industry with $n \geq 2$ firms. If all firms collude, each firm earns a per-period cartel profit equal to $\pi > 0$ minus the expected fine $qf$. If all firms compete, they make zero profits. If one firm unilaterally deviates from the cartel while the others continue to collude, the deviating firm earns the whole short-term cartel profit $n\pi$ alone. The firms that stick to the agreement receive zero. The firms use grim trigger strategies and thus punish a deviation by reversion to competition. The punishment starts the period following the deviation and lasts forever after. After a cartel conviction, the AA does not monitor the industry, and the firms simply return back to collusion in the next period. The expected discounted value $V$ each firm gets from collusion is then

$$V = \frac{\pi - qf}{1 - \delta}$$

The cartel is sustainable only if the expected discounted value is as least as big as the gain from a unilateral deviation:

$$V \geq n\pi - qf$$

This incentive constraint defines the threshold function $\widetilde{\delta}(q,f)$ such that the cartel is stable if and only if

$$\delta \geq \frac{(n-1)\pi}{n\pi - qf} \equiv \widetilde{\delta}(q,f)$$

A firm has no incentive to unilaterally deviate from the collusive equilibrium if $\delta \geq \widetilde{\delta}(q,f)$ and thus, collusion is sustainable. Below this threshold, the firms anticipate that no one would stick to the agreement, and therefore they do not form the cartel in the first place. The stability threshold $\widetilde{\delta}(q,f)$ increases in $q$ and $f$. Intuitively, the higher the probability of conviction and the higher the fine, the more firms have to value future flows of collusive profits, and thus, the higher the $\delta$ needed to sustain the cartel. For collusion to be a problem in at least some of the industries, we need $\widetilde{\delta}(q,f) < 1 \rightarrow \frac{f}{\pi} < \frac{1}{q}$ which implies that the fine-profit ratio must be sufficiently low.

## 3.3 The Effect of a Policy Instrument

Let us now examine the effect of a policy instrument $R$ on the AA's optimal detection effort. Proposition 6 states a sufficient condition for $R$ and $q^*(R)$ to be complements.

**Proposition 6** *Assume that $\widetilde{\delta}(q,R)$ depends on $q$ and $R$ only through the interaction term $qR$, i.e. there exists a function $g$ such that $\widetilde{\delta}(q,R) = g(qR)$. If $x \longrightarrow xg'(x)$ is increasing (over the relevant range), i.e. $g$ is convex or moderately concave, then $q^*(R)$ is increasing in $R$, and the optimal detection probability and the policy instrument are complements.*

**Proof** See Appendix 3.A.

Proposition 6 suggests that, if the policy instrument enters the collusion rate only through an interaction term with $q$, we have complementarity. Let us illustrate this result by using two different policy instruments. First, we consider an increase in the level of fines. Second, we use a leniency program. We ease the exposition by examining the special case in which $\delta$ is uniformly distributed over $[0,1]$, i.e. $F(\delta) = \delta$, such that the collusion rate is $1 - \widetilde{\delta}(q,R)$.

### 3.3.1 Increase in the Level of Fines

Suppose that $R$ stands for an increase in $f$. It is easy to see from the cartel stability condition that the fine parameter $f$ enters the collusion rate only through the expected fine, and thus only through the interaction with $q$. In this case, Proposition 6 predicts complementarity between the fine increase and the detection effort. This signifies that the cross derivative in Proposition 5 must be positive:

$$\frac{\partial^2}{\partial q \partial f}\left(\frac{(n-1)\pi}{n\pi - qf}\right) > 0$$

It is easy to check that this condition always holds. Hence, higher fines should optimally go hand in hand with higher detection efforts and thus, more resources should be spent on the detection of cartels.

Note that in our setting, fines are not costly. The complementarity result may not or only partly arise if we take into account that the antitrust authority may commit legal errors by e.g. mistakenly taking a research joint venture for a cartel. If such errors may happen, firms may not be willing to form socially desirable research collaborations if the expected fines are high enough. Hence, fines may be socially costly, and this cost increases with the probability of detection and the level of fines. In this case, we may still see complementarity if expected fines are sufficiently low. Substitutability may then however arise for high levels of expected fines.

