Vertical relations in cartel theory: managerial incentives, buyer groups & antitrust damages

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Background material to this dissertation is available at carteltheory.com. You can find my research and papers in their most updated form, as well as media files on cartels, such as a Netherlands Competition Authority (NMa) film on leniency programs; the trailer of cartel movie The Informant featuring Matt Damon; and undercover FBI footage of the Lysine Cartel’s secret hotel meetings (Lysine Tapes).
VERTICAL RELATIONS IN CARTEL THEORY

Managerial Incentives, Buyer Groups & Antitrust Damages

Martijn A. Han
VERTICAL RELATIONS IN CARTEL THEORY
Managerial Incentives, Buyer Groups & Antitrust Damages

ACADEMISCH PROEFSCHRIFT

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aan de Universiteit van Amsterdam
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ten overstaan van een door het college voor promoties ingestelde commissie,
in het openbaar te verdedigen in de Aula der Universiteit
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door

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Dr. J. Tuinstra

Faculteit Economie en Bedrijfskunde
To my parents and my brother,
Menno, Henriëtte & Parcival Han,
PART I: MANAGERIAL INCENTIVES IN CARTELS

2 Monitoring Managers Through Corporate Compliance Programs
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1 Introduction

A cartel is a group of firms collectively attempting to restrict or eliminate competition among them. Cartel members most commonly do this by fixing prices, sharing markets, or rigging bids. Such coordinated behavior, which is called collusion, affects the process of fair market competition and is illegal in virtually all capitalist countries.

This dissertation aims to contribute to the theoretical basis of an effective competition policy, which is the set of legal measures to fight cartels and other anticompetitive practices. I investigate how the incentives to operate a cartel are affected by vertical relations both within firms (owners-management) and among firms (suppliers-buyers). Before outlining the details of such vertical relationships, I provide three examples of cartels active on the European, American, and Dutch market, respectively.

The LCD Panel Cartel is a recent example of an international price-fixing cartel prosecuted by the European Commission. Executives of six producers of liquid crystal display (LCD) panels arranged secret meetings—the so-called Crystal Meetings—in Taiwanese hotels. During these meetings, the cartel members agreed on minimum prices and other commercial terms of LCD panels for the European market. The European Commission charged the cartel a total fine amount of €649 million.

In the United States, a prime example of a price-fixing and market-sharing conspiracy is the Lysine Cartel. The CEOs and other executives of five American and Asian producers of lysine, an amino acid used mainly in animal feeds, collectively raised prices and allocated customers among themselves on the worldwide lysine market. Interestingly, the FBI managed to record undercover tapes of the cartel’s secret hotel meetings. These so-called Lysine Tapes illustrate the essence of the conspiracy when a CEO tells a senior executive from his largest competitor that “you are my friend” and “our customers are the enemy.” In addition to corporate prosecution by the U.S. Department of Justice, three executives were sentenced to a total of 99 months in federal prison.

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1 See the European Commission’s decision of 8 December 2010 in Case COMP39309-LCD.
2 See, for instance, the speech Caught in the Act: Inside an International Cartel, delivered by Hammond (2005) on behalf of the U.S. Department of Justice, Antitrust Division.
3 The Lysine Tapes are accessible online via carteltheory.com/references.
In Holland, a well-known case of collusion is the Dutch Construction Cartel, the *bouwfraude.* A substantial part of the Dutch construction sector engaged in bid-rigging: construction firms would coordinate their bids in tenders so as to artificially increase profits. The Netherlands Competition Authority (NMa) imposed monetary sanctions on more than 1,400 companies. For similar practices, three executives of construction firms recently received individual fines of up to €250,000.5

As the examples illustrate, cartels most commonly entail horizontal conspiracies among competitors at the same level of the production chain. However, as I will argue below, vertical relations both within firms (owners-management) and among firms (suppliers-buyers) can have an important impact on the operation of cartels. In this dissertation, I investigate this impact by extending the basic cartel model.

**Basic cartel model.** The basic model of cartels and collusion considers firms as profit-maximizing integrated black boxes on the same horizontal level of production. Figure 1.1 provides a stylized graphical representation of the basic cartel model for two firms; the arrowed lines represent the flow of goods (or services), and the dashed line represents strategic interaction. Both firms produce goods for consumers and strategically interact with each other on the market by setting, for example, prices, quantities, quality or service levels. The resulting market outcome depends on how firms strategically interact—that is, whether they compete or form a cartel.

I extend the basic horizontal cartel model to allow for vertical relations both within firms (owners-management) and among firms (suppliers-buyers). Investigating such vertical relations enriches the understanding of how cartels operate, which allows for an assessment of the design of an effective competition policy. This dissertation studies three types of vertical relations in cartel theory: managerial incentives in cartels, buyer groups operating as cartels, and antitrust damages in longer chains of production.

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4For the complete *bouwfraude* file, see the websites of the Netherlands Competition Authority (NMa) and the Dutch Public Prosecution Service (OM), at nma.nl and om.nl, respectively. The first pieces of evidence were exposed by the Dutch current affairs television program Zembla in 2001; Zembla and the ACLE have collaborated to produce a DVD of the full story with English subtitles and voiceovers, accessible online via [carteltheory.com/references](http://carteltheory.com/references).

5See NMa decisions of 29 October 2010 in cases 6494 and 6836 (*Limburgse bouwzaken*).
Part I: managerial incentives. The first part of this dissertation (Managerial Incentives in Cartels) studies vertical relations within firms. Cartels often involve firms that have separated ownership and control in such a way that the incentives of the key decision maker (CEO, manager) are not fully aligned with those of the profit-motivated owners (shareholders). Figure 1.2 conceptually illustrates this extension of the basic cartel model. I open the black box of the firm: two managers strategically interact on the product market and choose whether to compete or to form a cartel. Their behavior is affected by the type of employment contract offered by the owners (superiors in general).

Such intra-firm vertical relations may give rise to several corporate governance issues. For example, the operation of cartels may be affected by the type of managerial compensation—such as fixed wages vs. variable wages, bonus plans, and stock options plans—the duration of the employment contract, and personal considerations such as career concerns and attitudes toward corporate crime. With regard to the examples above, one might expect that the cartelization decisions by the executives in the LCD Panel Cartel depend on the details of their compensation packages negotiated through the vertical relationship with their board of shareholders. Similarly, the Lysine Tapes reveal that the CEOs in the Lysine Cartel were challenged to vertically implement their price-fixing arrangements through intra-firm hierarchical relationships with their sales managers.

Parts II & III: buyer groups & antitrust damages. The second and third parts of this dissertation investigate vertical relations among firms. The second part (Buyer Groups and Cartels) studies how retailers teaming up to jointly buy their inputs through a buyer group can serve as a collusive device against final consumers. Figure 1.3 conceptually represents this set-up: two retailers interact with their suppliers through a buyer group.

The buyer group allows the retailers to jointly source their inputs and to coordinate their negotiations with suppliers regarding prices and other commercial terms. On the output market, the two retailers compete for consumers. This set-up allows to study how
a buyer group on the input market can effectively operate as an “implied cartel,” thereby contributing to the theoretical basis of competition policy aimed toward buyer groups.

The third part (Antitrust Damages) investigates the distribution of economic harm caused by a cartel in a vertical production chain; victims of a cartel can sue the cartel for such harm. Figure 1.4 graphically represents a vertical production chain with a cartel in the second layer. The two firms engaging in the cartel source their inputs from two suppliers and sell their products to two retailers. The retailers, in turn, resell these products to final consumers. The model studies how an anticompetitive price increase by a cartel in a longer production chain can percolate through to final consumers. Insights about the distribution and passing on of antitrust harm is key in determining the damages that direct victims (retailers), as well as indirect victims (final consumers and possibly even the suppliers), can claim in court.

The Dutch Construction Cartel illustrates the relevance of the second and third parts of this dissertation. The intricate vertical relationships between suppliers and buyers at various levels of the production chain is expected to affect both the behavior and the harmful effects of the cartel.

This introductory chapter proceeds as follows. In Section 1.1, I briefly present the underlying rationale of cartel policy as well as the policy elements that are studied throughout this dissertation. This sets the stage to introduce the three topics of this dissertation in more detail in Section 1.2. Section 1.3 describes the research methodology and Section 1.4 presents the dissertation’s outline.
1.1 Cartel Policy: Rationale and Key Elements

Cooperation and trust are great entrepreneurial traits and provide the basis for well-functioning markets. However, when firms cooperate by coordinating their behavior through a cartel instead of competing for customers, prices are likely to rise while product quality and service levels may fall. Although this is expected to benefit cartel members, it may hurt customers. The overall economy can suffer from such price increases, as some customers do not buy at the elevated cartel price, but would have bought at the competitive price. Thus, cartelization is likely to result in inefficiencies.

Arguably more important, the restriction or elimination of competition can reduce firms’ incentives to outperform each other. This may result in a lower level of product innovation, which, in turn, inhibits welfare-enhancing developments and can lead to less product variety. Although a precise quantification of these effects is complex, Connor and Helmers (2007) estimate that discovered international cartels in the period 1990–2005 caused price increases worth over $600 billion.⁶ Therefore, cartels are considered detrimental to the economy.⁷

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⁶Connor and Helmers (2007) report total overcharges of over $550 billion in 2005 dollars, which is over $600 billion in 2011 dollars when corrected for inflation.

⁷Every rule has its exceptions. If efficient firms are struck by extraordinary circumstances, such as a severe economic crisis, temporary cartelization through a so-called crisis cartel may allow them to survive, which could potentially be beneficial in the long run. Also, a cartel can be beneficial if the consumption or production of the products entails negative externalities; for example, a cartel among tobacco companies may be welfare-enhancing as cigarettes become more expensive, thereby reducing the number of smokers and, thus, the incidence of smoking-related diseases. In addition, one may argue that cartels can enhance efficiency when cartel members exchange information, allowing them to better serve consumers, or when they cooperate on research and development or the joint purchase of inputs—see Chapter 5.
These economic insights are the underlying rationale for the illegality of cartels under competition or antitrust laws. Such laws are enforced by competition or antitrust authorities, on both the national and European level. Besides the detection and punishment of cartels, competition authorities have a broader task to execute and develop competition policy. This is the set of rules and instruments aimed at ensuring that fair competition in the market is not distorted. Competition policy, therefore, encompasses not only cartel policy, but also the assessment of mergers, dominant positions, vertical restraints and state aid, as well as other arrangements affecting the competitive process, such as collaboration through joint ventures and standardization agreements.

While a detailed discussion of competition policy is beyond the scope of this section, I here briefly discuss five key elements of cartel policy that are studied throughout this dissertation. Without aiming to provide an exhaustive description of all the legal and economic elements of cartel policy, the following descriptions introduce the policy tools that are relevant to the discussion of this dissertation's topics in Section 1.2.

First, competition authorities impose corporate fines on cartel members, which are at most 10% of annual affected turnover under European competition law. The stakes are high: the total amount of fines imposed by the European Commission in the period 2006–2010 was €12.1 billion, with the largest fines for the firms having engaged in the Car Glass Cartel (€1.4 billion). The size of these corporate fines depend on the duration of the cartel as well as potential mitigating circumstances, such as limited participation in the cartel, or aggravating circumstances, such as being the ring-leader of the cartel or having engaged in previous infringements of competition law.

Second, some jurisdictions allow for individual sanctions aimed at executives involved in cartelization practices. Most notably, in the United States (U.S.), involved employees are criminally prosecuted and face substantial personal fines and even jail sentences. Although European competition law is an administrative law not targeting individuals, some European Union (E.U.) Member States—such as the United Kingdom (U.K.), Ireland, and Estonia—have enacted laws to criminally prosecute involved employees on the

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8In Europe, the U.S., and the Netherlands, respectively, cartels are banned under Article 101(1) of the Treaty of the Functioning of the European Union (TFEU), Section 1 of the Sherman Act, and Article 6(1) of the Mededingingswet.
9In Europe, the U.S., and the Netherlands, respectively, the competition authorities are: the European Commission’s Directorate General for Competition (DG Competition); the U.S. Department of Justice (DOJ) and the Federal Trade Commission (FTC); and the Netherlands Competition Authority (NMa).
10Vertical restraints are agreements between suppliers and buyers, such as retail price maintenance, exclusive dealing contracts, rebate schemes, or slotting allowances—see also Chapter 5.
national level. Moreover, the U.K. system allows for “director disqualifications,” and in the Netherlands, individuals involved in cartelization can be personally fined.

Third, competition authorities have implemented leniency programs. Under the E.U. corporate leniency program, cartel members have the option to report evidence to the European Commission (“blow the whistle”) in exchange for full immunity from legal sanctions aimed at the corporation. The U.S. corporate leniency program also protects employees from legal sanctions when the corporation reports the cartel. In addition, the U.S. individual leniency program grants the involved employee full immunity when coming forward with incriminating evidence. The objective of such leniency programs is to incentivize corporations and individuals to blow the whistle, which is expected to destabilize cartels from an ex ante perspective.

Fourth, victims (customers and final consumers) of cartels can sue the cartel in court and claim private damages for the economic harm suffered. While the U.S. has decades of experience with private damages law suits, Europe is in the early stage of developing such a practice. The U.S. Clayton Act allows direct customers to sue the cartel for three times the harm (“treble damages”). In contrast, the European Commission aims for a European private damages practice, with both direct and indirect customers being able to recover single damages. Such private law suits not only serve as an extra means to punish cartels, but also allow for reparation of the economic harm caused by the cartel.

Fifth, competition authorities aim to prevent the formation of cartels by encouraging firms to implement antitrust compliance programs. These programs entail internal firm measures to educate employees about competition law infringements and to monitor their behavior. Examples of such monitoring are unannounced inspections of documents, email messages, and telephone records, as well as lawyers accompanying managers to business meetings (Stephan, 2009). When well-designed and properly implemented, compliance programs have the potential to deter and detect illegal managerial conduct.

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14 See, for example, U.K. Office of Fair Trading (2010).
15 See Articles 56(1) and 57(1) of the Dutch Mededingingswet.
16 Clear overviews of leniency programs are presented in Wils (2007) and Spagnolo (2008). The Netherlands Competition Authority (NMa) made a film about the Dutch leniency program; it shows how a fictional cartel member feels uncomfortable and applies for leniency—see the link at carteltheory.com/references.
17 See the European Commission’s 2008 White paper on damages actions for breach of the EC antitrust rules, pp. 3 and 7. The practical implementation of such a damages practice entails not only economic challenges, but also several legal issues—see, for example, the 2010 Fédération Internationale de Droit Européen (FIDE) conference proceedings (Rodríguez Iglesias and Ortiz Blanco (Eds.), 2010).
1.2 Vertical Relations in Cartel Theory

This dissertation extends the basic horizontal model of cartels—see Figure 1.1—to allow for three types of vertical relations. These extensions aim to contribute to the continuous development of the policy elements presented in the previous section. The next three subsections briefly discuss the three topics of this dissertation in more detail: managerial incentives in cartels (1.2.1), buyer groups operating as cartels (1.2.2), and antitrust damages in longer chains of production (1.2.3).

1.2.1 Managerial Incentives in Cartels

The majority of the literature on cartels and collusion treats the firm as profit-maximizing integrated entities (black boxes), thereby deriving key insights into the economic forces governing the operation of cartels. However, virtually all discovered cartels are formed and operated by managers (executives) whose incentives may not be fully aligned with those of the profit-motivated owners (shareholders). Such misalignment of incentives can have a key impact on the stability and behavior of cartels.

The greater part of this dissertation aims to understand how horizontal collusion among firms is affected by vertical corporate governance issues within firms. To that end, Chapters 2–4 extend the basic horizontal cartel model by incorporating the employment relationship of the key decision maker within the firm.

Insights from discovered cartels indeed illustrate the central role of corporate governance issues and managerial incentives in cartels. From a sample of 40 international cartels, Stephan (2009) reports that decisions to engage in collusion are typically made by senior management. Moreover, as discussed earlier, top management struggled to keep sales representatives in line with price agreements in the Lysine Cartel (Eicherwald, 2000). Similarly, in the Sotheby’s Christie’s Auction House Cartel, the two involved CEOs instructed their managers to implement the collusive agreement (Mason, 2004). The conceptual model in Figure 1.2 can be used to investigate such vertical relations between either shareholders and senior management, or senior management and middle (or lower) management. Chapters 2, 3 and 4 develop different versions of this model.

Chapter 2 investigates the impact of monitoring managers through antitrust compliance programs on the authority’s optimal sanctions and leniency policy. Competition authorities encourage firms to implement such programs. However, whether such programs are indeed effective in preventing violations of competition law depends on the details of their implementation, as well as their interaction with other policy instruments. The model in Chapter 2 allows to study the optimal degree of corporate versus manage-

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18Buccirossi and Spagnolo (2007) provide an overview of corporate governance factors in cartels.
rrial liability; the design of corporate and individual leniency programs; and whether the authority should regard the adoption of an antitrust compliance program as a mitigating circumstance when determining sanctions.

In Chapter 3, I investigate how commonly observed short-term, renewable CEO employment contracts affect cartel stability and behavior. The type of employment contract and remuneration package of key decision makers within firms may have an important impact on the stability and behavior of cartels. For example, Spagnolo (2000) argues that stock-related managerial compensation can improve cartel stability. The model in Chapter 3 allows to derive the impact of the short-termism associated with commonly observed executive contracts on the internal operation of cartels.

Chapter 4 studies how the decision to delegate control to a manager who is remunerated with a share of profits and sales affects the stability of cartels between firms. In the Lysine Cartel and the Sotheby’s Christie’s Auction House Cartel, for example, delegation of decision rights to managers was a challenge to executives. The model in Chapter 4 exposes an economic mechanism through which delegation of decisions to managers can improve the stability of cartels.

1.2.2 Buyer Groups Operating As Cartels

Buyer groups are cooperative arrangements between firms (usually: retailers) to combine their purchases in input markets—see Figure 1.3. Such groups are widespread in the economy, especially in the European grocery industry. While buyer groups are not \textit{per se} illegal under either E.U. competition law or U.S. antitrust law, there is a growing debate among both academics and practitioners on their competitive effects. Chapter 5 of this dissertation investigates how retailers forming a buyer group on their input market can induce a stable cartel outcome on their output market by making use of slotting allowances, rebate schemes, and other vertical restraints.

The discussion on the competitive effects of buyer groups has traditionally mirrored the discussion surrounding the issue of buyer power more generally. A buyer group may enable firms to exercise countervailing power over their suppliers, thereby allowing them to obtain lower input prices. Such a reduction in input prices may be passed on to consumers in the form of lower retail prices, provided that there is effective retail competition (Inderst and Mazzarotto, 2007). Moreover, buyer groups can potentially serve to level the playing field among downstream firms by allowing smaller buyers to source against the same terms of trade as larger buyers.

\footnote{See, for example, Dobson and Waterson (1997, 1999) and Inderst and Wey (2003, 2007).}

\footnote{See, for example, U.K. Office of Fair Trading (2007).}
While buyer groups potentially allow for several competitive effects based on buyer power considerations, such arrangements may also affect the operation and stability of cartels. For example, the group arrangement can facilitate the sharing of information between firms or can increase the degree of symmetry between members, thereby possibly facilitating collusion.\(^{21}\) Also, purchasing quotas negotiated through a buyer group can effectively be targets for market shares in the downstream market.\(^{22}\) The contribution in this dissertation relates to Piccolo (2010) and Foros and Kind (2008) and shows how buyer group members can coordinate on wholesale contractual provisions so as to effectively form a stable cartel on the output market.

### 1.2.3 Antitrust Damages in Longer Production Chains

Anticompetitive price increases by cartels can cause widespread harm throughout the economy. In the U.S. and the E.U., victims (customers) of cartels can sue the cartel to compensate them for such harm. However, the identification of antitrust harm can be complicated. In longer supply chains, in which one product is an input in the production of the next, an illegal price increase somewhere in the chain can percolate through to the other layers in a ripple of partial pass-ons—see Figure 1.4. Chapter 6 presents a model that allows to study how such harm is distributed within the chain of production.

In the U.S., the difficulties in determining antitrust harm have, to some extent, been circumvented by case law. The combination of the Clayton Act, Hannover Shoe\(^{23}\) (1986), and Illinois Brick\(^{24}\) (1977) implies that only direct purchasers of the cartel can claim three times the so-called direct-purchaser overcharge, which is the number of products bought multiplied by the collusive price increase. Schinkel, Tuinstra and Rügeberg (2008) argue that such a policy, in which indirect purchasers do not have legal standing, can result in arrangements in which the cartel forwards a share of the collusive profits to direct purchasers so as to disincentivize them from claiming damages.

The European Commission promotes a European private damages practice in which all direct and indirect purchasers have legal standing. Its 2008 White Paper calls for “simplified rules on estimating the loss” from antitrust infringements, compensating direct and “indirect purchasers” for their “actual loss,” as well as “the loss in profit as a result of any reduction in sales.”\(^{25}\) Chapter 6 of this dissertation shows that there is no simple structural relationship between the direct-purchaser overcharge and the true harm caused by a cartel in the full chain of production.

\(^{21}\) See fn. \(^{20}\).

\(^{22}\) See the Commission’s decision of 20 October 2004 in *Case COMP/C.38.238/B.2-Raw Tobacco-Spain*.

\(^{23}\) *Hannover Shoe Inc. v. United Shoe Machinery Corp.* 392 U.S. 481 (1968).


\(^{25}\) See fn. \(^{17}\).
1.3 Methodology and Analytical Concepts

The two dominant methodologies to derive economic insights are based on empirical observations and game-theoretic modeling. These methodologies are complementary in developing progressing economic knowledge. Examples of empirical research range from fully-fledged econometric models to anecdotal observations, and from large-scale natural experiments to precisely controlled experiments in an artificial setting.

The predominant approach in microeconomic theory is game theory, which is the methodology used in this dissertation. A game is a situation in which two or more players strategically interact with each other. Strategic interaction means that the payoff (or: utility) of at least one player depends on the action taken by at least one other player. The players of a game each have their own pieces of information about several aspects, such as the structure of the game, the actions available to and taken by other players, and the objectives of the players. Each player plays the game with a certain strategy.

Game theory serves to better understand the underlying forces governing human as well as economic interactions. Modeling complex situations as simplified games can help to develop insights about such situations. For the reader without an economics background, the following example, based on Chapter 2, loosely illustrates the idea of a game. Consider as the players of the game a law-enforcing authority, the board of shareholders of a firm, and its CEO. The authority’s task is to design a policy ensuring that the firm complies with the laws. The shareholders offer the CEO an employment contract so as to maximize the firm’s net profit. In turn, the CEO may (secretly) form a cartel, thereby increasing profits. Such a set-up allows to analyze several questions: What are the optimal sanctions? Should the authority implement a whistle-blower scheme? If so, how should the whistle blower be treated? Would it be smart for the authority to rely on the board of shareholders to monitor the CEO’s behavior? Should the authority reward firms for such monitoring? These questions are considered in Chapter 2 by game-theoretically modeling the authority-shareholders-CEO relationship.

It is important to address two related points about the practical relevance of game theory. First, game-theoretic results must always be interpreted in light of the assumptions made in the model. That is, economic insights obtained through game-theoretic analysis should be carefully weighted against unmodeled considerations; by definition, no (economic) model can capture all the subtleties of reality. Second, the players of all models in this dissertation are assumed to be rational. Although, in reality, people’s behavior is sometimes rational and sometimes irrational, the rationality assumption serves as a solid benchmark against which considerations of irrationality can be placed.

All models in this dissertation use non-cooperative game theory, which means that players behave independently. The games are solved by determining sets of strategies
that satisfy the Nash equilibrium concept. A set of strategies is a Nash equilibrium if and only if no player is better off by unilaterally adopting a different strategy. Most of the chapters deal with infinitely repeated games and solve for the subgame perfect Nash equilibrium—that is, the equilibrium strategies satisfy the Nash equilibrium concept in every possible stage of the game. All games in this dissertation are characterized by complete information: the players know the structure of the game as well as the payoffs and actions available to the other players. The games in Chapters 2 and 3 are characterized by imperfect information: the players do not know all the payoff-relevant information or do not observe the actions of other players.

1.4 Dissertation Outline

This dissertation presents five pieces of research on vertical relations in cartel theory. Each of the Chapters 2–6 is a stand-alone theoretical contribution and can be read independently of the others; the corresponding research papers on which the chapters are based are available in their most updated form at [carteltheory.com](http://carteltheory.com). Each chapter begins with an introduction and motivation; provides an overview of the related literature; develops the formal model; presents the results; discusses the policy implications (when applicable); and closes with concluding remarks.

Chapter 2 (Monitoring Managers Through Corporate Compliance Programs, joint with Charles Angelucci) aims to shed light on the effectiveness of (antitrust) compliance programs in deterring corporate crime. Modeling a compliance program as a monitoring technology vis-à-vis employees, we show how compliance programs entail a perverse effect: superiors may, in fact, use the information that comes available through the compliance program to encourage employees to breach the law. We coin this the “credibility issue” of compliance programs. Our three-tier principal-agent hierarchy authority-shareholder-manager also allows to derive the optimal sanctions and leniency policy. Our results partly contrast the U.S. Federal Sentencing Guidelines, the U.S. and E.U. corporate leniency program, and the U.S. individual leniency program. In particular, we find that the authority optimally (i) grants partial corporate leniency when the corporation blows the whistle, while not granting leniency to the involved individual; (ii) does not always grant individual leniency when an employee blows the whistle; and (iii) does not apply a discount on the corporate fine for the mere fact of having adopted a compliance program. Finally, we discuss the implications for competition policy.

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26 Although the project was initially motivated from an antitrust perspective, the model is more broadly applicable to any type of corporate crime that benefits the firm, absent intervention by the law enforcer. Examples include tax evasion, cooking the books (i.e., accounting fraud), and environmental fraud.
Chapter 3 (Short-Term Managerial Contracts and Cartels) asks how commonly observed short-term, renewable CEO employment contracts affect the stability and behavior of cartels. Departing from the collusion literature with long-term contracts, I show how the threat of not being rehired associated with a short-term contract may reduce the manager’s incentives to defect from a collusive agreement. Additionally, the model allows for an analysis of fixed-term vs. profit-dependent salary components, as well as of the impact of firms engaging in “serial collusion.” Extending the model to a dynamic game of contracts spanning multiple periods, I argue that short-term contracts can be a source of cyclical collusive pricing. Finally, reinterpreting the model in light of firm financing shows how firms financed by debt can form more-stable cartels than firms financed by equity.

Chapter 4 (Strategic Delegation Improves Cartel Stability) deals with collusion and strategic delegation. I extend the Cournot strategic delegation model by Fershtman and Judd (1987) and Skliva (1987) to an infinitely repeated setting, thereby allowing both firm owners and managers to collude. I find that strategic delegation allows a cartel to be stable for a larger set of discount factors than collusion in the standard Cournot model. The reason is that the unprofitable static Nash delegation equilibrium is used by owners to commit to punishing deviant managers by firing them.

Chapter 5 (Efficient Cartelization Through Buyer Groups, joint with Chris Doyle) shows how retailers can extract monopoly profits on their output market by coordinating on wholesale contracts on their input market. We show that coordination through such an anticompetitive buyer group allows for increased cartel stability when retailers sign exclusive dealing or minimum purchase provisions, which are commonly observed vertical restraints used by a buyer group. Moreover, we extend the model to allow for cost efficiencies—a commonly claimed rationale for forming a buyer group—thereby showing that a buyer group may induce the joint monopoly outcome for every discount factor, while, in fact, raising consumer welfare above the competitive level. Finally, we discuss the implications of our findings for competition policy aimed toward buyer groups.

Chapter 6 (The Overcharge as a Measure for Antitrust Damages, joint with Maarten Pieter Schinkel and Jan Tuinstra) presents a model showing how a cartel’s price increase inflicted on direct purchasers is passed on to indirect customers in lower levels of the production chain. The resulting increase in the price for final consumers leads to additional harm caused by a reduction in demand to downstream (in)direct purchasers, as well as to upstream suppliers. Taking the perspective of a practical measure of antitrust harm, we show that there is no structural relationship between the direct-purchaser overcharge and the true harm inflicted by an antitrust violation on all of the direct and indirect purchasers and sellers in the chain of production.

Finally, Chapter 7 (Implications for Competition Policy and Conclusions) presents policy implications and conclusions.
Part I

Managerial Incentives in Cartels
2 Monitoring Managers Through Corporate Compliance Programs

Abstract. Compliance programs entail monitoring of employees’ behavior with the objective of fighting corporate crime. (Competition) Authorities encourage such intra-firm monitoring. In a three-tier hierarchy model, authority-shareholder-manager, we study the impact of managerial monitoring through a compliance program on contracting within the firm and the authority’s optimal sanctions and leniency policy. We find that compliance programs are beneficial in the fight against corporate crime if and only if the managerial sanction is low. Moreover, when the shareholder blows the whistle, the authority optimally grants partial corporate leniency, while not granting individual leniency to the involved employees. Conversely, when the employee blows the whistle, the authority grants individual leniency if and only if the expected managerial sanction is either particularly high or particularly low. Finally, we find that the authority does not apply a discount on the corporate sanction for the mere fact of having adopted a compliance program. We discuss our results in light of the U.S. and E.U. corporate leniency programs, the U.S. individual leniency program, and the U.S. Federal Sentencing Guidelines.

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2.1 Introduction

A compliance program (CP) is a corporate scheme to educate employees about illegal activities, to monitor their behavior, and to discipline them in case of illegal conduct. When well-designed, legal scholars advocate such schemes as an effective means to deter corporate crime. However, we argue that, depending on the extent to which the judicial system targets involved employees, CPs can indeed be helpful to deter corporate crime, but can also entail a perverse feature that actually encourages violations of the law. Moreover, we show that in both the U.S. and E.U., the current sanctions and leniency practice toward corporations and involved individuals may be suboptimal when taking into account the existence of CPs.

This chapter focuses on the monitoring and disciplining dimensions of CPs. Examples of monitoring employees are unannounced inspections of documents, email messages and telephone records, as well as lawyers accompanying managers to business meetings (Stephan, 2009). Authorities may regard such monitoring as an effective means to rely on the firm to prevent employees from engaging in corporate crime. However, a credibility issue arises when the illegal act not only benefits the involved employees, but also the firm to which they belong, i.e., the shareholders. In such cases, the (board of) shareholders may not take (serious) measures against the involved employees when an illegal act is uncovered. They may even use the obtained information to reward employees for engaging in illegal acts, while hiding the evidence from the authority.

To address this credibility issue, we build a three-tier hierarchy, authority-shareholder-manager and define a CP as a monitoring technology. The shareholder owns the firm and pays the manager to run it. The manager can unobservably breach the law, resulting in a personal benefit while stochastically increasing the shareholder’s profit; this gives rise to the credibility issue of relying on the shareholder to control her manager. The shareholder can adopt a CP to monitor whether the manager breaches the law, which brings about hard evidence of the violation with some probability. The shareholder and the manager both have the opportunity to blow the whistle by reporting evidence to the authority, whose objective is to deter breaches at the lowest possible cost. After a report, the authority imposes sanctions on the shareholder and the manager; otherwise, the authority investigates the firm with some costly probability and imposes sanctions if it uncovers a breach. Sanctions are contingent on (i) whether the shareholder or the

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28 See, for example, Webb and Molo (1993), Calkins (1997), Langevoort (2002), and Wils (2006). If a CP deters illegal conduct, it allows corporations to avoid being exposed to lengthy litigation and costly sanctions. In addition, detection of a violation through a CP allows the corporation to apply for leniency.
29 We do not consider the educational aspect of CPs. For many serious corporate crimes, such as price-fixing by cartels or tax evasion, employees know that such behavior is illegal and need not be educated.
manager blew the whistle—thus allowing for corporate and individual leniency—and (ii) whether a CP was adopted—thus allowing for a reduction of the sanction for having implemented a CP.

Our work applies to the field of antitrust law enforcement. We explicitly comment on the impact of CPs on (i) the sanction policy in the U.S. (the Federal Sentencing Guidelines) and Europe; (ii) the effectiveness of the U.S. and E.U. corporate leniency programs; and (iii) the U.S. individual leniency program. Our analysis, however, applies more broadly to any type of corporate crime, or non-compliance with a binding standard, that benefits both the organization and the involved individuals; examples include tax evasion, cooking the books, environmental fraud, and misselling of a product.30

In the U.S., employees involved in antitrust violations are criminally prosecuted, while European competition law does not target individuals.31 Since our model allows for varying the size of the maximum managerial fine prescribed by the law and endogenously solves for the optimal fine and leniency policy, we are able to derive policy implications for both the U.S. and Europe. Below, we summarize our findings from a more general economics perspective, while we discuss the implications for competition policy for both jurisdictions in Section 2.6.

**Desirability of compliance programs.** Monitoring managers through a CP reduces information asymmetries within the firm.32 The shareholder can then at lower cost prevent the manager to breach the law (beneficial for social welfare), but potentially also at lower cost induce managerial violations (detrimental for social welfare). We find that the adoption of a CP is beneficial for social welfare if and only if the managerial sanction is low. The reason is that if the expected managerial sanction imposed by the authority is lower than the individual gain from breaching the law, then the shareholder pays a positive information rent to prevent a breach, but no information rent to induce it. A CP would then reduce the salary to prevent a breach without affecting the salary to induce it, thereby making a breach relatively less profitable for the shareholder. A symmetric reasoning suggests that if the managerial sanction is high, a CP can make corporate crime actually relatively more profitable for the shareholder. We do not want to make the claim that firms adopt CPs with only the objective to reduce information asymmetries so as to

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30 Different interpretations of our three-tier hierarchy are authority-“seller of a product”-salesman (Inderst and Ottaviani, 2009), authority-“seller of a financial product”-broker, or society-lender-entrepreneur.

31 Some E.U. Member States have however enacted laws to criminally prosecute involved employees on the national level, such as the United Kingdom, Ireland and Estonia. See Wils (2005), p. 130, for an overview of criminalization of competition law in E.U. Member States.

32 In Price Waterhouse Coopers’ (2009) Global Economic Crime Survey, the share of firms responding that they have “suffered” from an economic crime committed by an employee increases with firm size. This may indicate that information asymmetries indeed matter when controlling employees’ behavior.
encourage employees to misbehave; the result does, however, suggest a potential perverse effect of increasing the monitoring of harmful activities.

**Corporate leniency program.** The E.U. corporate leniency program allows firms to blow the whistle in exchange for full immunity from legal sanctions aimed at the corporation; the U.S. corporate leniency program also fully protects involved employees from individual legal sanctions.\(^{33}\) Such a “blanket” covering the entire corporation as well as its employees has the objective to incentivize employees to report illegal acts to superiors, so as to file for leniency together (Hammond, 2004). In our model, however, we find that the authority optimally grants *partial* leniency to the shareholder when she blows the whistle, while *not* granting leniency to the manager. Three arguments drive this result.

First, corporate leniency increases the effectiveness of CPs to fight corporate crime. A reduction in the corporate sanction incentivizes the shareholder to report evidence uncovered through a CP to the authority, resulting in a managerial sanction. Thus, the *combination* of corporate leniency and the adoption of a CP increases the expected managerial sanction, which, in turn, disincentivizes the manager to breach the law, thereby reducing the salary cost to prevent managerial violations, while increasing the salary cost to induce such violations. Hence, in the presence of a CP, corporate leniency increases (reduces) the salary cost of inducing (preventing) a breach, thereby making it relatively more profitable for the firm to prevent corporate crime.

Second, although corporate leniency increases the effectiveness of CPs to fight corporate crime, the reduction in the corporate fine also makes a breach less costly to the shareholder. The authority optimally balances this tradeoff by providing *just enough* leniency to incentivize the shareholder to blow the whistle whenever she possesses evidence. Hence, the authority grants *partial* corporate leniency.

Third, the authority does not grant leniency to the manager when the shareholder blows the whistle. The reason is that such leniency would reduce the *ex ante* managerial fine, thereby incentivizing the manager to breach the law and, thus, aligning the manager’s incentives with those of a shareholder that wants an infringement to occur.

**Individual leniency program.** Under the U.S. individual leniency program, the involved employee receives full immunity from legal sanctions when blowing the whistle.\(^{34}\) In our model, however, the authority finds it not always optimal to grant individual leniency. The reason is that individual leniency makes a violation less costly for the manager, because the managerial fine is reduced. Granting individual leniency then entails

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\(^{33}\)See Commission Notice on Immunity from fines and reduction of fines in cartel cases, Official Journal C298/17 (2006); and the U.S. Department of Justice’s *Corporate Leniency Policy* (10 August 1993).

\(^{34}\)See the U.S. Department of Justice’s *Leniency Policy for Individuals* (10 August 1994).
the tradeoff that (i) it requires a high salary to induce a breach, because the shareholder must compensate (bribe) the manager not to file for leniency, but (ii) it also requires a high salary to prevent a breach, because the shareholder must reward the manager for not “breaching and blowing the whistle” instead of “not breaching.” We find that the authority optimally grants individual leniency if and only if the expected managerial fine is either particularly high or particularly low. In addition, whenever individual leniency is granted, the authority fully sanctions the firm.

**CP and fine reduction.** In *Electrical and mechanical carbon and graphite products*, “the [European] Commission considers that it is not appropriate to take the existence of a compliance programme into account as an attenuating circumstance for a cartel infringement.”\(^{35}\) In contrast, according to the U.S. Federal Sentencing Guidelines, a firm engaged in illegal activities is eligible to receive a reduced sanction if a well-designed CP was in place at the time of the infringement; in some cases the reduction is up to 95% of the original fine.\(^{36}\) In our model, however, such a policy has a perverse effect. As outlined above, we find that the shareholder optimally receives a reduced sanction for having adopted a CP and blowing the whistle, not for the mere act of adopting a CP. The reason is that a CP can be used to more effectively prevent a breach, but also to induce a breach (see above): the mere act of implementing a CP is, therefore, not informative of the shareholder’s intentions. Thus, our results confirm the European Commission’s view.

We proceed by discussing related literature in Section 2.2. Section 2.3 presents the model. Section 2.4 derives conditions under which CPs are helpful in the fight against corporate crime by solving for (i) the impact of a CP on salary costs; (ii) optimal sanctions and corporate leniency policy; and (iii) the authority’s equilibrium investigation probability. Section 2.5 extends the model to study the U.S. individual leniency policy. In Section 2.6, we discuss the policy implications of our model for both the U.S. and the E.U. Section 2.7 concludes.

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\(^{36}\)Having implemented an “effective compliance and ethics program” reduces the so-called Culpability Score on which the fine is based—see Section 8C2.5(f) of the U.S. Federal Sentencing Guidelines and U.S. Sentencing Commission (2010). However, according to Section 8C2.5(f)(3)(B)(2), the discount does not apply if the involved individual has price-setting power. See also Wils (2006), pp. 200–201.
2.2 Related Literature

Our work relates to three strands of literature: (i) managerial incentives with harmful activities, (ii) leniency programs, and (iii) optimal liability rules. Most papers in these literatures consider two-tier hierarchy games: either (i) the authority and the black boxed corporation are strategic players, abstracting away from games within the firm, or (ii) the firm owner (principal or shareholder) and the employee (agent or manager) are strategic players, with the authority assumed to be an exogenous technology. We take a step beyond these models by considering a three-tier hierarchy game: the authority, principal, and agent are all strategic players.

Managerial incentives with harmful activities. In any model opening the black box of the firm, the nature of the employment contract is central to the analysis. Scharfstein (1988) and Schmidt (1997) study the manager’s incentives to exert effort, taking into account the degree of competition in the industry. In Fershtman and Judd (1987), Sklivas (1987), and Spagnolo (2000), an owner offers the manager a publicly observable and binding contract as a commitment device to soften competition or even to sustain tacit collusion. Hiring a manager with strong preferences for income smoothing serves a similar purpose in Spagnolo (2005). These models show how an employment contract might be deliberately used by an employer to reach a socially sub-optimal outcome.

From a different perspective, Inderst and Ottaviani (2009) model a seller of a good contracting with an agent to prospect for consumers as well as to provide advice concerning the suitability of the product to the consumer’s needs. The consumer is taken to be a fully rational and strategic player. The employment contract, which is soft private information as in our model, determines the degree of miselling in equilibrium.

These models do not consider the authority as a fully-fledged strategic player. Aubert (2009) does take into account a strategic authority: she investigates the impact of employment contracts on the incentives for managers to unobservably substitute productive effort with price fixing. In her model, as in ours, the bonus scheme (i) is soft private information to insiders and can be deliberately used by the principal to induce an illegal activity, and (ii) takes into account that cartelization leads to evidence being created, possibly resulting in public intervention by the authority. In our model, unlike Aubert’s, in addition to the authority’s intervention, internal contracting is potentially also affected

37 A notable exception being Inderst and Ottaviani (2009).

38 Empirical anecdotes hint in the same direction. Price Waterhouse Coopers’ (2009) Global Economic Crime Survey states that the main motivation driving employees to commit fraud is “incentives and pressure,” such as bonuses, financial targets and fear of losing jobs. Also, Khanna (1996) notes that “shareholders can influence the behavior of corporation managers and employees in a number of ways, such as by modifying employment contracts.”
by the presence of a CP: the principal contracts on profits, evidence generated by the CP and, potentially, evidence brought forward by the employee himself.

Leniency programs. In our model, we allow both the employer as well as the employee breaching the law to file for (endogenous) leniency from legal sanctions\textsuperscript{39} where the employer can come into possession of evidence either through a CP, or through a report by the employee. Thus, our work relates to the literature that studies mechanisms incentivizing wrongdoers to self-report. To our knowledge, most work considering such leniency programs focuses on antitrust and, in particular, on cartels. Motta and Polo (2003) and Chen and Rey (2007), for instance, show that leniency programs can have two opposing effects: they destabilize existing collusion by increasing the incentives to deviate from the collusive agreement, but also make collusion \textit{ex ante} more profitable by reducing the expected sanction\textsuperscript{40}.

In contrast to these papers, we study leniency programs that potentially jeopardize a conspiracy vertically \textit{within} the firm, rather than horizontally \textit{between} firms. The resulting effects are different. On the one hand, granting leniency to an employer reduces the expected corporate sanction, which incentivizes the employer to blow the whistle. This, in turn, increases the expected managerial sanction, which allows for a reduction in salary costs necessary to prevent corporate crime, while increasing salary costs necessary to induce it. On the other hand, granting leniency to an employee reduces the expected managerial sanction, thereby increasing salary costs to ensure that the manager does not blow the whistle. This leads to \textit{vertical} destabilization, which parallels \textit{horizontal} destabilization in, for example, Spagnolo (2004) who shows that the authority should grant leniency only to the first horizontal party coming forward with evidence. Similarly, we argue that leniency should apply only to the first vertical party blowing the whistle, that is, either the employer or the employee.

Aubert, Rey and Kovacic (2006) (ARK) consider a set-up in which the firm (principal) itself commits the crime, but employees have information about the crime. They argue that it might be optimal to reward employees for blowing the whistle in order to worsen firms’ internal incentives\textsuperscript{41}. In contrast, in our model the employee (agent) is the individual possibly breaching the law. The force identified by ARK is then present, that is, an employer wishing her employee to breach the law must commit to a higher wage to keep him silent. However, there is another side of the coin: granting leniency to an em-

\textsuperscript{39}See Miller (2009) for recent empirical results concerning the efficacy of leniency programs in the U.S.

\textsuperscript{40}Harrington (2008) shows that a third force is present when a time varying probability of conviction is considered: as all players rush to apply for leniency, but only one comes first, overall sanctions may end up being higher compared to the case in which no leniency is available.

\textsuperscript{41}Such individual rewards also provide incentives to individuals to retain evidence.
ployee increases his incentives to breach the law in the first place, making it more difficult for a firm to deter misconduct.\footnote{Aubert (2009), also considering individual leniency programs, identifies this tradeoff as well.} Thus, we find that individual leniency (or: individual rewards) is not always the optimal policy and depends on the manager’s private benefit resulting from the crime.

\textbf{Optimal liability rules.} Our work also relates to the literature investigating to which extent firms and individuals should be liable for corporate crime\footnote{See Khanna (1996) for an exposition of the various liability regimes.} Sykes (1984) and Segerson and Tietenberg (1992), for instance, consider types of corporate crime that hurt the firm; they argue that, in the presence of agency costs, the authority targeting individuals directly is more effective than targeting the firm. We find that if the authority offers corporate leniency, targeting individuals generally works better at reducing public enforcement costs than targeting the firm, regardless of agency costs. However, since we consider types of corporate crime that actually benefit the corporation, some degree of corporate liability is always needed, which contrasts Segerson and Tietenberg (1992)\footnote{The threat of corporate sanctions effectively forces firms to internalize the potential social harm caused by their employees, thereby (at least partially) delegating the task of fighting corporate crime to the firm. Thus, firms may choose to monitor employees by adopting a CP.}

Polinsky and Shavell (1993) and Shavell (1997) call for managerial legal sanctions as the firm itself might be limited in its capacity to punish its employees. In our model, where the employer can actually punish its employees in the form of foregone bonuses, it is preferable to have managerial legal sanctions for an additional reason: the employer cannot be trusted to take appropriate measures as the illegal act itself benefits the employer. Focusing on managerial incentives to form cartels, Stephan (2009) argues that CPs may be ineffective if employees bear no liability, because then employees commit the crime anyway. Our results differ; we find that CPs are actually most useful when employees bear no liability, because then employers can use the information obtained through the CP to internally punish employees.

When the probability of conviction increases with the amount of internal monitoring, Arlen (1994) identifies a potentially perverse effect of holding firms liable: improved internal monitoring would expose the firm to heavy sanctions. As a result, the firm might be reluctant to disclose evidence or to choose the right level of monitoring. Our model eliminates this effect by allowing for corporate leniency, which reduces the expected corporate sanction when the firm monitors and reports when evidence is found. In equilibrium, the authority grants partial corporate leniency so as to take away Arlen’s perverse effect, while not reducing the fine by too much. Thus, such a corporate leniency policy incentivizes firms to fight corporate crime by monitoring employees through a CP.
2.3 Set-up of the Model

In this section, we present the set-up of the model, assuming that the manager cannot apply for leniency. We relax this assumption in Section 2.5.

Outline & players. Consider the following three-tier hierarchy: an owner or shareholder of the firm (principal) contracts with a manager (agent) who runs the firm and possibly breaches the law. An authority aims at deterring breaches of the law. The manager does not (Section 2.4) or does (Section 2.5) possess evidence of the violation, while the shareholder may receive hard evidence, either directly through the manager, or through monitoring the manager with a CP. The manager and/or the shareholder can blow the whistle and report evidence to the authority, which then imposes corporate and managerial fines. If neither the shareholder nor the manager blows the whistle, the authority investigates the firm with costly probability $\beta$ and imposes fines when a breach of the law is uncovered. Figure 2.1 illustrates this set-up. All players are risk neutral. We refer to the manager in the male form (he/his), the shareholder in the female form (she/her), and the authority in the neutral form (it/its).