Another situation in which complementarity between detection efforts and fine increases may not hold occurs if we change the AA's objective. If we follow Harrington (2010), who suggests that the objective of an agency is to maximize the number of cartels prosecuted rather than minimizing the cartels formed, setting $q = 1$, even at zero cost, would never be optimal. In this case, the detection effort and the fine increase may be substitutes, especially if the deterrent effect of the fines is already strong.

### 3.3.2 Leniency Program

Consider a leniency program that helps to combat collusion.[9] A leniency program is effective if a firm which unilaterally deviates also immediately reports the cartel. For this to be the case, the first firm that reports the cartel must be eligible for a reduced fine $(1-\alpha)f$ smaller than the expected fine without reporting $qf$, i.e. $\alpha \in ]1-q,1]$. Then, the possibility to benefit from leniency tightens the incentive constraint and makes collusion more difficult:

$$V \geq n\pi - (1-\alpha)f$$

The above condition implies that a firm can apply for leniency in each period irrespective of whether the AA has convicted the cartel previously. Hence, leniency is equally offered to repeated offenders.[10] Collusion is sustainable if and only if

$$\delta \geq \frac{(n-1)\pi - (1-\alpha-q)f}{n\pi - (1-\alpha)f} \equiv \widetilde{\delta}(q,\alpha)$$

From the above expression, we can see that the policy instrument $\alpha$ does not enter the cartel stability condition through the interaction with $q$. Hence, we cannot use Proposition 6 to determine the relationship between $q^*(\alpha)$ and $\alpha$. We therefore check whether the cross derivative in Proposition 5 is positive:

$$\begin{aligned} \frac{\partial^2}{\partial q \partial \alpha}\left(\frac{(n-1)\pi - (1-\alpha-q)f}{n\pi - (1-\alpha)f}\right) &> 0 \\ \frac{-f^2}{(n\pi - (1-\alpha)f)^2} &> 0 \end{aligned}$$

It is easy to see that this inequality cannot hold which suggests that the leniency program and the optimal detection probability are substitutes. Hence, the leniency program should optimally be accompanied by lower detection efforts.

[9] The firms may use the leniency program to their advantage and play alternative collusive strategies which reduce expected fines and facilitate collusion (see e.g. Harrington (2008), Chen and Rey (2007) and Motta and Polo (2003)). While we acknowledge that leniency programs may, under certain circumstances, encourage collusion, we focus here on leniency programs which are beneficial to antitrust enforcement.

[10] Under the 2002 EU Leniency Program, a repeated offender can apply for leniency. This is consistent with Chen and Rey (2007) who show that ruling out leniency for repeated offenders may weaken antitrust enforcement.

### 3.3.3 Discussion

Our results suggest that whether we have complementarity or substitutability depends on the nature of the policy instrument. Two policy instruments, even though they both have a positive effect on cartel deterrence, can have diametrically opposed effects on the optimal level of detection efforts. Intuitively, this difference is due to the fact that the fine increase influences the firms' incentives to form a cartel only in combination with the detection probability (see Proposition 6). A fine increase strengthens the impact of the detection effort and vice-versa. This is however not the case with the leniency program. A lower fine for the first reporting firm makes a deviation more attractive independently of the probability of detection and therefore makes the detection effort marginally less effective. The AA's optimal response to a more effective leniency program is thus to decrease its effort.

## 3.4 Extended Model With Monitoring

We now relax the 'no monitoring' hypothesis and assume that, after a cartel conviction, the AA can forever monitor the previously collusive industry in which case the firms compete and never return back to collusion. Monitoring happens with probability $1-k$, and thus, the firms return to collusion with probability $0 \leq k < 1$ each period. Note that the policy instrument now affects the cost that guarantees a specific per-period detection probability $q$. This is because, with monitoring, the future collusive mass of industries, which determines this cost, is the current collusive mass which has not been detected plus the current collusive mass which has been detected but returns back to collusion with probability $k$. Since $R$ determines the current collusive mass via the collusion rate and therefore affects the future collusive mass of industries, it enters the total expected discounted detection cost $C(q, R, \delta_s, k)$.[11] The expected collusion rate is non stationary and mechanically decreases with $t$. At time $t = 0, 1, \ldots$, it is equal to $(1 - q + qk)^t[1 - F(\widetilde{\delta}(q, R))]$.

[11] We develop the expression of $C(q, R, \delta_s, k)$ with a constant unit cost of an investigation in Appendix 3.B for the special case $k = 0$.

### 3.4.1 Antitrust Authority

After the introduction of the policy instrument, the optimality condition is defined by

$$\frac{\partial}{\partial q}S(q^*, R, \delta_s, k) = \frac{\partial}{\partial q}C(q^*, R, \delta_s, k)$$

This condition differs from the one under the 'no monitoring' assumption in two ways. First, as just discussed, the cost function explicitly depends on the policy instrument $R$. Second, the denominator of expression $S(q, R, \delta_s, k)$ contains $q$, i.e. $S(q, R, \delta_s, k) = -\frac{D(1-F(\delta(q,k,R)))}{1-\delta_s(1-q(1-k))}$.

**Lemma 3** *(a) If $\frac{\partial^2}{\partial q \partial R}S(q, R, \delta_s, k) - \frac{\partial^2}{\partial q \partial R}C(q, R, \delta_s, k) > 0$, then $q^*(R)$ increases with $R$; the policy instrument $R$ and the optimal law enforcement are complements.*

*(b) If $\frac{\partial^2}{\partial q \partial R}S(q, R, \delta_s, k) - \frac{\partial^2}{\partial q \partial R}C(q, R, \delta_s, k) < 0$, then $q^*(R)$ decreases with $R$; the policy instrument $R$ and the optimal law enforcement are substitutes.*

**Proof** Follows directly from the differentiation of both sides of the optimality condition with respect to $R$.

From Lemma 3 we know that, if $\frac{\partial^2}{\partial q \partial R}C(q, R, \delta_s, k) \leq 0$, the condition in Lemma 2 is still sufficient for complementarity but not for substitutability. Therefore, under the plausible assumption that the cross derivative of the cost function is weakly negative, we have complementarity between the policy instrument $R$ and the optimal detection effort $q^*(R)$ if the cross derivative of the benefit in terms of social loss reduction is positive. Proposition 7 gives the new complementarity condition:

**Proposition 7** *When $\frac{\partial^2}{\partial q \partial R}C(q, R, \delta_s, k) \leq 0$, the policy instrument $R$ and the optimal law enforcement are complements, i.e. $q^*(R)$ increases with $R$, if*

$$\delta_s(1-k)\frac{\partial}{\partial R}F\left(\widetilde{\delta}(q,k,R)\right) - (1-\delta_s\left(1-q(1-k)\right))\frac{\partial^2}{\partial q \partial R}F\left(\widetilde{\delta}(q,k,R)\right) < 0$$

**Proof** Follows directly from Lemma 2 and 3.

Proposition 7 suggests that the effect of $R$ on the optimal rate of detection is composed of two, potentially opposed, effects. First, there is a direct effect of $R$ on $\widetilde{\delta}(q, k, R)$

which implies that the existence of the instrument prevents more firms from entering collusive agreements. This is because the instrument tightens a firm's incentive constraint and makes cheating more attractive. Second, an indirect effect exists through the effect on the marginal efficiency of $q$. The policy instrument can make a single investigation more or less effective and thus, also enters the incentive constraints through its effect on $q$. Complementarity occurs if the indirect effect is positive and prevails. The reason is straightforward: If $R$ raises the effectiveness of $q$ in deterring collusion substantially more than it directly acts on deterrence, it is optimal to increase the detection probability. If, however, either the indirect effect is negative or the direct effect of $R$ dominates the indirect positive effect, it is the size of the cross derivative of the cost function that determines whether the detection effort and the policy instrument are complements or substitutes. If the negative effect of $R$ on the marginal cost of $q$ is strong enough, we have complementarity. If the effect is rather weak, we have substitutes, and it is optimal to reduce costly investigations. Hence, whether we have complements or substitutes depends, first, on the sign of the indirect effect, second, if the latter is positive, on the relative strength of the two effects, and third, on the size of the reduction in the marginal cost of $q$.