![Diagram](image)

**Figure 2.1** The players: authority, shareholder (principal), and manager (agent).

Actions

*Manager.* The manager unobservably takes action $a \in \{b, n\}$, where $b$ is breaching the law and $n$ is not breaching the law. The manager’s action stochastically affects the realization of firm profit $\pi \in \{0, 1\}$. The following table contains the probability distribution over firm profit $\pi$ given action $a$, where $\rho_{\pi} > \frac{1}{2}$, that is, breaching the law increases the firm’s expected profit.
\[
\begin{array}{c|c|c}
\mathbf{a} = b & \mathbf{a} = n \\
\hline
\pi = 1 & \rho_\pi & 1 - \rho_\pi \\
\pi = 0 & 1 - \rho_\pi & \rho_\pi \\
\end{array}
\]

In Section 2.4, we consider the case in which the manager does not possess evidence when he breached the law. Section 2.5 solves the case when the manager does possess evidence, which he may report to her shareholder and/or the authority. This allows to study the interaction of CPs with the U.S. individual leniency program; details about this adapted set-up are outlined in Section 2.5.

Shareholder. The shareholder takes three possible actions: (i) she offers the manager a take-it-or-leave-it employment contract; (ii) she chooses whether or not to adopt a CP, and (iii) she chooses whether or not to report evidence to the authority if she comes into possession of such evidence. Regarding the latter two actions, the shareholder has the following three reporting strategies: she either does not adopt a CP and has nothing to report \((i = N)\); adopts a CP and reports whenever possible \((i = R)\); or adopts a CP and never blows the whistle \((i = C)\).

Adopting a CP allows the shareholder to uncover perfectly informative hard evidence of a breach with probability \(\rho_\sigma > 0\). Whether she indeed finds evidence is indicated by signal \(\sigma \in \{0, 1\}\), where \(\sigma = 1\) means evidence and \(\sigma = 0\) means no evidence. The next table contains the probability distribution over signal \(\sigma\), given managerial action \(a\).

\[
\begin{array}{c|c|c}
\sigma = 1 & \mathbf{a} = b & \mathbf{a} = n \\
\hline
\rho_\sigma & 0 \\
1 - \rho_\sigma & 1 \\
\end{array}
\]

Consider now the employment contract. The shareholder offers the manager a take-it-or-leave-it contract, which defines transfers \(t_{\pi, \sigma}\) contingent on the realization of profit \(\pi \in \{0, 1\}\), as well as the signal \(\sigma \in \{0, 1\}\) (if a CP is in place). The shareholder may use the contract to either induce or to prevent her manager to breach the law.

---

\[45\text{For simplicity, we assume that a CP is costless to implement. Based on an earlier version of the model, we discuss in the concluding remarks that the results remain qualitatively unchanged when a CP is costly.}

\[46\text{For simplification, we assume that a CP possibly gives rise to hard information. If the shareholder were to possess soft information and transmit it to the authority, then an investigation would still be needed as judges and courts are reluctant to rely on testimonies which are not backed by factual evidence. The possibility of soft information is left for future work.}

\[47\text{We assume that the shareholder cannot contract on the outcome of the authority’s investigation. This contracting incompleteness yields the same results that we would obtain in a frictionless contracting environment in which the authority commits (not too frequent) type I/II errors. If completeness is restored in the current framework, most results qualitatively hold but less economic forces are at play.}
The employment contract is assumed to be soft private information. The shareholder can credibly commit to making the transfers as stated in the employment contract, while she cannot credibly commit to a specific reporting strategy, though she would prefer to.

The transfers \( t_{\pi,\sigma} \) are associated with four possible states of nature \( \{ \pi, \sigma \} \). The following table states the probabilities \( p_{\pi,\sigma}^{a,i} \) of these states of nature occurring, given the manager’s action \( a \in \{ b, n \} \) and the shareholder’s choice \( i \in \{ N, C, R \} \), where \( \rho^i_{\sigma} = \rho_{\sigma} \) if \( i \in \{ C, R \} \), and \( \rho^b_{\sigma} = 0 \) if \( i = N \).

<table>
<thead>
<tr>
<th>State of nature ( { \pi, \sigma } ) and associated transfer ( t_{\pi,\sigma} )</th>
<th>Probability if ( a = b )</th>
<th>Probability if ( a = n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( { \pi = 1, \sigma = 1 } ), ( t_{11} )</td>
<td>( p_{11}^{b,i} = \rho_{\pi} \rho^i_{\sigma} )</td>
<td>( p_{11}^{n,i} = 0 )</td>
</tr>
<tr>
<td>( { \pi = 1, \sigma = 0 } ), ( t_{10} )</td>
<td>( p_{10}^{b,i} = \rho_{\pi} ) ( 1 - \rho^i_{\sigma} )</td>
<td>( p_{10}^{n,i} = 1 - \rho_{\pi} )</td>
</tr>
<tr>
<td>( { \pi = 0, \sigma = 1 } ), ( t_{01} )</td>
<td>( p_{01}^{b,i} = (1 - \rho_{\pi}) \rho^i_{\sigma} )</td>
<td>( p_{01}^{n,i} = 0 )</td>
</tr>
<tr>
<td>( { \pi = 0, \sigma = 0 } ), ( t_{00} )</td>
<td>( p_{00}^{b,i} = (1 - \rho_{\pi}) (1 - \rho^i_{\sigma}) )</td>
<td>( p_{00}^{n,i} = \rho_{\pi} )</td>
</tr>
</tbody>
</table>

**Authority.** The authority imposes corporate fine \( F^i \) on the shareholder and individual fine \( f^i \) on the manager, subject to legal caps \( \overline{F} \) and \( \overline{f} \), respectively. Varying the legal cap \( \overline{f} \) allows to interpret the results in light of U.S. policy (positive managerial sanctions, i.e., \( \overline{f} > 0 \)) and E.U. policy (no managerial sanctions, i.e., \( \overline{f} = 0 \)).

If the shareholder blows the whistle, the authority imposes sanctions \( F^R \) and \( f^R \) (in Section 2.3, we extend the analysis by also allowing the manager to blow the whistle). If instead no report is made, the authority commits to investigate the firm with probability \( \beta \) in which case it always uncovers the breach if it occurred. The authority then imposes sanctions \( F^C \) and \( f^C \) when a CP was in place, or sanctions \( F^N \) and \( f^N \) when a CP was not in place.

**Information.** All actions are observable to all players, except (i) whether the manager breaches the law or not, which is unobservable to the shareholder as well as the authority, and (ii) whether the shareholder has adopted a CP, which is observed by the manager, but not by the authority.

---

48We adopt the conventional wisdom that the logic behind bonuses is opaque to outsiders, but perfectly understandable to insiders. We also assume that such bonuses are credible as they involve relatively small amounts of money. Committing whether or not to report, however, may involve colossal amounts of money and is only credible if it is *ex post* rational to do so.

49If the authority cannot credibly commit to a probability of investigation, the equilibrium is in mixed strategies—see for instance Khalil (1997).

50Aubert, Rey and Kovacic (2006) and Aubert (2009) also make the assumption that an investigation always leads to conviction if a breach occurred.

51We do not consider signaling games in which the authority tries to separate the behavior of a shareholder preventing a breach from that of a shareholder inducing a breach. Equivalently, we could have assumed
Whether the shareholder uncovers evidence through the adoption of a CP is observable to the manager, but unobservable to the authority; only if the shareholder blows the whistle then the authority knows that the shareholder has found evidence. The nature of the employment contract is unobservable to the authority, even in case of an investigation.  

**Payoffs**

**Shareholder.** The shareholder receives realized profit $\pi \in \{0, 1\}$ and pays managerial salary $t_{\pi, \sigma}$. If the manager breaches the law, the firm faces expected corporate fine

$$E_i[F] = \begin{cases} 
\beta F^N & \text{if } i = N \\
\beta F^C & \text{if } i = C \\
\rho \sigma f^R + (1 - \rho \sigma) \beta F^C & \text{if } i = R,
\end{cases}$$

(2.1)

where the expected corporate fine when the shareholder adopts a CP and reports evidence ($i = R$) consists of two parts: (A) with probability $\rho \sigma$ the shareholder finds evidence and blows the whistle in which case the authority imposes fine $F^R$, and (B) with probability $1 - \rho \sigma$ the shareholder finds no evidence in which case the authority investigates the firm with probability $\beta$ and imposes fine $F^C$. Given the expected corporate fine $E_i[F]$ and the expected transfer $E_i[t^a] = \sum_{\pi=0}^{1} \sum_{\rho=0}^{1} p_{\pi, \sigma} t_{\pi, \sigma}$, the shareholder’s expected payoff $\Pi_i^a$ is then

$$\Pi_i^a = \begin{cases} 
1 - \rho \pi - E_i[t^a] & \text{if } a = n \\
\rho \pi - E_i[t^b] - E_i[F] & \text{if } a = b.
\end{cases}$$

(2.2)

**Manager.** The manager receives his salary $t_{\pi, \sigma}$. When breaching the law, he also receives private gain $G \geq 0$, which can be interpreted as a benefit either directly or indirectly resulting from the breach, such as the possibility to work less hard. Moreover, the manager then faces expected managerial fine

$$E_i[f] = \begin{cases} 
\beta f^N & \text{if } i = N \\
\beta f^C & \text{if } i = C \\
\rho \sigma f^R + (1 - \rho \sigma) \beta f^C & \text{if } i = R.
\end{cases}$$

(2.3)

that the authority does observe whether the shareholder has implemented a CP, but does not ex ante act on that by adapting its investigation probability.

\footnote{This captures the idea that in many cases it is difficult for the judicial system to observe the set of incentives in place at the time of the infringement. Thus, whenever we find that the optimal policy is to sanction the shareholder, this is not based on factual evidence of culpability, but on efficiency grounds. We thank Michael Riordan for pointing this out.}

\footnote{In Aubert (2009), for example, managerial effort and cartelization are strategic substitutes: forming a cartel allows the manager to exert less costly effort, which is an indirect benefit.}
Given this expected managerial fine \( E_i[f] \) and the expected transfer \( E_i[t^a] \), the manager’s expected payoff \( M_i^a \) then boils down to

\[
M_i^a = \begin{cases} 
E_i[t^a] & \text{if } a = n \\
E_i[t^b] - E_i[f] + G & \text{if } a = b.
\end{cases}
\]

The manager has a zero outside option and is protected by limited liability with respect to salary, but not with respect to the managerial fine.

**Authority.** The authority’s cost of investigating firms \( K(\beta) \) is increasing in the investigation probability, i.e., \( K'(\beta) > 0 \). Fines are costless to impose and collect. We assume that breaches are so detrimental to society that the authority’s objective is to minimize investigation cost \( K(\beta) \) subject to breaches being deterred:

\[
\begin{align*}
& \min_{\beta, \{F^N,F^C,F^R\}, \{f^N,f^C,f^R\}} K(\beta) \\
& \text{s.t.} \\
& F^i \leq F, \quad \forall i, \\
& f^i \leq f, \quad \forall i, \\
& \max \{\Pi^N, \Pi^b_C, \Pi^b_R\} \geq \max \{\Pi^b_N, \Pi^b_C, \Pi^b_R\},
\end{align*}
\]

where constraint (2.4) ensures that the shareholder writes an employment contract that prevents her manager to breach, that is, the shareholder’s expected payoff when inducing a breach (RHS) must not be higher than her payoff when preventing a breach (LHS). Another interpretation of this minimization problem is that the authority executes a pre-written law at the least possible costs.

**Timing.** The timing of the game is as follows and schematically depicted in Figure 2.2:

1. The authority sets its policy parameters \( \beta, \{F^N,F^C,F^R\}, \{f^N,f^C,f^R\} \).
2. The shareholder chooses her reporting strategy, \( i \in \{N,C,R\} \).
3. The shareholder offers a take-it-or-leave-it contract to the manager, which the manager accepts or rejects.
4. The manager breaches the law or not, \( a \in \{b,n\} \).
5. Firm profit \( \pi \in \{0,1\} \) and signal \( \sigma \in \{0,1\} \) are realized.

---

\[^4\text{This assumption allows for a mathematically clean analysis; when some breaches are not so detrimental to society we expect the same qualitative results.}\]
6. If evidence of a breach becomes available through the CP ($\sigma = 1$), the shareholder blows the whistle if and only if $i = R$.\(^{55}\)

7. If the authority receives a report, the authority imposes sanctions. If the authority receives no report, the authority investigates the firm with probability $\beta$ and imposes sanctions when a violation indeed occurred.

8. The employment contract is executed.\(^{56}\)

![Figure 2.2 Timing of the game.](image)

### 2.4 The Impact of Compliance Programs on Optimal Policy

This section solves the model for the case in which the manager does not possess evidence when he breached the law, as outlined in the previous section. In Subsection 2.4.1, we solve for the expected transfers associated with the optimal employment contracts. Subsection 2.4.2 determines the authority’s optimal sanctions and leniency policy. Subsection 2.4.3 derives the impact of CPs on the optimal level of investigations necessary to deter corporate crime.

#### 2.4.1 Optimal Expected Transfers

In this subsection, we present the expected transfers associated with the manager’s employment contract when the shareholder either induces or prevents the manager to breach the law. We define $\gamma^N = \frac{\rho_\pi}{2\rho_\pi - 1} > 1$ and $\gamma^C = \frac{\rho_\pi}{\rho_\pi - (1-\rho_\pi)(1-\rho_\sigma)} > 1$ as measures of information asymmetries, where $\gamma^N > \gamma^C$, because $\rho_\pi > \frac{1}{2}$.

\(^{55}\)We consider reporting to (possibly) happen before the authority’s investigation so as to study the impact of leniency programs on practices that are not yet under investigation. Motta and Polo (2003) show that it can be efficient to reduce fines even when the authority has already started an investigation, but has not yet obtained evidence of misbehavior.

\(^{56}\)While the employment contract is executed after the possible investigation, the contract is not contingent on the outcome of the investigation. This assumption is similar in effect to Aubert (2009) who instead assumes that the contract is executed before a possible investigation, but managerial whistle blowing (see Section 2.5) cannot take place after the contract is executed.
Lemma 2.1 (No compliance program) If a compliance program is not adopted \((i = N)\), the expected transfer to induce or to prevent a breach, respectively, is

\[
E_N \left[ t^b \right] = \max \left\{ \gamma^N \left( \beta f^N - G \right), 0 \right\}, \\
E_N \left[ t^n \right] = \max \left\{ \gamma^N \left( G - \beta f^N \right), 0 \right\}.
\]

Proof. See Appendix A.1.1. \qed

When the shareholder wants to prevent (induce) a breach, she pays a positive expected transfer if and only if the manager’s gain \(G\) from breaching is higher (lower) than the expected managerial fine \(\beta f^N\) — that is, if and only if the incentives of the shareholder and the manager are not aligned. The resulting expected transfer is the difference between \(G\) and \(\beta f^N\), inflated by the measure of information asymmetries \(\gamma^N\), caused by the fact that the only (imperfect) information that the shareholder has about managerial behavior is the realization of profit.

Lemma 2.2 (Compliance program) If a compliance program is adopted \((i \in \{C, R\})\), the expected transfer to induce or to prevent a breach, respectively, is

\[
E_i \left[ t^b \right] = \max \left\{ E_i \left[ f \right] - G, 0 \right\}, \\
E_i \left[ t^n \right] = \max \left\{ \gamma^C \left( G - E_i \left[ f \right] \right), 0 \right\}.
\]

Proof. See Appendix A.1.1. \qed

The adoption of a CP reduces the moral hazard problem, because the shareholder receives informative signal \(\sigma\). As a result, the measure of information asymmetries decreases from \(\gamma^N\) to \(\gamma^C\) when the shareholder prevents her manager to breach, while information rents disappear altogether when the shareholder induces her manager to breach as evidence \((\sigma = 1)\) is a perfectly informative signal about a breach having occurred.

We again have that the shareholder pays a positive expected transfer if and only if the incentives of the shareholder and the manager are not aligned. This expected transfer is the difference between \(G\) and \(E_i \left[ f \right]\), which is inflated by the measure of information asymmetries \(\gamma^C\) when the shareholder prevents a breach.

2.4.2 Optimal Sanctions and Leniency Policy

The authority’s objective is to implement a policy that deters breaches at the lowest possible cost, i.e., with the lowest possible investigation probability \(\beta\). Before determining
this optimal $\beta$ in the next subsection, we solve for the optimal schedule of fines and determine whether and when the authority optimally grants leniency to the shareholder and/or the manager.

Recall that constraint (2.4) ensures that the shareholder does not find it profitable to induce a managerial violation. Substituting for the shareholder’s expected payoffs (equation (2.2)) and subsequently for the expected corporate fines (equation (2.1)) yields

$$1 - \rho_{\pi} - \min \{E_N [t^n], E_C [t^n], E_R [t^n]\} \geq$$

$$\rho_{\pi} - \min \left\{ E_N [t^b] + \beta F^N, E_C [t^b] + \beta F^C, E_R [t^b] + \rho_{\sigma} F^R + (1 - \rho_{\sigma}) \beta F^C \right\},$$

(2.5)

which allows to determine the schedule of fines $\{F^N, F^C, F^R\}$ and $\{f^N, f^C, f^R\}$ that ensures that (2.4) is satisfied for the lowest possible investigation probability $\beta$.

**Proposition 2.1** The authority’s optimal policy is to set all fines to their legal maximum, but to provide partial corporate leniency when the shareholder blows the whistle, that is,

1. $f^N = \bar{f}, F^N = \bar{F}$;
2. $f^C = \bar{f}, F^C = \bar{F}$; and
3. $f^R = \bar{f}, F^R = \beta \bar{F} - |\epsilon|,$

where $\epsilon$ is arbitrarily small.\(^57\)

The manager receives no individual leniency when the shareholder blows the whistle and there is no reduction on the corporate fine for having adopted a compliance program.

**Proof:** See Appendix A.1.2. \qed

The authority optimally sets all managerial fines to their legal maximum and provides no individual leniency when the shareholder blows the whistle. The intuition is that increasing the managerial fines leads to (i) a better alignment of the manager’s incentives with those of the shareholder aiming to prevent a breach, resulting in a weakly lower expected transfer, and (ii) more misalignment between the manager’s incentives and those of the shareholder aiming to induce a breach, resulting in a weakly higher expected transfer. Setting all managerial fines to their legal maximum optimally relaxes (2.5): it becomes cheaper for the shareholder to prevent a breach, but more expensive to induce a breach.

---

\(^{57}\)We realize that “$\epsilon$ is arbitrarily small” violates the equilibrium concept, because all variables are continuous. The same results would however be obtained when rewriting the proofs with corporate fines defined in a discrete grid. This makes practical sense as monetary values cannot be split infinitely.
The authority sets corporate fines to their legal maximum, but grants partial leniency to the shareholder when she blows the whistle. Consider first the case in which the shareholder does not adopt a CP and, thus, never receives evidence. We then have the Beckerian result that the authority sets the corporate fine to its legal maximum so as to maximally deter the shareholder from inducing her manager to breach, i.e., $f^N = \bar{F}$.

Suppose now the shareholder adopts a CP, which possibly provides her with evidence of a breach. Substituting the optimal managerial fines $f^N = f^C = f^R = \bar{f}$ into $E_C [f]$ and $E_R [f]$, gives expected managerial fines

$$E_R [f] = [\rho_\alpha + (1 - \rho_\alpha) \beta] \bar{f} > E_C [f] = \beta \bar{f},$$

that is, the expected managerial fine is higher when the shareholder blows the whistle than if she does not blow the whistle, because the manager is convicted for sure after a report by the shareholder. Thus, blowing the whistle weakly reduces the expected salary cost to prevent a breach, but weakly increases the expected salary cost to induce a breach. Therefore, a shareholder aiming to prevent a breach would like to commit vis-à-vis her manager to blow the whistle whenever she finds evidence, while a shareholder aiming to induce a breach would like to commit not to blow the whistle.

Whether such commitments are credible depends on the relative sizes of the corporate fines: blowing the whistle is ex post rational for the shareholder if and only if reporting leads to a lower corporate fine than not reporting, i.e., if and only if $F^R < \beta F^C$. To maximally deter the shareholder from inducing a breach, the authority sets $F^C$ and $F^R$ as high as possible, with the restriction that $F^R < \beta F^C$ so as to (i) provide the breach-preventing shareholder with the commitment to report, while (ii) destroying the breach-inducing shareholder’s commitment to not report. When the shareholder implements a CP, the authority, thus, optimally sets the corporate fine when no report is made to the legal maximum, i.e., $F^C = \bar{F}$, while granting partial leniency to the shareholder when she reports, i.e., $F^R = \beta \bar{F} - |\epsilon|$, where $\epsilon$ is arbitrarily small. Hence, the authority does not reduce the corporate fine for the mere fact of having adopted a CP.

Combining the results regarding optimal transfers (Lemmas 2.1 and 2.2) with the authority’s optimal sanctions and leniency policy (Proposition 2.1), we state the impact of the adoption of a CP on expected transfers in the following corollary.

**Corollary 2.1** Provided the implementation of the authority’s optimal policy, monitoring managers through a compliance program

1. reduces information asymmetries within the firm (by assumption); and

2. increases the expected managerial fine.
The former effect entails a downward pressure both on the transfer to prevent breaches and on the transfer to induce breaches. The latter effect entails a downward pressure on the transfer to prevent breaches and an upward pressure on the transfer to induce breaches.

Proof. The former effect directly follows from Lemmas 2.1 and 2.2. The latter effect follows from Lemmas 2.1 and 2.2 and Proposition 2.1 by noting that the managerial fine is (i) \( E_N [f] = \beta \bar{f} \) when no CP is adopted, and (ii) \( E_R [f] = \rho \sigma \bar{f} + (1 - \rho \sigma) \beta \bar{f} > E_N [f] \) when a CP is adopted, because the authority’s optimal policy makes it \textit{ex post} rational for the shareholder to report whenever she finds evidence through the CP. □

Adopting a CP affects expected transfers through two channels. First, since a CP reduces information asymmetries within the firm, it decreases information rents (if any), thereby weakly reducing expected salary costs. This effect is beneficial in the fight against corporate crime when the shareholder aims to prevent managerial violations, but entails a perverse effect when the shareholder uses the information obtained through the CP to promote such violations. Second, given the authority’s optimal sanctions and leniency policy, adopting a CP increases the expected managerial fine from \( E_N [f] = \beta \bar{f} \) to \( E_R [f] = \rho \sigma \bar{f} + (1 - \rho \sigma) \beta \bar{f} \), because the shareholder finds it \textit{ex post} rational to blow the whistle whenever she finds evidence, which results in a sure conviction of the manager. This effect helps to deter violations as it increases the manager’s expected cost of breaching, thereby reducing the expected transfer to prevent a breach and increasing the expected transfer to induce a breach. We then arrive at the following corollary.

**Corollary 2.2** A shareholder that prevents breaches optimally adopts a compliance program. A shareholder that induces breaches not always adopts a compliance program, because it reduces information asymmetries, but increases the expected managerial fine.

Proof. The first result follows directly by noting that both effects stated in Corollary 2.1 entail a downward pressure on the expected transfer to prevent breaches. The second result follows by Corollary 2.1 and the proof of Proposition 2.1. □

Adopting a CP unambiguously helps the shareholder to prevent managerial violations: a CP reduces information asymmetries and increases the expected managerial fine, which both entail a downward pressure on the optimal expected transfer to prevent a breach. In contrast, when the shareholder aims to induce a breach she faces a tradeoff: a CP entails a downward pressure on the expected transfer through reducing information asymmetries, but an upward pressure through increasing the expected managerial fine.
2.4.3 Social Desirability of Compliance Programs

Given the authority’s optimal sanctions and leniency policy, we now determine the net impact of the CP, i.e., the monitoring technology, on the authority’s costly investigation probability. We do so by comparing the minimum investigation probability $\beta^*$ that satisfies constraint (2.3) with the minimum investigation probability $\tilde{\beta}^*$ in a hypothetical scenario in which the monitoring technology is not available. Proposition 2.2 then states the conditions under which monitoring managers through CPs is socially desirable ($\beta^* < \tilde{\beta}^*$) or undesirable ($\beta^* > \tilde{\beta}^*$); we graphically illustrate the results in Figures 2.3AB. Denote by $F'$ and $F''$ thresholds on the corporate fine, where $F' < F''$. We assume that the corporate fine $F$ is high enough for $\beta^* < 1$ to exist.

**Proposition 2.2** If the managerial fine is lower than the manager’s private benefit from the breach ($\bar{f} \leq G$), monitoring him through a compliance program is welfare enhancing.

If the managerial fine is higher than the manager’s private benefit from the breach ($\bar{f} > G$), monitoring him through a compliance program is

1. detrimental for welfare if the corporate fine is low ($F < F'$);
2. welfare neutral if the corporate fine is intermediate ($F' \leq F < F''$); and
3. welfare enhancing if the corporate fine is high ($F > F''$).

**Proof.** See Appendix A.1.3.

---

**Figures 2.3AB** Optimal investigation probability when CPs are available ($\beta^*$), or not available ($\tilde{\beta}^*$); with (2.3a) a low managerial fine ($\bar{f} \leq G$), or (2.3b) a high managerial fine ($\bar{f} > G$).

---

58Such a situation could be due to very high implementation costs, but also to cultural or legal reasons.
When the managerial fine is lower than the manager’s private benefit from the breach \((\bar{f} < G)\), the manager has private incentives to breach the law when a CP is not adopted. The shareholder then pays a zero salary to induce a breach, but a positive expected salary, including an information rent, to prevent a breach. As discussed in the previous two subsections, adopting a CP has two effects: it decreases information rents, while increasing the expected managerial fine. Thus, the former effect decreases the expected transfer to prevent a breach, while not affecting the zero transfer to induce a breach. The latter effect has a disincentivizing effect on the manager to breach, thereby reducing the positive transfer to prevent a breach and (weakly) increasing the zero transfer to induce a breach. Altogether, the adoption of a CP reduces the salary cost of preventing a breach, while (weakly) increasing the salary cost of inducing a breach. This makes a breach of the law relatively less profitable for the shareholder, thereby allowing the authority to reduce its costly investigation probability.

Consider now the case in which the managerial fine is higher than the manager’s private benefit from the breach \((\bar{f} \geq G)\). In such cases, the manager has private incentives to breach if \(\beta \bar{f} < G\), but has no private incentives to breach if \(\beta \bar{f} \geq G\). For the following argumentation, we note that the corporate fine \(\bar{F}\) and the investigation probability \(\beta\) are substitutes in deterring corporate crime, that is, a high \(\bar{F}\) allows for a low \(\beta\), while a low \(\bar{F}\) requires a high \(\beta\).

Suppose the corporate fine is high \((\bar{F} \geq F'')\). By substitutability of \(\bar{F}\) and \(\beta\), the authority can set the investigation probability \(\beta\) relatively low. In particular, the investigation probability is so low that \(\beta \bar{f} < G\), that is, the manager has private incentives to breach. Without a CP, the shareholder then pays a zero salary to induce a breach, but a positive expected salary, including an information rent, to prevent a breach. By the same arguments as above (“low managerial fine”), a CP reduces the salary cost of preventing a breach, while (weakly) increasing the salary cost of inducing a breach. This makes corporate crime relatively less profitable for the shareholder, which allows the authority to reduce its costly investigation probability.

Suppose now the corporate fine is not so high \((\bar{F} < F'')\). By substitutability of \(\bar{F}\) and \(\beta\), the authority needs to set the investigation probability \(\beta\) relatively high, resulting in \(\beta \bar{f} > G\), that is, the manager has no private incentives to breach. Without a CP, the shareholder then pays a zero salary to prevent a breach, but a positive expected salary, including an information rent, to induce a breach. Then, adopting a CP by the shareholder that aims to prevent a breach has no effect on the expected transfer as it is zero anyway.

However, the shareholder inducing a breach faces a tradeoff: adopting a CP (i) reduces the information rent, which gives a downward pressure on the expected transfer, but (ii) if the shareholder finds evidence she cannot help reporting it to the authority so as to receive partial leniency, which gives an upward pressure on the expected transfer. When
the corporate fine is low \( \overline{F} < F' \), the former effect outweighs the latter\(^59\) adopting a CP then allows the shareholder to reduce the salary cost of inducing breach, which pushes the authority to increase its costly investigation probability to be able to deter corporate crime. Conversely, when the corporate fine is intermediate \( F' \leq \overline{F} < F'' \), the latter effect outweighs the former: the shareholder inducing a breach would not adopt a CP. The availability of CPs then has no impact on the authority’s investigation probability.

### 2.5 Individual Leniency

In this section, we study how managerial leniency interacts with the effects of a CP. To that end, we extend our set-up by assuming that if the manager breaches the law he comes into possession of a piece of verifiable evidence, which he can (i) report to the shareholder \( (r_p = 1) \) or not \( (r_p = 0) \), and (ii) report to the authority \( (r_a = 1) \) or not \( (r_a = 0) \), where a report to the authority is observed by the shareholder. This set-up allows the shareholder to condition transfers on such reports. Similarly, the authority conditions fines on the manager blowing the whistle, which we denote by \( F^r \) and \( f^r \).

The timing of the game is adapted by taking into account that the manager can make reports either immediately after breaching the law, or after (possibly) payoff-relevant information comes available. Figure 2.4 indicates those stages by 4’ and 5’, respectively, which we refer to as the “ex-ante (reporting) stage” and “interim (reporting) stage.”

\[ \rho \sigma \overline{f} + (1 - \rho \sigma) \beta \overline{f} - \beta \overline{f} \]

\[ \beta \overline{f} \]

**Figure 2.4** Revised timing of the game. The manager can report immediately after he breaches (ex-ante stage 4’), or after the realization of payoff-relevant information (interim stage 5’).

\(^{59}\)The intuition runs as follows. The latter effect (i.e., the difference in the expected managerial fine with and without a CP, \( \rho \sigma \overline{f} + (1 - \rho \sigma) \beta \overline{f} - \beta \overline{f} \)) is less pronounced the higher the investigation probability is. The reason is that with a high investigation probability, the expected managerial fine is relatively high already without a CP. Now, if the corporate fine is low \( \overline{F} < F' \), then the investigation probability \( \beta \) needs to be relatively high by substitutability of the corporate fine and the investigation probability. This reduces the scope of the latter effect.
As the derivation of the equilibrium is tedious and replicates many of the steps taken in the previous section, we focus on the results that differ from the previous section. Subsection 2.5.1 deals with the impact of the adapted set-up on optimal transfers, Subsection 2.5.2 discusses the optimal individual leniency policy, and Subsection 2.5.3 states the impact of the individual leniency policy on the effectiveness of CPs.

2.5.1 Optimal Expected Transfers: Reporting Constraints

Since the manager now holds verifiable evidence of his breach, the shareholder faces an additional incentive compatibility constraint when offering the employment contract. She must ensure that her manager does not blow the whistle by reporting evidence to the authority so as to receive managerial leniency. We coin this constraint the reporting constraint and show how it affects the expected transfers.\footnote{Technically, there are several reporting constraints, because the manager may report to the authority at several points in time during the game. However, these reporting constraints boil down to one relevant constraint that dominates all others—see Appendix A.2.}

By the same reasoning as in the previous section, the authority optimally (i) sets the managerial fines $f^N$, $f^C$ and $f^R$ to their legal maximum $\overline{f}$; (ii) sets the corporate fines $F^N$ and $F^C$ to their legal maximum $\overline{F}$; and (iii) grants partial corporate leniency when the shareholder reports evidence to the authority, i.e., $F^R = \beta F - |\epsilon|$, thereby ensuring that the shareholder always reports when she has evidence of a breach. The formal proof is delegated to Appendix A.2 and is simultaneously derived with the optimal transfers.

If the authority grants managerial leniency, the reporting constraint turns up in the contracting problem of the shareholder inducing a breach, but also in the contracting problem of the shareholder preventing a breach, thus introducing a tradeoff. The following lemmas state the optimal expected transfers.

**Lemma 2.3 (Preventing a breach)** If the shareholder prevents a breach, she adopts a compliance program, resulting in expected transfer

$$E_R [\tau^p] = \max \left\{ \gamma^C \left( G - E_R [f] \right), G - f^*, 0 \right\}.$$ 

**Proof.** See Appendix A.2.1. \hfill \Box

If the shareholder prevents a breach she adopts a CP, because that (i) decreases the information asymmetry, while (ii) increasing the expected managerial fine. The shareholder now faces two ICs: she must not only make sure that the manager does not breach, but also that he does not “breach and blow the whistle” so as to possibly receive individual
This introduces the additional restriction \( E_R[t^n] \geq G - f^r \), that is, the expected payment when the manager does not breach must be at least as large as the managerial gain \( G \) when he breaches, minus the managerial fine \( f^r \) when he reports.

**Lemma 2.4 (Inducing a breach)** If the shareholder induces a breach without adopting a compliance program, the expected transfer is

\[
E_N \left[ t^b \right] = \max \left\{ \gamma^N \left( \beta \bar{f} - G \right), 0 \right\} + \max \left\{ \beta \bar{f} - f^r, 0 \right\},
\]

while if she instead adopts a compliance program and respectively requests or does not request evidence from the manager, the expected transfer is

\[
E_R \left[ t^b \right] = \max \left\{ \bar{f} - G, \left( 1 - \rho \sigma \right) \left( 1 - \beta \right) \bar{f}, f^r, 0 \right\},
\]

\[
E_R \left[ t^b \right] = \max \left\{ E_R[f] - G + \max \left\{ \beta \bar{f} - f^r, 0 \right\}, E_R[f] - f^r, 0 \right\}.
\]

**Proof.** See Appendix A.2.2.

If the shareholder induces a breach, she must ensure that the manager (i) breaches the law; (ii) does not report evidence immediately after having breached; and (iii) does not report after the realization of payoff-relevant information, i.e., profit \( \pi \) or signal \( \sigma \).

Suppose the shareholder does not adopt a CP. She then induces a breach by rewarding the manager if profit is high \( (\pi = 1) \), resulting in payment \( A \). She must also reward the manager for not blowing the whistle at any time, resulting in additional payment \( B \). Payment \( B \) comes in addition to payment \( A \) as it is paid for being silent, that is, it is being paid to the manager if he breaches the law and stays silent, but also if he does not breach the law as he then has nothing to confess and, thus, stays silent automatically.\(^{61}\)

Suppose now the shareholder adopts a CP. If she does not request evidence from the manager, payment \( C \) ensures that the manager breaches the law and does not blow the whistle immediately, while payment \( D \) ensures that the manager does not blow the whistle after the realization of signal \( \sigma = 0 \). If the shareholder does request to see evidence, she

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\(^{61}\) Managerial strategy “breach and report to the shareholder” is irrelevant as it is weakly dominated by the strategy “breach and report to the authority,” because \( f^r \leq f^R = \bar{f} \).

\(^{62}\) The strategy “adopt no CP and request evidence” is irrelevant as it entails a weakly higher expected transfer than the strategy “adopt a CP and request evidence”—see Appendix A.2.2.5.
rewards the manager if and only if he hands in evidence and does not blow the whistle. Noting that the shareholder cannot help to blow the whistle when she possesses evidence, the expected transfer must ensure that the manager does not (i) “not breach” \((E)\); (ii) “breach and report no evidence to the shareholder” \((F)\); and (iii) “breach and blow the whistle” \((H)\). The following corollary qualitatively summarizes Lemmas 2.3 and 2.4.

**Corollary 2.3** Individual leniency weakly increases both the expected transfer to induce a breach and the expected transfer to prevent a breach.

**Proof.** Comparing Lemmas 2.1–2.4 straightforwardly shows that the introduction of the reporting constraints weakly increases the expected transfers.

The authority faces a tradeoff when granting leniency to the manager: the reporting constraint weakly increases the expected transfer both to induce and to prevent a breach. Indeed, by Lemmas 2.3 and 2.4, individual leniency (i) weakly increases the expected transfer to induce a breach as the manager must be compensated for staying silent in stages 4’ and 5’, but (ii) also weakly increases the expected transfer to prevent a breach as she must compensate the manager for not “breaching the law and blow the whistle.”

**2.5.2 Optimal Individual Leniency Policy**

Provided the tradeoff faced by the authority, the following Proposition states the optimal individual leniency policy. We consider the authority granting either full individual leniency or no leniency. For the sake of brevity, we focus on the case in which monitoring through a CP is relatively precise, i.e., \(\rho_\sigma > (1 - \rho_\pi) / \rho_\pi\). Denote by \(\tilde{f}\) and \(\tilde{F}\) thresholds on the managerial and corporate fine, respectively.

**Proposition 2.3** When the manager blows the whistle, the authority grants individual leniency if and only if either

1. the managerial fine is low \((\tilde{f} \leq \tilde{f})\); or
2. the managerial fine is high \((\tilde{f} > \tilde{f})\) and the corporate fine is low \((\tilde{F} \leq \tilde{F})\).

The authority does not grant corporate leniency when the manager blows the whistle.

**Proof.** See Appendix A.3.

The reason that the authority does not grant corporate leniency when the manager blows the whistle is that the shareholder failed to prevent her manager from breaching
the law and should optimally be punished for that. The intuition behind the authority’s optimal individual leniency policy is explained in the next two paragraphs.

Suppose that the cap on the managerial fine is relatively low ($\bar{f} \leq \bar{f}$). The manager’s private incentive to breach the law is then relatively large, regardless of other parameters. Absent individual leniency, it is then relatively costly for the shareholder to prevent a breach, while costless to induce a breach. As a result, introducing the reporting constraint through individual leniency (i) has either no or a small upward impact on the expected transfer to prevent a breach, while (ii) substantially increasing the expected transfer to induce a breach due to the bribe necessary to keep the manager silent. Therefore, the authority optimally grants individual leniency when the manager blows the whistle.

Suppose now that the cap on the managerial fine is relatively high ($\bar{f} > \bar{f}$). The manager’s incentive to breach the law is then relatively low. Introducing the reporting constraint through individual leniency (i) increases the expected transfer to prevent a breach by $G$, and (ii) increases the expected transfer to induce a breach by $\beta \bar{f}$. Recall that the corporate fine $\bar{F}$ and the investigation probability $\beta$ are substitute instruments to deter corporate crime. Therefore, when the corporate fine is relatively low ($\bar{F} \leq \bar{F}$), the authority sets a relatively high investigation probability $\beta$, resulting in $\beta \bar{f} > G$. Thus, the reporting constraint increases the expected transfer to induce a breach by more than the expected transfer to prevent a breach: the authority optimally grants individual leniency when the manager blows the whistle. By a symmetric reasoning, when the corporate fine is relatively high ($\bar{F} > \bar{F}$), the authority sets a relatively low investigation probability $\beta$, resulting in $\beta \bar{f} \leq G$ in which case no individual leniency is optimal.

2.5.3 Individual Leniency and Compliance Programs

The following Proposition states the interaction between individual leniency and CPs.

**Proposition 2.4** Individual leniency reduces the scope of both the welfare detrimental and the welfare enhancing effect of compliance programs.

**Proof:** By Lemmas 2.3 and 2.4 and their proofs in Appendix A.2, granting individual leniency introduces reporting constraints. If such a reporting constraint becomes binding, CPs are ineffective at reducing the expected transfer, because information asymmetries have become irrelevant.

The intuition is straightforward. If the authority grants individual leniency, then the reporting constraint may become binding, thereby determining the expected transfer. As a result, adopting a CP would not decrease the expected transfer, since it does not affect the reporting constraint. That is, adopting a CP does not affect the shareholder’s
employment cost whenever the reporting constraint binds. Therefore, both the welfare
detrimental and welfare enhancing effect of CPs are reduced.

The finding that the welfare enhancing effect of CP is reduced by individual leniency
does not mean that individual leniency has a perverse effect on deterring corporate crime. After all, the authority chooses whether or not to grant individual leniency and would, therefore, only do so if it helps the authority to deter illegal activities. The result rather implies that individual leniency and CPs are substitute tools to decrease the shareholder’s relative profitability of inducing a breach. Without individual leniency, a CP would be used by the shareholder to reduce the expected transfer needed to prevent corporate crime, thereby reducing the (costly) investigation probability. However, implementing an optimal individual leniency policy reduces the investigation probability by more through changing the shareholder’s contracting problem.

2.6 Policy Implications and Discussion

The set-up of our model accommodates for a discussion of the U.S. as well as the E.U. practice. Under E.U. competition law, individuals are not sanctioned and, thus, individual leniency policy is non-existent: the model of Section 2.4 applies with a zero cap on the managerial fine ($\tilde{f} = 0$). In contrast, U.S. antitrust law targets individuals and encompasses individual leniency policy: the models of both Sections 2.4 and 2.5 apply with a positive cap on the managerial fine ($\tilde{f} > 0$).

U.S. and E.U. corporate leniency program. In both the U.S. and the E.U., the corporate leniency program (CLP) allows firms to blow the whistle in exchange for full immunity from corporate legal sanctions. Our results suggest that partial corporate leniency is more effective, because that would still incentivize the corporation to come forward, while not reducing the corporate sanction to zero. However, in practice it may be extremely difficult to determine the optimal amount of leniency, because the authority needs to estimate the corporation’s benefit from the breach, which is different for each (type of) breach. The danger is then that the authority implements a policy granting too little leniency, which makes the CLP ineffective altogether. Therefore, although we find partial leniency to be optimal in theory, full leniency may be a practical second-best solution.63 Also, we note that for violations involving horizontal strategic interaction, optimal policy should weigh our “partial leniency result” against ex ante strategic deterrence considerations of full leniency.

63Spagnolo (2008) states that the number of leniency applications increased twentyfold after the introduction of automatic full immunity for the first corporation to self-report. This may suggest that an inappropriate level of partial immunity does not have the desired reporting and deterrence effect.
U.S. corporate leniency program. The U.S. CLP not only protects the corporation, but also provides involved employees with full immunity from legal sanctions. Hammond (2004) argues that such a “blanket” covering the entire corporation and its employees has the objective to incentivize employees to report illegal acts to their superiors so as to file for leniency together. However, we show that such a policy has a perverse effect: breaching the law becomes cheaper for the economic agent executing the illegal act, i.e., the employee. This makes corporate crime more attractive to the corporation as the employee does not need to be heavily compensated (indemnified) by its superiors to breach the law.

This result is particularly relevant for types of corporate crime that do not involve strategic interaction with other conspirators. The blanket covering employees then results in a lower expected cost of breaching the law for the entire corporation. However, when the illegal act involves coordination with others, which is the case in cartels, then our result should be balanced with the impact of the blanket on strategic considerations. Co-conspirators anticipate that the blanket reduces the corporation’s expected cost of corporate crime, which results in the fear that a rival corporation files for leniency, thereby ex ante destabilizing the conspiracy. Thus, it is important that competition policy balances the blanket’s indirect destabilizing effect through strategic interaction with our direct corporate crime stabilizing effect through reducing the expected indemnification costs.

U.S. individual leniency program. The U.S. individual leniency program (ILP) grants the involved employee full immunity from legal sanctions when coming forward with incriminating evidence. If the breach involves strategic interaction with a co-conspirator, such a policy destabilizes criminal cooperation as each conspirator fears that the other files for individual leniency.\footnote{See, for example, Motta and Polo (2003) and Chen and Rey (2007).} We show that individual leniency not only entails such horizontal destabilization, but also vertical destabilization. Individual leniency makes breaching the law more expensive for the employee’s superior (the corporation), as the employee needs to be bribed not to file for individual leniency. This makes breaching the law relatively more expensive for the entire cooperation as a vertical structure.

However, we also show that individual leniency entails a perverse effect. Individual leniency not only increases the cost of a breach for the corporation (through the cost of bribing the employee not to file for leniency), it also increases the cost of preventing a breach for the corporation, because the employee must be compensated not to “breach the law and file for leniency” instead of not breaching the law.

Our results suggest that authorities should only grant individual leniency if the expected managerial fine is either particularly low or particularly high. In practice, how-
ever, it may be very difficult to determine the managerial fine perceived by the manager. Providing individual leniency for all types of corporate crime may then be a practical second-best solution, although it entails the perverse effect outlined above and may, thus, increase the profitability of some types of corporate crime.

**Vertical race to the courthouse.** The ILP has been used rarely in practice (Spagnolo, 2008). Hammond (2004) argues that this is not a sign that the ILP is ineffective: an employee considering to blow the whistle through the ILP can tell its superior who then has an incentive to file for leniency on behalf of the entire corporation as a “vertical structure” through the CLP. Therefore, it is argued that the mere existence of the ILP encourages the usage of the CLP.

However, the leniency policy as outlined in this chapter entails another effect by misaligning the incentives of the corporation and the employees. Our results suggest that it is optimal not to provide the employee (corporation) immunity when the corporation (employee) files for corporate (individual) leniency. Such a policy effectively introduces a “vertical race to the courthouse” between the corporation and the employee: the corporation and the employee cannot trust each other to stay silent.

**Compliance programs and fine reductions.** While “the [European] Commission considers that it is not appropriate to take the existence of a compliance programme into account as an attenuating circumstance for a cartel infringement,” the U.S. Sentencing Guidelines allow for a mitigation of the corporate fine when the corporation had a well-designed CP in place at the time of the infringement, in some cases up to 95%. Our results suggest that it is not optimal to apply such a fine reduction. The reason is that monitoring through a CP can be used to indeed prevent corporate crime, but also to encourage it. Thus, our results confirm the European Commission’s view.

However, we do realize that our model is based on the monitoring aspect of CPs and leaves out practicalities of how exactly the CP is implemented. Therefore, the potentially perverse effect of reducing information asymmetries may not always be present. In particular, the perverse effect may be less relevant when the shareholder delegates the implementation and execution of the CP to a third party like an in-house or external lawyer that can credibly live up to its reputation.

**Desirability of compliance programs.** Focusing on the monitoring aspect of CPs, we argue that CPs may be beneficial in the fight against corporate crime when individual sanctions are low, but detrimental when individual sanctions are high. Although we

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65 See fn. 35 and 47, respectively.
do not want to make the claim that firms adopt CPs with the only objective to reduce information asymmetries so as to promote its employees to misbehave, the result does however suggest a potential perverse effect of increasing the monitoring of harmful activities. Since individual sanctions are non-existent in the E.U. and relatively high in the U.S., our results suggest that monitoring behavior through CPs is more desirable in the E.U. than in the U.S.

2.7 Concluding Remarks

In this chapter, we examined the desirability of the firm’s monitoring effort and its impact on optimal (competition) policy. We stressed that the information obtained by monitoring employees through a CP may be used to prevent corporate crime, but also to encourage corporate crime. Thus, we argued that corporations having adopted a CP should not automatically qualify for a discount on the corporate fine, which contradicts the U.S. Federal Sentencing Guidelines. Also, we provided arguments that the corporate leniency program may be improved upon by granting partial immunity instead of full immunity to the corporation, while granting no immunity to the involved individuals. Finally, we showed that for some types of corporate crime an individual leniency program entails the perverse effect of actually encouraging breaches of the law.

We assumed that a CP is costless to implement so as to not complicate the analysis with exogenous fixed costs. If the adoption of a CP entails a fixed cost, then the qualitative results remain unchanged; the only difference would be that, in equilibrium, a CP is adopted for less parameter values, because the shareholder would compare its cost with the reduction in salary cost caused by the CP.

Our results may be reinterpreted in light of the literature on collusion between the middle and lower layer of a three-tier hierarchy—see for instance Faure-Grimaud, Laffont and Martimort (1999) for a model in an adverse selection framework. Our hierarchy can be seen as one in which the highest layer has delegated (some) authority to the middle layer that, in turn, delegates to the lower layer. Our results then imply that improving the contracting framework at the bottom, in our model through lower information asymmetries, may either reduce or increase the payoff of the highest layer. This is, to the best of our knowledge, in contrast to the existing literature in which such improvements always negatively affect the highest layer.66

66 Some E.U. Member have however criminal laws on the national level—see fn. 51
67 We are grateful to Yeo-Kee Cho for pointing this out.
3 Short-Term Managerial Contracts and Cartels

Abstract. This chapter shows how a series of commonly observed short-term CEO employment contracts can improve cartel stability compared to a long-term contract. When a manager’s short-term appointment is renewed if and only if the firm hits a certain profit target, then (i) defection from collusion results in superior firm performance and, thus, reduces the chance of being fired immediately, while (ii) future punishment results in inferior firm performance, thereby increasing the chance of being fired in the future. The introduction of this re-employment tradeoff intertwines with the usual monetary tradeoff and can improve cartel stability. Studying the impact of fixed versus variable salary components, I find that fixed components can facilitate collusion with a short-term contract, while not affecting cartel stability with a long-term contract. I extend the model to argue that short-term, renewable contracts are a source of cyclical collusive pricing. Finally, interpreting the results in light of firm financing shows how debt-financed firms can form more-stable cartels than equity-financed firms.

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3.1 Introduction

The majority of the literature on cartels and collusion treats the firm as a profit-maximizing decision maker, thereby deriving key insights on cartel stability and behavior from a profit-maximizing perspective. However, cartels often involve firms having separated ownership and control in such a way that the incentives of the key decision maker (CEO, manager) are not fully aligned with those of the profit-maximizing shareholders. The resulting corporate governance factors can have a key impact on the operation of cartels.\(^6\)

This chapter studies how short-term, renewable employment contracts affect cartel stability and behavior. Although one may expect that short-sighted CEOs are incapable of running a stable cartel,\(^7\) I show how short-termism generated through such contracts can in fact improve cartel stability. Moreover, contrary to conventional wisdom that profit-dependent remuneration can incentivize CEOs to misbehave, the model shows that short-term contracts with fixed (as opposed to: variable) salary components can improve cartel stability.

From a sample of 375 CEO employment contracts of large public corporations, Schwab and Thomas (2006) find that 81% specify a length of five years or less, with a mean of 3.6 years. Similarly, Gillian, Hartzell and Parrino (2009) find that the median and mean length in a sample of 184 S&P 500 CEO contracts is 3.4 and 3.0 years, respectively. Moreover, recent work by Jenter and Lewellen (2010) indicates that CEO turnover decisions are very sensitive to stock price performance: from a sample of 2,569 publicly traded U.S. firms from 1992 to 2005, they find that 44% of CEOs left the firm within 4 years as a result of bad firm performance.\(^8\) These empirical findings show that executives typically have a short-term, renewable employment contract, that is, a contract for a finite period of time which is renewed if and only if the firm performs sufficiently well.

In this chapter, I take such a typical CEO contract as exogenously given and aim to understand its impact on the operation of cartels.\(^9\) Assuming that managerial remuneration as well as the probability of contract renewal is positively related to firm profit, the manager can stochastically increase profit by forming a cartel with rival firms, while even further stochastically increasing profit by defecting from the collusive agreement.

\(^6\) See Buccirossi and Spagnolo (2007) for a research agenda on corporate governance factors and collusion.

\(^7\) For example, Aubert, Rey and Kovacic (2006) argue that short-term contracts may incentivize managers to apply for leniency as they may leave the firm anyway; this effect tends to destabilize collusion.


\(^9\) The model abstracts away from the underlying motivation of adopting short-term, renewable contracts over long-term contracts or no contract at all. Such motivations include risk sharing or adverse selection—see the papers referenced above. In more general principal-agent models, Aubert (2009) and Chapter 2 of this dissertation endogenously derive optimal employment contracts.
Two interrelated forces then dictate cartel stability. The manager compares the immediate expected salary gain resulting from defection, with the future expected salary losses resulting from punishment—the monetary tradeoff. The manager also compares the immediate increase in the probability of contract renewal resulting from the higher expected profit during defection, with the future decrease in the probability of contract renewal resulting from the lower expected profits during future punishment—the re-employment tradeoff. While the monetary tradeoff parallels the familiar problem faced by integrated, profit-maximizing integrated firms engaging in cartelization, the re-employment tradeoff originates from the manager’s fear of not being rehired.

Whether a series of short-term, renewable contracts strictly enhance cartel stability compared to a long-term contract depends on two effects. First, the manager is unsure whether he will be rehired even if he colludes and, hence, the game ends for him with some positive probability: this is a collusion-destabilizing effect. Second, noting that after defection the manager only cares about re-employment if the expected remuneration during punishment is not too small, the re-employment tradeoff can dominate the collusion-destabilizing effect if the probability of re-employment is relatively low during punishment, while the expected remuneration during punishment is indeed not too small. This ensures that the manager misses out (in expectation) on a substantial amount of future salary as he is fired in the future with a high probability.

The model also shows how a fixed salary component can stabilize collusion when a short-term contract is in place, while not affecting cartel stability when a long-term contract is in place. The intuition is that with a long-term contract, the fixed salary component is paid out in every period independent on managerial behavior and, therefore, does not affect the manager’s incentives to collude. However, with a short-term contract, the fixed component is only paid out in periods in which the manager is indeed working for the firm. The manager anticipates that defection leads to a higher probability of being fired in the future—that is, losing out on future fixed salary components—which may amount to a large expected loss when he is relatively patient. In that case, the board of shareholders (more generally: the principal) optimally makes the fixed component an important part of the manager’s salary so as to stabilize collusion.

In addition, I study the case in which managers may revert from punishment to collusion when one of the managers is fired and replaced by another. The rationale behind such “serial collusion” is that managerial replacement restores the trust needed for a cartel to work. Such restoration of trust destabilizes collusion. The reason is that serial collusion increases the continuation value of defection, because (i) defection instantaneously increases the probability that the rival manager is fired, in which case collusion is immediately restored, and (ii) punishment is less fierce as it ends when the rival manager is fired at some point.
PART I. MANAGERIAL INCENTIVES IN CARTELS

Finally, I consider the case in which managers engage in multiple sequential interactions within the span of the employment contract, thereby showing that short-term employment contracts may be an explanation for cyclical collusive pricing. Suppose, for example, that the manager is halfway through his employment contract and has been colluding up until now, but that earlier firm profits have been extremely low due to random market conditions. In such a case, the profits during the second half of his employment contract should be extremely high for the manager’s contract to be renewed. Since extremely high profits are very unlikely to occur even with collusion, the manager anticipates that his contract is unlikely to be renewed, resulting in defection from the collusive agreement. However, rational managers fix such destabilization by ex ante agreeing that the collusive strategy entails collusion if and only if earlier firm profits during the same employment contract have not been too low. The optimal collusive strategy then entails waves of competition, i.e., price wars, in equilibrium.

This chapter is organized as follows. Section 3.2 discusses related literature. Section 3.3 presents the model, identifies the key tradeoff, and shows how short-term contracts can increase cartel stability. Section 3.4 investigates the impact of fixed salary components and serial collusion on cartel stability. Section 3.5 considers an employment contract covering multiple interactions on the product market over the contractual period, thereby allowing for cyclical collusive pricing. In Section 3.6, I reinterpret the results in light of firm financing, thereby arguing how debt-financed firms can form more-stable cartels than equity-financed firms. Section 3.7 concludes.

3.2 Related Literature

This chapter relates to two strands of literature: (i) managerial incentives in cartels, and (ii) collusion and price wars. I discuss how my work relates to each in turn.

Managerial incentives in cartels. This chapter departs from the traditional literature on cartels and collusion by separating the firm’s ownership and control so as to focus on the impact of short-term contracts on cartel stability and behavior. The papers discussed hereafter deal with the impact of several other common characteristics of managerial compensation on cartels.

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72 The strategic delegation literature considers a related issue of how delegation affects the competitive outcome on the product market. The seminal papers are Fershtman and Judd (1987) and Sklivas (1987), which were preceded by Fershtman (1985) and Vickers (1985). Lamberti and Trombetta (2002), De Lamirande, Guigou and Lovat (2011), and Chapter 2 of this dissertation extend the seminal strategic delegation models to a repeated setting so as to allow for collusion.
Spagnolo (2000) shows that stock-related compensation improves the stability of collusion: if stock markets have perfect foresight and are informed about the collusive agreement, then future punishment following a defection is immediately discounted in current stock prices, thereby instantaneously reducing the gain from defection. Moreover, Spagnolo (2005) argues that collusion is more stable when managers have a preference for income smoothing, that is, when managers are provided with low-powered incentives so that they prefer a smooth stream of profits over time. The manager is then averse to variance in profits, which disincentivizes him to defect as that leads to a high profit today, followed by low punishment profits in the future. Also, Spagnolo (2005) shows that well-chosen capped bonus plans allow collusion to be stable for any discount factor, because the gain from defection will be capped. In contrast to Spagnolo’s work, this chapter specifically allows contracts to be finite, thereby introducing a collusion-stabilizing tradeoff based on the manager’s fear to be fired.

Since cartels are illegal, a written contract between the firm owner and the manager that explicitly induces the manager to form a cartel is not enforceable in court. Therefore, the firm owner needs to rely on a relational contract with the manager to induce cartelization. Chen (2008) shows how such a relational contract between the owner and the manager facilitates collusion as (i) it prevents the manager to cheat on the product market, because defection results in collusion breaking down in which case the owner will pay nothing to the manager and the relational contract breaks down, while (ii) the owner cannot cheat on the relational contract by inducing the manager to defect, because the owner cannot credibly commit to rewarding the manager for a defection. Thus, Chen (2008) concludes that there exists no self-enforcing relational contract that can induce the manager to cheat on the product market. This chapter, however, circumvents the need for a relational contract as contracting on profits in a short-term contract introduces a new tradeoff that can be used to stabilize collusion.

The manager’s decision to form a cartel may interfere with other managerial duties. Aubert (2009) builds an elegant model of double moral hazard in which the manager chooses whether to exert costly effort which increases profits, while either competing or colluding on the product market. In such a scenario, a high-powered incentive contract aimed at inducing the manager to exert effort has the perverse effect of also inducing the manager to form a cartel. This conflict between incentives results in equilibrium contracts inducing a suboptimal effort level, leading to welfare losses even if there is no collusion in equilibrium. In a similar model of (single) moral hazard, Chapter 2 of this dissertation considers a three-tier hierarchy, authority-shareholder-manager, so as to study the effects of

\footnote{In a market with stochastic, autocorrelated demand development, Neubecker (2005) confirms Spagnolo's (2000) finding that stock-based compensation facilitates collusion.}
intra-firm monitoring on fighting corporate crime, such as cartels. While Aubert (2009) and Chapter 2 take a general approach to open up the black box of the profit-maximizing firm so as to endogenously determine the optimal contract, this chapter takes the short-termism and renewability of observed CEO contracts as exogenously given.

More generally, Bull (1987) and Baker, Gibbons and Murphy (2002), for instance, study relational contracts. They argue that such informal agreements and unwritten codes of conduct are widespread within firms and have an important impact on the incentives of individuals. Baker, Gibbons and Murphy (2002) show that the optimal allocation of decision rights minimizes the maximum temptation to renege on relational contracts. This chapter takes the perspective of common formal, short-term, renewable CEO contracts.

**Cartels and price wars.** Empirical work shows that episodes of collusion often involve price wars—see, for example, Slade (1990), Harrington (2006), and Levenstein and Susan low (2006). As a founder of cartel theory, Stigler (1964) pointed out that prices are high during cartelization, while *out-of-equilibrium* price wars occur after cartel breakdown. Since then, many authors have contributed to explaining patterns of elevated prices and price wars in *equilibrium*.

Such explanations include imperfect monitoring with demand uncertainty (Green and Porter, 1984; Abreu, Pearce and Stacchetti, 1986), demand cyclicality (Rotemberg and Saloner, 1986; Haltiwanger and Harrington, 1991), learning about unknown demand parameters with exogenous demand shocks (Slade, 1989), renegotiation of the collusive pie (Levenstein, 1997), and inducing exit of “dying” cartel members (Fershtman and Pakes, 2000). These contributions treat the firm as profit-maximizing integrated entities.

In contrast, this chapter presents an explanation for equilibrium price wars based on managerial issues. Since executives’ compensation depends on their performance during the *full* contractual employment period, they optimally condition their pricing decision on profits realized earlier during their contractual employment period.

### 3.3 A Model of Cartel Stability with Short-Term Contracts

This section introduces the model (3.3.1); identifies the tradeoff associated with short-term contracts and cartel stability (3.3.2); shows that short-term contracts can improve cartel stability (3.3.3); and performs comparative statics of the key proposition (3.3.4).

---

74 I follow the literature by using the term “price wars” for episodes of lower prices than the collusive price, which can be caused by cartel break-down or endogenously arising as part of the collusive equilibrium.

75 More recent contributions include the cartel members’ concerns about detection by the antitrust authority (Harrington, 2004a), lifting prices after detection to push for lower damages in court (Harrington, 2004b), and cost variability in the presence of buyer detection (Harrington and Chen, 2006).
3.3.1 Set-up of the Model

**Outline & players.** Consider two firms $i \in \{1, 2\}$, where each firm $i$ is owned by shareholder $i$ who employs a manager $i$ to run the firm. In an infinitely repeated game, the managers interact with each other on the product market in each period $t \in \{1, ..., \infty\}$. I refer to shareholders in the female form (she/her), managers in the male form (he/his) and firms in the neutral form (it/its). Figure 3.1 graphically summarizes the players.

![Figure 3.1 The players: shareholders and managers.](image)

**Managerial action.** In each period $t \in \{1, ..., \infty\}$, both managers simultaneously decide whether to compete or collude on the product market. Managerial behavior stochastically affects the realization of the firms’ profits\(^7\). Let profit of firm $i$ in period $t$ be a random variable $\pi_t \geq 0$ with cumulative distribution function (CDF)

$$F_a(x) = \Pr[\pi_t \leq x | a], \forall x \geq 0,$$

where $a \in \{N, C, D, T\}$ represents the combination of behavior of manager $i$ and $j$ on the product market,

1. $a = N$ if both managers compete (Nash competition);
2. $a = C$ if both managers collude (Collusion);
3. $a = D$ if manager $i$ competes and manager $j$ colludes (Defection by manager $i$);
4. $a = T$ if manager $i$ colludes and manager $j$ competes (manager $i$ has been Tricked, because manager $j$ defected).

---

\(^7\)Gillian, Hartzell and Parrino’s (2009) empirical results show that an explicit short-term contract is more likely to be implemented when there is greater uncertainty about firm performance.
Assume that $F_a(x)$ is increasing over the entire domain $x \geq 0$, i.e., $\frac{\partial F_a(x)}{\partial x} > 0$ has full support. Defection is more profitable in expectation than collusion, which is, in turn, more profitable in expectation than Nash competition, in the sense of first order stochastic dominance, that is,

$$F_D(x) \leq F_C(x) \leq F_N(x),$$

for every $x \geq 0$, with a strict inequality for at least one value of $x$. By definition of stochastic dominance, expected profit in period $t$, $E_a(\pi_t)$, then satisfies $E_D(\pi_t) > E_C(\pi_t) > E_N(\pi_t)$. Moreover, collusion stochastically dominates being tricked, that is,

$$F_C(x) \leq F_T(x),$$

for every $x \geq 0$, with a strict inequality for at least one value of $x$. Thus, expected profits are such that $E_C(\pi_t) > E_T(\pi_t)$.

To stay in line with the literature and to focus on the impact of short-term contracts on cartel stability, I consider the grim-trigger collusive strategy: a manager colludes as long as his rival colluded in all previous periods, but reverts to Nash forever after a defection.

**Shareholder’s actions.** The shareholder appoints her manager for one period by offering a contract that is renewed for another period if and only if the firm’s profit $\pi_t$ is above some threshold profit level $\pi \in [0, \infty)$ chosen by the shareholder in period $t = 0$. Otherwise, the manager is fired and replaced by a new manager. This simple rule of *perform well or beat it* is motivated by (i) observations of CEOs and managers being fired after bad firm performance;\(^\text{77}\) (ii) the debate in academic journals as well as in the popular press that shareholders are focused on the short-term;\(^\text{78}\) and (iii) the fact that the stock market allows investors (shareholders) to invest in a variety of financial products, thus rationalizing the shareholder to require a minimum threshold profit level that at least *beats the stock market*.\(^\text{79}\)

In period $t = 0$, the shareholder also sets the managerial per-period salary scheme, consisting of a fraction $\beta \in [0, 1]$ of per-period profit $\pi_t$, plus a fixed component $\alpha \geq 0$ in each period.\(^\text{80, 81}\)

\(^{77}\)See, for example, Lausten (2002), Farrell and Whidbee (2003), and Jenter and Kanaan (2006).

\(^{78}\)See, for example, Bolton, Scheinkman and Xiong (2006).

\(^{79}\)Kaplan and Minton (2010) make the specific point that CEO replacement is related to firm performance relative to the performance of the overall stock market.

\(^{80}\)This chapter does not consider shareholders colluding in setting managerial incentive schemes. See Lambertini and Trombetta (2002) and Chapter 4 for models in which firm owners collude on this.

\(^{81}\)To focus on the impact of short-term managerial contracts on cartel stability, I abstract away from dynamic contracting and do not allow managerial compensation to be based on profit realizations in previous or
**Information.** Managerial behavior is observable to the rival manager, but unobservable to shareholders. The motivation is that close managerial interaction on the product market reveals their actions to each other. However, as cartels are illegal, it would be virtually impossible for managers to credibly communicate to shareholders that there is a cartel without creating suspicion from the law enforcers.

**Payoffs and objectives.** In each period, the manager receives his salary, while the shareholder receives realized firm profit minus managerial salary. In period $t$, the shareholder’s net profit $\Pi_t(\pi_t)$ and the manager’s salary $S_t(\pi_t)$ are, respectively,

$$\Pi_t(\pi_t) = (1 - \beta) \pi_t - \alpha,$$

$$S_t(\pi_t) = \alpha + \beta \pi_t.$$

The manager has limited liability, which is taken care of by $\alpha$ and $\beta$ being non-negative by assumption. The shareholder and the manager are risk neutral, have zero outside options, and discount payoffs with factor $\delta$. The manager’s objective is to maximize his discounted stream of expected payoffs. The owner’s objective is to maximize cartel stability.\footnote{It is left for future work to consider the owner to maximize her discounted stream of expected payoffs.}

**Timing.** In period $t = 0$, both shareholders independently set salary scheme $(\alpha, \beta)$, as well as the threshold profit level $\pi$ that a manager needs to realize to be reappointed. In all subsequent periods $t \in \{1, \ldots, \infty\}$, (i) the managers interact on the product market by taking action pair $a \in \{N, C, D, T\}$; (ii) firm profit $\pi_t$ is realized; and (iii) the manager is either fired or reappointed, depending on the realization of profit and the profit threshold level $\pi$ set in period $t = 0$. The timing of the game is graphically depicted in Figure 3.2.

![Figure 3.2 Timing of the game.](image)

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Note: \footnote{Section 3.3 considers the contract to be contingent on previous profit realizations; for compensation schemes based on future profit realizations, see Spagnolo (2000), discussed in Section 3.2.}
3.3.2 Cartel Stability: Monetary and Re-employment Tradeoff

To focus on the main tradeoff, I assume for now that managerial salary entails no fixed component, i.e., $\alpha = 0$. Subsection 3.4.1 relaxes this assumption.

As usual in the literature on collusion, the measure of cartel stability is the lowest discount factor $\delta$ such that the gain from defection does not exceed the expected discounted punishment: the lower is this discount factor, the more stable is the cartel.

**Benchmark stability.** Before solving the game outlined above, consider the benchmark model in which the manager has a long-term employment contract: he is hired forever without ever being fired. In that case, the necessary and sufficient condition for collusion to be stable is

$$\sum_{t=1}^{\infty} \delta^{t-1} \beta E_C (\pi_t) \geq \beta E_D (\pi_t) + \sum_{t=2}^{\infty} \delta^{t-1} \beta E_N (\pi_t),$$

iff.

$$\frac{\delta}{1 - \delta} \frac{(E_C (\pi_t) - E_N (\pi_t))}{A} \geq \frac{E_D (\pi_t) - E_C (\pi_t)}{B} \geq \frac{E_N (\pi_t)}{C},$$

which represents the familiar result that collusion is stable if and only if the immediate expected monetary gain from defection ($C$) is not larger than the expected monetary loss from punishment in each future period ($B$), discounted to the present ($A$). Fraction $\beta$ does not turn up in the stability condition as it cancels out in each term.

**Stability with short-term contracts.** For notational convenience, denote by $G_a (x) = 1 - F_a (x) = \Pr \{ \pi_t \geq x \mid a \}$ the probability of realizing profit $\pi_t \geq x$ when the managers take action combination $a \in \{ N, C, D, T \}$. Thus, given that the shareholder requires a profit of at least $\pi$, the probability of re-employment for another period is $G_a (\pi)$. The following lemma states the stability of collusion in the model with short-term contracts.

**Lemma 3.1** With short-term contracts, collusion is stable if and only if

$$\delta \left( \frac{G_C (\pi)}{1 - \delta G_C (\pi)} E_C (\pi_t) - \frac{G_D (\pi)}{1 - \delta G_N (\pi)} E_N (\pi_t) \right) \geq E_D (\pi_t) - E_C (\pi_t).$$

\(^{83}\)In reality, even if the manager has a long-term employment contract, the shareholders may find some way to fire the manager, for example, by creatively interpreting the just cause doctrine to terminate the contract or to settle on an appropriate “golden handshake” with the manager. In this chapter, to focus on the impact of contract duration on cartels, I abstract away from such behavior and implicitly assume that the termination costs of a long-term contract are infinitely high.
Proof. Collusion is stable if and only if the discounted expected payoff from defection is not larger than the discounted expected payoff from collusion, i.e., if and only if

\[
\sum_{t=1}^{\infty} (\delta G_C (\pi))^{t-1} \beta E_C (\pi_t) \geq \beta E_D (\pi_t) + \delta G_D (\pi) \sum_{t=1}^{\infty} (\delta G_N (\pi))^{t-1} \beta E_N (\pi_t),
\]

iff.

\[
E_C (\pi_t) \geq E_D (\pi_t) + \delta G_D (\pi) \frac{E_N (\pi_t)}{1 - \delta G_N (\pi)},
\]

which yields condition (3.3) when rearranging terms.

The stability condition in Lemma 3.1 compares the immediate expected gain from defection (RHS) with the discounted expected future losses from punishment (LHS). As is the case in the benchmark stability condition, fraction \( \beta \) cancels out in each term. Stability now depends on two interrelated tradeoffs: (i) the immediate expected monetary gain from defection, compared with the discounted expected monetary loss from future punishment (monetary tradeoff), and (ii) the immediate increase in re-employment probability from defection, compared to the future decrease in re-employment probability due to punishment (re-employment tradeoff).

The monetary tradeoff and the re-employment tradeoff are intertwined. To gain intuition, I rewrite condition (3.3) as

\[
\frac{G_C (\pi) \delta}{1 - G_C (\pi) \delta} (E_C (\pi_t) - E_N (\pi_t)) + \left( \frac{G_C (\pi) \delta}{1 - G_C (\pi) \delta} - \frac{G_D (\pi) \delta}{1 - G_N (\pi) \delta} \right) \frac{E_N (\pi_t)}{E_D (\pi) \delta} \geq E_D (\pi_t) - E_C (\pi_t),
\]

which shows that collusion is stable if and only if

(A) the immediate expected monetary gain from defection is not larger than

(B) the future per-period expected monetary loss from punishment, taking into account

(C) that the probability of re-employment is \( G_C (\pi) \) in each equilibrium period, which

(D) increases to \( G_D (\pi) \) in the period of defection, while

(E) decreasing to \( G_N (\pi) \) in all following punishment periods.

Below, I describe the intuition behind these effects and how they compare to the effects in the benchmark model.
(A) Monopoly gain. The expected monopoly gain from defection, \( E_D (\pi_t) - E_C (\pi_t) \), is the same as in the benchmark model. The reason is that the immediate expected monopoly gain is not contingent on whether the manager will be rehired in the future.

(B) Monetary loss. Provided that a punishment period is reached, the per-period expected monopoly loss from punishment, \( E_C (\pi_t) - E_N (\pi_t) \), is the same as in the benchmark model, because the expectations over profit realizations do not change by allowing managers to be fired.

(C) Continuation probability. In equilibrium, the probability that a manager is being reappointed is \( G_C (\pi) \) in each period, whereas this probability is one in the benchmark model. When discounting the expected monopoly losses from punishment \( (B) \) to the present, we should, therefore, premultiply the discount factor by \( G_C (\pi) \). This decreases the manager’s discounted expected loss of future punishment compared to the benchmark model and, thus, has a collusion-destabilizing effect.

(D) Re-employment gain. Defection results in a one-time increase in the probability of re-employment from \( G_C (\pi) \) to \( G_D (\pi) \). As a result, although the expected monopoly payoff decreases to \( E_N (\pi_t) \) after defection, the continuation probability of the game increases from \( G_C (\pi) \) to \( G_D (\pi) \). This effectively leads to a reduction in the expected loss from punishment, which is indicated by the numerators of the factors that premultiply \( E_N (\pi_t) \) in condition (3.4). This reduction in the loss from punishment amounts to destabilizing collusion.

(E) Re-employment loss. Punishment leads to a decrease in the probability of reappointment from \( G_C (\pi) \) to \( G_N (\pi) \) in all future periods. Therefore, not only decreases the expected monopoly payoff to \( E_N (\pi) \), the continuation probability in all future periods of the game decreases from \( G_C (\pi) \) to \( G_N (\pi) \). This makes punishment fiercer through an increase in the expected loss from punishment, which is indicated by the denominators of the factors that premultiply \( E_N (\pi_t) \) in condition (3.4). This increase in the loss from punishment amounts to stabilizing collusion.

3.3.3 Short-Term Contracts Can Increase Cartel Stability

Given profit threshold level \( \pi \), Proposition 3.1 states the characteristics of the probability distributions over profits \( F_a (\cdot) \) such that collusion with short-term contracts is more stable than collusion with long-term contracts.
Proposition 3.1  Collusion with short-term contracts and threshold profit level \( \pi \) is more stable than collusion with long-term contracts if and only if

\[
\frac{E_C (\pi_t)}{E_N (\pi_t)} < \frac{1 - \delta G_C (\pi)  - (1 - \delta) G_D (\pi)}{1 - \delta G_N (\pi)},
\]

(3.5)

Proof. Collusion is more stable compared to the benchmark model if and only if condition (3.3) is satisfied for more discount factors than condition (3.2), i.e., if and only if

\[
\delta \left( \frac{G_C (\pi)}{1 - G_C (\pi)} E_C (\pi_t) - \frac{G_D (\pi)}{1 - G_N (\pi)} E_N (\pi_t) \right) > \frac{\delta (E_C (\pi_t) - E_N (\pi_t))}{1 - \delta},
\]

(3.6)

which yields condition (3.5) when simplifying. \( \square \)

Short-term contracts stabilize collusion if and only if (i) the increase in reappointment probability during defection from \( G_C (\pi) \) to \( G_D (\pi) \) is relatively small compared to the reduction in reappointment probability during punishment \( G_C (\pi) \) to \( G_N (\pi) \) (RHS), while (ii) the monetary loss during punishment from \( E_C (\pi_t) \) to \( E_N (\pi_t) \) is not too large (LHS). The intuition is based on the following three forces.

First, with a short-term contract, the manager is *ex ante* unsure whether he will be rehired even if he colludes. This has a destabilizing impact on collusion as it incentivizes the manager to deviate so as to grab as much salary as possible in the current period, while at the same time increasing the immediate probability of re-employment.

Second, short-term contracts introduce the re-employment tradeoff, which has a stabilizing impact on collusion if and only if the immediate increase in re-employment probability resulting from defection is small compared to the future reduction in re-employment probability resulting from punishment, that is, if and only if \( G_D (\pi) - G_C (\pi) \) is small relative to \( G_C (\pi) - G_N (\pi) \). If the re-employment tradeoff is sufficiently positive for collusive stability, it can offset the first force.

Third, the higher is the reduction in expected salary resulting from punishment, the less does the manager care about being rehired in the future, that is, the lower is the impact of the re-employment tradeoff, i.e., the second force.

Altogether, the re-employment tradeoff (force 2) stabilizes collusion by more than force 1 destabilizes collusion if and only if (i) the increase in reappointment probability during defection is small compared to the decrease in reappointment probability during punishment, provided that (ii) the monetary loss from punishment is not too large.
Proposition 3.2 Short-term contracts can stabilize cartels compared to long-term contracts.

Proof. If condition (3.5) holds for some $\pi$, then the shareholder chooses one of those $\pi$ such that (3.3) is satisfied. If condition (3.5) does not hold for any $\pi$, then the shareholder sets $\underline{\pi} = 0$, thereby effectively mimicking a long-term contract. \hfill \Box

When there exists a profit level such that condition (3.6) is satisfied, then the optimal short-term contract stabilizes collusion. When no such profit level exists, the optimal short-term, renewable contract replicates an indefinite employment contract by setting the profit threshold level in such a way that even a manager that competes in the product market will achieve that profit level, i.e., $\underline{\pi} = 0$. A short-term contract then effectively mimics the collusive stability associated with a long-term contract. In that case, a strict short-term, renewable contract with $\underline{\pi} > 0$ would actually destabilize collusion.

3.3.4 Comparative Statics

The only assumptions on profit distributions are full support over the domain $\pi_t \geq 0$ and first order stochastic dominance of defection over collusion over Nash. Therefore, any change in profit distributions has an ambiguous impact on the direction as well as the size of the change of both $E_a(\pi_t)$ and $G_a(\underline{\pi})$. The ultimate impact on Proposition 3.1 is condition (3.5) then depends on the relative changes in $E_a(\pi_t)$ and $G_a(\underline{\pi})$.

As a result, even very stylized comparative statics with respect to profit distributions leads to a large number of cases entailing tedious analyses without generating substantive insights in the model. The key point remains that changes in the parameters facilitate collusive stability if (i) the increase in reappointment probability during defection becomes smaller; (ii) the reduction in reappointment probability during punishment becomes larger; or (iii) the monetary loss from punishment becomes smaller—see the first paragraph after Proposition 3.1.

However, since the distribution over profit when defecting only appears once in condition (3.5) in the form of $G_D(\underline{\pi})$, some meaningful comparative statics are possible.

Proposition 3.3 Cond. (3.5) is easier (more difficult) to satisfy if distribution $F_D(x)$ is

1. shifted to the left (right);
2. more (less) dispersed, provided that $\underline{\pi} < E_D(\pi_t)$ and keeping $E_D(\pi_t)$ fixed; or
3. less (more) dispersed, provided that $\underline{\pi} \geq E_D(\pi_t)$ and keeping $E_D(\pi_t)$ fixed.

Proof. See Appendix B.1. \hfill \Box
The intuition is that changes entailing a reduction (increase) in $G_D (\pi)$, while not affecting the other parameters, make condition (3.5) easier (more difficult) to satisfy, because such changes make defection more attractive to the manager in the sense that the probability of re-employment increases after a defection.

### 3.4 Fixed Salary Components and Serial Colluders

This section considers the impact on cartel stability of fixed salary components (3.4.1), as well as the possibility to revert from punishment to collusion after replacement of a manager, which I refer to as “serial collusion” (3.4.2).

#### 3.4.1 Fixed Salary Components Can Stabilize Cartels

This subsection relaxes the assumption that contracts contain no fixed salary component, that is, the shareholders are now free to set any $\alpha \geq 0$ and $\beta \geq 0$. I thereby show that a fixed salary component affects cartel stability when short-term contracts are in place, but not when long-term contracts are in place.

**Benchmark stability.** First, consider long-term contracts. With long-term contracts, there exists a rather trivial optimal solution in which $\beta = 0$, because then the manager is indifferent between all possible actions as he is hired forever and earns $\alpha$ in every period. He has no incentives to defect, which makes collusion stable for all discount factors. This solution is not so interesting; therefore, I assume $\beta > 0$ from now on.

When $\beta > 0$ the stability with long-term contracts is unchanged when allowing for a fixed salary component, because collusion is stable if and only if

$$
\frac{\delta}{1 - \delta} \left[ (\alpha + \beta E_C (\pi_t)) - (\alpha + \beta E_N (\pi_t)) \right] \geq (\alpha + \beta E_D (\pi_t)) - (\alpha + \beta E_N (\pi_t)),
$$

iff.

$$
\frac{\delta}{1 - \delta} (E_C (\pi_t) - E_N (\pi_t)) \geq E_D (\pi_t) - E_C (\pi_t),
$$

which is equivalent to benchmark stability condition (3.2). The reason is that the fixed salary component is paid out in every period and, thus, cancels out.

**Stability with short-term, renewable contracts.** The following lemma states the stability condition with short-term contracts and a fixed salary component.
Lemma 3.2 Allowing for a fixed salary component $\alpha$, collusion is stable if and only if
\[
\delta \left( \frac{G_C(\pi)}{1 - \delta G_C(\pi)} E_C(\pi t) - \frac{G_D(\pi)}{1 - \delta G_N(\pi)} E_N(\pi t) + K \frac{\alpha}{\beta} \right) \geq E_D(\pi t) - E_C(\pi t),
\]
where $K = \frac{G_C(\pi)}{1 - \delta G_C(\pi)} - \frac{G_D(\pi)}{1 - \delta G_N(\pi)}$.

Proof. Collusion is stable if and only if the discounted expected payoff from defection is not larger than the discounted expected payoff from collusion, i.e., if and only if
\[
\delta \left( \frac{G_C(\pi)}{1 - \delta G_C(\pi)} (\alpha + \beta E_C(\pi t)) - \frac{G_D(\pi)}{1 - \delta G_N(\pi)} (\alpha + \beta E_N(\pi t)) \right) \geq \alpha + \beta E_D(\pi t) - (\alpha + \beta E_C(\pi t)),
\]
which gives condition (3.8) when rearranging terms. \qed

For now, note that this stability condition differs from the stability condition without the fixed salary component in Lemma 3.1 by the term $\delta K \frac{\alpha}{\beta}$ on the LHS. I provide intuition for this difference below. Defining $\tilde{\delta} = \frac{G_D(\pi) - G_C(\pi)}{G_C(\pi)(G_D(\pi) - G_N(\pi))}$, the following lemma states the optimal salary scheme from the shareholder’s perspective and the impact of the fixed salary component $\alpha$ on the stability of collusion.

Lemma 3.3 If $\delta > \tilde{\delta}$, collusion is stable and the optimal wage schedule entails an arbitrarily small fraction of firm profit $\beta > 0$ and a positive fixed salary component $\alpha > 0$. If $\delta \leq \tilde{\delta}$, collusion is stable if and only if condition (3.3) holds and the optimal wage schedule entails an arbitrarily small fraction of firm profit $\beta > 0$ and a zero fixed salary component $\alpha = 0$.

Proof. We have that $K > 0 \iff \delta > \tilde{\delta}$. Therefore, if $\delta > \tilde{\delta}$, the LHS of condition (3.8) can be made arbitrarily large by setting $\alpha$ to any positive value and $\beta$ arbitrarily small. However, if $\delta \leq \tilde{\delta}$, it is best to set $\alpha = 0$ (because $K < 0$), and collusion is stable if and only if condition (3.3) holds. \qed

The intuition for this result runs as follows. Dividing all managerial payoffs by $\beta$, we have that with action $\alpha \in \{N, C, D\}$, the manager’s expected payoff is $\frac{\alpha}{\beta} + E_a(\pi t)$. The normalized fixed component $\frac{\alpha}{\beta}$ cancels out in “the gain from defection”—i.e., the RHS of condition (3.8)—because the fixed component is being paid in the current period independent of managerial behavior, that is, independent of whether the manager colludes or defects. However, the fixed component does not cancel out in the “future
losses from punishment”—i.e., the LHS of condition (3.8)—because the manager is being paid the fixed component in a future period if and only if the manager is actually hired in that future period, the probability of which depends on whether the manager colludes or defects in the current period.

If the “future losses from punishment with regard to the fixed component” is positive, i.e., if $K > 0$, then it is optimal for the shareholder to set $\alpha > 0$ so as to use the fixed salary component to increase stability. The shareholder can amplify this effect by making the fixed component a relatively important part of the wage schedule compared to the variable component, that is, by setting $\beta$ sufficiently small relative to $\alpha$. Note that if $\delta > \tilde{\delta}$, stability does not depend on the size of $\pi$, because the shareholder can play around with $\alpha$ and $\beta$ to make collusion stable for every $\pi$. The next Proposition summarizes these results.

**Proposition 3.4** Allowing for a salary scheme with a fixed component weakly stabilizes collusion with short-term contracts, while not affecting collusive stability with long-term contracts.

**Proof.** If $\tilde{\delta}$ satisfies condition (3.3), then we know from Lemma 3.3 that it is optimal to set $\alpha = 0$, resulting in condition (3.3) and (3.8) to be equivalent. If $\delta$ violates condition (3.3), then we know from Lemma 3.3 that it is optimal to set $\alpha > 0$, resulting in condition (3.8) to hold for a larger set of discount factor than condition (3.3). From (3.7) we know that a fixed salary component does not affect collusive stability. □

### 3.4.2 Serial Colluders Destabilize Cartels

This subsection assumes that managers revert from punishment to collusion after one of the managers has been replaced during the punishment phase. The motivation is that mistrust may be eliminated when a new manager is appointed; when a new manager enters the firm, he starts with a “clean sheet” and will restore collusion with his rival.

**Proposition 3.5** If replacement of a manager during the punishment regime results in the newly appointed manager to switch to collusion with his rival, then collusion is stable for less discount factors than if collusion is not restored after a managerial replacement.

**Proof.** Let $V_C = \frac{E_C(\pi)}{1-\delta G_C(\pi)}$ be the manager’s continuation value of the collusive state. When collusion cannot (can) be restored, let $V_D$ ($V_D'$) and $V_N$ ($V_N'$) be the continuation value of the punishment state and defection state state, respectively. From (3.1), $G_T(\pi) \leq G_C(\pi)$ is the probability of hitting at least profit level $\pi$ when the rival manager defected from the collusive agreement.
Without restoration of collusion, collusion is stable if and only if \( V_C \geq V_D \), where
\[
V_D = E_D (\pi_t) + \delta G_D (\pi) V_N.
\]

With restoration of collusion, collusion is stable if and only if \( V_C \geq V_D^r \), where
\[
V_D^r = E_D (\pi_t) + \delta G_D (\pi) G_T (\pi) V_N^r + (1 - G_T (\pi)) V_C,
\]
and \( V_N^r \) is determined by solving
\[
V_N^r = E_N (\pi_t) + \delta G_N (\pi) G_N (\pi) V_N^r + (1 - G_N (\pi)) V_C,
\]
\[
\Leftrightarrow V_N^r = \frac{E_N (\pi_t) + \delta G_N (\pi) (1 - G_N (\pi)) V_C}{1 - \delta (G_N (\pi))^2}.
\]

Noting that \( V_N = \frac{E_N (\pi_t)}{1 - \delta G_N (\pi)} \), straightforward algebra yields \( V_N^r > V_N \), and, therefore, we have \( V_D^r > V_D \). \qed

If a manager can switch from punishment to collusion with a newly appointed rival manager, this effectively results in the continuation value of defection to increase for two reasons. First, defection results in an immediate reduction in the probability that the rival manager is reappointed, that is, an increase in the probability that a new rival manager is appointed and collusion is restored instantaneously. Second, the continuation value of defection is higher as in each punishment period collusion will be restored with probability \( G_N (\pi) \). In essence, Proposition 3.5 echoes McCutcheon (1997) who argues that meetings facilitate renegotiation, which effectively reduces the scope for punishment and thereby destabilizes collusion.

### 3.5 Short-Term Contracts Entail Equilibrium Price Wars

Typically, CEO contracts span several years. Therefore, this section studies the model when managers interact multiple times on the product market within the course of their contractual employment period. This allows for dynamic pricing in the sense that a manager may find it optimal to make his behavior during his employment period contingent on profit realizations occurring earlier within the same contractual period.

---

\(^{84}\)In the extreme case in which \( G_T = 0 \), collusion is unstable for every discount factor \( \delta \in [0, 1] \) as defection automatically results in a new rival manager being appointed immediately: collusion is restored instantaneously and no punishment occurs.

\(^{85}\)See, for example, Schwab and Thomas (2006) and Gillian, Hartzell and Parrino (2009).
3.5.1 Set-up of the Dynamic Model

To keep the analysis clean and to focus on the impact of multiple interactions within the same employment period on cartel behavior, I assume that managers interact on the product market twice during their employment period, and that they do not discount their payoffs within the employment period. More than two interactions within the same contractual period and within-contract discounting would not bring essential insights, while mathematically complicating the model substantially.

Consider the model as outlined in Subsection 3.3.1, but now suppose that each period \( t \in \{1, 2, \ldots, \infty\} \) consists of two sequential stages \( k \in \{1, 2\} \). In both stages, the managers take action pair \( a_k \in \{N, C, D\} \), resulting in profit \( \pi_t^k \geq 0 \), and the manager is reappointed for the next period \( t + 1 \) if and only if \( \pi_t^1 + \pi_t^2 \geq \pi \). The conditional probability distributions over profit are the same as outlined in Subsection 3.3.1 and independent between periods and stages. Also, as before, managerial behavior is observed by the rival manager immediately after taking the action, thus allowing for punishment during the next interaction. The new timing of the game is depicted in Figure 3.3.

In terms of notation, define \( G_{a_1,a_2} (\pi) = \Pr [ \pi_t^1 + \pi_t^2 \geq \pi | a_1, a_2] \) as the ex ante probability of realizing at least aggregate profit \( \pi \) in period \( t \), provided that the managers take action pair \( a_1 \) in stage 1 and \( a_2 \) in stage 2. Noting that \( E_a (\pi_t^1) = E_a (\pi_t^2) \), I leave out the argument \( \pi_t^k \) in the expected value \( E_a (\pi_t^k) \) for ease of notation, which then simply writes as \( E_a \).

To derive more precise results, I assume the following regularity condition,

\[
\frac{\partial (G_D (x) - G_C (x))}{\partial x} > 0,
\]

that is, the difference in re-employment probability between defection and collusion increases in the profit threshold \( \pi \). This means that increasing the profit threshold \( \pi \) reduces the probability of re-employment more when colluding than when defecting.

![Figure 3.3 Timing of the dynamic game.](image-url)
3.5.2 Collusion in Both Stages

The most straightforward grim-trigger collusive strategy is to collude in both stages as long as the rival manager colluded in all previous stages in all previous periods, while punishing forever otherwise. The stability of this strategy is pinned down by the following lemma.

**Lemma 3.4** Collusion in both stages is a stable strategy if and only if

\[ 2\delta \left( \frac{G_C(\pi)}{1 - \delta G_{CC}(\pi)} E_C - \frac{G_D(\pi)}{1 - \delta G_{NN}(\pi)} E_N \right) \geq E_D - E_C. \]  

(3.10)

*Proof.* See Appendix B.2. \qed

For a collusive strategy to be stable in the dynamic model, the manager must (i) not defect in stage 1, and (ii) not defect in stage 2 after any possible profit realization in stage 1, \( \pi^1 \geq 0 \). Consider first the managerial incentive to defect in stage 2. The monetary tradeoff is independent of the profit realization in stage 1: defection immediately increases the manager’s expected salary from \( E_C \) to \( E_D \), while decreasing it from \( E_C \) to \( E_N \) in each future punishment stage. However, the re-employment tradeoff does depend on the profit realization in stage 1: defection in stage 2 immediately increases the probability of re-employment from \( G_C(\pi - \pi^1) \) to \( G_D(\pi - \pi^1) \), while decreasing it from \( G_{NN}(\pi) \) to \( G_{CC}(\pi) \) in each future punishment period. Since defection increases the immediate re-employment probability more the higher is the profit level that needs to be attained (by the regularity condition), the manager finds it most attractive to defect when the profit realization in the first stage was the lowest realization possible—i.e., \( \pi^1 = 0 \)—because then he must hit a high profit of at least \( \pi - \pi^1 = \pi \) in the second stage, the probability of which is substantially increased when defecting.

Consider now the managerial incentive to defect in stage 1. This is lower than the managerial incentive to defect in stage 2 after the realization of profit \( \pi^1 = 0 \). The reason is two-fold. First, in stage 1, the manager has two interactions to attain aggregate profit \( \pi^1 + \pi^2 \geq \pi \), while after the realization of a zero profit in stage 1 the manager has only one interaction left to attain \( \pi^2 \geq \pi \). Second, defection in stage 1 is immediately followed by punishment in stage 2 without intra-period discounting, while defection in stage 2 is followed by punishment in the next period, which entails discounting.

Combining the arguments, collusion in both stages is a stable strategy if and only if the manager is patient enough not to defect in the second stage after the realization of a zero profit in the first stage, which is represented by condition (3.10).
3.5.3 Collusion Conditional on Profit Realization in Stage 1

The dynamic nature of the game allows the manager to condition his action in the second stage on the profit realization in the first stage. By the argument based on the regularity condition in the previous subsection, if the manager is patient enough to collude in stage 2 after profit realization $\pi_1^1 = \tau$, then he is also patient enough to collude in stage 2 after profit realization $\pi_1^1 > \tau$, but may not be patient enough to collude in stage 2 after any profit realization $\pi_1^1 < \tau$. The intuition is that the closer is stage 1’s profit realization to the profit threshold $\pi$, the less attractive is defection in terms of increasing the immediate re-employment probability.

Compared to collusion in both stages, the manager potentially increases cartel stability by adopting a strategy that entails collusion in stage 2 only after profit realization $\pi_1^1 \geq \tau$, which I define as $\tau$-conditional collusion. The reason is that the stability of collusion in both periods is determined by the manager’s incentive to defect in stage 2 after a zero profit realization in stage 1, while $\tau$-conditional collusion removes this concern as the manager competes as part of the collusive strategy for all $\pi_1^1 < \tau$. The next two subsections investigate the stability of $\tau$-conditional collusion in stage 2 when the manager either colludes or competes in stage 1.

Collusion in stage 1 and $\tau$-conditional collusion in stage 2. Consider the collusive strategy in which the manager colludes in stage 1, while colluding in stage 2 if and only if $\pi_1^1 \geq \tau$. Define the ex ante re-employment probability of this strategy as $P_C (\pi, \tau) = \int_\tau^\infty \Pr (\pi_1 = x | a = C) G_C (\pi - x) \, dx + \int_0^\tau \Pr (\pi_1 = x | a = C) G_N (\pi - x) \, dx$, & denote the ex ante expected per-period payoff as $K_C (\tau) = (1 + G_C (\tau)) E_C + (1 - G_C (\tau)) E_N$. The following lemma pins down the stability of this strategy.

Lemma 3.5 Collusion in stage 1 and $\tau$-cond. collusion in stage 2 is a stable strategy iff.

\[
\begin{align*}
\delta \left( \frac{P_C (\pi, \tau)}{1 - \delta P_C (\pi, \tau)} K_C (\tau) - \frac{G_C (\pi - \tau)}{1 - \delta G_N (\pi)} 2E_N \right) & \geq E_D - E_C, \quad (3.11) \\
\delta \left( \frac{G_C (\pi - \tau)}{1 - \delta C (\pi, \tau)} K_C (\tau) - \frac{G_D (\pi - \tau)}{1 - \delta G_N (\pi)} 2E_N \right) & \geq E_D - E_C, \quad (3.12)
\end{align*}
\]

and is potentially more stable than collusion in both stages.