### 3.4.2 Cartel Stability

The expected discounted value from collusion is

$$\begin{aligned} V &= q(\pi - f + k\delta V) + (1-q)(\pi + \delta V) \\ V &= \frac{\pi - qf}{1 - \delta\left(1 - q(1-k)\right)} \end{aligned}$$

The deviation payoff is the same as in the case without monitoring, and the cartel is sustainable only if no firm has an incentive to deviate, i.e.

$$\begin{aligned} V &\geq n\pi - qf \\ \delta &\geq \frac{(n-1)\pi}{\left(1 - q(1-k)\right)(n\pi - qf)} \equiv \widetilde{\delta}(q,k,f) \end{aligned}$$

For collusion to be a problem, i.e. $\widetilde{\delta}(q,k,f) < 1$, the fine-profit ratio must be sufficiently low such that $\frac{f}{\pi} < \frac{1-nq(1-k)}{q(1-q(1-k))}$.

### 3.4.3 Policy Instrument

Let us again illustrate our theoretical considerations by using the increase in the level of fines and the leniency program as policy instruments. We focus on the case where $\frac{\partial^2}{\partial q \partial R} C(q,R,\delta_s,k) \leq 0$. As above, we assume that $\delta$ is uniformly distributed over $[0,1]$, i.e. $F(\delta) = \delta$, such that the collusion rate is $1 - \widetilde{\delta}(q,k,R)$.

#### Increase in the Level of Fines

As $f$ enters the cartel stability condition only through the expected fines and thus, through the interaction with $q$, Proposition 6 predicts that the optimal detection effort and the fine increase are complements. We can easily check this by computing the simple and the cross derivatives of $\widetilde{\delta}(q,k,f)$ with respect to $f$ and with respect to $q$ and $f$. The complementarity condition writes as

$$\delta_s q(1-k)\left(1-q(1-k)\right)\left(n\pi - qf\right) - \left(1-\delta_s\left(1-q(1-k)\right)\right)\left(n\pi + qf - 2q^2 f(1-k)\right) < 0$$

$$\frac{n\pi + qf - 2q^2 f(1-k)}{\left(1-q(1-k)\right)\left(q(1-k)(n\pi - qf) + n\pi + qf - 2q^2 f(1-k)\right)} > \delta_s$$

The latter condition holds for any $\delta_s \leq 1$. If $\frac{\partial^2}{\partial q \partial R} C(q,R,\delta_s,k) \leq 0$, we have thus the same result as in the case without monitoring: The fine increase and the detection effort are complements.

#### Leniency Program

The possibility to apply for leniency affects the firm's deviation payoff. Collusion is now sustainable only if

$$\begin{aligned} V &\geq n\pi - (1-\alpha)f \\ \delta &\geq \frac{(n-1)\pi - (1-q-\alpha)f}{\left(1-q(1-k)\right)\left(n\pi - (1-\alpha)f\right)} \equiv \widetilde{\delta}(q,k,\alpha) \end{aligned}$$

Proposition 6 does not apply because $\alpha$ does not enter the cartel stability condition through the interaction with $q$. Hence, we have to compute the derivatives of $\widetilde{\delta}(q,k,\alpha)$ with respect to $\alpha$ and with respect $q$ and $\alpha$. The former gives us

$$\frac{\partial}{\partial\alpha}\widetilde{\delta}(q,k,\alpha)=\frac{f(\pi-qf)}{(1-q(1-k))\left(n\pi-(1-\alpha)f\right)^2}$$

This expression is positive because, under the assumption that $\frac{f}{\pi}<\frac{1-nq(1-k)}{q(1-q(1-k))}$, we know that $1-q\frac{f}{\pi}>0$. This implies that the leniency program has a positive direct effect on deterrence by increasing the threshold above which collusion is profitable. For the cross derivative we get

$$\frac{\partial^2}{\partial q\partial\alpha}\widetilde{\delta}(q,k,\alpha)=\frac{f\left(\pi(1-k)-f\right)}{(1-q(1-k))^2\left(n\pi-(1-\alpha)f\right)^2}$$

Whereas the denominator is positive, the numerator is negative when $\frac{f}{\pi}>1-k$ and positive when $\frac{f}{\pi}<1-k$. If the numerator is negative, whether we have substitutes or complements solely depends on the strength of the negative effect of $\alpha$ on the marginal cost of $q$. If the numerator is positive, we can again have both complementarity and substitutability. The complementarity condition then writes

$$\delta_s(1-k)\left(1-q(1-k)\right)(\pi-qf)-\left(1-\delta_s(1-q(1-k))\right)\left(\pi(1-k)-f\right)<0$$
$$\frac{\pi(1-k)-f}{(1-q(1-k))\left(2\pi(1-k)-f\left(1+q(1-k)\right)\right)}>\delta_s$$