Proof. See Appendix B.3.
in stage 2 to be stable is determined by the lowest possible profit realization in stage 1 that still entails collusion in stage 2, that is, profit realization \( \pi_l^1 = \tau \). This constraint is represented by condition (3.12): \( \tau \)-conditional collusion in stage 2 (i) potentially makes collusion more stable than sure collusion in stage 2 as defection entails a lower increase in re-employment probability, that is \( G_D (\pi - \tau) - G_C (\pi - \tau) < G_D (\pi) - G_C (\pi) \), but (ii) may also decrease collusive stability as the equilibrium payoff is lower than collusion in both stages, that is \( K_C (\tau) < 2E_C \), and its equilibrium continuation probability is lower, that is \( P_C (\pi, \tau) < G_{CC} (\pi) \). The net effect depends on the precise specification of the density functions over profit and the level of \( \tau \).

If the manager is patient enough to collude in stage 2 after \( \pi_l^1 \geq \tau \), he is not necessarily also patient enough to collude in stage 1. The intuition is that in stage 1, the manager has two interactions to achieve aggregate profit \( \pi_l^1 + \pi_l^2 \geq \pi \), while in stage 2 the binding constraint prescribes that the manager has one interaction to achieve profit \( \pi_l^2 \geq \pi - \tau \). Depending on the precise specification of the density functions over profit and the level of \( \tau \), the constraint in stage 1, i.e., (3.11), may or may not be the binding constraint.

**Competition in stage 1 and \( \tau \)-conditional collusion in stage 2.** If constraint (3.11) is the binding constraint for collusion in stage 1 and \( \tau \)-conditional collusion in stage 2 to be stable, the manager may circumvent this and increase stability by constructing a collusive agreement that entails competition in stage 1 and \( \tau \)-conditional collusion in stage 2. Define the \textit{ex ante} re-employment probability associated with this strategy as \( P_N (\pi, \tau) = \int_\pi^\infty \Pr (\pi_l^1 = x \mid a = N) G_C (\pi - x) dx + \int_0^\tau \Pr (\pi_l^1 = x \mid a = N) G_N (\pi - x) dx \), and denote the \textit{ex ante} expected per-period payoff as \( K_N (\tau) = G_N (\tau) E_C + (2 - G_N (\tau) E_N) \). The following lemma pins down the stability of this strategy.

**Lemma 3.6** \textit{Competition in stage 1 and \( \tau \)-cond. collusion in stage 2 is a stable strategy iff:}

\[
\delta \left( \frac{G_C (\pi - \tau)}{1 - \delta P_N (\pi, \tau)} K_N (\tau) - \frac{G_D (\pi - \tau)}{1 - \delta G_{NN} (\pi) E_N} \right) \geq E_D - E_C, \quad (3.13)
\]

\textit{and is potentially more stable than (i) collusion in both stages, and (ii) collusion in stage 1 and \( \tau \)-conditional collusion in stage 2.}

**Proof.** See Appendix B.4. \( \square \)

Stability is not a concern in the first stage, simply because the collusive strategy prescribes competition in stage 1. Similarly to the argument presented in the previous subsection, the binding constraint for the collusive strategy to be stable in the second stage is determined by profit realization \( \pi_l^1 = \tau \). If constraint (3.11) is the binding constraint
in Lemma 3.3, then competition in stage 1 instead of collusion in stage 1 increases cartel stability provided that constraint (3.13) is satisfied for a larger set of discount factors than constraint (3.11), which depends on the precise specification of the density functions over profit and the level of \( \tau \).

### 3.5.4 Equilibrium Price Wars, Stability, and Profitability

This subsection collects the results from the previous three lemmas and summarizes the behavioral implications when the managers adopt a strategy with \( \tau \)-conditional collusion in stage 2.

**Proposition 3.6** Short-term contracts spanning multiple managerial interactions on the product market can entail price wars in equilibrium, thereby increasing cartel stability, while reducing cartel profitability.

**Proof.** See Appendix B.5.

Consider a manager colluding in both periods. Then, the critical constraint for collusion to be stable is whether the manager is patient enough to collude in stage 2 after a low profit realization in stage 1, because the manager has only one opportunity left to attain its contractual profit threshold level. However, if this jeopardizes cartel stability, then the managers may fix stability by adopting a collusive strategy in which they always collude in the first stage, while colluding in the second stage only if profit realization in the first stage was relatively high. In that way, they eliminate the concern of defection after a low profit realization, because the collusive equilibrium itself already specifies competition after a low profit realization.

It may be the case that such a strategy is still not stable, because the managers have incentives to defect in the first stage now. Then, the managers can change their strategy and compete in stage 1 as part of the collusive equilibrium, while colluding in stage 2 only if the profit realization in stage 1 is high enough.

Both strategies entail competition (price wars) as part of the collusive equilibrium. Although such price wars increase cartel stability, they decrease cartel profitability, because by stochastic dominance (i) expected profit of competition is lower than expected profit of collusion, and (ii) the continuation probability of collusion in both stages is higher than the continuation probability when the manager competes in the second (and possibly: the first) stage with some probability.
3.6 How Debt-Financed Firms Can Form Stable Cartels

The model can also be interpreted in light of firm financing, thereby showing how firms that are financed by debt, i.e., highly leveraged firms, can form more-stable cartels than firms financed by equity. This finding is consistent with Schleifer and Vishny (1992) and Khanna and Tice (2000), although through a different mechanism.

In the spirit of the model presented in this chapter, consider the stylized situation of a firm fully financed by short-term debt. Assume that (i) the bank liquidates this firm immediately if it misses out on a periodical repayment, and (ii) all the profits left after the repayment are reinvested in the firm. Thus, to meet its repayment obligations, this debt-financed firm must each year make a profit of at least the amount that needs to be repaid. If such a firm colludes with its rivals, it faces the following tradeoff: defection makes it more likely to meet its current repayment obligation (due to a higher expected profit in the current period), but punishment makes it less likely to meet its future payment obligations (due to lower expected profits in future punishment periods). In other words, defection makes liquidation less likely in the current period, but more likely in future periods. This parallels the managerial tradeoff that defection makes being fired less likely in the current period, but more likely in future periods. Therefore, debt contracts can be designed in such a way to stabilize collusion and may be a source of cyclical pricing.\textsuperscript{86}

3.7 Concluding Remarks

This chapter has presented a mechanism through which commonly observed short-term, renewable employment contracts can improve cartel stability, while dynamically affecting firms’ pricing behavior. Motivated by empirical observations, the model takes such short-term, renewable contracts as exogenously given, thereby abstracting away from the question which type of employment contracts would endogenously arise when the shareholders’ main goal is to induce the CEO to either form or stay away from a cartel. This issue is at the center of the analysis in Aubert (2009) and Chapter 2 of this dissertation.

The model assumes that managers can observe each other’s actions. However, if managers would not be able to observe the rival’s action, Green and Porter (1984) suggest that the collusive strategy entails reversion to Nash for some periods after a low profit realization. How such unobservability of actions interacts with the impact of short-term, renewable contracts on cartel stability is left for future research.

In the current model, the shareholder’s strategy to hire a new manager when profit turns

\textsuperscript{86}Apart from the described forces, another important force is that liquidation of the firm will result in a change of market structure, which would \textit{ex ante} affect incentives. The impact of this force on overall cartel stability is an interesting avenue to explore in future research.
out to be low is rational, because hiring costs are assumed to be zero and all managers are of the same type. It is then costless to hire a new manager. In contrast, if hiring costs are positive, one may expect the current manager to haggle with the shareholder to renew his contract after a low profit realization; this is work for future research.

The model treats a long-term contract as an infinite contract such that the manager is never dismissed, thereby implicitly assuming that the termination cost of a long-term contract is infinitely high. However, sometimes a long-term contract can be terminated by paying some fixed firing cost, such as a “golden parachute”. In such cases, a long-term contract may display the same collusion-stabilizing effect as a short-term contract as the contract is then effectively not indefinite.

Finally, the mechanism outlined in this chapter implicitly assumes that employment contracts are observable to rival managers. Although recently, more and more firms publish the remuneration package and employment conditions of their executives, this may not always be the case. When rivals’ employment contracts are not observable, then correct beliefs about these contracts may still induce the cartel-stabilizing mechanism.

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87This may be due to, for example, search costs or costs associated with drafting a new contract.
4 Strategic Delegation Improves Cartel Stability

Abstract. In the one-shot Cournot game, strategic delegation reduces profits of the firm (Fershtman and Judd, 1987; Sklivas, 1987). Allowing for infinitely repeated interaction, strategic delegation improves cartel stability, thereby actually increasing firm profits for discount factors for which a cartel in the one-shot Cournot game is unstable.

This chapter is based on the identically titled paper, available online at [carteltheory.com/delegation]. I thank Jeanine Miklos-Thal, Patrick Rey, Maarten Pieter Schinkel, Bert Schoonbeek, Randolph Sloof, Jan Tuinstra, and Jeroen van de Ven for constructive discussions and comments.
4.1 Introduction

The strategic delegation literature shows how firms’ profitability is reduced by delegating control to a manager being remunerated with a fraction of profit and sales—see Fershtman and Judd (1987) and Sklivas (1987) (hereafter: FJS). This chapter extends FJS’s seminal model to an infinitely repeated setting, thereby allowing firm owners as well as managers to collude. Strategic delegation can then actually increase firms’ profitability through improving cartel stability compared to the non-delegation Cournot game.

The intuition is two-fold. First, a manager defecting from collusion can be fiercely punished by the owner as she can stop delegating control and fire him. Second, this punishment strategy is more stable than normal collusion in the infinitely repeated standard Cournot game, because it is supported by the threat of reverting to FJS’s unprofitable one-shot delegation equilibrium. Thus, FJS’s key result of “unprofitable delegation” helps owners to credibly commit to a fierce punishment strategy, thereby increasing cartel stability and increasing firm profits when collusion in the static Cournot game is unstable.

4.2 The Repeated Strategic Delegation Model

Consider FJS’s delegation game. Two homogenous firms $i = \in \{1, 2\}$ produce at unit cost $c \geq 0$ and compete in quantities facing linear demand

$$p = a - bQ, \quad b > 0, \ a > c,$$

where $p$ is market price, $q_i$ is output of firm $i$, and $Q = q_1 + q_2$ is total output. Each firm $i$ is owned by profit-maximizing owner $i$ (female) who may delegate control to manager $i$ (male) by remunerating him with a fraction $\alpha_i$ of profit $\pi_i$, plus a fraction $1 - \alpha_i$ of sales $S_i$, that is,

$$M_i = \alpha_i \pi_i + (1 - \alpha_i) S_i,$$

which can be rewritten as $M_i = (p - \alpha_i c) q_i$. If the owner does not delegate control to her manager, and instead fires him, then the manager earns his outside option which is normalized to zero.

In their original framework, FJS consider rewards $A_i + B_iM_i$. Since the managerial outside option is normalized to zero, owners can optimally set $A_i = 0$ and $B_i$ arbitrarily normalized to zero.

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88 This result holds for FJS’s most elaborate case of Cournot competition.
small, say $B_i = \epsilon_i > 0$. With delegation, owner $i$ then earns $\pi_i - \epsilon_i M_i$ and manager $i$ earns $\epsilon_i M_i$. In the limit when $\epsilon_i \downarrow 0$, (i) term $\epsilon_i M_i$ has an infinitesimally small impact on owner $i$’s payoff and, therefore, she essentially behaves so as to maximize profit $\pi_i$, whereas (ii) manager $i$’s payoff only consists of $\epsilon_i M_i$ and, therefore, she maximizes $M_i$. The timing of the stage game is:

1. Both owners simultaneously decide whether to delegate or to keep control.

2. If owner $i$ delegates, she sets incentives $\alpha_i$ (possibly) simultaneously with her rival.

3. The players in control of the firms simultaneously set quantities on the market.

Extending FJS, this stage game is played in each period $t \in \{1, 2, \ldots, \infty\}$, thereby allowing for collusion on three dimensions: the delegation decision, incentives, and quantities.

Owners and managers maximize their discounted stream of payoffs using discount factor $\delta_o$ and $\delta_m$, respectively. To keep the analysis clean and to stay in line with the literature, collusion is on the monopoly quantity and punishment on the product market is characterized by reversion to the static Nash equilibrium forever. Everything is common knowledge and fully observable to all players. I focus on symmetric equilibria and denote $i$’s rival by $j$.

### 4.3 Delegation Improves the Stability of Collusion

To save on notation, (i) superscripts \{N, C, D\}, respectively, denote the Nash, collusion, and deviating variables in the standard Cournot game; (ii) superscripts \{dN, dC\}, respectively, denote the Nash and collusion variables in FJS’s Cournot delegation game; while (iii) the deviating variables in the delegation game do not have a superscript as there are going to be several ways to deviate.

Collusion by player $p_i \in \{\text{owner } i, \text{manager } i\}$ is stable if and only if

$$\delta_{p_i} \geq \frac{\text{“defection payoff of player } p_i \text{”} - \text{“collusive payoff of player } p_i \text{”}}{\text{“defection payoff of player } p_i \text{”} - \text{“punishment payoff of player } p_i \text{”}}, \quad \forall i \in \{1, 2\},$$

(4.1)

where mathematical symbols are avoided, because there are several ways to deviate and to punish. Since the owners optimally set $A_i = 0$ and $B_i = \epsilon_i$ as discussed above, (i) the term $\epsilon_i$ cancels out in determining the managerial stability condition, and (ii) the term $\epsilon_i M_i$ can be effectively neglected in the owner’s stability condition as $\epsilon_i$ is infinitesimal.

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90The purpose of this model is to isolate the impact of strategic delegation on collusive stability; it, therefore, abstracts away from the impact of fixed payments on collusive stability by normalizing the manager’s outside option to zero. For a discussion of fixed payment issues and collusive stability, see Section 3.4.
4.3.1 Benchmarks

Consider the following benchmarks, which are formally derived in Appendix C.1. In FJS’s one-shot Cournot delegation game, owners are captured in a prisoner’s dilemma and cannot avoid delegation, resulting in equilibrium incentives, quantities and payoffs

\[
\alpha_i^{dN} = \frac{6}{5} - \frac{a}{5c}, \quad q_i^{dN} = \frac{2(a - c)}{5b}, \quad M_i^{dN} = \frac{4(a - c)^2}{25b}, \quad \pi_i^{dN} = \frac{2(a - c)^2}{25b},
\]

which entails a lower profit than if owners would have been able to escape delegation and play the standard Cournot game,

\[
q_i^N = \frac{a - c}{3b}, \quad \pi_i^N = \frac{(a - c)^2}{9b}.
\]  

In the infinitely repeated standard Cournot game, collusion is stable if and only if

\[
\delta_o \geq \frac{\pi_i^D - \pi_i^C}{\pi_i^D - \pi_i^N} = \frac{9}{17}, \quad \text{with}
\]

\[
q_i^C = \frac{a - c}{4b}, \quad \pi_i^C = \frac{(a - c)^2}{8b}.
\]  

4.3.2 Collusive Equilibrium with Delegation

In the infinitely repeated version of FJS’s delegation game, the collusive delegation equilibrium yielding full monopoly profits entails owners delegating control by giving no incentives for sales, thereby “selling the store” to managers whose objective then is to maximize profit. Appendix C.2 formally derives that in the delegation game the Collusive equilibrium is characterized by

\[
\alpha_i^{dC} = 1, \quad q_i^{dC} = \frac{a - c}{4b}, \quad M_i^{dC} = \frac{(a - c)^2}{8b}, \quad \pi_i^{dC} = \frac{(a - c)^2}{8b},
\]

which is stable if and only if owners as well as managers have no incentive to defect.

**Owner’s defection.** Owners can defect in two ways: they can (i) defect in stage 2 by setting incentives different from \(\alpha_i^{dC}\), or (ii) defect in stage 1 by not delegating at all.

If owner \(i\) defects by setting different incentives, then managers optimally react with Nash competition in stage 3 so as to punish the deviant owner. Conditional on owner \(i\) defecting to incentives \(\alpha_i\), Nash quantities in stage 3 are \(q_i(\alpha_i) = \frac{a + (1 - 2\alpha_i)c}{3}\) and
\[ q_j (\alpha_i) = \frac{a + (\alpha_i - 2)c}{3}, \text{ yielding} \]
\[ \pi_i (\alpha_i) = \left( a - b \left( \frac{a + (1 - 2\alpha_i) c}{3} + \frac{a + (\alpha_i - 2) c}{3} \right) - c \right) \frac{a + (1 - 2\alpha_i) c}{3}, \]

which is maximized at \( \alpha_i = \frac{5}{4} - \frac{a}{4c} \) with \( \pi_i \) = \( \frac{(a-c)^2}{8b} \). As defection profit equals collusive profit, while triggering future punishment, owners would never make such a defection.

If instead owner \( i \) defects by not delegating, this triggers Nash competition with her rival's manager \( j \) in stage 3. Owner \( i \) and manager \( j \) respectively maximize \( \pi_i (q_i, q_j) = (a - b (q_i + q_j) - c) q_i \) and \( M_j (q_i, q_j) = B (a - b (q_i + q_j) - c) q_j \), resulting in profit \( \pi_i = \frac{(a-c)^2}{9b} \), which is lower than the collusive profit. Therefore, owners do not defect from the delegation decision. Lemma 4.1 summarizes.

**Lemma 4.1** Independent of the discount factor \( \delta_o \), owners do not defect from collusion.

**Managerial defection.** If manager \( i \) defects from the collusive quantity \( q_i^{dC} = \frac{a-c}{4b} \), she does so by maximizing
\[
M_i (q_i) = \left( a - b \left( q_i - \frac{a-c}{4b} \right) - c \right) q_i,
\]
yielding deviant quantity \( q_i = \frac{3(a-c)}{8b} \) with payoff \( M_i = \frac{9(a-c)^2}{64b} \). To optimally prevent such a managerial defection, owners will try to commit to avoid delegating control in future periods and fire them, thereby fiercely punishing the manager with a zero payoff. Using condition (4.1), i.e., \( \delta_m \geq \left( \frac{9(a-c)^2}{64b} - \pi_i^{dC} \right) / \left( \frac{9(a-c)^2}{64b} - 0 \right) \), Lemma 4.2 states the resulting stability condition.

**Lemma 4.2** Managers do not defect from collusion if and only if \( \delta_m \geq \frac{1}{9} \).

**Owner's commitment to avoid delegation.** Whether owners are indeed able to punish managers by avoiding delegation depends on the owners' patience \( \delta_o \). Appendix C.4 shows that the owners' commitment to not delegate suffers from FJS's prisoners dilemma when owners compete in quantities while keeping control, but it is no concern when owners collude on quantities while keeping control.

When owners punish a deviant manager by keeping control and colluding on quantities themselves, equilibrium profit during punishment is \( \pi_i^c = \frac{(a-c)^2}{8b} \), while defection

\[ ^{91} \text{Appendix C.3 checks that such punishment is indeed optimal taking into account the owners' ability to commit to such punishment.} \]
results in profit \( \pi^D_i = \frac{9(a-c)^2}{64b} \), but triggers FJS’s one-shot delegation equilibrium with profit \( \pi^{dN}_i = \frac{2(a-c)^2}{25b} \). Using condition (4.1), i.e., \( \delta_o \geq \left( \pi^D_i - \pi^C_i \right) / \left( \pi^D_i - \pi^{dN}_i \right) \), Lemma 4.3 states the resulting stability condition.

**Lemma 4.3** After a manager defected, owners can commit to avoid delegation iff. \( \delta_o \geq \frac{25}{97} \).

Since discount factors are determined on financial markets, rational owners and managers with access to such markets can be assumed to be equally patient, i.e., \( \delta_o = \delta_m = \delta \). Combining Lemmas 4.1, 4.2, and 4.3, I then arrive at the following proposition.

**Proposition 4.1** Collusion is more stable in the infinitely repeated Cournot delegation model \( (\delta \geq \frac{25}{97}) \) than in the infinitely repeated standard Cournot model \( (\delta \geq \frac{9}{17}) \).

The intuition is that managers face an extremely bad consequence from defection as owners will punish them by firing them. Owners can commit to such punishment for a large set of discount factors, because an owner’s defection from this punishment results in FJS’s unprofitable one-shot delegation equilibrium.

Comparing profits in the infinitely repeated version of FJS’s Cournot delegation model with those in the infinitely repeated standard Cournot model yields a lower equilibrium profit \( \frac{2(a-c)^2}{25b} < \frac{(a-c)^2}{9b} \) for low discount factors \( \delta < \frac{25}{97} \), but a higher equilibrium profit \( \frac{(a-c)^2}{8b} > \frac{(a-c)^2}{9b} \) for intermediate discount factors \( \frac{25}{97} \leq \delta < \frac{9}{17} \), and the same equilibrium profit \( \frac{(a-c)^2}{8b} \) for high discount factors \( \delta \geq \frac{9}{17} \). Proposition 4.2 summarizes.

**Proposition 4.2** In an infinitely repeated setting, FJS’s static key result that delegation reduces firms’ profitability does not hold for high discount factors, is reversed for intermediate discount factors, and survives for low discount factors.

**4.4 Concluding Remark**

Whether delegation improves cartel stability and increases profits in more general frameworks is an ongoing debate. Recent contributions, such as Aubert (2009) and Chapter 2 of this dissertation model, model this question in principal-agent frameworks, thereby studying issues related to information asymmetries.
Part II

Cartels and Buyer Groups
5 Efficient Cartelization Through Buyer Groups

Abstract. In industries with unobservable wholesale contracting, retailers may enjoy cartel rents on their output market through the formation of a buyer group on their input market. A buyer group allows retailers to credibly commit to increased input prices, which serve to reduce combined final output to the monopoly level; increased input costs are then refunded from suppliers to retailers through slotting allowances or rebates. The stability of such an implied cartel depends on the retailers’ incentives to secretly source from a supplier outside of the buyer group arrangement at lower input prices. Cheating is limited if retailers sign exclusive dealing or minimum purchase provisions. If the buyer group brings about cost efficiencies, the mechanism may be stable for every discount factor, while consumer welfare may actually be raised above competitive levels.

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*RBB Economics, London.
5.1 Introduction

Buyer groups are cooperative arrangements between retailers to combine their purchases in input markets. Such groups are widespread, especially in the European grocery industry—see, for example, Dobson and Waterson (1999). A common rationale for forming a buyer group is to exercise buyer power (countervailing power) over suppliers, thereby obtaining more favorable contractual terms, such as lower wholesale prices or increased input quality. As such, buyer groups have the potential to improve welfare, since lower input prices may be passed on to consumers.

In this chapter, we abstract away from countervailing power motivations and focus on the stability of a strictly anticompetitive rationale behind the formation of buyer groups in wholesale markets where contracting is unobservable. While allowing for extraction of monopoly rents on the output market, the anticompetitive buyer group can potentially be more stable than a hardcore output cartel. Moreover, when the buyer group brings about cost efficiencies, its stability increases and consumers are hurt less, or may even benefit. The buyer group then essentially induces an efficient cartel that increases welfare.

Shaffer (1991) shows that, if wholesale contracts are observable, retailers may dampen competition in their output market by accepting contracts with input prices greater than marginal cost. These contracts induce higher retail prices, to which rival retailers respond by also raising retail prices, thereby reducing retailer competition in the output market. Increased input costs are then refunded from suppliers to retailers through slotting allowances, allowing retailers to expropriate greater profits.

The assumption of observable wholesale contracting is not always realistic, because wholesale prices are usually not publicly listed and negotiations often take place behind closed doors. In such cases, Shaffer’s mechanism breaks down, because retailers are unable to credibly (observably) commit to contracts with increased input prices.

However, an outcome similar to Shaffer’s reemerges if retailers form a buyer group, thereby allowing them (i) to jointly negotiate wholesale contracts with the objective of maximizing their joint profits, and (ii) to centrally source inputs so as to save on costs, as well as to monitor each retailer’s behavior. Such an arrangement does not directly

\[^{92}\]Some buyer groups exist only within a market segment such as the Independent Grocers Association (IGA), which is the world’s largest supermarket network with aggregate worldwide retail sales of more than $21 billion per year. Other buyer groups extend across different markets; for example, Corporate United covers industries as various as healthcare, chemicals, telecommunications, defense and financial services. Its membership employs over 1.2 million people and have combined revenues of more than $400 billion.

\[^{93}\]Sources of buyer power include retailers’ capacity to integrate backwards (Katz, 1987), to sponsor entry upstream (Inderst and Shaffer, 2007), to thwart collusion by suppliers (Snyder, 1996, 1998), to engage in multiple sourcing (Inderst, 2008), their position as “gatekeepers” (Majumdar, 2006), explanations related to economic dependency (OECD, 1998), and buyers’ sophistication (Nordemann, 1995).

\[^{94}\]See Katz (1991) for an early critique of contract observability.
relies on Shaffer’s strategic effect: explicit coordination, i.e., joint negotiation of wholesale contracts, eliminates the strategic effect and unit wholesale prices are set “high enough” to induce the joint monopoly outcome in the final output market. Since buyer groups are not per se illegal, this mechanism may be a smart cartelization strategy.

Foros and Kind (2008) have demonstrated the workings of such a mechanism in a static environment. In a dynamic environment, however, similar to the stability concerns of a standard output market cartel, the stability of an anticompetitive buyer group depends on the ability and incentives of retailers to cheat on the buyer group by secretly signing an additional contract outside of the anticompetitive arrangement at lower input prices. Such a move allows the deviant retailer to source cheaper inputs, so as to gain a competitive advantage over its rivals in the output market, and is, therefore, a relevant concern for the stability of the anticompetitive mechanism.

We show that commonly observed vertical restraints—exclusivity provisions, minimum purchase clauses, and rebate schemes—facilitate the stability of the buyer group. These restraints effectively limit the deviant retailers’ ability to source from suppliers outside of the joint agreement. Consider the exclusivity provision which prohibits buyer group members from sourcing from alternative supplier(s) outside of the buyer group arrangement. By including such provisions in the wholesale contracts, retailers credibly tie their own hands, thus committing not to cheat altogether. If exclusivity provisions can be legally enforced, the buyer group induced monopoly outcome is then stable for all discount factors. Relaxing the possibility that contracts may contain exclusivity provisions, the buyer group arrangement can still be as stable as standard output market collusion if contracts contain minimum purchase clauses. A minimum purchase clause limits a deviant retailer’s ability to source from alternative suppliers to the extent that a minimum quantity of inputs must be sourced through the buyer group.

We also examine the model without the presence of vertical restraints. The buyer group arrangement can then still induce extraction of cartel rents as long as retailers are sufficiently patient. However, the mechanism is less stable than standard output market collusion, because a deviant retailer not only earns standard deviation profits, but also receives the slotting allowance independent of whether there is defection. This increases the temptation to cheat and, therefore, reduces the stability compared to standard collusion in the output market. However, if the negative fixed fee is paid as a rebate conditional on the volume of inputs purchased, we show that rebate schemes restore the buyer group’s stability to that of standard output market collusion.

Finally, we allow for buyer group specific savings, (possibly) caused by central sourcing. One may think of a reduction in the variable part of transportation or transaction costs, or more generally, savings through bulk ordering and scale economies. The stability of the anticompetitive buyer group increases with the size of cost savings, because (i) buyer
group profits with cost savings are relatively large in comparison to cheating profits without cost savings, and (ii) Nash punishment after cheating is relatively fierce since buyer group specific cost savings are lost in punishment. The mechanism becomes stable for all discount factors when cost savings are sufficiently large. Moreover, total welfare and even consumer welfare may be raised above competitive levels as cost savings are partially passed on to consumers and may outweigh the anticompetitive effect of inducing the downstream monopoly outcome. Thus, an essentially anticompetitive buyer group may actually serve as a welfare enhancing cartel; this is the case if the competitive equilibrium generates lower welfare than the monopoly outcome with cost savings.

This chapter is set up as follows. In Section 5.2, we discuss related literature. Section 5.3 shows that a buyer group on the input market may serve to fully extract cartel rents on the output market, and that exclusivity provisions make the mechanism stable for all discount factors. In Section 5.4, we show that, in the absence of exclusivity provisions, minimum purchase clauses or rebate schemes make the arrangement still as stable as an output market cartel; without vertical restraints, the arrangement is stable if retailers are patient enough. Section 5.5 allows for cost efficiencies to be realized through the buyer group and shows that this may make the buyer group stable for all discount factors, while total and consumer welfare may actually be above competitive levels. Section 5.6 discusses the policy implications of the model. Section 5.7 concludes.

5.2 Related Literature

Existing explanations for buyer groups include reducing wholesale prices when facing monopolistically competitive suppliers (Mathewson and Winter, 1997), managing competition in healthcare markets (Che and Gale, 1997), strategic commitments to buy on the basis of price alone (Dana, 2003), creating a stronger joint bargaining position (Chae and Heidhues, 2004), and allowing for welfare-enhancing loyalty discounts (Marvel and Yang, 2008). In these papers, the buyer group explicitly affects the competitive process between suppliers and retailers. In contrast, we abstract away from buyer power motivations; the main purpose of the buyer group in our model is to facilitate coordination on the input market that affects the competitive outcome on the output market, while possibly generating efficiencies in marginal costs. Our work most relates to Foros and Kind (2008) and Piccolo (2010); we discuss each in turn.

In a dynamic setting, this chapter employs an anticompetitive mechanism similar in spirit to that outlined by Shaffer (1991). In a static framework, Foros and Kind (2008) show that a buyer group may implement Shaffer’s mechanism by making wholesale contracting observable. Their focus is on the welfare effects of slotting allowances used by buyer groups in a one-shot game, while we focus on the stability of buyer groups us-
ing slotting allowances, rebate schemes, and other vertical restraints. We examine the stability of an anticompetitive buyer group in a dynamic environment by constructing an infinitely repeated game similar to models of collusion, while allowing for (i) secret contracting outside of the buyer group arrangement, and (ii) buyer group specific cost efficiencies. The buyer group effectively acts as an implicit cartel facing a stability issue similar to that of an output market cartel.

Complementary to our work, Piccolo (2010) studies the impact of wholesale contracting on an output market cartel and discusses the role of communication between retailers in sustaining such a cartel. He studies a non-standard cartel program and demonstrates how coordination on the input market enhances collusion on the output market, while we show how collusion on the input market alone is sufficient to achieve the monopoly outcome, without firms forming an output cartel and with wholesale contracts being unobservable. Allowing for exclusive dealing contracts, Piccolo shows that the joint monopoly outcome can be more easily sustained, but not for all discount factors as is the case in our model. The reason is that in Piccolo’s model collusion takes place on the output market, and, therefore, deviation also takes place on the output market. In contrast, in our model collusion takes place on the input market, so deviation (on the input market) is fully restricted by exclusive dealing contracts.

The underlying idea of the Shaffer (1991) effect has its roots in the strategic delegation literature. Fershtman and Judd (1987) and Sklivas (1987) are the seminal papers, which show that commitment on a particular incentive scheme for managers allows firms to soften or intensify product market competition. In the same spirit, Shaffer (1991) shows that commitment on increased wholesale prices in the input market allows retailers to soften competition on the output market.\textsuperscript{95} Two assumptions play a key role in the strategic delegation framework: (i) observability of contracts, and (ii) commitment to contracts. As discussed above, our model does not require observability of contracts. As for the commitment aspect, Rey and Stiglitz (1995) argue that irreversibility of wholesale contracts may be a reasonable assumption, since wholesale prices are usually determined before the price game between retailers takes place; as noted by Foros and Kind (2008), retailers usually do not engage in long-term contracting with consumers, while wholesale contracts are often set for longer periods.

Although we abstract away from countervailing power motivations, our work is closely related to the policy debate surrounding the issue of buyer power, which has been the focus of increased attention from both practitioners and academics\textsuperscript{96} Therefore, Section

\textsuperscript{95}While Shaffer (1991) assumes that retailers have full bargaining power, Irmen (1998) assumes that suppliers have full bargaining power and finds the same result as Shaffer (1991), but with a positive instead of a negative fixed fee.

\textsuperscript{96}Work on buyer power includes, for example, Snyder (1996, 1998), Dobson and Waterson (1997), and
5.6 discusses the policy implications of our results, arguing that similar mechanisms are at work with franchising, joint ventures and resale price maintenance. We also relate to the exclusive dealing literature as we show that vertical restraints tie the hands of retailers and, therefore, serve as credible commitment devices for them to adhere to the anticompetitive buyer group arrangement.

5.3 Buyer Groups and Exclusive Dealing

In this section, we describe the game and show that slotting allowance contracts negotiated through buyer groups allow retailers to expropriate the monopoly rents on the output market. Exclusive dealing provisions ensure this to be stable for all discount factors.

Players. Consider an industry consisting of \( n \) identical retailers, sourcing from perfectly competitive suppliers that produce at constant marginal cost \( c \). The retailers costlessly transform one unit of input into one unit of output, and face continuously differentiable consumer demand \( D(p) \), where \( D'(p) < 0 \).

Timing and actions. Retailers have the option to form a buyer group, which means that (i) the participating retailers jointly negotiate wholesale contracts, while (ii) they source their inputs centrally through this buyer group. The latter assumption allows for monitoring the behavior of each buyer group member, as well as a reduction in marginal costs from \( c \) to \( c - \alpha \).

Firms interact for an infinite number of periods. Each period consists of three stages:

1. **Buyer group stage.** Retailers each individually decide whether to sign up to a buyer group, and are able to condition their participation on other retailers joining.

2. **Contracting stage.** If the buyer group is not established in stage 1, retailers independently and simultaneously negotiate wholesale contracts with suppliers. If a buyer group is established, then its members jointly negotiate wholesale contracts with one or more suppliers with the objective of maximizing the joint profits of the buyer group members.

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98 We model perfectly competitive suppliers to abstract away from countervailing power motivations; that is, retailers extract all wholesale surplus, independent of the existence of a buyer group. In the concluding remarks, we argue that buyer power generated through the buyer group can reinforce our results.
The buyer group members also have the possibility to (secretly) negotiate additional contracts outside of the group arrangement. Contracting takes the form of each retailer $i$, or the buyer group on behalf of all retailers, making a take-it-or-leave-it two-part tariff offer to a supplier, consisting of a linear element $w_i$ and a fixed fee element $\tau_i$. The supplier accepts or rejects the offer.\(^99\)

3. \emph{Competition stage.} Given prevailing wholesale contracts, retailers compete in their output market by simultaneously setting either quantities or prices.

\textbf{Information.} All contracts negotiated outside of the buyer group arrangement are unobservable to rival retailers. That is, contracts are private information if (i) no buyer group is established in the first place, or (ii) a buyer group is established, but a buyer group member decides to negotiate an additional contract outside of the buyer group arrangement. However, both the contracts negotiated through the buyer group, and the volume of inputs sourced through the group, are observable to all buyer group members.

The competitive outcome on the output market (i.e., quantities and prices) are observable by all retailers.

\textbf{Payoffs.} If retailer $i$’s offer is accepted by a supplier, the fixed amount $\tau_i$ is paid immediately after the contracting stage, while the variable amount $q_iw_i$ is paid immediately after the competition stage, where $q_i$ is the quantity sourced by retailer $i$. Payoffs are discounted with factor $\delta$.

We make the following assumptions on each retailer $i$’s profit function $\pi_i(\mathbf{w}, \mathbf{\tau})$,

$$
\frac{\partial \pi_i(\mathbf{w}, \mathbf{\tau})}{\partial w_i} \leq 0, \quad \frac{\partial \pi_i(\mathbf{w}, \mathbf{\tau})}{\partial w_j} \geq 0, \quad (5.1)
$$

$$
\frac{\partial \pi_i(\mathbf{w}, \mathbf{\tau})}{\partial \tau_i} < 0, \quad \frac{\partial \pi_i(\mathbf{w}, \mathbf{\tau})}{\partial \tau_j} = 0, \quad \forall i, \forall j \neq i, \quad (5.2)
$$

where $\mathbf{w} = [w_1, \ldots, w_n]$ and $\mathbf{\tau} = [\tau_1, \ldots, \tau_n]$ are the vectors of linear and fixed elements of prevailing wholesale contracts, respectively. Assumption (5.1) guarantees that a retailer’s profit weakly decreases (increases) with its own (rival’s) variable input costs. Assumption (5.2) states that a retailer’s profits decrease (do not change) with its own (rival’s) fixed input costs. Note that, given prevailing wholesale contracts, retailers’ competitive behavior on the output market depends on marginal input costs only, because fixed input costs are sunk.

\(^99\)Since the upstream industry is perfectly competitive, retailers extract all of the surplus independent of the bargaining framework. That is, we could equally have suppliers making take-it-or-leave-it offers to retailers: equilibrium contracts would be the same, since suppliers have no bargaining power.
Equilibrium concept. We solve for the symmetric subgame perfect equilibrium of the game. First, in the contracting stage we solve for wholesale contracts that maximize the buyer group members’ joint profits when they (Nash) compete in the competition stage. Second, if such a strategy is unstable due to the threat of buyer group members deviating and secretly sourcing outside of the buyer group arrangement, we solve for the critical discount factor such that the maximum joint profit (monopoly profit) is supported by grim-trigger punishment in the form of reversion to Nash behavior.

For now, we abstract away from buyer group specific cost savings, i.e., \( \alpha = 0 \). In Section 5, we introduce those savings and show to what extent the upcoming results carry over.

5.3.1 No Buyer Group

When none of the retailers sign up to the buyer group, each retailer individually and unobservably negotiates with perfectly competitive suppliers. By assumption (5.1), in the contracting stage, each retailer prefers to write a contract with variable costs as low as possible, so as to secure an optimal competitive position vis-à-vis rival retailers in the competition stage. This leads to \( w_i = c \) for every \( i \). That is, by setting the linear element at the suppliers’ marginal cost \( c \), retailers overcome the double-marginalization problem and are able to achieve the vertically integrated outcome. Each retailer sets the fixed fee at zero, so as to keep all of the profits, resulting in suppliers earning zero profits and each retailer earning competitive profits \( \pi^c \equiv \pi_i (w^c, \tau^c) \) in each period, where \( w^c = [c, \ldots, c] \) and \( \tau^c = [0, \ldots, 0] \), that is,

\[
(w_i^c, \tau_i^c) = (c, 0),
\]

for every retailer \( i \in \{1, \ldots, n\} \), where superscript ‘\( c \)’ represents the competitive case.

5.3.2 Fully Stable Buyer Group

Consider the situation in which retailers are able to sign contracts containing exclusive dealing clauses, which specify that retailers may only source through the current contract and are prohibited from sourcing through alternative suppliers. We assume that such contracts are legally binding and credibly enforceable, such that breaking the exclusive dealing clause leads to the deviant retailer facing an expected fine large enough to deter a retailer from such a deviation.

Denote by \( Q^m \) and \( p^m \) the retailers’ total monopoly quantity and price, respectively.
Proposition 5.1 All retailers join the buyer group and jointly negotiate the exclusive dealing contract \((w^m, \tau^m)\), where \(w^m\) and \(\tau^m\) are such that, for every retailer \(i\),

\[
q_i(w^m) = q^m \text{ in the case of quantity competition among retailers, or} \\
p_i(w^m) = p^m \text{ in the case of price competition among retailers; and} \\
\tau^m = -(w^m - c) q^m,
\]

where \(q^m = Q^m / n\) and \(w^m = [w^m, \ldots, w^m]\). This contract allows retailers to jointly extract monopoly profits, and is stable against deviation for all discount factors.

Proof: The buyer group members negotiate wholesale contracts that maximize their joint profits. With quantity or price competition, respectively, the retailers achieve this by solving \((w, \tau)\) from

\[
\max_{(w, \tau)} \sum_{i=1}^{n} \pi_i((w, \tau)) = \max_{(w, \tau)} \sum_{i=1}^{n} \left[ q_i(w) \left( p(Q(w)) - w_i \right) - \tau_i \right], \text{ or}
\]

\[
\max_{(w, \tau)} \sum_{i=1}^{n} \pi_i((w, \tau)) = \max_{(w, \tau)} \sum_{i=1}^{n} \left[ q_i(p(w)) \left( p_i(w) - w_i \right) - \tau_i \right],
\]

such that suppliers do not earn negative profits.

In the case of quantity (price) competition, industry profits are then maximized if wholesale contracts specify linear elements \(w^m\) that induce the downstream monopoly output (price). That is, \(q_i(w^m) = Q^m / n\) in case of quantity competition, and \(p_i(w^m) = p^m\) in case of price competition, for every retailer \(i\). The revenue earned by each active supplier from each retailer is refunded via the fixed fee, \(\tau^m = -(w^m - c) q^m\). An exclusive dealing provision prevents retailers from deviating by signing an additional contract outside of the buyer group, which makes it stable for all discount factors.

The buyer group allows retailers to jointly commit to higher wholesale tariffs \(w^m > c\), which dampens competition at the retail level, resulting in joint monopoly profits. The revenue earned by each active supplier \((w^m - c) q^m\) from each retailer is refunded through a negative fixed fee \(\tau^m\), which corresponds to a slotting allowance. This mechanism allows retailers to jointly expropriate monopoly profits by coordinating their wholesale contracts through a buyer group on the input market, without engaging in per se illegal collusion on the output market.

\[\text{Footnote: An analysis of slotting allowances is presented in Shaffer (1991) and Marx and Shaffer (2007), who describe the practice as widespread across many industries, particularly grocery retailing. The Federal Trade Commission (2003) conducted an analysis of slotting allowances in the supermarket industry and found them to be common practice.}\]
PART II. BUYER GROUPS AND CARTELS

Such an outcome is not possible without the presence of the buyer group. Retailers would then prefer an unobservable wholesale contract specifying a wholesale tariff $c$, so as to be able to increase output (or decrease price) at the expense of rivals’ profits. The buyer group serves to prevent such opportunistic behavior by allowing buyer group members to jointly commit to wholesale tariff $w^m$. This contract can be with one or several suppliers, provided that the contract(s) is (are) negotiated jointly by all group members.

Although retailers have all the bargaining power, they choose to sign exclusive deals that restrict them, not their suppliers. This may seem counterintuitive in the sense that we may expect the opposite to occur in practice, i.e., powerful retailers may try to bind suppliers solely to them. Instead, in our model retailers use their bargaining power to tie their own hands. The intuition is that the exclusive deal serves as a commitment device for retailers to not deviate in the input market, resulting in the stabilization of the coordinated input market arrangement. Not only retailers prefer exclusivity provisions, suppliers also prefer them: the exclusivity provision is a means of guaranteeing that suppliers can recoup their expenditure on slotting allowances. Without such a clause, a supplier cannot legally prevent a retailer from sourcing from another supplier outside of the buyer group arrangement.

An exclusive deal set up by a buyer group may attract the attention of competition authorities. However, the European Commission’s guidelines on horizontal cooperation agreements recognize that:

“An obligation to buy exclusively through the cooperation can in certain cases be indispensable to achieve the necessary volume for the realization of economies of scale.”

Hence, buyer groups using exclusive deals in their contracts are not necessarily illegal, and can actually be falsely defended using the argument that they are required to allow the group to achieve sufficient scale.

5.4 Minimum Purchase Clauses and Rebate Schemes

We now relax the assumption that retailers are able to sign exclusive deals with suppliers, and examine the stability of the buyer group arrangement when this is not the case. Instead, we allow contracts to specify a minimum order size that the retailer in question is legally obliged to purchase from the relevant supplier. Such minimum purchase provisions are widespread; for example, Doucette (1997) notes that “a key characteristic of a successful GPO [group purchasing organization] is its ability to obtain price

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concessions from suppliers, usually in exchange for some guaranteed minimum purchase volume by its members.” By logical extension of the EC guidelines, minimum purchase provisions may be permitted by regulators as they may be perceived to be necessary to achieve economies of scale.

Before moving on to examine the stability of the buyer group arrangement in the presence of minimum purchase provisions, we determine the stability of a standard output market cartel. This will serve as a benchmark to which we compare the stability of the buyer group arrangement.

With symmetric output market collusion, each retailer raises price to \( p^m \) or restricts quantity to \( q^m \), such that they jointly extract monopoly profits \( \pi^m \), with each retailer earning \( \pi^m / n \) per period. Given that all other retailers play the collusive strategy, retailer \( i \) may deviate and earn single-period deviation profit \( \pi^d \) by setting \( q_i \) or \( p_i \) to solve

\[
\pi^d \equiv \max_{q_i} \left( p \left( \frac{n - 1}{n} Q^m + q_i \right) - c \right), \text{ or } \pi^d \equiv \max_{p_i} q_i \left( p_i, p_{m-i} \right) \left( p_i - c \right).
\]

Deviation is observed by rival retailers and induces grim-trigger Nash punishment, resulting in retailers earning competitive profits \( \pi^c \) in all future periods. Therefore, collusion is sustained if and only if the usual incentive compatibility constraint holds,

\[
\sum_{t=1}^{\infty} \delta^{t-1} \frac{\pi^m}{n} \geq \pi^d + \sum_{t=2}^{\infty} \delta^{t-1} \pi^c, \text{ iff } \delta \geq \delta^* = \frac{\pi^d - \pi^m}{\pi^d - \pi^c}.
\]

### 5.4.1 Minimum Purchase Clauses

The stability of the buyer group arrangement depends on the temptation of retailers to cheat on their input market and to secretly negotiate additional wholesale contracts outside of the buyer group arrangement—just like the stability of standard output market collusion depends on the temptation to cheat on the output market and undercut rivals. The optimal strategy to deter deviation from the buyer group arrangement is to join the buyer group in a given period if and only if (i) all rival retailers join the buyer group; (ii) all rival retailers joined the buyer group in all previous periods; and (iii) none of the rival retailers negotiated contracts outside of the buyer group arrangement in previous periods. This strategy is conceptually equivalent to the grim-trigger Nash punishment strategy in games of output market collusion.
A retailer negotiating an additional unobservable contract outside of the buyer group arrangement, with a wholesale price lower than $w^m$, gains a competitive advantage over its rivals in the subsequent competition stage, because rivals are supplied at $w^m$. The optimal additional contract a deviant retailer negotiates prescribes a wholesale price equal to marginal cost,

$$(w, \tau) = (c, 0),$$

which allows the deviant retailer to price below $p^m$ or increase final output above $q^m$ in the competition stage.

Minimum purchase clauses obligate retailers to source a minimum quantity of inputs through the buyer group at wholesale price $w^m$, which makes secret negotiation of an additional contract outside of the buyer group arrangement less profitable. That is, the deviant retailer cannot buy its entire deviant quantity outside of the buyer group arrangement at the lower wholesale price $c$, but only the amount the deviant retailer produces on top of the amount dictated by the minimum purchase clause.

Such a deviation is detected by rival retailers through observing the competitive outcome on the output market. That is, they would observe that the deviant retailer produces more outputs, i.e., sources more inputs, than would be expected at wholesale price $w^m$.

**Proposition 5.2** When contracts can specify minimum purchase provisions, the buyer group optimally negotiates contracts specifying $(w^m, \tau^m)$, as well as a minimum purchase clause of $q^m$. Retailers then jointly extract monopoly profits, and the buyer group arrangement is stable for the same set of discount factors for which standard output market collusion is stable,

$$\delta^{*}_{bg} = \delta^{*}.$$ 

**Proof.** Denote by $\tilde{q}$ the minimum purchase quantity. In the profit maximizing equilibrium, each retailer produces $q^m$ and, therefore, the group strictly prefers to set $\tilde{q} \leq q^m$. The optimal contract that a retailer is able to secretly negotiate outside of the buyer group arrangement is $(w, \tau) = (c, 0)$. Restricted by the quantity clause, the defecting retailer is obliged to source an amount $\tilde{q}$ through the buyer group at marginal cost $w^m$, and can only source incremental amounts outside of the buyer group arrangement at marginal cost $c$. Therefore, noting that the deviating retailer will only produce $q_i \geq \tilde{q}$, it sets $q_i$ or $p_i$ to solve, respectively,

$$\pi^d_{bg} = \max_{q_i} q_i p \left( \frac{n - 1}{n} Q^m + q_i \right) - (\tilde{q}w^m + (q_i - \tilde{q})c) - \tau^m,$$

or

$$\pi^d_{bg} = \max_{p_i} q_i (p_i, p_{-i}^m) p_i - (\tilde{q}w^m + (q_i (p_i, p_{-i}^m) - \tilde{q})c) - \tau^m.$$
We have \( \frac{\partial n_{bg}^d}{\partial q} < 0 \), and, therefore, the optimal minimum purchase quantity is \( \bar{q} = q^m \), which gives \( n_{bg}^d = \pi^d \) by simplifying (5.4) and (5.5), because \( \pi^m = - (w^m - c) q^m \).

Again, the per-period profit earned by participating in the buyer group is \( \pi^m / n \), while the profit decreases to \( \pi^c \) in periods following defection. As a result, the buyer group induced monopoly outcome is stable if and only if

\[
\frac{\pi^m}{(1 - \delta) n} \geq \pi^d + \frac{\delta \pi^c}{1 - \delta},
\]

iff. \( \delta \geq \delta_{bg} = \frac{\pi^d - \Pi^m}{\pi^d - \pi^c} = \delta^* \).

The buyer group arrangement is now as stable as standard collusion, because the deviation profits are equal in both cases. The intuition is that the deviant retailer negotiates a contract outside of the group arrangement with a wholesale price of \( c \), which is the same wholesale price a deviant retailer would face in the case of conventional collusion. As a result, the “marginal condition” is equal in both cases, leading to the same deviation output or price. This, in turn, leads to the same deviation profits: although the group contract specifies a wholesale price \( w^m > c \) on the first \( q^m \) units, the difference is refunded through the slotting allowance and, thus, has no net effect on deviation profits.

### 5.4.2 No Additional Clauses

Consider the case of simple two-part tariff contracts without the option to sign additional clauses. Again, we allow retailers to unobservably deviate from the buyer group by secretly signing additional wholesale contracts, and examine the stability of the arrangement. Such a deviation would be detected by rival retailers through observing the competitive outcome on the output market, because the deviant retailer produces more outputs, i.e., sources more inputs, than would be expected at wholesale price \( w^m \). The following proposition states that, in such a case, the buyer group arrangement is less stable than standard output market collusion.

**Proposition 5.3** Without the possibility of committing to vertical restraints, if retailers are patient enough, the buyer group induces the joint monopoly outcome through wholesale contracts specifying \((w^m, \pi^m)\). The group is less stable than standard output market collusion,

\[
\delta_{bg}^* > \delta^*.
\]

**Proof.** The per-period profit earned by participating in the buyer group is \( \pi^m / n \), while the profit decreases to \( \pi^c \) in periods following defection from the common arrangement.
Because now the buyer group has no minimum purchase requirement, the deviating retailer sources all of his inputs through the supplier he secretly negotiated with instead of through the buyer group contract, because \( c < w^m \). In case of quantity or price competition, the deviating retailer sets \( q_i \) or \( p_i \) so as to solve, respectively,

\[
\tilde{\pi}_{bg}^d = \max_{q_i} \left( \rho \left( \frac{n-1}{n} Q^m + q_i \right) - c \right) - \tau^m, \quad \text{or} \quad (5.6)
\]

\[
\tilde{\pi}_{bg}^d = \max_{p_i} \left( p_i, p_{m-i}^m \right) \left( p_i - c \right) - \tau^m.
\]

The retailer that secretly negotiated an additional contract effectively faces the same optimization problem as a retailer that deviates from tacit collusion—compare, for example, (5.3) and (5.6). These equations are identical except for the slotting allowance term, that is, \( \tilde{\pi}_{bg}^d = \tilde{\pi}^d - \tau^m \). The slotting allowance is fixed (sunk) and, therefore, has no impact on the optimal deviation strategy: a retailer deviating from the buyer group arrangement sets the same price or quantity as a retailer deviating from standard output market collusion. As a result, the buyer group is stable if and only if

\[
\frac{\pi^m}{(1-\delta) n} \geq \pi^d - \tau^m + \frac{\delta \pi^c}{1-\delta},
\]

iff.

\[
\delta \geq \delta_{bg}^* = \frac{\pi^d - \tau^m - \frac{n}{\pi^d - \tau^m - \pi^c}}{\pi^d - \tau^m - \pi^c} > \delta^*,
\]

because \( \tau^m < 0 \) (the fixed fee is a slotting allowance).

The intuition for this result is that the deviant retailer not only earns an amount \( \pi^d \) by sourcing through a different supplier; this retailer also receives the slotting allowance prescribed in the buyer group contract. In other words, sticking to the buyer group strategy gives a payoff equal to the conventional collusive payoff, while negotiating an additional contract outside of the buyer group arrangement gives the collusive deviating payoff plus the slotting allowance. The temptation to deviate from the buyer group arrangement is, thus, higher than the temptation to deviate from conventional collusion.

Deviation by sourcing an amount \( q^d \) outside of the buyer group arrangement is detected by rival retailers through observing the competitive outcome on the output market. Now consider the following type of deviation: the deviant retailer buys the amount \( q^m \) at wholesale price \( c \) outside of the buyer group arrangement. Again, the deviant retailer would increase its earnings, because it sources at price \( c \) instead of \( w^m \), while still receiving the slotting allowance \( \tau^m \). Such a deviation would not be observable on the output market as the volume of outputs produced is \( q^m \). However, deviating by sourcing amount \( q^m \) through a different supplier is dominated by deviating by sourcing amount \( q^d \), because
(i) it is less profitable, because deviating with an amount $q^m$ gives a lower payoff than deviating with the optimal amount $q^d$, and (ii) it is still detected by other buyer group members since the deviant retailer does not source any inputs centrally through the buyer group. In the next section, we show that such a deviation is unprofitable altogether in the case of rebate schemes instead of slotting allowances.

5.4.3 Rebate Schemes

In the analysis so far, we assumed that the payment of the (negative) fixed fee is not contingent on the volume of purchases. We now relax this assumption and allow for rebate schemes, that is, payment of the fixed fee depends on the volume of inputs purchased. These rebates are paid retroactively after all inputs have been purchased. Let subscript ‘rs’ denote the case in which the buyer group contract allows for rebate schemes.

Proposition 5.4 When contracts can specify that the fixed fee can be paid as a rebate, the buyer group optimally negotiates contracts specifying $(w^m, \tau^m)$, where $\tau^m$ is paid if and only if the retailer sources at least $q^m$ units of inputs through the buyer group contract. Retailers then jointly extract monopoly profits, and the buyer group arrangement is stable for the same set of discount factors for which standard output market collusion is stable,

$$\delta_{bg}^* = \delta^*. $$

Proof. The contract that allows retailers to extract joint monopoly profits on the output market is still $(w^m, \tau^m)$, while the optimal contract that a retailer is able to secretly negotiate outside of the buyer group is $(w, \tau) = (c, 0)$. Denote by $q_{rs}$ the volume of inputs that must be purchased through the buyer group in order to receive the rebate $\tau^m$.

There are two ways for a buyer group member to deviate: (i) sourcing an amount $q_{rs}$ against unit cost $w^m$ through the buyer group, thereby receiving the rebate $\tau^m$, while sourcing an amount $q_i - q_{rs}$ outside of the group against unit cost $c$, or (ii) sourcing the full amount $q_i$ outside of the group against unit cost $c$ without receiving the rebate.

The first type of deviation gives deviating profit $\pi^d_{rs} = \pi^d_{bg}$ as in expressions (5.4) and (5.5) with $\bar{q}$ replaced by $q_{rs}$. Noting that retailers strictly prefer $q_{rs} < q^m$ (otherwise the rebate may incentivize retailers to produce more than the monopoly output), and that $\frac{\partial \pi^d_{rs}}{\partial q_{rs}} < 0$, we have that optimally the buyer group sets the rebate threshold at $q_{rs} = q^m$. This then means that $\pi^d_{rs} = \pi^d$. 

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In the second type of deviation, the deviant retailer sets \( q_i \) or \( p_i \) to solve, respectively,
\[
\pi^d_{bg} = \max_{q_i} q_i p_i \left( \frac{n - 1}{n} Q^m + q_i \right) - q_i c, \text{ or }
\pi^d_{bg} = \max_{p_i} q_i \left( p_i, P^m_{-i} \right) p_i - q_i \left( p_i, P^m_{-i} \right) c,
\]
which is equivalent to equations (5.3). Therefore, we again have that \( \pi^d_{rs} = \pi^d \). Thus, both types of deviation give the same deviating profit.

Since the per-period profit earned by participating in the buyer group is \( \pi^m/n \), while the profit decreases to \( \pi^c \) in periods following defection, the buyer group induced monopoly outcome is stable if and only if
\[
\delta \geq \delta^*_b = \frac{\pi^d - \frac{n \pi^m}{n}}{\pi^d - \pi^c} = \delta^*. \quad \square
\]

Thus, rebate schemes, instead of slotting allowances, in the input market also allow retailers to achieve the monopoly outcome in the output market. The difference between rebates and slotting allowances is that rebates are paid after the purchase of inputs (conditionally dependent of the purchased volume), while slotting allowances are paid before the purchase of inputs (independent of the purchased volume). Now, deviating can take two forms: (i) sourcing just enough inputs through the buyer group so as to receive the rebate, while sourcing the remaining inputs outside of the buyer group at lower input cost \( c \), or (ii) sourcing the entire deviating quantity outside of the buyer group.

Since the optimal rebate threshold is \( q^m \), the first type of deviation entails the same deviating payoff as with minimum purchase clauses, from which we already know that its stability is the same as that of a standard output market cartel. With the second type of deviation, the deviant retailer sources all of its inputs outside of the buyer group arrangement at unit cost \( c \) without receiving the rebate, which also gives the same deviating payoff as that of a standard output cartel. Hence, rebate schemes allows the stability of the anticompetitive buyer group to be restored to \( \delta^* \).

Note that the type of deviation discussed in the last paragraph of the previous subsection is unprofitable with rebate schemes. That is, deviating by sourcing \( q^m \) outside of the buyer group at wholesale price \( c \) results in the rebate \( \pi^m \) not being paid out. Thus, deviation gives the same profit in the current (deviation) period as sticking to the equilibrium strategy, i.e., \( q^m \left( p^m - c \right) = \frac{\pi^m}{n} \), while resulting in future Nash punishment.
5.5 Efficient Cartelization

So far, we assumed that there are no monetary benefits from centrally sourcing through the buyer group. We now allow for buyer group specific cost savings, (possibly) caused by central sourcing. For example, the Floral Buyers Group claims to realize cost savings through more efficient transportation and storage of flowers, while the Adelaide Buyers Group saves on overheads by jointly purchasing power generating components.

In this section, we examine how buyer group specific cost efficiencies affect the buyer group’s stability and the implications for welfare. We focus on efficiencies in marginal costs, such as a reduction in the variable part of transportation or transaction costs, or more generally, savings through bulk ordering and scale economies. Subsection 5.5.1 shows that the presence of buyer group specific cost savings increases the stability of the anticompetitive arrangement, while Subsection 5.5.2 shows that these can increase consumer and total welfare above competitive levels.

5.5.1 Stability

Suppose that sourcing from within the buyer group reduces the suppliers’ marginal cost from $c$ to $c - \alpha$, where $0 < \alpha \leq c$. For expositional purposes, we put more structure on the model and consider the Cournot case with inverse demand $P(Q) = 1 - Q$, where $Q = \sum_{i=1}^{n} q_i$. Different demand structures give the same qualitative results.

The buyer group’s stability increases as cost savings are larger. Moreover, the buyer group is stable against cheating for all discount factors if cost savings are large enough. The following proposition formalizes this result. Define $\alpha' = \frac{(n-1)(1-c)}{n+1}$.

**Proposition 5.5** When the buyer group induces cost savings $\alpha$, the critical discount factor is

$$\delta_{bg}^* (\alpha) = \begin{cases} \frac{(n+1)^2 \left\{ [n+1](1-c)-(n-1)\alpha]^2 - 4(1-(c-\alpha))^2 \right\}}{(n+1)^2 \left\{ [n+1](1-c)-(n-1)\alpha]^2 + 4(n-1)(1-(c-\alpha))^2 \right\} - 16n^2(1-c)^2} & \text{if } \alpha < \alpha' \\ 0 & \text{if } \alpha \geq \alpha' \end{cases}$$

which is below $\delta_{bg}^*$ and monotonically decreases in $\alpha \in (0, (n-1)(1-c)/(n+1))$.

**Proof.** See Appendix D.1. \qed

---

\(^{102}\)Reductions in fixed costs would have the same qualitative effect on the buyer group’s stability. Consumer welfare would be unaltered, however, as fixed costs are sunk and do not alter the retailers’ behavior on the output market. See the concluding remarks for more discussion.

\(^{103}\)Instead, allowing the buyer group to reduce the retailers’ marginal cost—for example, variable production costs or transaction costs—will generate the same results. For simplicity, however, we stick to retailers having zero marginal costs, while the suppliers’ marginal costs are decreased by the buyer group.
A buyer group with cost savings is always more stable than a buyer groups without cost savings, i.e., $\delta^*_b (\alpha) < \delta^*_b$. Intuitively, there are two reasons for this. First, defection is relatively less profitable, because the deviant retailer does not enjoy cost savings when sourcing from a supplier outside of the buyer group arrangement. Second, Nash punishment after defection is relatively fiercer, because no cost efficiencies are realized during punishment. The larger the cost savings, the larger are these two effects. As a result, the buyer group becomes more stable as cost savings increase.

When sourcing through the buyer group, retailers benefit from the cost savings, as well as from collusion. The collusion effect has the tendency to increase linear wholesale prices in equilibrium, so as to decrease retailers’ output to the monopoly level, whereas cost savings have the tendency to decrease linear wholesale prices—these opposing effects are formally decomposed in Appendix D.2. When cost savings are relatively large, they dominate the collusion effect in the sense that $w_i$ is pushed below $c$. In such cases, defection is never profitable, because the defection contract with wholesale price $c$ is then worse than the buyer group contract with wholesale price $w_i$. Therefore, when cost savings $\alpha$ are large enough, the anticompetitive buyer group is stable against cheating for all discount factors, i.e., $\delta^*_b (\alpha) = 0$.

Proposition 5.5 is graphically represented in Figure 5.1 for two retailers ($n = 2$). Note that we obtain a graph only if $\alpha \leq c$, otherwise buyer group costs become negative. Keeping marginal cost $c$ fixed, we observe that the critical discount factor $\delta^*_b (\alpha)$ decreases when cost savings $\alpha$ increase, as discussed above. At some point, cost savings become large enough for the critical discount factor to hit zero. In particular, this is the case if $\alpha \geq (n - 1) (1 - c) / (n + 1)|_{n=2} = (1 - c)/3$. The buyer group is then stable for all discount factors.

![Figure 5.1](image-url)  

**Figure 5.1** The critical discount factor $\delta^*_b (\alpha)$ as a function of marginal cost $c$ and cost savings $\alpha \leq c$, for $n = 2$. The buyer group gets more stable as $\alpha$ increases and is stable for all discount factors if and only if $\alpha \geq (1 - c)/3$. 

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5.5.2 Welfare Implications

The buyer group’s implications for welfare are ambiguous. Obviously, retailers always benefit from establishing a buyer group. Whether consumers benefit as well, and how much, depends on the relative importance of the pass-through of cost efficiencies compared to the anticompetitive cartelization effect. The following proposition summarizes the welfare consequences of the arrangement, indicating that an anticompetitive buyer group may actually be welfare enhancing compared to the fully competitive situation.

Proposition 5.6 Retailer profits unambiguously increase by forming a buyer group, total welfare increases if and only if $\alpha > \alpha^{TW}$, and consumer surplus increases if and only $\alpha > \alpha^{CS}$, where

$$\alpha^{TW} = \frac{\sqrt{\frac{4}{3}n(n+2) - (n+1)}(1-c)}{n+1} < \alpha^{CS} = \frac{(n-1)(1-c)}{n+1}.$$ 

Proof. See Appendix D.2.

The intuition relies on the relative importance of cost savings and collusion. Retailers unambiguously benefit from the buyer group, because they profit both from collusion and savings in marginal costs. Consumers benefit from the anticompetitive buyer group if and only if the pass-on of cost savings outweighs the collusion effect. Collusion tends to reduce output, whereas cost savings tend to increase output; the latter effect dominates the former if and only if $\alpha > \alpha^{CS}$. Both effects are decomposed in Appendix D.2.

Society as a whole benefits from the buyer group if and only if the gain of the retailers outweighs the loss, if any, of consumers. This is the case if and only if $\alpha > \alpha^{TW}$, because then cost savings together with the pass-on of cost savings are large enough to compensate the sum of the consumers’ dead weight loss and the retailers’ loss of business, if any. The threshold $\alpha^{TW}$ is lower than $\alpha^{CS}$, because for total welfare to increase it not necessary for consumers to gain; it is sufficient that retailers gain more than consumers lose.

The welfare implications of an anticompetitive buyer group with cost savings are graphically illustrated in Figures 5.2a–c for two retailers ($n = 2$). Per-retailer profit (5.2a), consumer surplus (5.2b) and total welfare (5.2c) are shown as a function of cost savings $\alpha$ and discount factor $\delta$. Original marginal cost is fixed at $c = 1/2$.

In Figure 5.2a, the flat triangular plane represents competitive per-retailer profit when the buyer group is unstable, which is the case if cost savings are small and/or retailers are

\footnote{Of course, the buyer group is always detrimental for consumers if one takes as the counterfactual the buyer group with cost efficiencies, but without collusion. Instead, we take as the counterfactual the fully competitive situation without the presence of the buyer group, because, if retailers had the choice, they would use the buyer group to extract monopoly profits.}
Figures 5.2A–C. Equilibrium per-retailer profit, consumer surplus and total welfare, for \( n = 2 \) and \( c = 1/3 \). The tilted (flat) plane represents utility when the buyer group is stable (unstable). The stability condition that “cuts” the two planes is \( \delta > 9 \left( -27\alpha^2 - 84\alpha + 20 \right) / \left( 405\alpha^2 + 108\alpha + 212 \right) \); the buyer group is always stable if and only if \( \alpha \geq 2/9 \). Profits, consumer surplus and total welfare are all increasing in cost savings \( \alpha \). The presence of a stable buyer group is (i) always beneficial for retailers, (ii) beneficial for consumers if and only if \( \alpha > \alpha^{CS} = 2/9 \approx 0.22 \), and (iii) beneficial for society as a whole if and only if \( \alpha > \alpha^{TW} = 2 \left( 4\sqrt{6} - 9 \right) / 27 \approx 0.06 > \alpha^{TW} \).

impatient. The tilted plane represents monopoly per-retailer profit when the buyer group is stable. The relevant stability condition on \( \delta \) and \( \alpha \) that “cuts” the flat and the tilted plane is pinned down in Proposition 5.5. Retailers are always better off with a buyer group than without it: the tilted plane is always above the flat plane. When the buyer group is stable, retailer profit increases with cost savings \( \alpha \), that is, the tilted plane slopes upwards when \( \alpha \) increases. Moreover, the buyer group is stable for all discount factors if cost savings \( \alpha \) are large enough; this result is represented by the fact that the tilted plane covers all discount factors for sufficiently high \( \alpha \).

In Figure 5.2B, the flat triangular plane represents consumer surplus when the buyer group is unstable, while the tilted plane represents consumer surplus when the buyer group is stable. When the buyer group is stable, consumer surplus increases with the size of cost savings \( \alpha \), because cost savings are partly passed on to consumers: the tilted plane slopes upwards when \( \alpha \) increases. A stable buyer group is beneficial for consumers if and only if cost savings are large enough, because then the pass-on of cost savings dominates the collusion effect. This result is graphically represented by the fact that the tilted plane is higher than the flat plane if and only if \( \alpha \) is large enough.

In Figure 5.2C, the flat triangular plane represents total welfare when the buyer group is unstable, while the tilted plane represents total welfare when the buyer group is stable. When the buyer group is stable, cost savings are beneficial for total welfare; again, the tilted plane slopes upwards with \( \alpha \). A stable buyer group is beneficial for society as a whole if and only if cost savings are large enough, because then cost efficiencies outweigh the consumers’ deadweight loss plus the retailers’ loss of business, if any. In that case, the tilted plane is above the flat plane. The tilted plane is above the flat plane for more values
of $\alpha$ in Figure 5.2c than in Figure 5.2b; the reason is that benefits for society are reached for more values of $\alpha$ than benefits for consumers.

To summarize, buyer group specific cost efficiencies increase the stability of an essentially anticompetitive mechanism. If cost savings are high enough, the implied cartel becomes stable for all discount factors. However, consumers may actually be better off compared to the fully competitive benchmark, because cost savings are partially passed on to them. Thus, a buyer group that serves to extract cartel rents on the output market may either hurt or benefit consumers, depending on the scope for buyer group specific cost efficiencies and its resulting stability.

5.6 Policy Implications and Discussion

Our findings contribute to the growing debate both among academics and practitioners on the competitive effects of buyer groups, and what the appropriate approach by regulators should be to dealing with such arrangements, which are not per se illegal under either U.S. antitrust law or E.U. competition law. This discussion has traditionally mirrored that which surrounds the issue of buyer power more generally. By enabling firms to exercise countervailing power over their suppliers, a buyer group can allow its members to obtain lower input prices, a significant proportion of which may be passed onto consumers in the form of lower retail prices, provided that there is effective retail competition (Inderst and Mazzarotto, 2007). On the other hand, it has been argued that the exercise of buyer power could potentially result in waterbed effects, resulting in rival buyers being charged higher prices or being offered inferior quality inputs (Majumdar, 2006, Inderst and Valletti, 2009).

Furthermore, buyer groups can potentially serve to level the playing field between firms downstream, by allowing smaller buyers access to the same terms of trade that larger buyers have access to. Finally, and of most relevance to our findings, buyers groups can have implications for the potential for tacit collusion between members. For example, the group arrangement may result in the sharing of information between firms or may serve to increase the degree of symmetry between members, thereby possibly facilitating collusion—see U.K. Office of Fair Trading (2007).

Our findings have highlighted additional factors that policy makers must be aware of when dealing with buyer groups. If buyer groups act as implied cartels, they may be mistakenly identified as procompetitive forces, with retailers arguing that a buyer group allows them to secure discounts from suppliers, which can then be passed on to consumers in the form of lower prices. In our model, retailers may use the high slotting allowances paid by the suppliers in equilibrium as “evidence” of the buyer group being a procompetitive organization acting to reduce input prices. We, therefore, caution policy makers
assessing the impact of a buyer group to be careful when interpreting evidence on input prices, and to recognize that high slotting fees will likely not result in enhanced downstream competition (as they are fixed payments) and that they may be paid in response to higher wholesale prices, which explicitly reduce downstream competition.\footnote{105}

A further key issue for policy makers which our conclusions highlight relates to the fact that an anticompetitive buyer group is likely to be harder to detect than standard forms of output market collusion, such as (tacitly) raising prices. An antitrust authority investigating the output market may not be able to find evidence of anticompetitive behavior if the retailers use a buyer group to jointly expropriate monopoly profits. An analysis of, for example, price-cost mark-ups would find no evidence of firms pricing above competitive levels if the retailers’ costs are taken as given. It may be a significant step for the antitrust authority to expand the analysis of suspected retailer collusion to include an examination of the process of wholesale contracting between retailers and suppliers in the upstream market, but our work highlights that this may indeed be necessary.\footnote{106}

Our work also contributes to the continuing policy debate regarding vertical restraints. Interestingly, in our model such restraints are not imposed on buyers by powerful suppliers in order to extract profits or exclude upstream rivals, but are willingly entered into by retailers themselves as a means by which they can jointly credibly commit to purchasing from the buyer group at higher wholesale prices. Our findings caution against possible anticompetitive effects when vertical restraints are observed in such circumstances. In the model, we explicitly considered exclusive dealing and minimum purchase clauses, as well as rebate schemes, but similar results would be obtained through the use of retail price maintenance (RPM). Then, retailers could coordinate wholesale contracts to include RPM clauses which tie their hands in the sense that they prevent them from pricing below the monopoly price on the output market.

Similar effects may be expected to arise from other restraints which serve to encourage buyers to purchase from a single supplier, such as input joint ventures and franchising. As for joint ventures, Priest (1977) and Chen and Ross (2003) show that an industry-wide joint venture, where its members are charged per-unit royalties, functions similarly as a buyer group with slotting allowances. The joint venture may set per-unit royalties on the input market high enough such that the monopoly outcome is realized on the output market, while sharing the joint venture’s profit among the retailers, resulting in

\footnote{105}{The fact that the given contract entails a higher wholesale price is not necessarily evidence of anticompetitive behavior. Foros, Kind and Sand (2009) present a model in which retailers optimally pay higher wholesale prices as this then gives suppliers greater incentives to undertake demand-enhancing non-contractible investment. The Federal Trade Commission (2003) explicitly recognizes this argument.}

\footnote{106}{For example, the Commission imposed fines on five firms active in the Spanish raw tobacco industry as it concluded that purchasing quotas served as targets for market shares in the downstream market—see the Commission’s decision of 20 October 2004 in Case COMP/C.38.238/B.2-Raw Tobacco-Spain.}
joint monopoly profits. Also, franchising is often organized as a buyer group (Blair and Lafontaine, 2005), implying the same anticompetitive effects as an implied cartel. However, even when the cartelization effect we identify is present, it cannot be interpreted in isolation from all of the other issues which surround buyer groups. We demonstrated that even when a buyer group serves to expropriate joint monopoly profits on the output market, consumers can still be better off when this effect is outweighed by efficiency savings which then result in lower retail prices. Therefore, the effect we identify must be considered alongside other evidence on how such groups affect the relationship between buyers and sellers, and competition in the downstream market.

Finally, as well as demonstrating that buyer groups can potentially facilitate explicit collusion, our work also serves to highlight the conditions under which this is likely to be a concern. Primarily, in exchange for the higher wholesale prices that buyers pay they must receive lump sum slotting fees in return, otherwise it would be the suppliers that expropriated the monopoly rents and the buyers would actually be worse off. In practice, this need not be an explicit “slotting fee,” but could, for example, be presented as a “marketing allowance” or an end of year rebate; and in principle it does not even need to be an explicit monetary payment; for example, the supplier could pass on technological knowhow or superior training methods of equal value. Secondly, an anticompetitive buyer group arrangement is much more likely to successfully arise when the membership of the group in question consists of all of the firms in the market. If many firms remain outside of the group, they would likely be able to undercut the higher retail prices offered by the group members (or increase output to make up for their restriction), and would, therefore, deter the group from attempting to undertake such a cost-raising arrangement in the first place.

5.7 Concluding Remarks

Buyer groups play an important role across a wide range of sectors in the economy. They may facilitate procompetitive forces based on buyer power considerations, acting to reduce wholesale prices and level the playing field between smaller firms and larger firms that can exercise buyer power unilaterally, which is potentially to the benefit of final consumers. We instead develop a model of a strictly anticompetitive effect of buyer groups in markets where wholesale contracting is unobservable. A buyer group allows its members to credibly commit to wholesale contracts that induce joint monopoly profits in the downstream market. We show that commonly observed vertical restraints and contracting terms—exclusivity provisions, minimum purchase clauses, and rebate schemes—enhance the stability of the buyer group by effectively limiting retailers’ ability or incentives to defect from the arrangement.
Efficiencies in marginal costs generated through the buyer group increase its stability; if cost savings are large enough, the anticompetitive mechanism becomes stable for all discount factors. However, total and consumer welfare actually increase above competitive levels when cost savings are sufficiently substantial. In such a case, an anticompetitive buyer group essentially behaves as a welfare-enhancing cartel: the monopoly outcome with cost efficiencies then generates greater welfare than the competitive outcome without cost efficiencies.

Other advantages of buyer groups, such as a reduction in fixed costs or the exercise of buyer power, would similarly stabilize the anticompetitive mechanism. The impact on consumers and welfare would again depend on the nature and pass-through of those advantages to consumers. For example, if the exercise of buyer power leads to increased product quality, consumers benefit in the sense that they consume a superior product than they otherwise would. On the other hand, while a buyer group specific reduction in fixed costs would increase the group's stability, consumers would in no way benefit since fixed costs do not affect the competitive outcome in the output market. Thus, the welfare effects of an anticompetitive buyer group critically depend on the type of efficiencies created, and how these tradeoff against the cartelization effect. However, although buyer groups may generate efficiencies that are to the benefit of final consumers, our work indicates that exclusive dealing and minimum purchase contracts negotiated through buyer groups, in combination with slotting allowances, or the use of rebate schemes, may be worthy of closer scrutiny by regulators.
Part III

Antitrust Damages
6 The Overcharge As a Measure for Antitrust Damages

Abstract. Victims of antitrust violations can recover damages in court. Yet, the quantification of antitrust damages and to whom they accrue is often complex. An illegal price increase somewhere in the chain of production percolates through to the other layers in a ripple of partial pass-ons. The resulting reductions in sales and input demands lead to additional harm to both downstream (in)direct purchasers and upstream suppliers. Nevertheless, U.S. civil antitrust litigation is almost exclusively concerned with direct purchaser claims for (treble) damages calculated on the basis of the overcharge. In the E.U., a private damages litigation practice is currently emerging, potentially based on the overcharge. In this chapter, we show that there exists no structural relationship between the direct-purchaser overcharge and the harm caused by an antitrust violation on all of the direct and indirect purchasers and sellers in a vertical chain of production.

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6.1 Introduction

Anticompetitive acts to eliminate competition can cause widespread harm. In the U.S., under Section 4 of the Clayton Act: “Any person who shall be injured in his business or property by reason of anything forbidden in the antitrust laws [...] shall recover threefold the damages by him sustained.” The vast majority of civil actions for antitrust damages concerns cartels. In Europe, a private litigation practice is currently emerging.\(^{107}\)

The identification of antitrust harm can be complicated. In longer supply chains, in which one product is an input in the production of the next, an illegal price increase somewhere in the chain can percolate through to the other layers in a ripple of partial pass-ons. The resulting reductions in sales cause additional harm to direct and indirect customers and suppliers of the wrongdoer(s).

In order to determine who is affected by an antitrust violation and to what extent, in principle all actual trades need to be compared to what would have been the market allocation without the anticompetitive behavior—the so-called “but-for” world.\(^{108}\) In practice this is often difficult. At a minimum, it requires information about consumer demand and the structure of the market, such as the number of layers in the production chain, the type and level of competition among firms in each layer, their production technologies and costs.

In the U.S., some of these complexities have been reduced by case law. At least since Chattanooga Foundry (1906) have direct purchasers been entitled to recover damages on the basis of the overcharge they paid as a result of the antitrust infringement.\(^{109}\) According to this prevailing method, basic damages—before trebling and interest, if applicable—are calculated as the difference between the anticompetitive price and the competitive but-for price, multiplied by the amount actually purchased. The overcharge ignores lost profits on transactions that could have been made at lower prices, which courts have been reluctant to award.

Indirect purchasers often do not have standing to sue. In Hanover Shoe (1968), the Supreme Court ruled against the use of the pass-on defense in Federal antitrust damage actions.\(^{110}\) In a pass-on defense, the defendant attempts to show that the plaintiff did not in fact suffer the amount of damages claimed on the argument that it was able to pass on all or part of the overcharges on downstream to it customers. In addition, in Illinois Brick (1977) the Supreme Court established that only the direct purchasers have legal

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\(^{107}\) See, for example, the European Commission’s 2008 White paper on damages actions for breach of the EC antitrust rules, pp. 3 and 7.

\(^{108}\) See Fisher (2006) for a survey of the methods that can be applied to determine but-for prices.

\(^{109}\) Chattanooga Foundry & Pipe Works v. Atlanta, 203 U.S. 396 (1906).

\(^{110}\) Hanover Shoe Inc. v. United Shoe Machinery Corp. 392 U.S. 481 (1968).
standing in Federal court to sue for antitrust damages. The Supreme Court in \textit{Hanover Shoe} and \textit{Illinois Brick} together cemented the use of the overcharge, which indeed disregard pass through.

Direct suppliers to a buyers cartel that colluded to depress input prices can in principle maintain a treble-damages action after \textit{Mandeville Island Farms} (1948). Yet, standing was denied by the Supreme Court to suppliers damaged by anticompetitively restricted demand for their produce in \textit{Associated Contractors} (1983). As a result of these legal constraints, in the vast majority of U.S. antitrust damages actions, the plaintiffs are direct purchasers and their claim is based on the overcharge.

In this chapter, we consider the effects of anticompetitively raised prices somewhere in a chain of production with an arbitrary number of layers. We will mostly refer to cartels, but our results have wider antitrust application. Competition in each layer is specified between perfect competition and monopoly. This allows us to exactly characterize the effects of the cartel’s direct and indirect purchasers, as well as its direct and indirect suppliers. We assess the bias introduced by relying on the overcharge on the direct purchasers, which we refer to as the \textit{direct-purchaser overcharge}, for the estimation of the actual antitrust harm in the chain.

We find that even in the most basic of settings—with unit pricing and input price taking—the direct-purchaser overcharge is a poor measure of the true antitrust harm. The overcharge can grossly underestimate the actual antitrust harm, depending on such characteristics of the market as the shape of demand, the number of producers, the type of competition, and the location of the cartel in the chain of production. In particular, we show that lost profit harm ignored by the direct-purchaser overcharge may increase without bound with the length of the production chain. Moreover, the method misses harm sustained upstream from the cartel, which can be substantial. The ratio of antitrust harm to the direct-purchaser overcharge can be anything between one and infinity.

The existing literature on cartel pass-on effects uses a model with only three layers: a top layer of input producers that form a cartel upstream, a layer of direct purchasers downstream who sell to a third layer of final consumers. \citet*{hellwig2006} shows that the deadweight-loss of a direct purchaser monopolist from discrete cartel price increases is equivalent to the part of the overcharge it was able to pass on to consumers. On this basis, \citet*{hellwig2006} argues that the direct-purchaser overcharge is a good measure for the actual

\footnotesize
\begin{itemize}
\item \textit{Illinois Brick Co. v. Illinois} 431 U.S. 720 (1977). Later, in \textit{California v. ARC America Corp.} 490 U.S. 93 (1989) the Supreme Court left it to the discretion of individual states whether or not to allow indirect purchaser suits. As a result, the rules on antitrust standing vary across the states, with a small majority allowing indirect purchaser suits under state law. See also Schinkel, Tuinstra and Rügeberg (2008).
\item \textit{Mandeville Island Farms, Inc. v. American Crystal Sugar Co.}, 334 U.S. 219 (1948).
\item \textit{Associated Gen. Contractors of Cal., Inc. v. Carpenters}, 459 U.S. 519 (1983). Suppliers standing is discussed more extensively in Subsection 6.3.2.
\item See Harris and Sullivan (1979) and Kosicki and Cahill (2006).
\end{itemize}
antitrust harm sustained by this group. Verboven and Van Dijk (2009) use this model to analyze an infinitesimal cartel price increase to determine “discounts” to be given on the direct-purchaser overcharge to correct for pass-on to consumers and output effects locally. Basso and Ross (2010) extend the approach to differentiated products, so that there can be input substitution, to produce a numerical table of correction factors for a discrete cartel price increase. Boone and Müller (2008) express the share of (otherwise unspecified) total antitrust harm borne by consumers for an infinitesimal price increase as a function of common measures such as the HHI and PCM.

This chapter is organized as follows. In Section 6.2, we decompose the various welfare effects caused by a cartel anywhere in a chain of production and relate aggregate and individual effects to the overcharge on the direct purchasers. In Section 6.3, we evaluate the direct-purchaser overcharge as an for antitrust harm. Section 6.4 concludes.

### 6.2 Cartel Effects in a Vertical Production Chain

In this section, we present the model (6.2.1); decompose cartel harm (6.2.2); and express this harm in terms of the direct-purchased overcharge.

#### 6.2.1 A Vertical Model of Production

Consider a vertical chain with several layers of intermediaries, each adding value to produce a homogenous consumer product. Let consumer demand for the final product be represented by an inverse demand function $P : \mathbb{R}_+ \rightarrow \mathbb{R}_+$, which is non-increasing, twice differentiable and continuous in aggregate production $Q$. Let there be $K$ layers of production, with $n_k$ firms active in layer $k$. Except for layer 1, where the raw materials originate, the firms in any layer $k$ each transform a homogeneous input they purchase from firms in layer $k - 1$, using a one-to-one technology, into a homogeneous new output, which they sell on to the firms in layer $k + 1$. Eventually, the firms in layer $K$ sell the final product to consumers. Figure 6.1 illustrates.

We assume that the number of firms in each layer is exogenously given and fixed. The cost function for firm $j$ in layer $k$ is given by $p_{k-1}q + c_{jk}(q)$, where $p_{k-1}$ is the unit price for the input from layer $k - 1$ (with $p_0 = 0$), and $c_{jk}(q)$ are the costs for transforming $q$ units of the input into $q$ units of the output. We abstract from nonlinear pricing or more general types of vertical relations between firms from different layers.

Firms move simultaneously within the same horizontal layer, and sequentially following the layer above—so layer 1 moves first, layer 2 second, and so on. That is, we assume that all firms in each layer are price takers in their input market. As a result, all upstream antitrust effects in our model are reduced input demand effects.
The market equilibrium is found by backward induction. First consider layer $K$. For any possible input price $p_{K-1}$, and given final consumer demand $P(Q)$, we can determine the resulting equilibrium output in layer $K$. Let the relationship between this equilibrium quantity and $p_{K-1}$ be represented by a uniquely defined, non-increasing, continuous and differentiable function $p_{K-1}(Q)$. This function serves as the inverse demand function for the firms in layer $K-1$. Firms in layer $K-1$ then determine, for any $p_{K-2}$ and given their inverse demand function $p_{K-1}(Q)$, their optimal production quantity. This, in turn, leads to an inverse demand function $p_{K-2}(Q)$ for firms in layer $K-2$, and so on.

For analytical convenience, we analyze a model with conjectural variations to simulate various types of competition in each layer. That is, in each layer $k$ firm $j$’s conjecture about the reaction of the other firms in that layer to its quantity decision is $\vartheta_k = \frac{\partial Q}{\partial q_{jk}}$. We assume that $\vartheta_k$ is the same for all firms in a horizontal layer, but may be different for firms across different layers. Hence, given input price $p_{k-1}$, the first-order condition for a symmetric equilibrium in layer $k$, with conjectural variations parameter $\vartheta_k$ is

$$p_k(Q) + \frac{\vartheta_k}{n_k}QP_k'(Q) - c_k - p_{k-1} = 0. \quad (6.1)$$

Note that the classic Cournot conjecture corresponds to $\vartheta_k = 1$. If $\vartheta_k = 0$, all

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115This is an assumption in so far that a priori it can be that for a certain value of $p_k$ there exist multiple equilibria in the quantity-setting subgame in layer $k$. For all specifications considered in this chapter, however, an explicit, continuous and differentiable relationship between $p_k$ and $Q$ exists for every $k$.

116Basso and Ross (2010) take the same approach. For a conceptual critique of the conjectural variations approach, see Hahn (1989).
firms in layer $k$ are price takers, so that in equilibrium prices will equal marginal costs, i.e., $p_k = p_{k-1} + c_k$. The specification $\vartheta_k = n_k$ is analytically equivalent to full horizontal collusion in layer $k$. Other values of $\vartheta_k$ close to $n_k$ can be interpreted as forms of imperfect collusion, in which joint-profit maximization is further constrained, for example, when the cartel members understand that the risk of discovery and the size of a consequential damage claim are likely to depend upon the cartel’s pricing and production strategy.\footnote{\textsuperscript{117}Salant (1987) and Harrington (2004b) offer analyses of such additional incentive constraints.}

We denote the ultimate equilibrium quantity on the inverse demand function $p_1 (Q)$ faced by the firms in layer 1 by $Q^\ast$. Equilibrium prices then clear as $p_1^\ast = p_1 (Q^\ast)$, …, $p_{k-1}^\ast = p_{k-1} (Q^\ast)$ and $p_k^\ast = P^\ast = P (Q^\ast)$. The individual level of production of firm $j$ in layer $k$ equals $q_{jk}^\ast$, with $\sum_{j=1}^{n_k} q_{jk}^\ast = Q^\ast$. Equilibrium profits and consumer surplus follow straightforwardly from these quantities and prices.

Now suppose that the firms in some layer $g \in \{1, \ldots, K\}$ form a cartel, while competitive conditions in all other layers remain the same—note that these may include pre-existing cartels elsewhere in the chain. Our set-up implies that the cartel uses its obtained market power to raise unit prices \textit{vis-à-vis} its customers, but remains a price-taker on the market for its inputs. We further assume that there are no cartel-specific efficiency gains that would somehow allow the cartel to produce at lower costs than its members could in competition. Let the resulting equilibrium quantity and equilibrium prices under the cartel regime be denoted by $Q^g$ and $p_k^g$ for $k = 1, \ldots, K$.\footnote{\textsuperscript{118}In our model it is optimal for the cartel to increase prices symmetrically, so that the cartel price $p_k^g$ is the same for each direct purchaser. Verbven and Van Dijk (2009) also consider various asymmetric cartel price mark-ups in their reduced form model. This could be relevant, for example, if some of the direct purchasers are integrated with a colluding firm.} Firm $j$ in layer $k$ produces $q_{jk}^g$ with $\sum_{j=1}^{n_k} q_{jk}^g = Q^g$, for all $k$.

### 6.2.2 Decomposition of Cartel Effects

The presence of the cartel causes harm to welfare in the form of high unit prices, resulting in lost profits throughout the chain of production, lost consumers surplus, and deadweight-losses, while the cartel members raise their profits. That is, $Q^g < Q^\ast$ and $p_k^g > p_k^\ast$. Typically also $p_k^g > p_k^g$ for $k > g$ and downstream intermediaries and consumers are harmed by the price conspiracy. Under certain specifications, the profits of some downstream intermediaries, in particular direct purchasers, may actually increase in response to the upstream price increases.\footnote{\textsuperscript{119}For an analysis of comparative statics effects in Cournot models, see Dixit (1986) and Quirmbach (1988).} Also, prices higher up in the chain may either in- or decrease, depending upon the shape of demand and cost functions. \textit{In toto}, however, collusion on unit prices is always bad for welfare.
The impact of the $g$-level cartel’s unit price increase on one particular layer $k$ of production that is downstream from layer $g$ can be decomposed into three distinct effects. The *overcharge effect* on layer $k$ is the amount by which the firms in this layer are overcharged by the previous layer $k - 1$. Part of the burden of this overcharge may be passed on by the firms in layer $k$ to the next layer of production, layer $k + 1$. This is the *pass-on effect*. Finally, the *output effect* results from the decrease in production due to the cartel. It amounts to the losses in profits from the reduction in sales.\textsuperscript{124} We consider each of these effects separately, as they are borne out in lost profits. Appendix E.1 graphically illustrates these effects.

Consider the aggregate profits of firms in layer $k$. In the competitive benchmark, these are $\pi_k^* = (p_k^* - p_{k-1}^*) Q^* - \sum_{j=1}^{n_k} c_{jk} (q_{jk}^*)$. Under the cartel regime, they are $\pi_k^g = (p_k^g - p_{k-1}^g) Q^g - \sum_{j=1}^{n_k} c_{jk} (q_{jk}^g)$. The difference $\triangle \pi_k = \pi_k^* - \pi_k^g$ can be decomposed as follows

\[
\triangle \pi_k = Q^g (p_{k-1}^g - p_{k-1}^*) - Q^g (p_k^g - p_k^*) + \\
\left[ (Q^* - Q^g) (p_k^* - p_{k-1}^*) + \sum_{j=1}^{n_k} c_{jk} (q_{jk}^g) - \sum_{j=1}^{n_k} c_{jk} (q_{jk}^*) \right] = \xi_k - \omega_k + \sigma_k. \tag{6.2}
\]

The first factor is the overcharge effect on firms in layer $k$, thus defined as

\[
\xi_k = Q^g (p_{k-1}^g - p_{k-1}^*), \quad \tag{6.3}
\]

or the price increase of the product of the previous layer $k - 1$, multiplied by the quantity purchased under the cartel regime.

The second factor,

\[
\omega_k = Q^g (p_k^g - p_k^*), \quad \tag{6.4}
\]

corresponds to the pass-on effect, which is the amount of the price increase that layer $k$ passes on to layer $k + 1$. It is equal to the price increase of layer $k$ multiplied by the quantity produced under the cartel regime. Note that $\omega_k$, the pass-on effect of layer $k$, equals the overcharge effect suffered by layer $k + 1$, that is, $\xi_{k+1} = \omega_k$.

\textsuperscript{124}Our decomposition follows Hellwig (2006), but we use a slightly different terminology. Where he distinguishes between a *direct cost effect* and a *business loss effect*, we use *overcharge effect* and *output effect*, respectively. Verboven and Van Dijk (2009) also analyze both effects, but for exogenous infinitesimal changes in the input prices, rather than endogenous discrete equilibrium effects. They speak of *direct cost effect* and *output effect*, respectively. All three papers share the definition of the *pass-on effect*.
The last factor in equation (6.2) is the output effect,

$$\sigma_k = (Q^* - Q^g) \left( p^*_k - p^*_{k-1} \right) + \sum_{j=1}^{n_k} \left( c_{jk} \left( q^g_{jk} \right) - c_{jk} \left( q^*_{jk} \right) \right).$$  \hspace{1cm} (6.5)

This part represents the loss of profits that could have been made on the larger volume in the competitive benchmark. It can be rewritten as the sum of individual firm output effect, $\sigma_k = \sum_{j=1}^{k} \sigma_{jk}$, with

$$\sigma_{jk} = \left( q^*_{jk} - q^g_{jk} \right) \left( p^*_k - p^*_{k-1} - \bar{c}_{jk} \left( q^*_{jk} \right) \right) + q^g_{jk} \left( \bar{c}_{jk} \left( q^g_{jk} \right) - \bar{c}_{jk} \left( q^*_{jk} \right) \right).$$

Here $\bar{c}_{jk} \left( q_{jk} \right) = c_{jk} \left( q_{jk} \right) / q_{jk}$ are the average costs for firm $j$ in layer $k$, evaluated at $q_{jk}$. The first part of the individual output effect, $\left( q^*_{jk} - q^g_{jk} \right) \left( p^*_k - p^*_{k-1} - \bar{c}_{jk} \left( q^*_{jk} \right) \right)$, equals the lost sales times the average profit margin and is always positive. The sign of the second part, $q^g_{jk} \left( \bar{c}_{jk} \left( q^g_{jk} \right) - \bar{c}_{jk} \left( q^*_{jk} \right) \right)$, is ambiguous. It is positive (negative) if average costs for firm $j$ in layer $k$ are decreasing (increasing).