The latter condition holds for any $\delta_s\leq 1$ if $\frac{f}{\pi}<\frac{2q(1-k)-1}{q^2(1-k)}$ which is necessarily true if $q\geq\frac{1}{2(1-k)}$. In this case, the leniency program and the optimal law enforcement are complements. If $q<\frac{1}{2(1-k)}$, we have still complementarity for $\frac{f}{\pi}$ small enough. For a sufficiently large $\frac{f}{\pi}$ and $\delta_s$ it depends on the size of the marginal cost effect whether we have substitutes or complements.

### 3.4.4 Discussion

Proposition 6 applies also if we relax the 'no monitoring assumption'. The fine increase and the optimal rate of law enforcement are again complements. For the leniency program, whereas we had substitutability without monitoring, complementarity can now occur. A possible explanation for this outcome is that the higher reporting benefits under the leniency program not only reduce the current number of cartelizing firms and thus the need for detection but also the future fraction of firms that will be able to return to collusion. By reducing the future collusive mass, the leniency program can make the detection effort marginally more effective.

## 3.5 Conclusion

This chapter characterizes the cartel detection effort that minimizes the collusion rate and shows that this effort may increase when the antitrust authority uses a policy instrument that itself has a positive effect on deterrence.

Our findings suggest that the effect on the optimal detection effort and, with it, the socially desired redirection of resources depend on the specific policy instrument. Complementarity occurs if the use of a particular instrument increases the marginal benefit of conducting investigations such that it is optimal to increase detection. We find this to be the case for instruments that affect the level of fines for convicted cartel members. If, however, the instrument an effective leniency program, the optimal rate of law enforcement decreases. This substitutability result is sensible to our 'no monitoring' hypothesis. Complementarity between the detection effort and the leniency program arises for some parameter values when we relax this assumption.

## 3.A Proofs

**Proof of Corollary 2** Assume that $F(.)$ is weakly convex. The cross derivative with respect to $q$ and $R$ can be rewritten as

$$\begin{aligned}\frac{\partial^2}{\partial q \partial R} F\left(\widetilde{\delta}(q,R)\right) &= \frac{\partial}{\partial q}\left[\frac{\partial}{\partial R} F\left(\widetilde{\delta}(q,R)\right)\right] \\ &= \frac{\partial}{\partial q}\left[F'\left(\widetilde{\delta}(q,R)\right) \cdot \frac{\partial}{\partial R}\widetilde{\delta}(q,R)\right] \\ &= \frac{\partial}{\partial q} F'\left(\widetilde{\delta}(q,R)\right) \cdot \frac{\partial}{\partial R}\widetilde{\delta}(q,R) + F'\left(\widetilde{\delta}(q,R)\right) \cdot \frac{\partial^2}{\partial q \partial R}\widetilde{\delta}(q,R)\end{aligned}$$

Since $F(.)$ is weakly convex, $F'(.)$ is weakly increasing which yields $\frac{\partial}{\partial q} F'\left(\widetilde{\delta}(q,R)\right) > 0$ because $\widetilde{\delta}(q,R)$ is increasing in $q$. As we consider only policy instruments that help deterrence, $\widetilde{\delta}(q,R)$ is also increasing in $R$. Therefore, $\frac{\partial}{\partial q} F'\left(\widetilde{\delta}(q,R)\right) \cdot \frac{\partial}{\partial R}\widetilde{\delta}(q,R) > 0$. From $F'\left(\widetilde{\delta}(q,R)\right) > 0$, we then can derive that a sufficient condition for $\frac{\partial^2}{\partial q \partial R} F\left(\widetilde{\delta}(q,R)\right) > 0$ is $\frac{\partial^2}{\partial q \partial R}\widetilde{\delta}(q,R) > 0$. ■

**Proof of Proposition 6** We can rewrite the cross derivative of the critical discount factor with respect to $q$ and $R$ as

$$\begin{aligned}\frac{\partial^2}{\partial q \partial R}\widetilde{\delta}(q,R) &= \frac{\partial}{\partial q}\left[\frac{\partial}{\partial R} g(qR)\right] \\ &= \frac{\partial}{\partial q}[qg'(qR)] \\ &= qRg''(qR) + g'(qR)\end{aligned}$$