The effects on layers upstream from cartel layer $g$ (i.e., layers $k < g$) can be decomposed in much the same way. These layers also each face an overcharge, a pass-on and an output effect. The effect of the cartel on upstream prices results from reduced derived demand and are ambiguous. As a result, so are the signs of the upstream overcharge and pass-on effects. If all upstream prices increase, the upstream overcharge and pass-on effect are positive. If all upstream prices decrease, both the overcharge effect and the pass-on effect of the upstream layers will be negative, corresponding to a decrease in input costs and a decrease in revenues, respectively. In certain specifications, it may also be that all upstream prices remain the same so that there are no upstream overcharge and pass-on effects. Generally, some of the upstream prices may increase and others decrease.

All the way at the end of the supply chain, the loss in consumer surplus of the final consumer is given by

$$\Delta CS = CS^* - CS^g = \xi_C + \sigma_C,$$

in which

$$\xi_C = Q^g \left( p^g_K - p^*_K \right) \quad \text{and} \quad \sigma_C = \int_{Q^g}^{Q^*} \left[ P \left( Q \right) - P \left( Q^* \right) \right] dQ,$$

where $p^g_K = P \left( Q^g \right)$ and $p^*_K = P \left( Q^* \right)$. Note that, since these are the final consumers,
there is no pass-on effect. Also note that, because \( Q^g < Q^* \), both \( \xi_C \) and \( \sigma_C \) are strictly positive and final consumers unambiguously suffer from the cartel.

Our decomposition of cartel effects allows us to formulate the following basic insight.

**Proposition 6.1** The direct-purchaser overcharge is equal to the sum of all downstream overcharges, net of pass-ons, \( \sum_{k=1}^{K} (\xi_k - \omega_k) + \xi_C = \xi_{g+1} \).

**Proof.** This follows directly from \( \xi_{k+1} = \omega_k \) for all \( k \) and \( \xi_C = \omega_K \). \( \square \)

Note that in an overcharge conception of compensatory damages, this result justifies obtaining the direct-purchaser overcharge proceeds first, and then redistributing them among indirect purchasers later.

### 6.2.3 Measure of Antitrust Harm

We are primarily interested in the relationship between the direct-purchaser overcharge and the net actual antitrust harm to total welfare. The latter is equal to the change in total profits in the chain, \( \sum_{k=1}^{K} \Delta \pi_k \), plus the change in consumer surplus, \( \Delta CS \), i.e.,

\[
\Delta W = \sum_{k=1}^{g-1} \Delta \pi_k + \Delta \pi_g + \left[ \sum_{k=g+1}^{K} \Delta \pi_k + \Delta CS \right] = d_U + \Delta \pi_g + d_D.
\]

The cartel gains are \( \Delta \pi_g \). The downstream damages \( d_D = \sum_{k=g+1}^{K} \Delta \pi_k + \Delta CS \) correspond to losses in profits and consumer surplus by all direct and indirect purchasers. In addition, there are upstream damages, \( d_U = \sum_{k=1}^{g-1} \Delta \pi_k \), equal to profit losses incurred by direct and indirect suppliers to the cartel.

We can use our decomposition of harm in equation (6.2) to evaluate each of these terms separately. We find

\[
\Delta W = \sum_{k=1}^{K} (\xi_k - \omega_k + \sigma_k) + \xi_C + \sigma_C = \sum_{k=1}^{K} \sigma_k + \sigma_C,
\]

where we used \( \xi_1 = 0 \) and the fact that the overcharge on layer \( k+1 \) equals the pass-on of layer \( k \), \( \xi_{k+1} = \omega_k \) for \( k = 1, \ldots, K \) and \( \xi_C = \omega_K \). The total welfare effect, therefore, coincides with the sum of the output effects.

Cartel profits are \( \Delta \pi_g = \xi_g - \omega_g + \sigma_g \). Downstream harm can be represented as

\[
d_D = \sum_{k=g+1}^{K} (\xi_k - \omega_k + \sigma_k) + \xi_C + \sigma_C = \xi_{g+1} + \sum_{k=g+1}^{K} \sigma_k + \sigma_C.
\]
or the sum of all output effects of direct and indirect purchasers plus the direct-purchaser overcharge. Upstream harm is equal to

\[ d_U = \sum_{k=1}^{g-1} (\xi_k - \omega_k + \sigma_k) = -\omega_{g-1} + \sum_{k=1}^{g-1} \sigma_k = -\xi_g + \sum_{k=1}^{g-1} \sigma_k. \]

We study the direct-purchaser overcharge, \( \xi_{g+1} \), in relation to these actual welfare effects. That is, we evaluate the ratio

\[ \lambda_W = \frac{\Delta W}{\xi_{g+1}} = \lambda_g + \lambda_D + \lambda_U, \]

in which

\[ \lambda_g = \frac{\Delta \pi_g}{\xi_{g+1}} = \frac{\xi_g + \sigma_g}{\omega_g} - 1, \]  

are the cartel gains expressed in the direct-purchaser overcharge,

\[ \lambda_D = \frac{d_D}{\xi_{g+1}} = 1 + \sum_{k=g+1}^{K} \frac{\sigma_k}{\xi_{g+1}} + \frac{\sigma_C}{\xi_{g+1}}, \]  

is the downstream harm to the direct-purchaser overcharge ratio, and

\[ \lambda_U = \frac{d_U}{\xi_{g+1}} = -\frac{\xi_g}{\omega_g} + \sum_{k=1}^{g-1} \frac{\sigma_k}{\xi_{g+1}}, \]  

is that ratio upstream.

In addition to these aggregate measures, we specify the individual harm to direct purchasers and to consumers as:

\[ \lambda_{g+1} = \frac{\xi_{g+1} - \omega_{g+1} + \sigma_{g+1}}{\xi_{g+1}} = 1 - \frac{\omega_{g+1} - \sigma_{g+1}}{\xi_{g+1}} \text{ and } \lambda_C = \frac{\xi_C + \sigma_C}{\xi_{g+1}}. \]

In the next section, we evaluate how these various ratios vary with the intensity of competition, the number of firms in each layer, the number of layers, and the position of the layer in which the anticompetitive behavior emerges in a vertical production model.
6.3 Damages Based On the Direct-Purchaser Overcharge

In order to explicitly characterize the ratios introduced above, we need to further specify our model. Suppose that marginal costs are constant and identical for every firm in the same layer. That is, for layer \( k \) we have \( c_{jk}(q) = c_k q \), for each \( j \in \{1, \ldots, n_k\} \). Let the inverse demand function be

\[
P(Q) = a - b Q^\gamma, \tag{6.10}
\]

with \( a, b \) and \( \gamma > 0 \). Inverse demand is a convex function of quantity for \( 0 < \gamma < 1 \), a concave function for \( \gamma > 1 \) and a linear function for \( \gamma = 1 \).

In this set-up, the equilibrium quantity and prices can be expressed as follows:

\[
Q^* = \left[ \frac{1}{b} \left( \prod_{i=1}^{K} \frac{n_i}{n_i + \gamma \vartheta_i} \right) \left( a - \sum_{j=1}^{K} c_j \right) \right]^{1/\gamma}, \tag{6.11}
\]

\[
p_k^* = \left( 1 - \prod_{i=1}^{k} \frac{n_i}{n_i + \gamma \vartheta_i} \right) \left( a - \sum_{j=1}^{K} c_j \right) + \sum_{l=1}^{k} c_l \quad \forall k \in \{1, \ldots, K\}. \tag{6.12}
\]

The competitive benchmark is characterized by a vector of conjectural variations parameters \( (\vartheta_1, \vartheta_2, \ldots, \vartheta_K) \in \times_{k=1}^{K} [0, n_k] \).

Collusion among the \( n_g \) firms in layer \( g \) (with \( n_g > 1 \)) results in an increase in \( \vartheta_g \) to \( \vartheta_g^c \in (\vartheta_g, n_g] \). It follows straightforwardly from equation (6.11) that such an increase in any \( \vartheta_k \) decreases the equilibrium quantity. For \( n_g > 1 \) and \( \vartheta_g^c \in (\vartheta_g, n_g] \), we can write the ratio of collusive output to total competitive output \( r \) as

\[
r = \frac{Q^g}{Q^*} = \left( \frac{n_g + \gamma \vartheta_g^c}{n_g + \gamma \vartheta_g} \right)^{1/\gamma}.
\]

Note that, although both \( Q^* \) and \( Q^g \) depend on market characteristics of every layer, apart from \( \gamma \), their ratio is a function only of characteristics of the colluding layer. If \( \gamma = 1, r \in \left[ \frac{1}{2}, 1 \right) \), with the lower bound corresponding to perfect competition in layer \( g \) in the but-for world. An increase (decrease) in \( \gamma \) above (below) 1 decreases (increases)

\[\text{121}\] In order to have gains from trade in this market, we naturally require \( a > \sum_{j=1}^{K} c_j \). That is, the consumer’s willingness to pay for the first unit (\( a \)) must exceed total costs to produce that unit (\( \sum_{j=1}^{K} c_j \)).

\[\text{122}\] Demand is nonnegative and non-increasing as well for \( a \geq 0, b < 0 \) and \( \gamma < 0 \)—see Genesove and Mullin (1998). We restrict attention to \( b, \gamma > 0 \), since in that case second-order conditions are always satisfied. Corbett and Karmarkar (2001) develop a multi-layered Cournot model with linear demand.

\[\text{123}\] See Proposition E.1 in Appendix E.3.
this lower bound value.\footnote{In particular, $\lim_{\gamma \to \infty} r = 1$ for all parameter values and $\lim_{\gamma \to 0} r = e^{-1}$ for $\vartheta_g = n_g$ and $\vartheta_g = 0$.}

Taken together, we can now characterize cartel profits in layer $g$ in terms of the direct-purchaser overcharge as

$$\lambda_g = \frac{\xi_g + \sigma_g}{\omega_g} - 1 = \frac{\gamma \vartheta_g}{n_g} \frac{(1 - r)}{r (1 - r \gamma)} - 1.$$  

Note that $\lambda_g = -1$ if prior to collusion layer $g$ was in perfect competition ($\vartheta_g = 0$ or $n_g \to \infty$). In that case, $\sigma_g = 0$ and the total cartel profit equals the overcharge on the direct purchasers. In all other benchmarks, (positive) cartel profits are always smaller than the direct-purchaser overcharge.

### 6.3.1 Downstream Damages

Downstream from cartel layer $g$, it follows from equation (6.12) that equilibrium prices $p_k^c$ (weakly) increase in all layers $k \geq g$, as each subsequent layer passes on part of the price increase it receives from its suppliers to its customers.\footnote{For $k \geq g + 1$, this pass-on rate $R_k$ can be expressed as}

$$R_k = \frac{\omega_k}{\xi_k} = \frac{p_k^c - p_{k-1}^c}{p_{k-1}^c - p_{k-1}} = \frac{n_k}{n_k + \gamma \vartheta_k}.$$  

This expression reveals that the direct-purchaser overcharge must generally be a poor estimator for actual direct purchaser harm. In the case of linear demand, for example, we obtain $Q^* \leq 2Q^g$ from equation (6.11), resulting in $\lambda_{g+1} \in \left[0, \frac{3}{2} \right]$. The upper bound is reached when the pre-cartel equilibrium in layer $g$ was perfectly competitive, so that $Q^* = 2Q^g$. The region only slightly changes when demand is non-linear.

The actual antitrust harm of direct purchasers will typically be small when there is strong competition between them, and/or competition in layer $g$ was weak to begin with. In these cases, the direct-purchaser overcharge will significantly overestimate the actual harm that direct purchasers suffer. In particular, if $n_{g+1} \geq 2$ and $\vartheta_{g+1} \leq 1$, in all cases
If on the other hand layer $g + 1$ is governed by a monopolist or a cartel itself (i.e., $\theta_{g+1} = n_{g+1}$), the direct-purchaser overcharge always underestimates the actual harm sustained by indirect purchasers. Naturally, it is possible to construct market structures in which the direct-purchaser overcharge turns out to be exact. This is so, for example, if direct purchasers have sufficient market power and pre-cartel competition in the colluding layer was strong. Such examples are specific, however.

Next consider normalized harm to final consumers

$$\lambda_C = \frac{\gamma}{\gamma + 1} \frac{1 - r^{\gamma+1}}{r (1 - r^\gamma)} \prod_{i=g+1}^{K} \frac{n_i}{n_i + \gamma \theta_i}.$$ 

Again we find for $\gamma = 1$ that $\lambda_C \in [0, \frac{3}{2}]$ with a slightly changed upper bound for nonlinear demand. If all intermediate layers downstream from the cartel are sufficiently competitive, the direct-purchaser overcharge underestimates actual final consumer harm and $\lambda_C > 1$. If instead there is substantial market power in enough of these layers, the direct-purchaser overcharge will overestimate consumer harm and $\lambda_C < 1$.

Aggregate downstream welfare effects relate to the direct-purchaser overcharge as

$$\lambda_D = \frac{1 - r^{\gamma+1}}{r (1 - r^\gamma)} \left( 1 - \frac{1}{\gamma + 1} \prod_{i=g+1}^{K} \frac{n_i}{n_i + \gamma \theta_i} \right).$$

(6.13)

Clearly, $\lambda_D$ decreases with $r$, a decrease in competition in one of the downstream layers, and an increase in the number of downstream layers. Note also that $\lambda_D$ is unaffected by changes in the number of upstream layers and their competitiveness.

In the case of linear demand, $\frac{1}{2} \frac{Q^* + Q_g}{Q_g} \leq \lambda_D < \frac{Q^* + Q_g}{Q_g}$. So we find quite intuitively that downstream harm is greater when the cartel reduces output more, which is the case,

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127 Verboven and Van Dijk (2009) propose their “discounts” on the direct-purchaser overcharge when awarding damages in direct purchaser suits on the claim that $\lambda_{g+1} \leq 1$, i.e., that the pass-on effect would always outweigh the output effect, $\omega_{g+1} \geq \sigma_{g+1}$ and, therefore, the direct-purchaser overcharge overestimates the actual harm. Note that this need not be true in our more general setting.

128 Hellwig (2006) bases his argument for restricting standing to sue to direct purchasers to the claim that the direct-purchaser overcharge exactly coincides with the actual harm if the direct purchaser layer is monopolized—and, thus, overestimates the actual harm in all other cases. Verboven and Van Dijk (2009) reproduce this result as a special case of their analysis. The marginal price increases in both papers correspond to a marginal increase in $\theta_g$ in our setting, for which we obtain $\lambda_{g+1} = \frac{2 \theta_{g+1}}{n_{g+1} + \omega_{g+1}}$, which indeed equals 1 for $\theta_{g+1} = n_{g+1}$ and is smaller otherwise.

129 Note that $\lambda_c$ can be written as $\lambda_c = \frac{1}{2} \frac{Q^* + Q_g}{Q_g} R_C$, where $R_C = \prod_{i=g+1}^{K} R_i = \prod_{i=g+1}^{K} \frac{p_{g+1}}{p_g}$ is the part of the price increase due to the cartel that ends up being paid by the final consumers.

130 See Proposition E.2 and Corollary E.1 in Appendix E.3 for details of the derivation.
for example, when the pre-cartel equilibrium is more competitive. When all intermediate layers are perfectly competitive, every layer fully passes on the overcharge which then is eventually borne by the end users, i.e., \( \lambda_D = \lambda_C = \frac{\xi_C + \sigma_C}{\xi_C} = \frac{1}{2} Q^* + Q^g > 1 \). This provides the lower bound of the actual harm. Monopolistic competition in the intermediate downstream layers increases actual downstream antitrust harm, with a strict upper bound of \( \lambda_D < \frac{Q^* + Q^g}{Q^g} \). Interestingly enough, we here find a rationale for awarding treble damages according to Section 4 of the Clayton Act.

**Proposition 6.2** For linear demand, three times the direct-purchaser overcharge is the exact upper bound of total downstream harm, i.e., \( 1 < \lambda_D < 3 \).

**Proof.** See Appendix E.2.

The two top-panels of Figure 6.2 plot the value of absolute and relative aggregate downstream antitrust harm against the number of cartel members (upper-left panel) and the number of direct purchasers (upper-right panel) in an example with linear demand.\(^{132}\) The value of \( \lambda_D \) increases monotonically with the number of firms in the cartel layer, since more competing firms implies a lower but-for price \( p^g \) and higher competitive output \( Q^* \). These changes increase the direct-purchaser overcharge \( \xi_{g+1} \), as well as the output effects, \( \sum_{k=g+1}^{K} \sigma_k + \sigma_C \). The net effect on the downstream damages measure \( d_D \) is positive, because output effects grow faster than the direct-purchaser overcharge. The downstream multiplier decreases if competition in any downstream layer rises. Both the downstream harm \( d_D \) and the direct-purchaser overcharge \( \xi_{g+1} \) increase because of increased output, but the latter increases at a faster rate. As a result, \( \lambda_D \) decreases in the number of direct purchasers of the cartel.\(^{133}\)

In the lower-left panel of Figure 6.2, the three parameters are plotted for the same specifications and a cartel in layer 1, varying the total number of downstream layers \( K \). Increasing the number of similarly imperfectly competing downstream layers steeply decreases \( \lambda_D \). Each additional downstream layer of production introduces an extra mark-up, which reduces implied demand for the colluding layer, thereby decreasing the direct-purchaser overcharge. As a result, less demand is affected by the cartel.\(^{134}\)

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\(^{131}\)This upper bound is reached with an infinite number of imperfectly competitive layers downstream. This limit case implies zero equilibrium quantities, \( \lim_{K \to \infty} Q^* = \lim_{K \to \infty} Q^g = 0 \)—see equation (6.11).

\(^{132}\)Although the multiplier \( \lambda_D \) does not depend upon the values of \( a, b \) and \( \sum_{k=1}^{K} c_k \), the direct-purchaser overcharge \( \xi_{g+1} \) and the total downstream harm \( d_D \) do. We have chosen these parameters in such a way that the three functions can be presented in the same graph, but they are otherwise non-specific.

\(^{133}\)For this parameter configuration, the downstream damage multiplier is equal to \( \frac{329}{216} \approx 1.52 \) for \( n_g = 2 \) and equal to \( \frac{47}{21} \approx 1.96 \) when \( n_g \to \infty \), as can be easily checked from (6.13). Moreover, it is equal to \( \frac{329}{216} \approx 1.93 \) for \( n_{g+1} = 2 \) and equal to \( \frac{47}{21} \approx 1.56 \) when \( n_{g+1} \to \infty \).

\(^{134}\)Note that an increase in the number of downstream layers decreases the equilibrium quantity, as can be seen from equation (6.11), but leaves the equilibrium price in layer \( g \) unaffected—see equation (6.12).
Figure 6.2 Downstream cartel effects under different numbers of firms per layer for \( \gamma = 1, K = 5, n_k = 5, \vartheta_k = 1, g = 3, \) and \( \frac{1}{8} \left( a - \sum_{k=1}^{K} c_k \right)^2 = 10. \) For the upper two panels, \( \vartheta^{5}_3 = 5. \) The upper-left panel shows the effect of an increase in the number of cartel members, the upper-right panel in the number of direct purchasers. The lower-left panel displays downstream harm under different numbers of downstream layers of production when there is a cartel in the first layer for \( \vartheta^{5}_1 = 5. \) The lower-right panel plots the effects of non-linearity of consumer demand.

The sum of output effects is the resultant of two opposite effects: the extra mark up increases downstream harm and the decrease in production decreases downstream harm. In the example in the figure, the first effect outweighs the second. However, the effect on the direct-purchaser overcharge dominates, leading to a monotonic increase in \( \lambda_D. \)

The lower-right panel of Figure 6.2 shows the effect of variations in the shape of demand. Both \( d_D \) and \( \xi_{g+1} \) decrease both sides from linearity, resulting in a monotonically decreasing value of \( \lambda_D \) over the spectrum.

It appears in these examples that the ratio between actual downstream harm and the direct-purchaser overcharge may be high. The following result establishes that there is no upper bound on the downstream damages multiplier.

**Proposition 6.3** For any finite number \( \overline{M} > 0, \) there exists a market structure such that \( \lambda_D \geq \overline{M}. \)

*Proof.* See Appendix E.3 and E.4. \qed
This result obtains as long as there is some degree of market power in sufficiently many downstream layers. The intuition is that in a two-layered model with cartelized suppliers directly supplying final consumers, the deadweight-loss triangle becomes a smaller fraction of the overcharge quicker when demand is more concave than when demand is increasingly convex. In both limit demand curves, the output effect goes to zero, but a decrease in $\gamma$ increases the output effect relative to the overcharge. The proof of Proposition 6.3 uses the fact that when demand becomes relatively elastic in the relevant region ($\gamma \to 0$), the output effect becomes large relative to the overcharge.

Finally, we compare total downstream harm with the sum total of direct-purchaser overcharges and lost profits (dead-weight loss). That is, we define

$$\tilde{\lambda}_D = \frac{d_D}{\xi_{g+1} + \sigma_{g+1}}.$$  

For some parameter specifications, adding the direct purchasers’ dead-weight loss to the denominator changes the damage multiplier somewhat. The total direct effect remains a poor estimator of total true antitrust harm, however. To see this, first note that if layer $g + 1$ is perfectly competitive—that is, $\vartheta_{g+1} \to 0$ and/or $n_{g+1} \to \infty$—there is no output effect for this layer of direct purchasers, i.e., $\sigma_{g+1} = 0$. This implies $\tilde{\lambda}_D = \lambda_D$. Obviously, $\tilde{\lambda}_D$ can, therefore, also take on any value. On the other hand, the output effect of the direct purchaser layer is large when this layer is fully monopolized, i.e., $\vartheta_{g+1} = n_{g+1}$. Yet even in that case there exists no upper bound on $\tilde{\lambda}_D$. One way of interpreting this finding in contrast to Proposition 6.1 is as the “direct purchaser deadweight loss” being a poor estimator of “total chain deadweight-losses.” Hence, even if lost profits would be recognized as (part of) antitrust harm, damage assessment at the direct purchaser level only in general provides no proper sense of the sum of actual downstream harm sustained in the chain.

### 6.3.2 Upstream Damages

Upstream from the cartel, the derived demand for inputs is reduced. Depending on market conditions, suppliers may optimally respond to this shift in demand by in- or decreasing output, resulting in an ambiguous effect on upstream prices. Under constant marginal costs of production, in our chosen demand specification (6.10) the price decreasing effect from reduced demand and the price increasing effect from reduced pro-

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135In fact, $\lambda_D$ is bounded from above by $(1 + K - g) (e - 1)$, with $e$ being the natural number. This bound is exact for $\gamma \to 0$, $\vartheta_g = 0$ and $\vartheta_g = n_g$, and $\vartheta_k = n_k$ for all downstream layers $k = g + 1, \ldots, K$. See Appendix E.3.3.

136See Lemma E.3 in Appendix E.4.
duction exactly offset. To see that upstream prices are indeed not affected by downstream overcharges, note that in equation (6.12) the equilibrium price in layer $k$ does not depend on $\vartheta_l$ or $n_l$ for any $l > k$. This implies that collusion in layer $g$ will not have any effect on prices upstream: $p_k = p_k^*$ for all $k < g$ and all upstream overcharges and pass-on effects vanish, $\xi_k = 0$ for $k = 1, \ldots, g$ and $\omega_k = 0$ for $k = 1, \ldots, g - 1$. This set-up allows us to focus on upstream output effects. In Appendix E.5, we offer an example of an upstream input price decrease (an “undercharge”) by which damages are passed up.

Moreover, the case of linear demand suffices to establish some limit properties of $\lambda_U$. Aggregate upstream antitrust harm relates to the direct-purchaser overcharge as

$$\lambda_U = \frac{(1 - r) \ n_g + \gamma \vartheta_g}{r (1 - r \gamma) \ n_g} \left( \prod_{i=1}^{g-1} \frac{n_i + \gamma \vartheta_i}{n_i} - 1 \right), \quad (6.14)$$

so that we immediately have the following result.

**Proposition 6.4** For any finite number $\overline{M} > 0$, there exists a market structure such that $\lambda_U \geq \overline{M}$.

*Proof.* See Appendix E.3 and E.6. \qed

Note also that $\lambda_U$ increases with a decrease in competition in one of the upstream layers, as well as with an increase in the number of imperfectly competitive upstream layers. It is furthermore invariant to changes in the number of downstream layers and their competitiveness.

The upper-left panel of Figure 6.3 shows numerically that both upstream antitrust harm $d_U$ and the direct-purchaser overcharge $\xi_{g+1}$ grow with the number of firms in the colluding layer—increasing competition in the “but-for” world—but that the upstream damage multiplier $\lambda_U$ remains constant. The upper-right panel shows the effect of an increase in the number of firms in one of the upstream layers. This decreases upstream harm $d_U$, since an increase in the number of firms in one layer decreases the mark up, and thereby the output effect, in that layer. This effect is only partially outweighed by an increase in the output effect that occurs due to the increase in production. At the same time, the direct-purchaser overcharge decreases with an increase in the number of firms in an upstream layer and the net effect is a decrease in the upstream damage multiplier.\(^{138}\)

\(^{137}\)Greenhut and Ohta (1976) and Haring and Kaserman (1978) find analogously for the case of linear demand and constant marginal costs that output changes but upstream input prices remain the same under vertical integration. In the next subsection we discuss variations in demand and cost functions.

\(^{138}\)For the parameter values here considered, the upstream damage multiplier is equal to $\frac{4}{5}$ for $n_{g-1} = 2$ and equal to $\frac{2}{5}$ when $n_{g-1} \to \infty$, as can be easily checked from equation (6.14).
The lower-left panel shows how the upstream damage multiplier varies with the number of upstream layers. If the number of (imperfectly competitive) upstream layers increases, production decreases, which decreases the direct-purchaser overcharge. The relationship between downstream damages $d_U$ and the number of upstream layers is non-monotonic in this linear example. An increase in the number of layers introduces additional mark-ups but decreases production. The first effect has a positive, and the second a negative impact upon upstream output effects. From Figure 6.3 it follows that the first (second) effect dominates when the number of layers is small (large). The net effect of an increase of the number of upstream layers on the upstream damage multiplier is always positive.

6.3.3 Cartel Location and the Distribution of Harm

Equations (5.13) and (5.14), as well as Figure 6.3 suggest that the upstream damages multiplier $\lambda_U$ is substantially larger than the downstream damage multiplier $\lambda_D$. This raises the question whether it is possible for total antitrust harm to be higher when the location of the colluding layer is closer to the final consumers. A priori, such proximity
might increase the harm done upstream more than it decreases the harm done downstream. While indeed the multipliers do not trade off perfectly, the absolute level of total cartel harm is unaffected by the location of the cartel.

**Proposition 6.5** Consider two layers, \( g \) and \( h > g \) that have the same characteristics: \( n_h = n_g, \vartheta_h = \vartheta_g \), and, if one of these layers would collude, \( \vartheta_h^c = \vartheta_g^c \). Let \( \Delta W_k \) be the change in welfare if layer \( k \) colludes. Then \( \Delta W_h = \Delta W_g, \xi_{h+1} < \xi_{g+1} \) and \( \lambda_{W,h} > \lambda_{W,g} \).

**Proof.** See Appendix E.3 and E.7.

The location of the cartel affects its ability to impose and overcharge. All other things equal, the lower the cartel is in the chain, the smaller is the direct-purchaser overcharge, while total cartel harm remains the same. Therefore, the upstream damages multiplier increases when the cartel is lower in the chain. The reason for this is that if the number of layers upstream from where the cartel forms is large, each of these layers will have put some mark-up on the price. This effectively reduces the scope for abuse of market power by the colluding layer. At the same time, more layers upstream and less downstream from the cartel implies that the direct-purchaser overcharge misses more of the total of effects.

Formally, the price overcharge is given as

\[
p_g^o - p_g^* = \Psi \prod_{i=1}^g \frac{n_i}{n_i + \gamma \vartheta_i},
\]

where \( \Psi \) is a function of the parameters of the model and independent of the location of the colluding layer. Clearly, when the number of imperfectly competitive layers (or for that matter: market power of existing upstream layers) increases, this difference decreases. As a consequence, the total welfare measure \( \lambda_W \) increases when the colluding layer is further downstream in the chain of production, not because absolute welfare effects are higher, but because the direct-purchaser overcharge goes down. Figure 6.4 illustrates.

Given that final output is independent of the location of the cartel, so is the increase of final consumer prices. Therefore if the colluding layer is higher up in the chain of production, only a larger increase in prices would result in the same increase in final consumer prices. This is because part of the price increase is absorbed by intermediate downstream layers. For this reason, the direct-purchaser overcharge for a cartel higher up the chain is higher. Hence, the closer the cartel is to the final customers, the more the direct-purchaser overcharge underestimates the actual harm, the larger share of which is borne by the producers upstream in the chain of production.
Figure 6.4 Damages and CHS as a function of cartel location. Down- and upstream damages and the CHS as a function of the location of the cartel in the chain of production for $n_k = 5$ and $\vartheta_k = 1$

for all $k$, $\frac{1}{b} \left( a - \sum_{k=1}^{K} c_k \right)^2 = 50$, and $\vartheta^C_g = 5$.

Figure 6.4 also plots the “consumer harm share” (CHS), a concept introduced in Boone and Müller (2008) as the share of final consumers in the sum total of downstream harm, that is, $CHS = \frac{\Delta CS}{d_U}$. So defined, the value of CHS increases, the closer the cartel is to the consumer market. In our set-up, the CHS is defined as the share in the total welfare effects. Since the sum of all welfare effects in the chain is independent of the location of the cartel, in our definition the consumer harm share is constant.

6.4 Concluding Remarks

We have assessed the pass-on of antitrust welfare effects in longer vertical supply chains, in which an antitrust violation may occur in any layer of production. We find that the direct purchaser overcharge generally grossly underestimates the total antitrust harm. While the direct-purchaser overcharge is equal to the sum of all passed on overcharges downstream, it misses the output effects in every layer. This problem is not generally remedied by including the direct purchaser output effect in the damage assessment. The share in total harm sustained by suppliers to the wrongdoer(s) may be large. Relying on the direct-purchaser overcharge becomes increasingly problematic, the longer the vertical chain of production and the closer the illegal price increases occur to the final consumers.

We conclude that there exist no simple multiplication factors to correct the established direct-purchaser overcharge for actual markets that rely on basic market structure characteristics—not even in the case of unit price overcharges. Nor are the lost profits of the direct purchasers a good measure for total chain deadweight-losses. This implies that it
will not generally suffice to collect the direct-purchaser overcharge first, and then redistribute this money over all antitrust victims later. The flip side is that duplicative recovery of uncorrected overcharges at several levels in the chain of production can easily create a problem of multiple liability for the defendant.

As the models in the existing literature, our model contains some specific assumptions. We have abstracted from non-linear cartel price elements, for example, which can reduce deadweight-losses, but also from additional negative effects that many cartels have on product quality and innovation. We have also not considered the effects of partial vertical integration in the chain of production. The cost structures we use are special, albeit that our results remain qualitatively unchanged in various variations with smoothly in- and decreasing marginal costs of production. In addition, we have not specified how cartels could use their market power *vis-à-vis* suppliers.\footnote{One way to represent upstream bargaining power in our model is as a reduction of \( g_{g-1} \) to \( g_{g-1} = 0 \) in response to a cartel forming in layer \( g \) if the cartel has full bargaining power. Lower input costs induce the cartel to produce more, thus reducing some of its detrimental effects. This approach is not entirely free from problems, however. For example, it leaves pre-cartel bargaining power unspecified.}

Our assumptions of homogeneity of products within each layer and one-to-one production between layers are not entirely innocuous either. Our fixed-proportion production technology implies that products of different layers are perfect complements. When there would be substitution possibilities between inputs instead, a price increase in one layer might induce firms in the next layer to substitute away from that input and toward an input produced in another chain all together. We ignore this competitive constraint on pricing in our analysis. The industry supplying the other input is furthermore likely to benefit from the cartel, since its demand may go up and it can raise prices as a result of the reduced competition. This is sometimes called the “umbrella effect.”\footnote{See Areeda and Hovenkamp (1992), para. 337.3, on the rules of standing for “umbrella” plaintiffs. The authors argue that purchasers from non-cartel members that were overcharged because of the umbrella effect should generally be granted standing to sue the cartel for damages, in particular when products are homogeneous. When products are differentiated, the authors recognize that it may be difficult to draw the line where standing ends.}

In light of our results, it appears to be an unbalanced spending of resources to devote considerable effort and econometric expertise to the characterization of but-for worlds—as is often the case in U.S. antitrust damage cases—only to subsequently use the so found but-for price to calculate the direct-purchaser overcharge. With the information obtained in such detailed but-for economic analyses, structural estimations are often possible and courts would do well to consider them. The same is true for claims of antitrust injury sustained by direct and indirect suppliers to antitrust violators.

We warn in this context also against the European Commission’s call for “simplified rules on estimating the loss” from infringements of the competition rules in its 2008
White Paper. The Commission’s stated primary objective and guiding principle in this document is full compensation of victims, which is in line with decisions of the European Court of Justice. It furthermore recognizes “actual damages, lost profits, and interest” for both direct and indirect purchasers. The Commission should realize that there is no hope for very simple rules on antitrust damage estimation.

Finally, our analysis has clarified the antitrust damages caused to direct and indirect suppliers. These upstream effects of a downstream cartel appear not to be properly viewed as antitrust damages in U.S. antitrust law. In *Mandeville Island Farms*, the Supreme Court had held that growers of sugar beets could maintain a treble-damages action against refiners who had allegedly conspired to fix the price that they would pay for the beets. In *Radovic* (1957) the Court further recognized a wide “zone of harm” caused by an antitrust violation that could potentially include customers as well as suppliers. Indeed in *Wilson v. Ringsby Truck Lines* (1970), truck drivers and warehousemen of Ringsby, a common carrier transporting between Colorado and Wyoming, were recognized by a district court as antitrust victims when their services were no longer needed after Ringsby joined a cartel that divided their markets geographically.

However, in the 1970s a number of supplier suits for antitrust damages failed when circuit courts gave no standing to classes of employees and suppliers of cartels. In *Illinois Brick*, the Supreme Court had concluded that: “An antitrust violation may be expected to cause ripples of harm to flow through the Nation’s economy; but despite the broad wording of Section 4 there is a point beyond which the wrongdoer should not be held liable.” In *Associated Contractors* (1983), the Court then denied standing to a class of carpenters who sought antitrust damages for business loss resulting from the contractors association using anticompetitive means to work around their union. It ruled that the carpenters union was not a person injured by reason of a violation of the antitrust laws within the meaning of Section 4, because of the “tenuous and speculative character of the causal relationship,” and the existence of “more direct victims” of the conspiracy, meaning consumers and competitors.

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141 See pp. 3 and 7 of the White Paper in fn. 107.
142 In addition, the Commission means to assist indirect purchasers by introducing a peculiar “rebuttable presumption that the illegal overcharge was passed on to them in its entirety”—see p. 8 of the White Paper in fn. 107. The use of “them” in this quote suggests that the drafters of the White Paper indeed had the mainstream two-layer upstream cartel model in mind.
145 In *Contreras v. Grower Shipper Veg. Ass’n of Cent. Cal.*, 484 F.2d 1346 (9th Cir. 1973), the 9th Circuit Court denied a class of employees laid off by an alleged price-fixer standing to sue for antitrust damages. In *Comet Mechanical Contractors, Inc. v. E.A. Cowen Constr. Inc.*, 609 F.2d 404 (10th Cir. 1980) a subcontractor could not seek compensation for reduced demand for its services resulting from alleged bid rigging by general contractors. See Page (1985), p. 1492.
Antitrust violations can cause substantial direct and indirect supplier harm. Analogous to customers of a cartel facing higher prices and reduced quantities of output, suppliers to a cartel may obtain lower prices for a reduced volume of input sales, even when the cartel does not execute collusive buyer power. It remains an open question of law, therefore, where exactly are the points beyond which the wrongdoers should no longer be held liable for the harm caused by their illegal actions.
7 Implications for Competition Policy and Conclusions

This dissertation presented five pieces of research on vertical relations in cartel theory. While the basic cartel model considers integrated profit-maximizing firms on the same horizontal level of production, I extended the basic model by investigating vertical relations both within firms (owners-management) and among firms (suppliers-buyers). I studied three topics in competition policy: (i) Chapters 2–4 investigated the impact of managerial incentives on the stability and behavior of cartels; (ii) Chapter 5 studied how joint purchasing agreements between firms on the input market (buyer groups) affect the competitive process on the output market; and (iii) Chapter 6 determined how the economic harm caused by a cartel is distributed along a longer chain of production.

In this concluding chapter, I discuss the implications for competition policy (Section 7.1) and summarize the approach and conclusions of the previous chapters (Section 7.2).

7.1 Implications for Competition Policy

The analyses in Chapters 2, 5 and 6 allowed to derive implications for competition policy, which were discussed in detail in Sections 2.6, 5.6 and 6.4. Here, I summarize these policy implications, arranged by four instruments: leniency policy, antitrust compliance programs, competition policy toward buyer groups, and Europe’s emerging antitrust damages practice. I also discuss the robustness of the policy implications by indicating the extent to which restrictive modeling assumptions drive the key results.

7.1.1 Corporate and Individual Leniency Programs

The optimal design of leniency policy is one of the foci of Chapter 2. The three-tier authority-shareholder-manager model derives optimal sanctions when either the corpora--
tion or an involved individual blows the whistle, thereby assessing the effects of the U.S. and E.U. corporate leniency programs, as well as the U.S. individual leniency program.

**Corporate leniency program.** The E.U. corporate leniency program (CLP) allows firms to blow the whistle in exchange for full immunity from legal sanctions aimed at the corporation. The CLP provides a full discount on the corporate fine for the first firm to come forward with evidence. The results of Chapter 2, however, suggest that partial corporate leniency may be more effective to fight corporate violations of the law as (i) firms would still receive a reduced sanction and would, thus, be incentivized to blow the whistle, while (ii) the sanction is not reduced all the way to zero and, thus, firms would still be punished to some extent.

However, as Chapter 2 abstracts away from strategic interaction between firms, optimal competition policy should carefully balance how the “partial corporate leniency result” operates in a strategic environment. It may well be the case that full corporate leniency adds to the fear of cartel members that a rival corporation will blow the whistle. Moreover, it may be practically difficult to determine the optimal amount of partial corporate leniency in the first place, because the authority then needs to estimate the corporation’s benefit from breaching the law, which is different for each (type of) cartel.

The U.S. CLP not only protects the whistle-blowing firm from corporate legal sanctions when blowing the whistle, but also provides its employees with full immunity from individual legal sanctions. The model shows that such a “blanket” covering the entire corporation, including its employees, entails a perverse effect: it removes the fear of involved employees that the corporation will blow the whistle. This, in turn, reduces the corporation’s expected indemnification costs—i.e., the corporation’s costs of bribing the employee to engage in cartelization—thereby increasing the attractiveness of forming a cartel. This consideration suggests a counterproductive effect of the CLP’s blanket over employees. However, the analysis in Chapter 2 abstracts away from strategic considerations between firms; it may be the case that the reduction in indemnification costs *ex ante* destabilizes collusion through the fear that another cartel member will blow the whistle.

**Individual leniency program.** The U.S. individual leniency program (ILP) allows involved employees to blow the whistle in exchange for full immunity from legal sanctions, such as personal fines or jail sentences. Such a policy is expected to horizontally destabilize cartels, as each firm fears that an employee of another firm will blow the whistle.

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148 See the U.S. Department of Justice’s *Corporate Leniency Policy* (10 August 1993).
149 See the U.S. Department of Justice’s *Leniency Policy for Individuals* (10 August 1994).
150 See, for example, Motta and Polo (2003) and Chen and Rey (2006).
In addition, Chapter 2 shows how the ILP *vertically* destabilizes cartels by introducing a hierarchical conflict of interest: employees need to be bribed by superiors not to file for individual leniency, thereby increasing the firm’s internal costs of forming a cartel.

Chapter 2 also argues that the ILP may actually increase the firm’s internal costs of complying with competition law, because employees must be compensated to prevent them from forming a cartel and file for individual leniency instead of complying with the law in the first place. When this perverse effect dominates the two positive effects from the previous paragraph, then the ILP may be counterproductive in fighting cartels. While this problem can be circumvented by granting individual leniency only for certain (types of) cartels, such a non-uniform policy may be difficult to practically implement due to complications in measuring the effects, as well as to arguments of legal certainty.

**Vertical race to the courthouse.** The analysis in Chapter 2 reveals that the combination of the ILP with a CLP *not* covering involved employees can trigger a “vertical race to the courthouse.” On the one hand, the CLP incentivizes the corporation to blow the whistle, in which case involved employees are fully sanctioned. On the other hand, the ILP incentivizes involved employees to blow the whistle, in which case the corporation is fully sanctioned. This leads to internal mistrust when engaging in a cartel, which may deter cartel formation from an *ex ante* perspective.

Such vertical destabilization parallels horizontal destabilization as discussed by, for example, Spagnolo (2004), who argues that the authority should grant leniency only to the first horizontal party coming forward with evidence. Similarly, Chapter 2’s model provides an economic argument for leniency to apply only to the first vertical party blowing the whistle—i.e., either the corporation or the employee. Such a policy can trigger a “vertical race to the courthouse” between the corporation and its employees.

### 7.1.2 Antitrust Compliance Programs

Antitrust compliance programs are corporate schemes to educate employees about competition law infringements, to monitor their behavior, and to discipline them in the case of illegal conduct. Chapter 2 focuses on the monitoring aspect of such programs and studies their impact on firm behavior, as well as on competition policy.

**Perverse effect of monitoring through compliance programs.** One of the features of a compliance program is to monitor employees so as to reduce information asymmetries within the firm. The analysis in Chapter 2 suggests that the information obtained by monitoring employees through compliance programs may be used not only to prevent

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managerial violations of competition law at lower cost, but also to promote such violations at lower cost. This effect is particularly relevant when individual legal sanctions are high, because the reduction in information asymmetries caused by the compliance program then allows for a relatively large reduction in the information rent needed to induce employees to engage in cartelization. Without claiming that firms adopt compliance programs with only the objective to reduce information asymmetries so as to encourage its employees to misbehave, the result does, however, suggest a potential perverse effect of increasing the monitoring of harmful activities.

Since individual sanctions are high in the U.S. (personal fines, jail sentences), while non-existent in Europe, the perverse monitoring aspect of compliance programs may be particularly pronounced in the U.S. The model, however, considers only the monitoring aspect of compliance programs and does not address the impact of the educational and disciplining aspects. To fully assess the impact of compliance programs on firm and individual behavior, all its dimensions should be carefully compared.

**Compliance programs as a mitigating factor.** While “the [European] Commission considers that it is not appropriate to take the existence of a compliance programme into account as an attenuating circumstance for a cartel infringement,” the U.S. Federal Sentencing Guidelines allow for a mitigation of the corporate fine when the corporation had a well-designed compliance program in place at the time of the infringement, in some cases up to 95%. The analysis in Chapter 2 suggest that it may not be optimal to apply such a fine reduction, because although monitoring through a compliance program can be useful to prevent corporate crime, it can also be used to promote corporate crime. The mere act of implementing a compliance program may, therefore, not be informative about the corporation’s intentions.

Chapter 2’s model is based on the monitoring aspect of compliance programs and leaves out practicalities of how, exactly, the compliance program is implemented. Therefore, the potentially perverse effect of reducing information asymmetries may not always be present. In particular, the perverse effect is less relevant when the shareholder delegates the implementation and execution of the compliance program to a third party, such as an in-house or external lawyer, that can credibly maintain its reputation.

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152 Some E.U. Member States—such as the United Kingdom, Ireland and Estonia—have, however, enacted laws to criminally prosecute involved employees on the national level. See Wils (2005), p. 130, for an overview of criminalization of competition law in E.U. Member States.

153 See footnotes 35 and 27.
7.1.3 Competition Policy Toward Buyer Groups

The results of Chapter 5 contribute to the growing debate among both academics and practitioners on the competitive effects of buyer groups, and what the appropriate approach by competition authorities should be to dealing with such arrangements. While Section 5.6 contains a more detailed policy discussion, here, I restrict attention to the two key policy implications relating directly to the analysis.

**Vertical restraints and anticompetitive buyer groups.** The analysis shows that a buyer group among retailers may act as an implied cartel, with high slotting allowances being paid by their suppliers. Such buyer groups may be mistakenly identified as pro-competitive forces, as retailers may use the high slotting allowances as “evidence” of the buyer group being a procompetitive organization acting to reduce input prices. Therefore, policy makers assessing the impact of a buyer group should be careful when interpreting evidence on input prices: high slotting fees will likely not result in enhanced downstream competition (as they are fixed payments), but may instead be paid in response to higher wholesale prices, which, in fact, reduce downstream competition.

Moreover, Chapter 5 shows how an anticompetitive buyer group can improve its stability by implementing other commonly observed vertical restraints, such as exclusive dealing clauses, minimum purchase clauses, and rebate schemes. When these vertical restraints are negotiated through buyer groups in combination with slotting allowances, they may be worthy of closer scrutiny by the competition authority.

**Detection of anticompetitive buyer groups.** Chapter 5 highlights an additional key issue for policy makers: an anticompetitive buyer group is likely to be harder to detect than standard forms of output market collusion, such as (tacitly) raising prices. A competition authority investigating the output market may not be able to find evidence of anticompetitive behavior if the retailers use a buyer group to jointly expropriate monopoly profits. An analysis of, for example, price-cost mark-ups would find no evidence of firms pricing above competitive levels if the retailers’ costs are taken as given. It may be a significant step for the authority to expand the analysis of suspected retailer collusion to include an examination of the process of wholesale contracting between retailers and suppliers in the upstream market, but Chapter 5 highlights that this may, indeed, be necessary.
7.1.4 Antitrust Damages Based on the Overcharge

In longer chains of production, the price increase caused by a cartel causes harm throughout different production layers. Chapter 6 investigates how such harm is distributed along the production chain and how it relates to the direct-purchaser overcharge, which is the anticompetitive price increase multiplied by the number of products bought by direct purchasers. Here, I present two policy implications directly resulting from the model, while I refer to Section 6.4 for a more detailed policy discussion.

The overcharge is an imprecise measure for vertical antitrust harm. In its 2008 White Paper, the European Commission calls for “simplified rules on estimating the loss” from antitrust infringements, compensating direct and “indirect purchasers” for their “actual loss,” as well as “the loss in profit as a result of any reduction in sales.”\(^{154}\) The Commission’s stated primary objective is full compensation of victims of a breach of European competition law with actual damages, lost profits, and interest awarded to direct, as well as indirect, purchasers. The analysis in Chapter 6 shows that no simplified rules based on the overcharge exist to achieve this objective. At a minimum, it requires information about consumer demand and the structure of the market, such as the number of layers in the production chain, the type and level of competition among firms in each layer, their production technologies and costs. Thus, the European Commission should either allow for more-involved rules to estimate the harm or be satisfied with a rough estimate of the harm.

Upstream suppliers damages. Not only (indirect) buyers of the cartel suffer from the cartel’s price increase, but suppliers of the cartel may also suffer. The reason is that the cartel’s price increase may result in a reduction in demand throughout the entire chain. However, such effects are not recognized by U.S. courts. In Associated Contractors (1983), the court denied standing to a class of carpenters who sought antitrust damages for business loss resulting from the contractors’ association using anticompetitive means to work around their union. It ruled that the carpenters’ union was not injured by reason of a violation of the antitrust laws, because of the “tenuous and speculative character of the causal relationship” and the existence of “more direct victims” of the conspiracy, meaning consumers and competitors. While such reasoning may prevent cases from being brought forward when the causation of the harm is unclear, it does not necessarily conform with economic arguments and the true distribution of harm along the chain.

\(^{154}\)See the European Commission’s 2008 White paper on damages actions for breach of the EC antitrust rules, pp. 3 and 7.
7.2 Summary and Conclusions

*Monitoring Managers Through Corporate Compliance Programs*

In Chapter 2 (joint with Charles Angelucci), we employed a three-tier hierarchy model, *authority-shareholder-manager*, to study the impact of increased managerial monitoring through a compliance program on the authority’s optimal sanctions and leniency policy. We found that compliance programs are beneficial in the fight against corporate crime if and only if the managerial sanction is relatively low. Moreover, we derived several insights that partly contradict the U.S. and E.U. corporate leniency programs, the U.S. individual leniency program, and the U.S. Federal Sentencing Guidelines. We revealed economic arguments suggesting that it may be optimal for the authority (i) to grant partial corporate leniency when the corporation blows the whistle, while *not* granting individual leniency to the involved employees; (ii) to not always grants individual leniency when an involved employee blows the whistle; and (iii) to not automatically apply a discount on the corporate sanction for the mere fact of having adopted a compliance program.

Our model focuses on the monitoring aspect of compliance programs and abstracts away from the educational and disciplining dimensions. Moreover, our findings are based on the firm’s owner, rather than an in-house or external lawyer, implementing the compliance program. Future research may take account of such considerations.

*Short-Term Managerial Contracts and Cartels*

In Chapter 3, I showed how a series of short-term executive employment contracts can increase cartel stability compared to a long-term contract. The intuition is that executives may be disincenitized to defect from a collusive agreement by the threat of not being re-employed after the expiration of a short-term contract. Extending the model to allow for multiple interactions on the market within the same contractual period, I argued that short-term renewable contracts can be an explanation for observed patterns of cyclical collusive pricing. The model also allowed to show how a fixed salary component may serve to improve cartel stability with short-term contracts, while not affecting cartel stability with long-term contracts. Finally, I interpreted the results in light of firm financing so as to present a mechanism through which debt-financed firms can form more-stable cartels than equity-financed firms can.

The model extends the standard profit-maximizing cartel model by introducing finite managerial appointments. The main challenge for future research is to study the impact of such *short-termism* generated through employment contracts in more-general principal-agent set-ups, such as the model developed in Chapter 2.
**Strategic Delegation Improves Cartel Stability**

Chapter 4 extended the Cournot strategic delegation model by Fershtman and Judd (1987) and Sklivas (1987) to an infinitely repeated setting, and showed that the option to delegate control to employees increases cartel stability compared to the model of collusion between integrated firms. The reason is that firm owners can fiercely punish deviant managers by firing them, where such a punishment strategy is supported by the threat of reverting to the unprofitable one-shot Nash delegation equilibrium.

The seminal strategic delegation model has a few restrictions, such as contracts being linear in profits and sales, and full observability of contracts and actions. Future research could, thus, benefit from more-general principal-agent set-ups.

**Efficient Cartelization Through Buyer Groups**

In Chapter 5 (joint with Chris Doyle), we studied buyer groups. Buyer groups may facilitate procompetitive forces based on buyer power considerations, acting to reduce wholesale prices and level the playing field between smaller firms and larger firms that can exercise buyer power unilaterally, which potentially benefits final consumers. We instead developed a model of a strictly anticompetitive effect of buyer groups in markets where wholesale contracting is unobservable. A buyer group allows its members to credibly commit to wholesale contracts that induce joint monopoly profits in the downstream market. We showed that commonly observed vertical restraints and contracting terms—exclusivity provisions, minimum purchase clauses, and rebate schemes—enhance the stability of the buyer group by effectively limiting retailers’ ability and incentives to defect from the arrangement.

The model assumes that suppliers of the buyer group are perfectly competitive and that all retailers join the group. Moreover, we assume that all buyer group members compete on the same output market. Future research may relax such assumptions.

**The Overcharge as a Measure for Antitrust Damages**

Finally, in Chapter 6 (joint with Maarten Pieter Schinkel and Jan Tuinstra), we assessed the passing on of antitrust harm in longer vertical supply chains in which an antitrust violation may occur in any layer of production. We found that there exist no simple multiplication factors to correct the established direct-purchaser overcharge so as to determine the true antitrust harm throughout the entire production chain. While the direct-purchaser overcharge is equal to the sum of all passed-on overcharges downstream, it misses the output effects in every layer. We also noted that the share of total harm sustained by suppliers to the cartel may be substantial.

Our model, like all models in the antitrust damages literature, assumes price-taking behavior in a particular structural set-up; this may not be suitable for all markets.
Appendices
Appendix A

This appendix contains the proofs of Chapter 2.

A.1 Proofs of Section 2.4

A.1.1 Proofs of Lemmas 2.1 and 2.2

We determine the expected transfers by solving for the schedule of transfers associated with the optimal contract that induces or prevents breaches, respectively.

**Contract inducing breaches.** If the shareholder wants to induce breaches of the law, then the optimal contract, given action \( j \in \{N, C, R\} \), is defined as the solution of

\[
\max_{t_{\pi, \sigma}} \left\{ p_{\pi} - \sum_{\pi=0}^{1} \sum_{\sigma=0}^{1} p_{\pi,\sigma}^{b,i} t_{\pi,\sigma} - E_{i} [F] \right\}, \quad \text{subject to} \quad t_{\pi,\sigma} \geq 0, \quad \forall \{\pi, \sigma\}, \quad (LL_{b})
\]

\[
\sum_{\pi=0}^{1} \sum_{\sigma=0}^{1} p_{\pi,\sigma}^{b,i} t_{\pi,\sigma} - E_{i} [f] + G \geq 0, \quad (PC_{b})
\]

\[
\sum_{\pi=0}^{1} \sum_{\sigma=0}^{1} \left( p_{\pi,\sigma}^{b,i} - p_{\pi,\sigma}^{n,i} \right) t_{\pi,\sigma} - E_{i} [f] + G \geq 0. \quad (IC_{b})
\]

By limited liability \((LL_{i})\), the participation constraint \((PC_{i})\) is satisfied whenever the incentive compatibility constraint \((IC_{i})\) is satisfied. Now, if \( E_{i} [f] \leq G \), then \((IC_{i})\) is satisfied by setting \( t_{\pi,\sigma} = 0, \forall \{\pi, \sigma\} \), and, thus, \( E_{i} [t^{b}] = 0 \) for \( i \in \{N, C, R\} \).

If \( E_{i} [f] > G \), the cheapest way to satisfy \((IC_{i})\) is to make a positive transfer only in

(i) state \( \{\pi, \sigma\} = \{1, 0\} \) if \( i = N \) (there is no CP, so evidence never comes available and profit realization \( \pi = 1 \) is most informative of a breach having occurred), and
(ii) any state in which \( \sigma = 1 \) if \( i \in \{ C, R \} \) (signal \( \sigma = 1 \) is a sufficient statistic), for example, state \( \{ \pi, \sigma \} = \{ 1, 1 \} \).

Consider first the case in which \( i = N \). Then, setting \( t_{\pi, \sigma} = 0 \) for every state of the world \( \{ \pi, \sigma \} \neq \{ 1, 0 \} \), while setting \( t_{10} \) to bind the incentive compatibility constraint, gives

\[
t_{10} = \frac{E_N[f^N - G]}{\rho_\pi(1-\rho_\pi)},
\]

which is paid out with probability \( \rho_\pi \) in equilibrium and, thus, \( E_N[t^b] = \gamma^N \left( \beta f^N - G \right) \), where \( \gamma^N = \frac{\rho_\pi}{2\rho_\pi - 1} \).

Consider now the cases in which \( i \in \{ C, R \} \). Then, setting \( t_{\pi, \sigma} = 0 \) for every state of the world \( \{ \pi, \sigma \} \neq \{ 1, 1 \} \), while setting \( t_{11} \) to bind the incentive compatibility constraint, gives

\[
t_{11} = \frac{E_i[f - G]}{\rho_\pi(1-\rho_\pi)},
\]

which is paid out with probability \( \rho_\pi \rho_\sigma \) in equilibrium and, thus, \( E_i[t^b] = E_i[f] - G \) if \( i \in \{ C, R \} \).

**Contract preventing breaches.** If the shareholder wants to prevent breaches of the law by action \( i \in \{ N, C, R \} \), the optimal employment contract is obtained by solving

\[
\max_{t_{\pi, \sigma}} \left\{ 1 - \rho_\pi - \sum_{\pi=0}^{1} \sum_{\sigma=0}^{1} p_{\pi, \sigma} t_{\pi, \sigma} \right\}, \quad \text{subject to}
\]

\[
t_{\pi, \sigma} \geq 0, \quad \forall \pi, \sigma, \quad (LL_n)
\]

\[
\sum_{\pi=0}^{1} \sum_{\sigma=0}^{1} p_{\pi, \sigma} t_{\pi, \sigma} = 0, \quad (PC_n)
\]

\[
\sum_{\pi=0}^{1} \sum_{\sigma=0}^{1} \left( p_{\pi, \sigma} - p_{\pi, \sigma}^{b, i} \right) t_{\pi, \sigma} + E_i[f] - G \geq 0. \quad (IC_n)
\]

Again, by limited liability \( (LL_n) \), the participation constraint \( (PC_n) \) is satisfied whenever the incentive compatibility constraint \( (IC_n) \) is satisfied. Now, if \( E_i[f] > G \), then \( (IC_n) \) is satisfied by setting \( t_{\pi, \sigma} = 0, \forall \{ \pi, \sigma \} \), and, thus, \( E_i[t^n] = 0 \) for \( i \in \{ N, C, R \} \).

If \( E_i[f] \leq G \), the cheapest way to satisfy \( (IC_n) \) is to make a positive transfer only in the state of the world that is most informative about the law not having been breached, i.e., state \( \{ \pi, \sigma \} = \{ 0, 0 \} \). Setting \( t_{\pi, \sigma} = 0 \) for every state of the world \( \{ \pi, \sigma \} \neq \{ 0, 0 \} \), while setting \( t_{00} \) to bind the incentive compatibility constraint, gives

(i) \( t_{00} = \frac{G - E_N[f]}{\rho_\pi(1-\rho_\pi)} \) if \( i = N \), which is paid out with probability \( \rho_\pi \) in equilibrium and, thus, \( E_N[t^n] = \gamma^N (G - \beta f^N) \), and

(ii) \( t_{00} = \frac{G - E_i[f]}{\rho_\pi(1-\rho_\pi)(1-\rho_\sigma)} \) if \( i \in \{ C, R \} \), which is paid out with probability \( \rho_\pi \) in equilibrium and, thus, \( E_i[t^n] = \gamma^C (G - E_i[f]) \) if \( i \in \{ C, R \} \), where \( \gamma^C = \frac{\rho_\pi}{\rho_\pi(1-\rho_\pi)(1-\rho_\sigma)} \).
Combining the results. Thus, if \( i = N \), we have

\[
E_N [t^b] = \begin{cases} 
0 & \text{if } \beta f^N \leq G \\
\gamma^N (\beta f^N - G) & \text{if } \beta f^N > G,
\end{cases}
\]

\[
E_N [t^n] = \begin{cases} 
\gamma^N (G - \beta f^N) & \text{if } \beta f^N \leq G \\
0 & \text{if } \beta f^N > G,
\end{cases}
\]

while if \( i \in \{C, R\} \), we have

\[
E_i [t^b] = \begin{cases} 
0 & \text{if } E_i [f] \leq G \\
E_i [f] - G & \text{if } E_i [f] > G,
\end{cases}
\]

\[
E_i [t^n] = \begin{cases} 
\gamma^C (G - E_i [f]) & \text{if } E_i [f] \leq G \\
0 & \text{if } E_i [f] > G,
\end{cases}
\]

which boils down to Lemma 2.1 and 2.2, respectively.

A.1.2 Proof of Proposition 2.1

By Lemmas 2.1 and 2.2, for any \( i \in \{N, C, R\} \), increasing \( f^i \) weakly increases \( E_i [t^b] \) and weakly decreases \( E_i [t^n] \), thereby weakly relaxing constraint (2.5). Thus, the authority optimally sets all managerial fines as high as possible, i.e.,

\[
f^N = f^C = f^R = \overline{f}.
\]

Increasing \( F^N \) and \( F^C \) also weakly relaxes constraint (2.5). The authority optimally sets

\[
F^N = F^C = \overline{F}.
\]

We derive the authority’s optimal choice of \( F^R \). Noting that \( \rho_\sigma f^R + (1 - \rho_\sigma) \beta f^C > \beta f^C \) (because \( f^C = f^R = \overline{f} \)), we have \( E_R [t^b] > E_C [t^b] \) and \( E_R [t^n] < E_C [t^n] \) by Lemma 2.2.

Shareholder prevents breach. Suppose the shareholder adopts a CP and prevents a breach. Since \( E_R [t^n] \leq E_C [t^n] \), the shareholder pays a lower salary if she can credibly commit to blow the whistle whenever she finds evidence. Such a commitment also relaxes constraint (2.5) and is ex post credible if and only if the authority sets \( F^R \leq \beta F^C \), because the shareholder then pays a lower fine if she reports \( F^R \) than if she does not report \( \beta F^C \).
Shareholder induces breach. Suppose now the shareholder adopts a CP and induces a breach. If the authority sets $F^R > \beta F^C$, the shareholder will not report evidence when she finds it. If instead $F^R < \beta F^C$, the shareholder cannot help but report evidence whenever she finds it. Finally, if the authority sets $F^R = \beta F^C$, the shareholder is ex post indifferent between reporting evidence or not. However, ex ante she prefers to commit to not reporting evidence, because that reduces her expected transfer since $E_C [t^b] < E_R [t^b]$. Thus, her expected payoff is

$$
\Pi_i^b = \begin{cases} 
\Pi_R^b = \rho_f - E_R [t^b] - \rho \sigma F^R - (1 - \rho \sigma) \beta F^C & \text{if } F^R < \beta F^C \\
\Pi_C^b = \rho_f - E_C [t^b] - \beta F^C & \text{if } F^R = \beta F^C \\
\Pi_C^b = \rho_f - E_C [t^b] - \beta F^C & \text{if } F^R > \beta F^C.
\end{cases}
$$

Now, decreasing $F^R = \beta F^C$ to $F^R < \beta F^C$ entails (i) a discrete downward jump from $\Pi_C^b$ to $\Pi_R^b$, because $E_R [t^b] > E_C [t^b]$ and $\rho \sigma F^R + (1 - \rho \sigma) \beta F^C = \beta F^C$ if $F^R = \beta F^C$, while (ii) continuously increasing $\Pi_R^b$, because $\Pi_R^b$ increases as becomes $F^R$ smaller. Thus, the authority optimally sets $F^R$ slightly under $\beta F^C$ so as to “impose” the discrete downward jump on the shareholder with a minimal effect of the continuous increase. Therefore, $F^R = \beta F^C - |\epsilon|$, where $\epsilon$ is arbitrarily small. \qed
A.1.3 Proof of Proposition 2.2

The proof consists of three steps: (i) we derive the optimal investigation probability $\beta^*$ when CPs are available; (ii) we derive the optimal investigation probability $\tilde{\beta}^*$ when CPs are not available; and (iii) we compare the relative sizes of $\beta^*$ and $\tilde{\beta}^*$.

A.1.3.1 Optimal Investigation Probability When CPs Are Available ($\beta^*$)

Lemma A.1 The optimal investigation probability $\beta^*$, as a function of $\overline{F}$ and $\bar{f}$, is

$$\beta^* = \begin{cases} 
\emptyset & \text{if } \overline{F} < F_0, \\
\frac{2\rho - 1 + \gamma C (G - \rho \bar{f})}{\gamma C (1 - \rho \bar{f}) + F} & \text{if } \overline{F} \geq F_0, 
\end{cases}$$

(A.1)

where $F_0 = 2\rho - 1 + \gamma C (G - \bar{f})$, $F_1 = (2\rho - 1) \pi + G - \bar{f}$, $F_3 = \frac{(2\rho - 1)\bar{f}}{G - \rho \bar{f}}$, $F_2 = \frac{(2\rho - 1)\pi + \gamma N \bar{f}}{\rho \bar{f} + (\gamma N - 1) \bar{f}}$, and $F_4 = \frac{(2\rho - 1)(1 - \rho \bar{f})}{G - \rho \bar{f}}$.

Proof. By Corollary 2.2, if the shareholder prevents a breach, she adopts a CP and the expected transfer is

$$E_R [t^n] = \max \left\{ \gamma C \left( G - \rho \bar{f} - (1 - \rho \bar{f}) \beta \bar{f} \right), 0 \right\}.$$  \hspace{1cm} (A.4)

Conversely, if the shareholder induces a breach, she may or may not adopt a CP, resulting
in expected transfer, respectively,

\[
E_R \left[ t^b \right] = \max \left\{ \rho_\sigma \bar{f} + (1 - \rho_\sigma) \beta \bar{f} - G, 0 \right\}, \tag{A.5}
\]

\[
E_N \left[ t^b \right] = \max \left\{ \gamma^N (\beta \bar{f} - G), 0 \right\}. \tag{A.6}
\]

The authority minimizes \( \beta \) subject to constraint (2.5), which then simplifies to

\[
1 - \rho_\pi - E_R [t^n] \geq \rho_\pi - \min \left\{ E_N \left[ t^b \right], E_R \left[ t^b \right] + \beta F - \rho_\sigma |\epsilon| \right\},
\]

where we neglect \( \epsilon \) for notational convenience, yielding

\[
1 - \rho_\pi - E_R [t^n] \geq \rho_\pi - \min \left\{ E_N \left[ t^b \right], E_R \left[ t^b \right] \right\} - \beta F. \tag{A.7}
\]

The expressions for the expected transfers \( E_R [t^n] \) and \( \min \left\{ E_N \left[ t^b \right], E_R \left[ t^b \right] \right\} \) depend on how managerial benefit \( G \) compares to the expected managerial fine—see (A.4), (A.5), and (A.6). These expressions are stated in the following table as a function of \( \beta \).

<table>
<thead>
<tr>
<th>Investigation Prob. ( \beta )</th>
<th>Preventing Breach: ( E_R [t^n] )</th>
<th>Inducing Breach: ( \min \left{ E_N \left[ t^b \right], E_R \left[ t^b \right] \right} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta \in \left[ 0, \frac{G - \rho_\sigma \bar{f}}{(1 - \rho_\sigma) \bar{f}} \right) )</td>
<td>( \gamma^C (G - \rho_\sigma \bar{f} - (1 - \rho_\sigma) \beta \bar{f}) )</td>
<td>( E_R \left[ t^b \right] = E_R \left[ t^b \right] = 0 )</td>
</tr>
<tr>
<td>( \beta \in \left[ \frac{G - \rho_\sigma \bar{f}}{(1 - \rho_\sigma) \bar{f}}, \frac{G}{\bar{f}} \right) )</td>
<td>0</td>
<td>( E_N \left[ t^b \right] = 0 )</td>
</tr>
<tr>
<td>( \beta \in \left[ \frac{G}{\bar{f}}, \frac{\rho_\sigma \bar{f} + (\gamma^N - 1)G}{(\gamma^N - (1 - \rho_\sigma) \bar{f})} \right) )</td>
<td>0</td>
<td>( E_N \left[ t^b \right] = \gamma^N (\beta \bar{f} - G) )</td>
</tr>
<tr>
<td>( \beta \in \left[ \frac{\rho_\sigma \bar{f} + (\gamma^N - 1)G}{(\gamma^N - (1 - \rho_\sigma) \bar{f})}, 1 \right] )</td>
<td>0</td>
<td>( E_R \left[ t^b \right] = \rho_\sigma \bar{f} + (1 - \rho_\sigma) \beta \bar{f} - G )</td>
</tr>
</tbody>
</table>

Depending on the relative sizes of \( \bar{f} \) and \( G \), some of the rows of this table violate \( \beta \in [0, 1] \) and, thus, need to be disregarded. We consider all possible cases in turn.

Suppose \( \bar{f} \in [0, G] \). Only the first row is then relevant, because \( \frac{G - \rho_\sigma \bar{f}}{(1 - \rho_\sigma) \bar{f}} \geq 1 \). We then have \( E_R [t^n] = \gamma^C (G - \rho_\sigma \bar{f} - (1 - \rho_\sigma) \beta \bar{f}) \) and \( \min \left\{ E_N \left[ t^b \right], E_R \left[ t^b \right] \right\} = E_N \left[ t^b \right] = 0 \). Substituting these transfers in constraint (A.7) and solving for \( \beta \) gives equation (A.4), where \( F \geq F_0 \) ensures that \( \beta^* \leq 1 \).

Suppose \( \bar{f} \in (G, \frac{G}{\rho_\sigma}) \). All rows of the table are then relevant. For each region of \( \beta \), i.e., for each row of the table, substituting the associated transfers in constraint (A.7) and
solving for $\beta$ gives equation (A.2), where the conditions on $\overline{F}$ ensure that the derived solution indeed lies within the relevant region of $\beta$.

Suppose $\bar{f} \in \left[\frac{G}{\rho \sigma}, \infty\right)$. Only the last three rows of the table are then relevant, because $\frac{G - \rho \bar{f}}{1 - \rho \sigma} \leq 0$. For each of the last three rows, substituting the associated transfers in constraint (A.7) and solving for $\beta$ gives equation (A.8), where the conditions on $\overline{F}$ ensure that the derived solution indeed lies within the relevant region of $\beta$. □

### A.1.3.2 Optimal Investigation Probability When CPs Are Not Available ($\beta^*$)

By Lemma 2.1, the expected transfer is $E_N \left[t^b\right] = \max \left\{ \gamma^N \left( \beta f^N - G \right), 0 \right\}$ when inducing a breach, and $E_N \left[t^n\right] = \max \left\{ \gamma^N \left( G - \beta f^N \right), 0 \right\}$ when preventing a breach. Thus, we have (i) if $G \leq \beta \bar{f}$ then $E_N \left[t^b\right] = \gamma^N \left( \beta f^N - G \right)$ and $E_N \left[t^n\right] = 0$, while (ii) if $G > \beta \bar{f}$ then $E_N \left[t^b\right] = 0$ and $E_N \left[t^n\right] = \gamma^N \left( G - \beta f^N \right)$. In both cases, we have $E_N \left[t^n\right] - E_N \left[t^b\right] = \gamma^N \left( G - \beta f^N \right)$.

The authority’s problem is to minimize $\beta$ subject to $\Pi^N_R \geq \Pi^b_N$, that is, subject to

$$1 - \rho \pi - E_N \left[t^n\right] \geq \rho \pi - E_N \left[t^b\right] - \beta \overline{F},$$

$$\iff \beta \overline{F} \geq 2 \rho \pi - 1 + E_N \left[t^n\right] - E_N \left[t^b\right].$$

Substituting for $E_N \left[t^n\right] - E_N \left[t^b\right] = \gamma^N \left( G - \beta f^N \right)$ and solving for $\beta$ gives

$$\tilde{\beta}^* = \begin{cases} 
0 & \text{if } \overline{F} < F_5 \\
\frac{2 \rho \pi - 1 + \gamma^N G}{\gamma^N f^N + F} & \text{if } \overline{F} \geq F_5,
\end{cases}$$

where $F \geq F_5 = 2 \rho \pi - 1 + \gamma^N (G - \bar{f})$ ensures that $\tilde{\beta}^* \leq 1$.

### A.1.3.3 Comparison of $\beta^*$ and $\tilde{\beta}^*$

Assuming that $\overline{F}$ is large enough for $\beta^*, \tilde{\beta}^* \leq 1$ to exist, we have by straightforward algebra

(i) $\beta^* < \tilde{\beta}^*$ if (a) $\bar{f} \leq G$; or (b) $\bar{f} \in \left( G, \frac{G}{\rho \sigma} \right)$ and $\overline{F} \geq F_3$; or (c) $\bar{f} \geq \frac{G}{\rho \sigma}$ and $\overline{F} \geq F_3$;

(ii) $\beta^* > \tilde{\beta}^*$ if (a) $\bar{f} \in \left( G, \frac{G}{\rho \sigma} \right)$ and $\overline{F} < F_2$; or (b) $\bar{f} \geq \frac{G}{\rho \sigma}$ and $\overline{F} < F_2$; and

(iii) $\beta^* = \tilde{\beta}^*$ if (a) $\bar{f} \in \left( G, \frac{G}{\rho \sigma} \right) & F_2 \leq \overline{F} < F_3$; or if (b) $\bar{f} \geq \frac{G}{\rho \sigma} & F_2 \leq \overline{F} < F_3$,

which is equivalent to Proposition 2.2, where we define $F' = F_2$ and $F'' = F_3$. □
A.2 Proofs of Lemmas 2.3 and 2.4

This appendix derives the expected transfers. Denote by \( i = Z \) the shareholder’s action of “not adopting a CP and blowing the whistle when the manager shows evidence to her.” Similar to the results in Section 2.4, we anticipate that the authority optimally (i) sets the managerial fines \( f^N, f^C \) and \( f^R \) to their legal maximum \( \overline{f} \); (ii) sets the corporate fines \( F^N \) and \( F^C \) to their legal maximum \( \overline{F} \); and (iii) grants partial corporate leniency when the shareholder reports evidence to the authority, i.e., \( F^R = \beta \overline{F} - |\epsilon| \), thereby ensuring that the shareholder always reports when she has evidence of a breach. We ex post verify that this anticipation is indeed correct; the proof is long and available on request.

A.2.1 Proof of Lemma 2.3

If the shareholder prevents a breach, she optimally implements a CP to monitor the manager, while paying him a positive transfer if and only if \( \pi = 0, \sigma = 0, r_a = 0 \) and \( r_p = 0 \). Denoting transfers by \( t_{\pi,\sigma,r_a,r_p} \), the shareholder minimizes \( t_{0,0,0,0} \geq 0 \), s.t.

\[
\begin{align*}
\rho_{\pi} t_{0,0,0,0} & \geq (1 - \rho_{\pi}) (1 - \rho_{\pi}) t_{0,0,0,0} + G - \rho_{\sigma} f^R - (1 - \rho_{\sigma}) \beta f^C, \\
\rho_{\pi} t_{0,0,0,0} & \geq G - f^r, \\
\rho_{\pi} t_{0,0,0,0} & \geq G - f^R, \\
\rho_{\pi} t_{0,0,0,0} & \geq 0,
\end{align*}
\]

where (A.8) ensures that the shareholder does not “breach and not show evidence to the shareholder and not blow the whistle,” (A.9) ensures that the shareholder does not “breach and blow the whistle,” (A.10) ensures that the manager does not “breach and show evidence to the shareholder,” and (A.11) is the participation constraint. Anticipating that \( f^C = f^R = \overline{f} \), we then have

\[
E_R [t^n] = \rho_{\pi} t_{0,0,0,0} = \max \{ \gamma^C (G - \rho_{\sigma} f^R - (1 - \rho_{\sigma}) \beta f^C), G - f^r, 0 \}.
\]  \( \Box \)

A.2.2 Proof of Lemma 2.4

When the shareholder induces a breach, she may do so by (i) adopting a CP or not, and (ii) requesting evidence from the manager or not, while (iii) ensuring that the manager does not blow the whistle.\(^{155}\) We consider the four possible cases in turn.

\(^{155}\)We assume that \( \overline{F} \) is sufficiently large such that the shareholder never induces a breach by requiring the manager to blow the whistle. Anticipating that the authority sets maximum corporate fines, this strategy would mean being imposed the corporate fine \( \overline{F} \) for sure, which is irrational if \( \overline{F} \) is large enough.
A.2.2.1 Case I: CP and No Request for Evidence

Suppose the shareholder adopts a CP and does not request evidence from the manager. She will then use signal $\sigma = 1$ to induce a breach, because $\sigma = 1$ is a perfectly informative signal of a breach having occurred. The realization of $\pi$ is then irrelevant. Moreover, the shareholder must ensure that the manager does not blow the whistle or shows evidence to the shareholder. Thus, transfers are contingent on the realization of $\sigma$, $r_a$ and $r_p$. We denote them by $t_{\sigma, r_a, r_p}$, such that $t_{\sigma, r_a, r_p} = 0$ if $r_a = 1$ and/or $r_p = 1$.

**Interim stage 5’.** Suppose the manager has breached and signal $\sigma$ has been realized. If $\sigma = 1$ the shareholder blows the whistle and the game ends. However, if $\sigma = 0$ the shareholder must ensure that the manager does not blow the whistle or reports to the shareholder, which is the case if she compensates him by $t_{0,0,0} \geq \beta f^C - \min \{ f^r, f^R \}$.

**Ex-ante stage 4’.** From the interim stage 5’, we know that the shareholder will set $t_{0,0,0} = \max \{ \beta f^C - \min \{ f^r, f^R \}, 0 \}$. The shareholder uses signal $\sigma = 1$ to induce a breach and solves for $t_{1,0,0}$ by minimizing $t_{1,0,0}$, subject to

\begin{align}
\rho_{\sigma} t_{1,0,0} + (1 - \rho_{\sigma}) t_{0,0,0} + G - E_R[f] &\geq t_{0,0,0}, \quad (A.13) \\
\rho_{\sigma} t_{1,0,0} + (1 - \rho_{\sigma}) t_{0,0,0} + G - E_R[f] &\geq G - \min \{ f^r, f^R \}, \quad (A.14) \\
\rho_{\sigma} t_{1,0,0} + (1 - \rho_{\sigma}) t_{0,0,0} + G - E_R[f] &\geq 0, \quad (A.15)
\end{align}

where (A.13) ensures that the manager does not “not breach the law,” (A.14) ensures that the manager does not “breach and blow the whistle or report to the shareholder,” and (A.15) is the participation constraint, which is implied by (A.13). We then have by (A.13) and (A.14), respectively,

\begin{align*}
t_{1,0,0} &\geq \frac{E_R[f] - G}{\rho_{\sigma}} + t_{0,0,0}, \\
t_{1,0,0} &\geq \frac{E_R[f] - \min \{ f^r, f^R \} - (1 - \rho_{\sigma}) t_{0,0,0}}{\rho_{\sigma}}.
\end{align*}

Thus, the authority optimally sets

\begin{align*}
t_{1,0,0} = \max \left\{ \frac{E_R[f] - G}{\rho_{\sigma}} + t_{0,0,0}, \frac{E_R[f] - \min \{ f^r, f^R \} - (1 - \rho_{\sigma}) t_{0,0,0}}{\rho_{\sigma}}, 0 \right\}.
\end{align*}
The expected transfer is then

$$E_R \left[ t^b \right] = \rho \sigma t_{1,0,0} + (1 - \rho \sigma) t_{0,0,0}$$

$$= \max \left\{ E_R \left[ f \right] - G + \rho \sigma t_{0,0,0}, E_R \left[ f \right] - \min \left\{ f^r, f^R \right\} - (1 - \rho \sigma) t_{0,0,0}, 0 \right\}$$

which, when substituting for $E_R \left[ f \right]$ and $t_{0,0,0}$, rewrites as

$$E_R \left[ t^b \right] = \max \left\{ \rho \sigma f^R + (1 - \rho \sigma) \beta f^C - G + \max \left\{ \beta f^C - \min \left\{ f^r, f^R \right\} , 0 \right\} \right\}$$

where labels $A$–$C$ are used later in this proof.

**A.2.2.2 Case II: No CP and No Request for Evidence**

Suppose the shareholder does not adopt a CP and does not request evidence from the manager. She will then use signal $\pi = 1$ to induce a breach. Moreover, the shareholder must ensure that the manager does not blow the whistle or reports evidence to the shareholder. Thus, transfers are contingent on the realization of $\pi$, $r_a$ and $r_p$. We denote them by $t_{\pi,r_a,r_p}$, such that $t_{\pi,r_a,r_p} = 0$ if $r_a = 1$ and/or $r_p = 1$.

**Interim stage 5’**. Suppose the manager has breached and profit $\pi$ has been realized. The shareholder then ensures that the manager does not blow the whistle or reports evidence to the shareholder by paying him $t_{\pi,0,0} \geq \beta f^N - \min \left\{ f^r, f^Z \right\}$ for both profit realizations $\pi \in \{0, 1\}$.

**Ex-ante stage 4’**. To induce the manager to breach the law in the first place, the shareholder must create a wedge, say $\Delta > 0$, between $t_{1,0,0}$ and $t_{0,0,0}$. She optimally does so by setting $t_{0,0,0} = \max \left\{ \beta f^N - \min \left\{ f^r, f^Z \right\} , 0 \right\}$ and minimizing $t_{1,0,0} = t_{0,0,0} + \Delta$,
subject to
\[
\rho_\pi (t_{0,0,0} + \Delta) + (1 - \rho_\pi) t_{0,0,0} + G - \beta f^N \geq (1 - \rho_\pi) (t_{0,0,0} + \Delta) + \rho_\pi t_{0,0,0},
\]
\[(A.17)\]
\[
\rho_\pi (t_{0,0,0} + \Delta) + (1 - \rho_\pi) t_{0,0,0} + G - \beta f^N \geq G - \min \{ f^r, f^Z \},
\]
\[(A.18)\]
\[
\rho_\pi (t_{0,0,0} + \Delta) + (1 - \rho_\pi) t_{0,0,0} + G - \beta f^N \geq 0,
\]
\[(A.19)\]

where \[(A.17)\] ensures that the manager does not “not breach the law,” \[(A.18)\] ensures that the manager does not “breach and blow the whistle or report to the shareholder,” and \[(A.19)\] is the participation constraint, which is implied by \[(A.17)\]. Noting that \[(A.18)\] is always satisfied, we have by \[(A.17)\] that
\[
\Delta = \max \left\{ \frac{\beta f^N - G}{2\rho_\pi - 1}, 0 \right\},
\]
resulting in expected transfer
\[
E_N \left[ t^b \right] = \rho_\pi (t_{0,0,0} + \Delta) + (1 - \rho_\pi) t_{0,0,0}
\]
\[
= \max \{ \gamma^N (\beta f^N - G), 0 \} + \max \{ \beta f^C - \min \{ f^r, f^Z \}, 0 \}.
\]

**A.2.2.3 Case III: CP and Request for Evidence**

Suppose the shareholder adopts a CP and requests evidence from the manager. She can optimally induce a breach by paying the manager a positive transfer if and only if \(r_a = 0\) and \(r_p = 1\): we denote the transfers by \(t_{r_a,r_p}\), where \(t_{r_a,r_p} = 0\) if \((r_a, r_p) \neq (0, 1)\).

The shareholder can request for evidence before or after profit \(\pi\) and signal \(\sigma\) are realized. Since both pieces of information do not affect the transfers, it does not matter when the shareholder requests for evidence. She minimizes \(t_{0,1}\), subject to
\[
t_{0,1} + G - f^R \geq 0, \quad (A.20)
\]
\[
t_{0,1} + G - f^R \geq G - \rho_\sigma f^R - (1 - \rho_\sigma) \beta f^C, \quad (A.21)
\]
\[
t_{0,1} + G - f^R \geq G - f^r, \quad (A.22)
\]
\[
t_{0,1} + G - f^R \geq 0, \quad (A.23)
\]

where \[(A.20)\] ensures that the does not “not breach,” \[(A.21)\] ensures that the manager does not “breach and not report evidence to the shareholder,” \[(A.22)\] ensures that the manager does not “breach and blow the whistle,” and \[(A.23)\] is the participation constraint. The
expected transfer is then

\[
E_R \left[ t^b \right] = \max \left\{ f^R - G, (1 - \rho_\sigma) \left( f^R - \beta f^C \right), f^R - f^r, 0 \right\}.
\]

**A.2.2.4 Case IV: No CP and Request for Evidence**

Suppose the shareholder does not adopt a CP, but requests to see the evidence. Again, she optimally induces a breach by paying the manager a positive transfer if and only if \( r_a = 0 \) and \( r_p = 1 \). Thus, we denote the transfers by \( t_{r_a, r_p} \), where \( t_{r_a, r_p} = 0 \) if \( (r_a, r_p) \neq (0, 1) \).

Again, the shareholder can request for evidence before or after profit \( \pi \) and signal \( \sigma \) are realized. Since both pieces of information do not affect the transfers, it does not matter when the shareholder requests for evidence. She minimizes \( t_{0,1} \), subject to

\[
\begin{align*}
t_{0,1} + G - f^Z &\geq 0, \\
t_{0,1} + G - f^Z &\geq G - \beta f^N, \\
t_{0,1} + G - f^Z &\geq G - f^r, \\
t_{0,1} + G - f^Z &\geq 0,
\end{align*}
\]

where (A.24) ensures that the manager does not “not breach the law,” (A.25) ensures that the manager does not “breach and not show evidence to the shareholder,” (A.26) ensures that the shareholder does not “breach and blow the whistle,” and (A.27) is the participation constraint. The expected transfer is then

\[
E_Z \left[ t^b \right] = \max \left\{ f^Z - G, f^Z - \beta f^N, f^Z - f^r, 0 \right\}.
\]

**A.2.2.5 Summary of Expected Transfers to Induce a Breach**

Substituting \( f^N = f^C = f^R = f^Z = \overline{f} \) into the expected transfers \( E_i \left[ t^b \right] \) derived above, we arrive at the following table for \( E_i \left[ t^b \right] \), where \( E_R \left[ f \right] = \rho_\sigma \overline{f} + (1 - \rho_\sigma) \beta \overline{f} \). We specifically note that term \( B \) in expression (A.16) is redundant, because by \( f^C = f^R = \overline{f} \) we have \( C > A \) and, therefore, \( C > B \).

<table>
<thead>
<tr>
<th>Request for evidence</th>
<th>Not request for evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td></td>
</tr>
</tbody>
</table>
| \[
\max \left\{ f - G, (1 - \rho_\sigma) \times (1 - \beta) \overline{f}, \overline{f} - f^r, 0 \right\}
\] | \[
\max \left\{ E_R \left[ f \right] - G + \max \left\{ \beta \overline{f} - f^r, 0 \right\}, E_R \left[ f \right] - f^r, 0 \right\}
\] |
| No CP                |                          |
| \[
\max \left\{ f - G, (1 - \beta) \overline{f}, \left( \ast \right) \overline{f} - f^r, 0 \right\}
\] | \[
\max \left\{ \gamma^N \left( \beta \overline{f} - G \right), 0 \right\}
\] + \[
\max \left\{ \beta \overline{f} - f^r, 0 \right\}
\] |
(⋆) Noting that the strategy “no CP, request for evidence” entails a weakly higher expected transfer than the strategy “CP, request for evidence,” we eliminate the former from the problem. The remaining expected transfers are stated in Lemma 2.4.

### A.3 Proof of Proposition 2.3

This appendix solves for the optimal managerial leniency policy \( f^r \), which the authority sets so as to maximize the wedge \( E \left[ t^b \right] - E \left[ t^n \right] \), where we omit the \( i \) in \( E_i \left[ t^a \right] \) for notational convenience. Subsections A.3.1 and A.3.2, respectively, determine this wedge if \( f^r = \bar{f} \) and \( \bar{f} = 0 \). We compare those wedges in Subsection A.3.3 so as to derive the optimal \( f^r \). Throughout the analysis, we assume \( \rho_\sigma > \frac{1 - \rho_\pi}{\rho_\pi} \) so as to reduce the number of cases in this proof.

#### A.3.1 No Managerial Leniency

Suppose the authority provides no managerial leniency, that is, \( f^r = \bar{f} \).

**Preventing a breach.** If \( f^r = \bar{f} \) the expected transfer to prevent a breach (A.12) becomes

\[
E \left[ t^n \right] = \max \left\{ \gamma^C \left( G - \rho_\sigma \bar{f} - (1 - \rho_\sigma) \beta \bar{f} \right), G - \bar{f}, 0 \right\},
\]

where constraint \( B \) is irrelevant, because (i) if \( \bar{f} < G \) then \( B < A \), and (ii) if \( \bar{f} \geq G \) then \( B < 0 \). Therefore,

\[
E \left[ t^n \right] = \max \left\{ \gamma^C \left( G - \rho_\sigma \bar{f} - (1 - \rho_\sigma) \beta \bar{f} \right), 0 \right\}. \tag{A.28}
\]

**Inducing a breach.** Substituting \( f^r = \bar{f} \) in the expressions in Subsection 7.2 yields

\[
E \left[ t^b \right] = \min \left\{ \max \left\{ \rho_\sigma \bar{f} + (1 - \rho_\sigma) \beta \bar{f} - G, 0 \right\}, \frac{\gamma^N (\beta \bar{f} - G), 0 \right\} \right\}. \tag{A.29}
\]

**The wedge.** From (A.28) and (A.29) we have that the wedge \( E \left[ t^b \right] - E \left[ t^n \right] \) is the same as in the case if manager does not possess evidence, yielding the table on page 150.
**A.3.2 Managerial Leniency**

Suppose the authority provides managerial leniency, that is, \( f^r = 0 \).

**Preventing a breach.** If \( f^r = 0 \) the expected transfer to prevent a breach \((A.12)\) becomes

\[
E \left[ t^n \right] = \max \left\{ \gamma^C \left( G - \rho_\sigma \bar{f} - (1 - \rho_\sigma) \beta \bar{f} \right), G, 0 \right\},
\]

and the reporting constraint \( G \) binds if and only if \( G > \gamma^C \left( G - \rho_\sigma \bar{f} - (1 - \rho_\sigma) \beta \bar{f} \right) \), that is, if and only if

\[
\beta > \beta = \frac{\left( \gamma^C - 1 \right) G - \gamma^C \rho_\sigma \bar{f}}{\gamma^C (1 - \rho_\sigma) \bar{f}},
\]

where we note that \( \beta > 0 \Leftrightarrow \bar{f} < \frac{(\gamma^C - 1) G}{\gamma^C \rho_\sigma} \) and \( \beta < 1 \Leftrightarrow \bar{f} > \frac{(\gamma^C - 1) G}{\gamma^C \rho_\sigma} \). The following table then summarizes the expected transfer needed to prevent a breach depending on \( \bar{f} \) and \( \beta \).

<table>
<thead>
<tr>
<th>Cap on managerial fine ( \bar{f} )</th>
<th>Inv. prob. ( \beta )</th>
<th>Expected transfer ( E \left[ t^n \right] )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 0, \frac{(\gamma^C - 1) G}{\gamma^C \rho_\sigma} )</td>
<td>( \beta \in [0, 1] )</td>
<td>( \gamma^C \left( G - \rho_\sigma \bar{f} - (1 - \rho_\sigma) \beta \bar{f} \right) )</td>
</tr>
<tr>
<td>( \frac{(\gamma^C - 1) G}{\gamma^C \rho_\sigma}, \infty )</td>
<td>( \beta \in [0, \hat{\beta}] )</td>
<td>( \gamma^C \left( G - \rho_\sigma \bar{f} - (1 - \rho_\sigma) \beta \bar{f} \right) )</td>
</tr>
<tr>
<td>( \frac{(\gamma^C - 1) G}{\gamma^C \rho_\sigma}, \infty )</td>
<td>( \beta \in [\hat{\beta}, 1] )</td>
<td>( G )</td>
</tr>
<tr>
<td>( \hat{\beta}, 1 )</td>
<td>( \beta \in [0, 1] )</td>
<td>( G )</td>
</tr>
</tbody>
</table>

**Inducing a breach.** Substituting \( f^r = 0 \) in the expressions in Subsection \( 7.2 \) yields

\[
E \left[ t^b \right] = \min \left\{ \bar{f}, \max \left\{ E_R[f] - G + \beta \bar{f}, E_R[f] \right\}, \max \left\{ \gamma^N \left( \beta \bar{f} - G \right), 0 \right\} + \beta \bar{f}, 0 \right\}, \quad (A.30)
\]

If either \( \bar{f} < G \) or \( \bar{f} > G \) and \( \beta < \frac{G}{\bar{f}} \), then \((A.30)\) becomes

\[
E \left[ t^b \right] = \min \left\{ \bar{f}, \rho_\sigma \bar{f} + (1 - \rho_\sigma) \beta \bar{f}, \beta \bar{f} \right\} = \beta \bar{f}. \quad (A.31)
\]
If $\bar{f} > G$ and $\beta > \frac{G}{\bar{f}}$, then we have

$$E \left[ t^b \right] = \min \left\{ \bar{f} \left. \rho_\sigma \bar{f} + (1 - \rho_\sigma) \beta \bar{f} - G + \beta \bar{f} \right. , \left. \gamma^N \left( \beta \bar{f} - G \right) + \beta \bar{f} \right\},$$

where we note that

$$B < A \iff \beta < \tilde{\beta} = \frac{\left( \gamma^N - 1 \right) G + \rho_\sigma \bar{f}}{\left( \gamma^N - (1 - \rho_\sigma) \right) \bar{f}},$$

$$B < \bar{f} \iff \beta < \tilde{\beta} = \frac{\gamma^N G + \bar{f}}{(\gamma^N + 1) \bar{f}},$$

$$A < \bar{f} \iff \beta < \tilde{\beta} = \frac{(1 - \rho_\sigma) \bar{f} + G}{(2 - \rho_\sigma) \bar{f}},$$

where $0 < \tilde{\beta} < \tilde{\beta} < \tilde{\beta} < 1$, because $\bar{f} > G$ and by assumption $\rho_\sigma > \frac{1 - \rho_\pi}{\rho_\pi}$. Thus,

$$E \left[ t^b \right] = B \iff \left\{ \beta < \tilde{\beta} \text{ and } \beta < \tilde{\beta} \right\} \iff \beta < \tilde{\beta},$$

$$E \left[ t^b \right] = A \iff \left\{ \beta < \tilde{\beta} \text{ and } \beta > \tilde{\beta} \right\},$$

which cannot hold, and

$$E \left[ t^b \right] = \bar{f} \iff \left\{ \beta > \tilde{\beta} \text{ and } \beta > \tilde{\beta} \right\} \iff \beta > \tilde{\beta}.$$

The following table summarizes.