If $xg'(x)$ is increasing, then its derivative $xg''(x) + g'(x)$ is positive which implies that $\frac{\partial \delta^2}{\delta q \delta R}\widetilde{\delta}(q,R) > 0$. From Proposition 5, we can conclude that $q^*(R)$ is increasing in $R$. ■

## 3.B Cost Function

$C(q, R, \delta_s)$ is the total expected discounted cost needed to guarantee a detection probability $q$ in each period $t = 0, 1, \ldots$. To see how this expression on $R$, denote the expected mass of collusive industries at time $t$ when the firms face a constant probability of detection $q$ each period $u_t$ which is

$$u_t = (1-q)^t h(q,R)$$

where $h(q,R) = 1 - F(\widetilde{\delta}(q,R))$. Hence, the expected mass of detected industries in period $t$ is then

$$v_t = qu_t = q(1-q)^t h(q,R)$$

The mass of collusive industries which have been detected during $t-1$ periods and which are under monitoring at the beginning of period $t \geq 1$ is

$$\begin{aligned} w_t &= \sum_{k=0}^{t-1} v_k \\ &= qh(q,R)\sum_{k=0}^{t-1}(1-q)^k \\ &= qh(q,R)\cdot\frac{1-(1-q)^t}{q} \\ &= h(q,R)\left(1-(1-q)^t\right) \end{aligned}$$

The mass of collusive industries not yet under monitoring at period $t \geq 1$ is then

$$y_t = 1 - w_t = 1 - h(q,R)\left(1-(1-q)^t\right)$$

If we denote $c$ the constant unit cost of an investigation, the total expected discounted cost needed to guarantee a detection probability $q$ in each period is

$$\begin{aligned} C(q,R,\delta_s) &= cq[1+\delta_s y_1 + \delta_s^2 y_2 + \delta_s^3 y_3 + \ldots] \\ &= cq\left[\left(\sum_{k=0}^{\infty}\delta_s^k\right) - h(q,R)\left(\sum_{k=1}^{\infty}\delta_s^k\right) + h(q,R)\left(\sum_{k=1}^{\infty}\delta_s^k(1-q)^k\right)\right] \\ &= cq\left[\frac{1}{1-\delta_s} - \frac{\delta_s h(q,R)}{1-\delta_s} + \frac{\delta_s(1-q)h(q,R)}{1-\delta_s(1-q)}\right] \\ &= cq\left[\frac{1-\delta_s h(q,R)}{1-\delta_s} + \frac{\delta_s(1-q)h(q,R)}{1-\delta_s(1-q)}\right] \end{aligned}$$

# Conclusion

This thesis consists of three essays in Industrial Organization which provide answers to the following questions:

1. What is the effect of Amnesty Plus and Penalty Plus on the incentives of firms to terminate and to report cartel activities to the antitrust authority?
2. Does the Amnesty Plus program encourage or rather discourage the formation of cartels, and how should an effective Amnesty Plus program be designed?
3. Should the antitrust authority decrease or rather increase its detection effort following the introduction or the modification of a policy instrument that helps cartel deterrence?

To answer the first question, I examine the treatment of parallel cartel involvements in the US. Contrary to the European policy, the US Leniency Program contains Amnesty Plus and Penalty Plus which provide financial incentives to firms, already convicted in one cartel, to report a second infringement. I show that these programs may have two effects: On the one hand, they can discourage leniency applications because the firms anticipate that the reporting of a first cartel results in the denunciation of a second, potentially very profitable, cartel. On the other hand, these programs can also encourage leniency applications and induce the firms to immediately report all their cartels. Which one of the effects prevails, depends on the specific parameters of the authority's enforcement policy.

To answer the second question, I set up an infinitely repeated game of collusion where the firms play multimarket trigger strategies and decide on cartel formation in two markets. I show that Amnesty Plus, while clearly encouraging reporting after a first detection, has an ambiguous effect at the stage of cartel formation. I suggest a simple and feasible policy rule that avoids any negative effects and makes a leniency program with Amnesty Plus perform better than one without.

To answer the third question, I change the focus of the analysis from leniency programs to more generic policy instruments. I determine the optimal detection effort of an antitrust authority to show how this optimal effort changes with the introduction of a policy instrument.

Altogether, this thesis contributes to the understanding of complex theoretical problems in competition policy with important practical implications for economic reality. There however remains a lot to be done. Apart from interesting generalizations and extensions of the theoretical framework, some empirical tests and experimental evidence would be particularly insightful. I can therefore only hope that my work has succeeded in awakening the interest of academic research on the topic.

# Bibliography


Apesteguia, J., M. Dufwenberg, and R. Selten (2003): "Blowing the Whistle," Bonn Econ Discussion Papers bgse9 2003, University of Bonn, Germany.

Aubert, C., W. Kovacic, and P. Rey (2006): "The impact of leniency and whistleblowing programs on cartels," *International Journal of Industrial Organization*, 24(6), 1241–1266.

Becker, G. S. (1968): "Crime and Punishment: an economic approach," *Journal of Political Economy*, 76, 169–217.

Bernheim, B. D., and M. D. Whinston (1990): "Multimarket Contact and Collusive Behavior," *RAND Journal of Economics*, 21(1), 1–26.

Bigoni, M., S.-O. Fridolfsson, C. Le Coq, and G. Spagnolo (2009): "Fines, Leniency and Rewards in Antitrust: An Experiment," CEPR Discussion Papers 7417.

Brenner, S. (2009): "An empirical study of the European Corporate Leniency Program," *International Journal of Industrial Organization*, 27(6), 639–645.

Brisset, K., and L. Thomas (2004): "Leniency Program: A New Tool in Competition Policy to Deter Cartel Activity in Procurement Auctions," *European Journal of Law and Economics*, 17(1), 5–19.

Bryant, P. G., and E. W. Eckard (1991): "Price Fixing: The Probability of Getting Caught," *The Review of Economics and Statistics*, 73(3), 531–36.

Chang, M.-H., and J. E. Harrington (2008): "The Impact of a Corporate Leniency

Program on Antitrust Enforcement and Cartelization," Economics Working Paper Archive 548, The Johns Hopkins University,Department of Economics.

Chen, Z., and P. Rey (2007): "On the Design of Leniency Programs," IDEI Working Papers 452, Institut d'Economie Industrielle (IDEI), Toulouse.

Choi, J. P., and H. Gerlach (2009a): "International Antitrust Enforcement and Multi-Market Contact," CESifo Working Paper Series 2599, CESifo.

——— (2009b): "Multi-Market Collusion with Demand Linkages and Antitrust Enforcement," CESifo Working Paper Series 2632, CESifo.

Combe, E., and C. Monnier (2009): "Fines Against Hard Core Cartels in Europe: The Myth of Over Enforcement," Discussion paper.

Combe, E., C. Monnier, and R. Legal (2008): "Cartels: The Probability of Getting Caught in the European Union," Discussion paper.

Connor, J. M. (2000): "Archer Daniels Midland: Price-Fixer to the World," Working paper, Purdue University.

——— (2003): "International Price Fixing: Resurgence and Deterrence," Working paper, Purdue University.

——— (2005): "Price Fixing Overcharges: Focus on Europe," Conference report, Purdue University.

Edwards, C. D. (1955): "Conglomerate Bigness as a Source of Power," In Business Concentration and Price Policy, NBER Conference Report, Princeton University Press.

Ellis, C. J., and W. W. Wilson (2003): "Cartels, Price-Fixing, and Corporate Leniency Policy: What Doesn't Kill Us Makes Us Stronger," mimeo, University of Oregon.

Evans, W. N., and I. N. Kessides (1994): "Living by the "Golden Rule": Multimarket Contact in the U.S. Airline Industry," *The Quarterly Journal of Economics*, 109(2), 341–66.

Feess, E., and M. Walzl (2004): "An Analysis of Corporate Leniency Programs and Lessons to Learn for US and EU Policies," Research Memoranda 039, METEOR, Maastricht Research School of Economics of Technology and Organization.

Fernandez, N., and P. L. Marin (1998): "Market Power and Multimarket Contact: Some Evidence from the Spanish Hotel Industry," *Journal of Industrial Economics*, 46(3), 301–15.

Goeree, M. S., and E. Helland (2009): "Do research joint ventures serve a collusive function?," IEW - Working Papers iewwp448, Institute for Empirical Research in Economics - IEW.

Hamaguchi, Y., and T. Kawagoe (2005): "An Experimental Study of Leniency Programs," Discussion papers 05003, Research Institute of Economy, Trade and Industry (RIETI).

Hammond, S. D. (2004): "Cornerstones of an Effective Leniency Program," Speech presented at the ICN Workshop on Leniency Programs, Sydney, Australia.

——— (2006): "Measuring the Value of Second-In Cooperation in Corporate Plea Negotiations," The 54th Annual American Bar Association Section of Antitrust Law Spring Meeting.

Harrington, J. E. (1987): "Collusion in Multiproduct Oligopoly Games under a Finite Horizon," *International Economic Review*, 28(1), 1–14.

——— (2008): "Optimal Corporate Leniency Programs," *Journal of Industrial Economics*, 56(2), 215–246.

——— (2010): "When is an Antitrust Authority not Aggressive Enough in Fighting Cartels?," *Forthcoming in the International Journal of Economic Theory.*

Hinloopen, J., and A. R. Soetevent (2008): "Laboratory evidence on the effectiveness of corporate leniency programs," *RAND Journal of Economics*, 39(2), 607–616.

Jarrett Arp, D., and G. R. Spratling (2003): "A new paradigm for counsel responding to international cartel investigations," *Global Competition Review*, 6, 28–33.

Jephcott, M. (2002): “The European Commission’s New Leniency Notice - Whistling the Right Tune,” *European Competition Law Review*, 23(8), 378–385.

Kim, H. E., and V. Singal (1993): “Mergers and Market Power: Evidence from the Airline Industry,” *American Economic Review*, 83(3), 549–69.

Mason, C. F., and O. R. Phillips (1996): “Market Regulation and Multimarket Rivalry,” *RAND Journal of Economics*, 27(3), 596–617.

Matsushima, H. (2001): “Multimarket Contact, Imperfect Monitoring, and Implicit Collusion,” *Journal of Economic Theory*, 98(1), 158–178.

McCutcheon, B. (1997): “Do Meetings in Smoke-Filled Rooms Facilitate Collusion?,” *Journal of Political Economy*, 105(2), 330–350.

McElwee, D. (2004): “Should the European Commission Adopt “Amnesty Plus” in its Fight Against Hard-Core Cartels?,” *European Competition Law Review*, 25(9), 558–565.

Miller, N. H. (2009): “Strategic Leniency and Cartel Enforcement,” *American Economic Review*, 99(3), 750–68.

Motchenkova, E., and R. Van der Laan (2005): “Strictness of Leniency Programs and Cartels of Asymmetric Firms,” CentER Discussion Paper 2005-74, Tilburg University.

Motta, M. (2007): “On cartel deterrence and fines in the EU,” mimeo, European University Institute, Florence and Universita di Bologna.

Motta, M., and M. Polo (2003): “Leniency Programs and Cartel Prosecution,” *International Journal of Industrial Organization*, 21(3), 347–379.

Parker, P. M., and L.-H. Roeller (1997): “Collusive conduct in duopolies: multimarket conduct and cross-ownership in the mobile telephone industry,” *RAND Journal of Economics*, 28(2), 304–322.

Spagnolo, G. (1999): “On Interdependent Supergames: Multimarket Contact, Concavity, and Collusion,” *Journal of Economic Theory*, 89(1), 127–139.

——— (2000): "Optimal Leniency Programs," Nota Di Lavoro 42.2000., Fondazione Eni Enrico Mattei.

——— (2004): "Divide et Impera: Optimal Leniency Programs," CEPR Discussion Papers 4840.

Spratling, G. R. (1999): "Making Companies an Offer They Shouldn't Refuse. The Antitrust Division's Corporate Leniency Policy - An Update," Discussion paper, US Department of Justice.

Thomas, C. J., and R. D. Willig (2006): "The risk of contagion from multimarket contact," *International Journal of Industrial Organization*, 24(6), 1157–1184.

Tirole, J. (1988): *The Theory of Industrial Organisation*. The MIT Press.

Wils, W. J. (2007): "Leniency in Antitrust Enforcement: Theory and Practice," *World Competition: Law and Economics Review*, 30(1).