<table>
<thead>
<tr>
<th>Cap on Managerial Fine $f$</th>
<th>Inv. Prob. $\beta$</th>
<th>Expected Transfer $E \left[ t^b \right]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f \in [0, G)$</td>
<td>$\beta \in [0, 1]$</td>
<td>$E \left[ t^b \right] = \beta \bar{f}$</td>
</tr>
<tr>
<td>$\bar{f} \in [G, \infty)$</td>
<td>$\beta \in \left[ 0, \frac{G}{\bar{f}} \right)$</td>
<td>$E \left[ t^b \right] = \frac{\beta \bar{f}}{\gamma^N}$</td>
</tr>
<tr>
<td></td>
<td>$\beta \in \left[ \frac{G}{\bar{f}}, \tilde{\beta} \right)$</td>
<td>$E \left[ t^b \right] = \gamma^N \left( \beta \bar{f} - G \right) + \beta \bar{f}$</td>
</tr>
<tr>
<td></td>
<td>$\beta \in [\tilde{\beta}, 1]$</td>
<td>$E \left[ t^b \right] = \bar{f}$</td>
</tr>
</tbody>
</table>

The wedge. Noting that $\left( \frac{\gamma^C - 1}{\gamma^C \rho_\sigma} \right) G < G$ by assumption $\rho_\sigma > \frac{1 - \rho_\pi}{\rho_\pi}$, the two tables above yield the wedge $E \left[ t^b \right] - E \left[ t^n \right]$ outlined in the following table.
### A.3.3 Deriving the Optimal $f^r$

Combining the last table above with that on page 150, we have the following table. Comparing the wedge $E [t^b] - E [t^n]$ if $f^r = 0$ and if $f^r = \bar{f}$, the last column states the optimal managerial leniency policy by maximizing this wedge. The cells containing numbers in brackets are not straightforward to determine and are derived in more detail below.

<table>
<thead>
<tr>
<th>Fine $\bar{f}$</th>
<th>Prob. $\beta \in$</th>
<th>Wedge if $f^r = 0$</th>
<th>Wedge if $f^r = \bar{f}$</th>
<th>Optimal $f^r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0, \left(\frac{(\gamma^C - 1)G}{\gamma^C}\right)$</td>
<td>$[0, 1]$</td>
<td>$\beta \bar{f} - \gamma^C (G - E_R [f])$</td>
<td>$-\gamma^C (G - E_R [f])$</td>
<td>0</td>
</tr>
<tr>
<td>$\left(\frac{(\gamma^C - 1)G}{\gamma^C}, \frac{(\gamma^C - 1)G}{\gamma^C \rho_\sigma}\right)$</td>
<td>$[0, \hat{\beta}]$</td>
<td>$\beta \bar{f} - \gamma^C (G - E_R [f])$</td>
<td>$-\gamma^C (G - E_R [f])$</td>
<td>0</td>
</tr>
<tr>
<td>$\left(\frac{(\gamma^C - 1)G}{\gamma^C \rho_\sigma}, G\right)$</td>
<td>$[\hat{\beta}, 1]$</td>
<td>$\beta \bar{f} - G$</td>
<td>$-\gamma^C (G - E_R [f])$</td>
<td>0 (1)</td>
</tr>
<tr>
<td>$[G, \infty)$ (*)</td>
<td>$0, \left(\frac{G - \rho_\sigma \bar{f}}{(1 - \rho_\sigma) f}\right)$</td>
<td>$\beta \bar{f} - G$</td>
<td>$-\gamma^C (G - E_R [f])$</td>
<td>$f^r = \bar{f}$ if $\beta &lt; \beta''$, $f^r = 0$ if $\beta &gt; \beta''$ (3)</td>
</tr>
<tr>
<td>$\left(\frac{G - \rho_\sigma \bar{f}}{(1 - \rho_\sigma) f}, \frac{G}{f}\right)$</td>
<td>$\beta \bar{f} - G$</td>
<td>$0$</td>
<td>$\bar{f}$ (2)</td>
<td></td>
</tr>
<tr>
<td>$\frac{G}{f}, \hat{\beta}$</td>
<td>$\gamma^N (\beta \bar{f} - G) + \beta \bar{f} - G$</td>
<td>$\gamma^N (\beta \bar{f} - G)$</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>$\hat{\beta}, \hat{\beta}$</td>
<td>$\bar{f} - G$</td>
<td>$\gamma^N (\beta \bar{f} - G)$</td>
<td>0 (4)</td>
<td></td>
</tr>
<tr>
<td>$\hat{\beta}, 1$</td>
<td>$\bar{f} - G$</td>
<td>$E_R [f] - G$</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

(*) The row with $\beta \in \left[0, \frac{G - \rho_\sigma \bar{f}}{(1 - \rho_\sigma) f}\right]$ is irrelevant if $\bar{f} > \frac{G}{\rho_\sigma}$, because then $\frac{G - \rho_\sigma \bar{f}}{(1 - \rho_\sigma) f} < 0$. 

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(1) Granting managerial leniency is optimal if and only if

\[ \beta \bar{f} - G > -\gamma C (G - \rho_\sigma \bar{f} - (1 - \rho_\sigma) \beta \bar{f}) \]

iff. \((\gamma C (1 - \rho_\sigma) - 1) \beta \bar{f} < (\gamma C - 1) G - \gamma C \rho_\sigma \bar{f}, \) \hspace{1cm} (A.32)

where the LHS is negative by assumption \(\rho_\sigma > \frac{1 - \rho_\sigma}{\rho_\sigma}\) and the RHS is positive by \(\bar{f} < \frac{(\gamma C - 1)G}{\gamma C \rho_\sigma}.\) Therefore, (A.32) holds and, thus, \(f^* = 0.\)

(2) Rewriting (A.32) gives

\[ \beta > \beta'' = \frac{\gamma C \rho_\sigma \bar{f} - (\gamma C - 1) G}{\gamma C \rho_\sigma \bar{f} - (\gamma C - 1) \bar{f}}, \]

where \(\beta'' > 1\) if \(\bar{f} > G\) and it can never be the case that \(\beta > \beta''\). Thus, \(f^* = \bar{f}.\)

(3) If \(\bar{f} < G\), then \(\beta'' < 1\) and, thus, we have \(f^* = 0\) if \(\beta > \beta''\), while \(f^* = \bar{f}\) if \(\beta < \beta''\).

(4) Granting managerial leniency is optimal if and only if \(\bar{f} - G > \gamma N (\beta \bar{f} - G) \Leftrightarrow \beta < \beta''' = \frac{(\gamma N - 1) G + \bar{f}}{\gamma N \bar{f}}.\)

In this region of \(\beta\), we have

\[ \beta < \bar{\beta} = \frac{(\gamma N - 1) G + \rho_\sigma \bar{f}}{(\gamma N - (1 - \rho_\sigma)) \bar{f}} = \frac{(\gamma N - 1) G + \bar{f} - (1 - \rho_\sigma) \bar{f}}{\gamma N \bar{f} - (1 - \rho_\sigma) \bar{f}}, \]

from which we see that \(\bar{\beta} < \beta'''\) and we have \(\beta < \beta''\) in this region. Thus, \(f^* = 0.\)

**Conclusion on managerial leniency.** From the table we observe the following:

1. If \(\bar{f} \in \left[0, \bar{f}\right]\), where \(\bar{f} = \frac{(\gamma C - 1)G}{\gamma C \rho_\sigma}\), then \(f^* = 0;\)

2. If \(\bar{f} \in \left[\bar{f}, G\right]\), then when \(f^* = \bar{f}\), we determine \(\beta^*\) and \(F^r\) by solving

\[ \pi - \beta \bar{f} - \beta F^r < 1 - \pi - G, \] \hspace{1cm} (A.33)

which is most easily satisfied when \(F^r = \bar{F}\) (no leniency) and rewrites as

\[ \beta > \frac{2\pi - 1 + G}{\bar{F} + \bar{f}} \Rightarrow \beta^* = \frac{2\pi - 1 + G}{\bar{F} + \bar{f}}, \] \hspace{1cm} (A.34)
provided that

$$\beta^* < \beta'' \iff F^* > F^* = \frac{2\pi - 1 + G}{\beta''} - \bar{f}; \text{ and}$$

3. If \( \bar{f} \in [G, \infty) \), then when \( f^r = \bar{f} \), we determine \( \beta* \) and \( F^r \) by solving (A.33), which is most easily satisfied when \( F^r = \bar{F} \) (no corporate leniency) and rewrites as (A.34), provided that

$$\beta^* < \frac{G}{\bar{f}} \iff F** = \frac{(2\pi - 1) \bar{f}}{G}.$$ 

These results are the technical equivalent of Proposition 2.3, where we denote

$$\tilde{F} = \begin{cases} 
F^* & \text{if } \bar{f} \in \left[ \bar{f}, G \right) \\
F^{**} & \text{if } \bar{f} \in (G, \infty).
\end{cases} \quad \square$$
Appendix B

This appendix contains the proofs of Chapter 3.

B.1 Proof of Proposition 3.3

(1) Shifting \( F_D(x) \) to the left (right) increases (decreases) \( G_D(\pi) \), which, in turn, increases (decreases) the LHS of condition (3.3). (2) Suppose \( \pi < E_D(\pi_t) \). Making \( F_D(x) \) more (less) dispersed increases (decreases) \( G_D(\pi) \), which, in turn, increases (decreases) the LHS of condition (3.3). (3) Suppose \( \pi \geq E_D(\pi_t) \). Making \( F_D(x) \) more (less) dispersed decreases (increases) \( G_D(\pi) \), which, in turn, decreases (increases) the LHS of condition (3.3). \( \square \)

B.2 Proof of Lemma 3.4

The manager has no incentive to defect in stage 1 if and only if

\[
\frac{2E_C}{1 - \delta G_{CC}(\pi)} \geq E_D + E_N + \delta G_{DN}(\pi) \frac{2E_N}{1 - \delta G_{NN}(\pi)},
\]

while, given the realization of \( \pi_1 \), he has no incentive to defect in stage 2 if and only if

\[
E_C + \delta G_C(\pi_1 - \pi) \frac{2E_C}{1 - \delta G_{CC}(\pi)} \geq E_D + \delta G_D(\pi_1 - \pi) \frac{2E_N}{1 - \delta G_{NN}(\pi)}.
\]

These two conditions rewrite as

\[
\min \left\{ E_C - E_N + 2\delta \left( \frac{G_{CC}(\pi)}{1 - \delta G_{CC}(\pi)} E_C - \frac{G_{DN}(\pi)}{1 - \delta G_{NN}(\pi)} E_N \right); \right. \tag{B.1}
\]

\[
2\delta \left( \frac{G_C(\pi_1 - \pi)}{1 - \delta G_{CC}(\pi)} E_C - \frac{G_D(\pi_1 - \pi)}{1 - \delta G_{NN}(\pi)} E_N \right) \right\} \geq E_D - E_C \tag{B.2}
\]
for every profit realization $\pi_t^1 \geq 0$. Subcondition (B.2) can be rewritten as

$$2\delta \left[ \frac{G_C (\pi - \pi_t^1) - G_D (\pi - \pi_t^1)}{1 - \delta G_{NN} (\pi)} E_N + \right.$$

$$G_C (\pi - \pi_t^1) \left( \frac{E_C}{1 - \delta G_{CC} (\pi)} - \frac{E_N}{1 - \delta G_{NN} (\pi)} \right) \right] \geq E_D - E_C,$$

where we note that (i) $G_C (\pi - \pi_t^1)$ is increasing in $\pi_t^1$, and (ii) $G_C (\pi - \pi_t^1) - G_D \times (\pi - \pi_t^1)$ is also increasing in $\pi_t^1$ by regularity condition (B.9). Thus, Subcondition (B.2) is most difficult to satisfy if $\pi_t^1 = 0$, that is, if

$$2\delta \left( \frac{G_C (\pi)}{1 - \delta G_{CC} (\pi)} E_C - \frac{G_D (\pi)}{1 - \delta G_{NN} (\pi)} E_N \right) \geq E_D - E_C. \quad (B.3)$$

Is (B.3) more difficult to satisfy than Subcondition (B.1)? Subtracting the LHS of (B.1) from the LHS of (B.3) yields

$$A := E_C - E_N + 2\delta \left( \frac{G_{CC} (\pi) - G_C (\pi)}{1 - \delta G_{CC} (\pi)} E_C - \frac{G_{DN} (\pi) - G_D (\pi)}{1 - \delta G_{NN} (\pi)} E_N \right),$$

where I rewrite

$$G_{CC} (\pi) - G_C (\pi) = \int_0^\infty \Pr (\pi_t^1 = x \mid a = C) \ G_C (\pi - x) \ dx - G_C (\pi) \quad (B.4)$$

$$= \int_0^\pi \Pr (\pi_t^1 = x \mid a = C) \ G_C (\pi - x) \ dx$$

$$+ \int_\pi^\infty \Pr (\pi_t^1 = x \mid a = C) \ G_C (\pi - x) \ dx - G_C (\pi) \quad (B.5)$$

$$= \int_0^\pi \Pr (\pi_t^1 = x \mid a = C) \ G_C (\pi - x) \ dx$$

$$+ \int_\pi^\infty \Pr (\pi_t^1 = x \mid a = C) \ dx - G_C (\pi) \quad (B.6)$$

$$= \int_0^\pi \Pr (\pi_t^1 = x \mid a = C) \ G_C (\pi - x) \ dx + G_C (\pi)$$

$$- G_C (\pi) \quad (B.7)$$

$$= \int_0^\pi \Pr (\pi_t^1 = x \mid a = C) \ G_C (\pi - x) \ dx, \quad (B.8)$$

where (B.4) follows by definition, (B.5) follows by splitting up the integral, (B.6) follows
by noting that $G_C (\pi - x) = 1$ for every $x \in [\pi, \infty)$, (B.7) follows by definition, yielding (B.8). Similarly,

$$G_{DN} (\pi) - G_D (\pi) = \int_0^\infty \Pr (\pi_1^1 = x \mid a = D) G_N (\pi - x) \, dx - G_D (\pi)$$

$$= \int_0^\pi \Pr (\pi_1^1 = x \mid a = D) G_N (\pi - x) \, dx + G_D (\pi) - G_D (\pi).$$

Therefore, $G_{CC} (\pi) - G_C (\pi) \geq G_{DN} (\pi) - G_D (\pi)$, because by stochastic dominance we have (i) $\int_0^\pi \Pr (\pi_1^1 = x \mid a = C) \, dx \geq \int_0^\pi \Pr (\pi_1^1 = x \mid a = D) \, dx$, and (ii) $G_C (\pi - x) \geq G_N (\pi - x)$ for every $x \in [0, \pi]$. Thus, noting that $E_C > E_N$ and $\frac{E_C}{1 - \delta G_{CC} (\pi)} > \frac{E_N}{1 - \delta G_{NN} (\pi)}$, we have $A > 0$ and, thus, (B.3) is the binding constraint. □

**B.3 Proof of Lemma 3.5**

The manager has no incentive to defect in stage 1 if and only if

$$\frac{E_C + G_C (\pi) E_C + (1 - G_C (\pi)) E_N}{1 - \delta P_C (\pi, \tau)} \geq E_D + E_N + \delta G_{DN} (\pi) \frac{2E_N}{1 - \delta G_{NN} (\pi)},$$

where $P_C (\pi, \tau) = \int_\tau^\infty \Pr (\pi_1^1 = x \mid a = C) G_C (\pi - x) \, dx + \int_0^\tau \Pr (\pi_1^1 = x \mid a = C) \times G_N (\pi - x) \, dx$.

Given the realization of $\pi_1^1$, he has no incentive to defect in stage 2 if and only if

$$E_C + \delta G_C (\pi - \pi_1^1) \frac{E_C + G_C (\pi) E_C + (1 - G_C (\pi)) E_N}{1 - \delta P_C (\pi, \tau)} \geq E_D + \delta G_D (\pi - \pi_1^1) \times \frac{2E_N}{1 - \delta G_{NN} (\pi)},$$

which rewrites as

$$\delta \left( \frac{G_C (\pi - \pi_1^1) K_C (\tau)}{1 - \delta P_C (\pi, \tau)} - \frac{G_D (\pi - \pi_1^1)}{1 - \delta G_{NN} (\pi)} \frac{2E_N}{1 - \delta G_{NN} (\pi)} \right) \geq E_D - E_C$$

for every profit realization $\pi_1^1 \geq \tau$. By the regularity condition, this boils down to combined conditions (3.11) and (3.12) in Lemma 3.5.

Noting that $P (\pi, \tau) < G_{CC} (\pi)$ and $E_C < K_C (\tau)$, we have that (3.11) is more difficult to satisfy than (B.1). However, constraint (B.1) is not the binding constraint for the “always collusion strategy” to be stable; constraint (B.2) with $\pi_1^1 = 0$ is the binding...
constraint. Thus, constraint (3.11) does not make the “τ-conditional collusion strategy” less stable than strategy “always collusion strategy” as long as τ is such that (3.11) is easier to satisfy than (B.2) with \( \pi^1_t = 0 \), which depends on the precise specification of the density functions.

Fixing \( \pi^1_t \geq 0 \), constraint (3.12) is more difficult to satisfy than constraint (B.2), because \( P(\pi, \tau) < G_{CC}(\pi) \) and \( E_{C} < K_{C}(\tau) \). However, depending on the precise specification of the density functions, constraint (3.12) may be easier to satisfy than constraint (B.2), because (i) both constraints are more difficult to satisfy the lower is \( \pi^1_t \); and (ii) constraint (B.2) needs to be satisfied for every \( \pi^1_t \geq 0 \); while (iii) constraint (3.12) needs only to be satisfied for every \( \pi^1_t \geq \tau \).

Thus, depending on the precise specification of the density functions, choosing an appropriate \( \tau \) potentially results in both constraints (3.11) and (3.12) to be satisfied for a larger set of discount factors than constraint (B.2).

\( \square \)

B.4 Proof of Lemma 3.6

Given the realization of \( \pi^1_t \), the manager has no incentive to defect in stage 2 iff.

\[
E_{C} + \delta G_{C}(\pi - \pi^1_t) \frac{E_{N} + G_{N}(\tau) E_{C} + (1 - G_{N}(\tau)) E_{N}}{1 - \delta P_{N}(\pi, \tau)} \geq E_{D} + \delta G_{D}(\pi - \pi^1_t) \times \frac{2E_{N}}{1 - \delta G_{NN}(\pi)},
\]

which rewrites as

\[
\delta \left( \frac{G_{C}(\pi - \pi^1_t)}{1 - \delta P_{N}(\pi, \tau)} K_{N}(\tau) - \frac{G_{D}(\pi - \pi^1_t)}{1 - \delta G_{NN}(\pi)} 2E_{N} \right) \geq E_{D} - E_{C},
\]

for every profit realization \( \pi^1_t \geq \tau \). By the regularity condition, we have that the above constraint is most difficult to satisfy if \( \pi^1_t = \tau \); thus, stability is determined by condition (3.13) in Lemma 3.6.

\( \square \)

B.5 Proof of Proposition 3.6

First claim: price wars in equilibrium. The collusive strategies described in Lemmas 3.5 and 3.6 entail competition in stage 2 after the realization of profit \( \pi^1_t < \tau \) in stage 1; also, the collusive strategy described in Lemma 3.6 always entails competition in stage 1. Moreover, the collusive strategies described in Lemmas 3.5 and 3.6 are potentially more stable than collusion in both stages. Thus, contracts that span multiple managerial interactions potentially entail price wars in equilibrium.
Second claim: if managers adopt a strategy entailing price wars in equilibrium, then cartel stability is increased. The collusive strategies described in Lemmas 3.5 and 3.6 are potentially more stable, but entail a lower profitability—see the proof below. Thus, if managers adopt such a strategy, it means that they are not patient enough to collude in both stages, and, thus, adopt a strategy entailing equilibrium price wars, while compromising on cartel profitability.

Third claim: price wars reduce cartel profitability. The profitability of (i) collusion in both stages; (ii) collusion in stage 1 and τ-conditional collusion in stage 2; and (iii) competition in stage 1 and τ-conditional collusion in stage 2 is, respectively,

\[
\frac{2E_C}{1 - \delta G_{CC}(\bar{\pi})} > \frac{K_C(\tau)}{1 - \delta P_C(\bar{\pi}, \tau)} > \frac{K_N(\tau)}{1 - \delta P_N(\bar{\pi}, \tau)},
\]

because \(2E_C > K_C(\tau) > K_N(\tau)\) and \(G_{CC}(\bar{\pi}) > P_C(\bar{\pi}, \tau) > P_N(\bar{\pi}, \tau)\). □
Appendix C

This appendix contains the derivations of Chapter 4.

C.1 Benchmarks of Subsection 4.3.1

Outcome (4.3) is straightforwardly obtained as the static Nash equilibrium when both owners independently maximize $\pi_i = (p - c) q_i$, while outcome (4.4) is obtained when owners jointly maximize $\sum_{i=1}^2 \pi_i$. When owner $j$ produces $q_j^C = \frac{a-c}{4b}$, owner $i$’s optimal defection quantity is $q_i^D = \arg\max_{q_i} \left\{ \left( a - b \left( q_i + q_j^C \right) - c \right) q_i \right\} = \frac{3(a-c)}{8b}$, leading to profit $\pi_i^D = \frac{9(a-c)^2}{64b}$. Thus, collusion is stable if and only if

$$\delta_o \geq \frac{\pi_i^D - \pi_i^C}{\pi_i^D - \pi_i^N} = \frac{9}{17}.$$

Consider FJS’s one-shot Cournot delegation game. In stage 3, both managers independently maximize $M_i = (p - \alpha_i c) q_i$, leading to quantities as a function of incentives

$$q_i (\alpha_i, \alpha_j) = \frac{a - 2\alpha_i c + \alpha_j c}{3b}. \quad (C.1)$$

In stage 2, both owners substitute these into $\pi_i = (a - b (q_i + q_j) - c) q_i$ to independently maximize profit, yielding outcome (4.2), provided that both owners indeed delegate in stage 1.

If both owners keep control, they each earn the Cournot Nash profit $\pi_i^N = \frac{(a-c)^2}{9b}$. If owner $i$ delegates, while owner $j$ keeps control, then quantities as a function of incentives $\alpha_i$ become $q_i (\alpha_i, 1)$ and $q_j (1, \alpha_i)$ by (C.1). In stage 2, owner $i$ then maximizes $\pi_i (\alpha_i) = (a - b (q_i (\alpha_i, 1) + q_j (1, \alpha_i)) - c) q_i (\alpha_i, 1)$, yielding $\alpha_i = \frac{5c-a}{4c}$ and

$$\pi_i = \frac{(a-c)^2}{8b}, \pi_j = \frac{(a-c)^2}{16b}. \quad (C.2)$$
Since owner $i$ is better off by delegating if her rival keeps control, while owner $j$ is worse off if she keeps control and her rival delegates compared to when both owners delegate, owners indeed delegate in stage 1.

C.2 Equilibrium Incentives With Delegation

In stage 3, managers jointly maximize $\sum_{i=1}^{2} M_i$, yielding $q_1 + q_2 = \frac{a-\alpha_1 c}{2b} = \frac{a-\alpha_2 c}{2b}$. Focusing on symmetric equilibria, both managers set the same quantity as a function of incentives, $q_1 = q_2 = \frac{a-\alpha c}{2b}$, which holds for symmetric incentives $\alpha_1 = \alpha_2 = \alpha$, resulting in $q_1 = q_2 = \frac{a-\alpha c}{2b}$. Substituting these in the owners’ profit functions gives $\pi_i (\alpha) = \frac{(a-(2-\alpha)c)(a-\alpha c)}{8b}$, which is maximized at $\alpha^C_1 = \alpha^C_2 = \alpha = 1$ in stage 2, resulting in outcome (4.5).

C.3 Optimality of “Not Delegating Control” As the Punishment Strategy

This appendix shows that not delegating control is indeed the best strategy for owners to punish a deviant manager. First, suppose owners instead punish by reverting to “delegation and compete in setting incentives.” We then get FJS’s static delegation outcome (4.2) with managerial payoff $M_i^{dN} = \frac{4(a-c)^2}{25b}$, which is actually higher than managerial payoff in the collusive delegation equilibrium $M_i^{dC} = \frac{(a-c)^2}{8b}$, thereby making collusion fully unstable in the first place.

Second, suppose owners punish by reverting to “delegation and collude in setting incentives.” In stage 3, managers set quantities as outlined in (C.1). In stage 2, owners substitute these into their joint profit function $\sum_{i=1}^{2} \pi_i$, which is maximized with symmetric incentives $\alpha_i = \frac{3}{4} + \frac{a}{4c}$, yielding $\pi_i = \frac{(a-c)^2}{8b}$ and $M_i = \frac{(a-c)^2}{18b}$. If owner $i$ deviates by setting different incentives, straightforward algebra leads to the optimal deviating incentive being $\alpha_i = \frac{21}{16} - \frac{5a}{16c}$, with profit $\pi_i = \frac{25(a-c)^2}{128b}$. This triggers punishment by FJS’s static Nash equilibrium with $\pi_i^{dN} = \frac{2(a-c)^2}{25b}$. Thus, owners can commit to punishment iff. $\delta_o \geq \frac{25(a-c)^2}{128b} - \frac{(a-c)^2}{8b} = \frac{25}{41}$, and managers do not defect in the first place iff. $\delta_m \geq \frac{9(a-c)^2}{25b} - \frac{(a-c)^2}{8b} = \frac{9}{49}$. These stability conditions are more difficult to satisfy than $\delta_o \geq \frac{25}{49}, \delta_m \geq \frac{1}{5}$.

C.4 Owner’s Commitment to Avoid Delegation

Suppose owners punish a deviant manager by keeping control, while competing on the product market. Owner $i$ then earns $\pi_i^{N} = \frac{(a-c)^2}{9b}$. If she defects from the punishment
scheme by delegating control, then in stage 3 manager $i$ and owner $j$ compete with respective payoffs $M_i(q_i, q_j) = (a - b (q_i + q_j) - \alpha_i c) q_i$ and $\pi_j(q_i, q_j) = (a - b (q_i + q_j) - c) q_j$, yielding quantities $q_i(\alpha_i) = \frac{a + (1 - 2\alpha_i) c}{3}$, $q_j(\alpha_i) = \frac{a + (\alpha_i - 2) c}{3}$ and profit

$$\pi_i(\alpha_i) = \left( a - b \left( \frac{a + (1 - 2\alpha_i) c}{3} + \frac{a + (\alpha_i - 2) c}{3} \right) - c \right) \frac{a + (1 - 2\alpha_i) c}{3},$$

which owner $i$ maximizes at $\pi_i = \frac{(a-c)^2}{8b}$ with $\alpha_i = \frac{5}{4} - \frac{a}{4c}$. Since defection triggers punishment by FJS’s one-shot delegation Nash equilibrium with profit $\pi_i^{dN} = \frac{2(a-c)^2}{25b} \left( \text{see equations (4.2)} \right)$, owners can commit to punishment if and only if $\delta_o \geq \frac{8(a-c)^2 - 9(a-c)^2}{2(a-c)^2} = \frac{25}{8}$. Now suppose owners punish a deviant manager by keeping control, while colluding on the product market. Owner $i$ then earns $\pi_i^C = \frac{(a-c)^2}{8b}$, while defection from the punishment scheme by delegating control results in competition between manager $i$ and owner $j$ with defection profit $\pi_i = \frac{(a-c)^2}{8b}$ (see equation (C.2)). Since defection profit equals collusive profit, owners will not defect from punishment through delegation.
Appendix D

This appendix contains the proofs of Chapter 5.

D.1 Proof of Proposition 5.5

Without a buyer group, competitive equilibrium wholesale contracts are \((w_i^c, \tau_i^c) = (c, 0)\), resulting in Cournot per-firm quantity, price and per-firm profit of

\[
q_i^c = \frac{1 - c}{n + 1}, \quad p_i^c = \frac{1 + nc}{n + 1}, \quad \pi_i^c = \frac{(1 - c)^2}{(n + 1)^2}, \quad \forall i.
\]

Below, we determine the optimal buyer group contracts (Lemma D.1) and deviation payoff (Lemma D.2) when the buyer group reduces marginal cost to \(c - \alpha\).

Lemma D.1 With buyer group specific cost savings \(\alpha\), optimal buyer group contracts are

\[
\left( w_i^{bg} (\alpha), \tau_i^{bg} (\alpha) \right) = \left( \frac{n - 1 + (n + 1)(c - \alpha)}{2n}, \frac{(n - 1)(1 - (c - \alpha))^2}{4n^2} \right), \quad \forall i
\]

resulting in per-firm quantity, price and profit of

\[
q_i^{bg} (\alpha) = \frac{1 - (c - \alpha)}{2n}, \quad p_i^{bg} (\alpha) = \frac{1 + (c - \alpha)}{2}, \quad \pi_i^{bg} (\alpha) = \frac{(1 - (c - \alpha))^2}{4n}.
\]

Proof. The buyer group sets linear fees \(w_i^{bg} (\alpha)\) that induce retailers to jointly produce the monopoly output with marginal cost \(c - \alpha\), i.e.,

\[
Q^m = \arg \max_Q \{ P (Q) - (c - \alpha) \}
\]

\[
= \frac{1 - (c - \alpha)}{2}.
\]
Denote by $Q_{-i} = \sum_{j \neq i} q_j$ the sum of all quantities produced, expect for retailer $i$. The retailers produce symmetric per-firm monopoly outputs if linear wholesale prices $w_i^{bg} (\alpha)$ satisfy Cournot reaction functions

$$q_i (Q_{-i}) = \frac{1 - Q_{-i} - w_i}{2}, \quad \forall i$$

with $q_i (Q_{-i}) = Q^m / n$, $Q_{-i} = (n - 1) Q^m / n$ and $w_i = w_i^{bg} (\alpha)$. This is the case if

$$w_i^{bg} (\alpha) = \frac{n - 1 + (n + 1) (c - \alpha)}{2n}.$$

The per-unit revenue made by suppliers on the linear wholesale fees is $w_i^{bg} (\alpha) - (c - \alpha)$, which is refunded to retailers via fixed fees, i.e.,

$$\tau_i^{bg} (\alpha) = -q_i^{bg} (\alpha) \left( w_i^{bg} (\alpha) - (c - \alpha) \right)$$

$$= - \frac{(n - 1) (1 - (c - \alpha))^2}{4n^2}.$$

\textbf{Lemma D.2} The optimal deviating contract is $(w_i^d, \tau_i^d) = (c, 0)$, resulting in deviating quantity, price and profit of

$$q_i^d (\alpha) = \frac{(n + 1) (1 - c) - (n - 1) \alpha}{4n},$$

$$p^d (\alpha) = \frac{n + 1 + (3n - 1) c - (n - 1) \alpha}{4n},$$

$$\pi_i^d (\alpha) = \frac{((n + 1) (1 - c) - (n - 1) \alpha)^2 + 4 (n - 1) (1 - (c - \alpha))^2}{16n^2}.$$

\textbf{Proof.} Retailer $i$ optimally defects by giving a best response to the per-firm monopoly quantities produced by all other retailers. The optimal deviating output is characterized by reaction function [D.1] with $w_i = c$ and $Q_{-i} = (n - 1) q_i^{bg} (\alpha)$, i.e.,

$$q_i^d (\alpha) = \frac{(n + 1) (1 - c) - (n - 1) \alpha}{4n},$$

from which price and profits are determined as $p^d (\alpha) = 1 - (n - 1) q_i^{bg} (\alpha) - q_i^d$ and $\pi_i^d (\alpha) = q_i^d (p^d - w_i^d) - \tau_i^{bg} (\alpha) - \tau_i^d$, respectively. \qed
Now, if the linear wholesale fee negotiated through the buyer group is lower than or equal to marginal cost $c$, then a retailer will never defect, i.e., $\delta^*_b (\alpha) = 0$. This is the case if and only if

$$w^b_i (\alpha) \leq w^d_i = c \iff \alpha \geq \frac{(n-1) (1-c)}{n+1}.$$ 

For $\alpha < (n-1) (1-c) / (n+1)$, the critical discount factor is

$$\delta^*_b (\alpha) = \frac{\pi^d_i (\alpha) - \pi^b_i (\alpha)}{\pi^d_i (\alpha) - \pi^c} = \frac{(n+1)^2 \left\{ (n+1) (1-c) - (n-1) \alpha \right\}^2 - 4 [1 - (c-\alpha)]^2}{(n+1)^2 \left\{ (n+1) (1-c) - (n-1) \alpha \right\}^2 + 4 (n-1) [1 - (c-\alpha)]^2}.$$ 

We have

$$\frac{\partial \delta^*_b (\alpha)}{\partial \alpha} = -\frac{16 (1-c) n^2 (n+1)^2 K_1}{(n-1) K_2},$$

where

$$K_1 = (1-c) \left[ 4 \alpha (n+1) + (1-c) (n^2 + 2n + 5) \right] - \alpha^2 (n+1)^2,$$

$$K_2 = \left\{ \alpha (n+1)^2 \left[ \alpha (n+3) - 2 (1-c) (n-3) \right] + (1-c)^2 (n^3 + 9n^2 + 3n + 3) \right\}^2 > 0.$$

To show that $\partial \delta^*_b (\alpha) / \partial \alpha < 0$ for $\alpha \in [0, (n-1) (1-c) / (n+1)]$, we need to show that $K_1 > 0$ in this domain. Therefore, substitute $\alpha = \beta (n-1) (1-c) / (n+1)$, with $\beta \in [0, 1]$, for $\alpha$ in $K_1$ to get

$$K_1 = (1-c)^2 \left[ \frac{(1-\beta^2) n^2 + (2+2\beta^2+4\beta) n + 5 - \beta^2 - 4\beta}{\geq0} \right] > 0,$$

thus showing that $\partial \delta^*_b (\alpha) / \partial \alpha < 0$ for $\alpha \in [0, (n-1) (1-c) / (n+1)]$. □
D.2 Proof of Proposition 5.6

Retailer $i$’s benefit from forming a buyer group can be decomposed into the gain resulting from the cost savings and the gain resulting from the collusion effect,

$$
\Delta \pi_i = \pi_i^{bg}(\alpha) - \pi_i^*,
\pi_i^{bg}(\alpha) - \pi_i^m + \pi_i^m - \pi_i^*,
$$

where $\pi_i^m = \max Q Q (p(Q) - c) / n = (1 - c)^2 / (4n)$ is the collusive (monopoly) per-firm profit when marginal cost is $c$. Substituting for the relevant profits gives the per-firm benefit from the buyer group,

$$
\Delta \pi_i = \frac{(n - 1)^2 (1 - c)^2 + \alpha (\alpha + 2 (1 - c)) (n + 1)^2}{4n (n + 1)^2} \geq 0.
$$

The consumers’ benefit from the buyer group can be decomposed into the gain resulting from the pass-on of cost savings and the loss resulting from the collusion effect,

$$
\Delta CS = CS^{bg}(\alpha) - CS^*
= CS^{bg}(\alpha) - CS^m - (CS^* - CS^m),
$$

where $CS^{bg}(\alpha)$, $CS^*$, and $CS^m$ are consumer surplus under the buyer group regime, without the buyer group and with a monopoly (cartel) without cost savings, respectively,

$$
CS^{bg}(\alpha) = \frac{(1 - (c - \alpha))^2}{8}, CS^* = \frac{n^2 (1 - c)^2}{2 (n + 1)^2}, CS^m = \frac{(1 - c)^2}{8}.
$$
Therefore, the increase in consumer surplus resulting from the buyer group is
\[
\Delta CS = \frac{\alpha (\alpha + 2 (1 - c)) (n + 1)^2 - (3n^2 - 2n - 1) (1 - c)^2}{8 (n + 1)^2}
\]
\[
= \frac{\alpha (\alpha + 2 (1 - c)) - (3n^2 - 2n - 1) (1 - c)^2}{8 (n + 1)^2},
\]
which is positive if and only if \(\alpha > \alpha^{CS} = (n - 1) (1 - c) / (n + 1)\).

Similarly, the increase in total welfare resulting from the buyer group is
\[
n\Delta \pi_i + \Delta CS = \frac{3 (n + 1)^2 (1 - (c - \alpha))^2 - 4n (n + 2) (1 - c)^2}{8 (n + 1)^2},
\]
which is positive if and only if
\[
\alpha > \alpha^{TW} = \frac{(1 - c) \left[ \sqrt{\frac{4}{3} n (n + 2) - (n + 1)} \right]}{n + 1}.
\]

We have that
\[
\alpha^{TW} < \alpha^{CS},
\]
because
\[
\alpha^{TW} - \alpha^{CS} = \frac{(1 - c) K_3}{n + 1},
\]
where \(K_3 = \sqrt{\frac{4}{3} n (n + 2) - 2n} < 0\) for all \(n \geq 2\). \(\square\)
Appendix E

This appendix contains the proofs and additional illustrations of Chapter 6.

E.1 Decomposition of Harm Illustrated

Figure ap.1 illustrates the various typical effects decomposed in Section 6.2.2 in a simple model with three production layers ($K = 3$) and final consumers.

Figure ap.1 Decomposition of antitrust harm in a three layer model.
We assume that marginal own production costs are constant and equal to zero for all firms, i.e., \( c_{j1}(q) = c_{j2}(q) = c_{j3}(q) = 0 \), for all \( j \) and every \( q \). Given inverse consumer demand \( P(Q) \), the implied inverse demand for the product of firms in layer 2 is given by \( p_2(Q) \). Competition in layer 2 results in inverse demand function \( p_1(Q) \) for the firms in layer 1. Their competitive benchmark is given by the quantity \( Q^* \) and prices \( P^*, p_2^* \) and \( p_1^* \), respectively. Now suppose firms in the second layer collude. This leads to a reduction in the quantity they supply. That is, for every price \( p_1 \), layer 2 demands less of the input supplied by layer 1, resulting in an inwards shift of \( p_1(Q) \) to \( p_1'(Q) \). Under the cartel regime, output decreases to \( Q^2 \), and equilibrium prices become \( P^2, p_2^2 \) and \( p_1^2 \), respectively. Note that in this illustration we assume that \( p_1 \) decreases under the cartel, which need not be the case.

It is insightful to identify some of the areas in the graph. The loss in profits of the direct purchasers of the cartel (layer 3) equal

\[
\triangle \pi_3 = \pi_3^* - \pi_3^2 = C + H - A = (B + C) - (A + B) + H = \xi_3 - \omega_3 + \sigma_3,
\]

with \( \xi_3 = (p_2^2 - p_2^*)Q^2 = B + C \) being the amount by which the firms in layer 3 are overcharged, \( \omega_3 = (P^2 - P^*)Q^2 = A + B \) the amount passed-on to the final consumers, and \( \sigma_3 = H \) the output effect. The loss in consumer surplus is

\[
\triangle CS = CS^* - CS^2 = (A + B) + G = \xi_C + \sigma_C,
\]

where \( \xi_C = A + B = \omega_3 \) is the overcharge imposed by layer 3, and \( \sigma_C = G \) is the output effect for consumers. Profits of the (direct) suppliers to the cartel change by

\[
\triangle \pi_1 = \pi_1^* - \pi_1^2 = E + F + J - F = E + J = -\omega_1 + \sigma_1,
\]

where \( \omega_1 = -E \) is the pass-on from layer 1 to layer 2, which is negative since \( p_1 \) has increased. Note that there is no overcharge for layer 1. Its output effect is given by \( \sigma_1 = J \). Finally, consider the colluding layer 2. Profits of the cartel members change by

\[
\triangle \pi_2 = \pi_2^* - \pi_2^2 = D + I - (B + C + D + E) = -E - (B + C) + I = \xi_2 - \omega_2 + \sigma_2,
\]

where \( \xi_2 = -E = \omega_1 \) is the overcharge from their direct suppliers, \( \omega_2 = B + C \) is the pass-on to the next layer and \( \sigma_2 \) is the output effect. The sum total of these effects is negative or otherwise it would not be profitable for the cartel to form. Notice also that

\[
\triangle \pi_1 + \triangle \pi_2 + \triangle \pi_3 + \triangle CS = G + H + J + I = \sigma_1 + \sigma_2 + \sigma_3 + \sigma_C,
\]
that is, the sum of all effects combined reduces to the sum of output effects.

E.2 Proof of Proposition 6.2

For $\gamma = 1$, we have

$$
\lambda_D = \frac{Q^* + Q^g}{Q^g} \left( 1 - \frac{1}{2} \prod_{i=g+1}^{K} \frac{n_i}{n_i + \vartheta_i} \right).
$$

It follows that we have $\frac{1}{2} \frac{Q^* + Q^g}{Q^g} \leq \lambda_D < \frac{Q^* + Q^g}{Q^g}$. The lower bound is reached if all downstream layers are perfectly competitive and the upper bound is reached with an infinite number of imperfectly competitive layers downstream. Since the cartel reduces production, we have $Q^g < Q^*$ and hence $\lambda_D > 1$. In addition, it follows from $\frac{Q^*}{Q^g} = \frac{n_g + \vartheta_g}{n_g + \vartheta_g}$ that $Q^* \leq 2Q^g$, with $Q^* = 2Q^g$ if the pre-cartel industry was perfectly competitive ($n_g \to \infty$ or $\vartheta_g = 0$) and the cartel sets the full cartel quantity ($\vartheta_g^c = n_g$). In this case $\frac{Q^* + Q^g}{Q^g} = 3$ and, therefore, $\lambda_D < 3$. \hfill \Box

E.3 Intermediate Results

This appendix derives intermediate results needed for the proofs of Propositions 6.3 (see E.4), 6.4 (see E.6), and 6.5 (see E.7).

Our first intermediate result characterizes the implied inverse demand function for each layer $k$.

**Lemma E.1** Given final consumer demand $P(Q) = a - bQ^\gamma$, constant marginal costs $c_k$ in layer $k$ and conjectural variations parameter $\vartheta_k$ in layer $k$, the implied inverse demand function faced by firms in layer $k$ is

$$
p_k(Q) = a - \left( b \prod_{i=k+1}^{K} \frac{n_i}{n_i + \gamma \vartheta_i} Q^\gamma + \sum_{l=k+1}^{K} c_l \right), \tag{E.1}
$$

for $k = 1, \ldots, K - 1$. Furthermore, $p_K(Q) = P(Q)$.

**Proof.** We will show that for a given $K$, (E.1) holds for all $1 \leq k \leq K - 1$. Consider firm $i$ in layer $k$. It maximizes profits $p_k(Q) q_i - (c_k - p_{k-1}) q_i$, where $p_k(Q)$ is the implied inverse demand function that the industry in layer $k$ faces. Using symmetry ($q_i = Q/n_k$) and conjectural variations ($\vartheta_k = dQ/dq_i$) the first-order condition equals
(6.1). Solving for \( p_{k-1} \) then gives

\[
p_{k-1} (Q) = p_k (Q) + \frac{\partial_k}{n_k} Q p'_k (Q) - c_k.
\] (E.2)

Given \( p_k (Q) \), the implied inverse demand for layer \( k - 1 \), \( p_{k-1} (Q) \) can, therefore, be determined recursively. We need to show that (E.1) satisfies the recursive relation (E.2) for all \( k = 2, \ldots, K \). First consider \( k = K \). Using \( p_K (Q) = P (Q) = a - b Q^\gamma \) (E.2) reduces to \( p_{K-1} (Q) = a - b \frac{n_K + \gamma \theta_K}{n_K} Q^\gamma - c_K \), which is equivalent to (E.1) for \( k = K - 1 \). Now we proceed by induction. Assuming that (E.1) holds for \( k \) we want to show that it also holds for \( k - 1 \). We have

\[
p_{k-1} (Q) = p_k (Q) + \frac{\partial_k}{n_k} Q p'_k - c_k
\]

\[
= a - \left( b \prod_{i=k+1}^{K} \frac{n_i + \gamma \theta_i}{n_i} Q^\gamma + \sum_{l=k+1}^{K} c_l \right) - \left( \gamma b \prod_{i=k+1}^{K} \frac{n_i + \gamma \theta_i}{n_i} \right)
\]

\[
\times \frac{Q^\gamma}{n_k} \frac{\partial_k}{n_k} - c_k
\]

\[
= a - \left( b \frac{n_K + \gamma \theta_k}{n_K} \prod_{i=k+1}^{K} \frac{n_i + \gamma \theta_i}{n_i} Q^\gamma + c_k + \sum_{l=k+1}^{K} c_l \right)
\]

\[
= a - \left( b \prod_{i=k}^{K} \frac{n_i + \gamma \theta_i}{n_i} Q^\gamma + \sum_{l=k}^{K} c_l \right).
\]

Therefore equation (E.1) holds for all \( k \) with \( 1 \leq k \leq K - 1 \). Finally, it is easily checked that \( \gamma > 0 \) is a sufficient condition for the second-order condition for an optimum to be satisfied for every individual firm at the equilibrium. 

Knowing the implied inverse demand functions (E.1), we can now determine equilibrium quantities and prices.

**Proposition E.1** In this model, equilibrium prices and quantities are given by

\[
Q^* = \left[ \frac{1}{b} \left( \prod_{i=1}^{K} \frac{n_i}{n_i + \gamma \theta_i} \right) \left( a - \sum_{j=1}^{K} c_j \right) \right]^\frac{1}{\gamma},
\] (E.3)

\[
p_k^* = \left( 1 - \prod_{i=1}^{k} \frac{n_i}{n_i + \gamma \theta_i} \right) \left( a - \sum_{j=1}^{K} c_j \right) + \sum_{l=1}^{k} c_l \quad \forall k \in \{1...K\}.
\] (E.4)
Aggregate profits of firms in layer \( k \) and consumer surplus are then given by

\[
\pi_k^* = \left( \frac{1}{b} \right)^\frac{1}{\gamma} \cdot \frac{\gamma \vartheta_k}{n_k + \gamma \vartheta_k} \prod_{i=1}^{k-1} \frac{n_i}{n_i + \gamma \vartheta_i} \left( \prod_{i=1}^{K} \frac{n_i}{n_i + \gamma \vartheta_i} \right)^\frac{1}{\gamma} \left( a - \sum_{j=1}^{K} c_j \right)^{\frac{2+1}{\gamma}} \tag{E.5}
\]

\[
CS = \frac{\gamma}{\gamma+1} \left( \frac{1}{b} \right)^\frac{1}{\gamma} \left( \prod_{i=1}^{K} \frac{n_i}{n_i + \gamma \vartheta_i} \right)^\frac{2+1}{\gamma} \left( a - \sum_{j=1}^{K} c_j \right)^{\frac{2+1}{\gamma}} \tag{E.6}
\]

**Proof.** Using (E.1) the first-order condition (6.1) for \( k = 1 \) reduces to

\[
a - \left( b \prod_{i=1}^{K} \frac{n_i + \gamma \vartheta_i}{n_i} Q^\gamma + \sum_{l=1}^{K} c_l \right) = 0.
\]

Solving for \( Q \) gives (E.3). Substituting \( Q^* \) into (E.1) gives (E.4). Profits and consumer surplus follow from substituting (E.3) and (E.4) in \( \pi_k^* = (p_k^* - p_{k-1}^* - c_k) Q^* \) and \( CS = \int_0^{Q^*} P(Q) dQ - p_k^* Q^* = \frac{\gamma}{\gamma+1} b (Q^*)^\gamma + 1 = \frac{\gamma}{\gamma+1} (a - p_k^*) Q^* \), resp.

We are interested in how the equilibrium quantity \( Q^* \) and equilibrium prices \( p_k^* \) depend upon the underlying model parameters. It is easily checked that \( Q^* \) increases with an increase in \( a \) or \( n_i \) and with a decrease in \( \vartheta_i \), \( b \) or the number of (imperfectly competitive) layers \( K \). The equilibrium price for layer \( k \), \( p_k^* \), increases with an increase in \( a \), \( \gamma \), \( c_i \) or \( \vartheta_i \), for \( i \leq k \), and with a decrease in \( n_i \) for \( i \leq k \), with a decrease in \( c_i \) for \( l > k \).

The dependence of \( Q^* \) on \( \gamma \), however, is ambiguous and \( Q^* \) could either decrease or increase with \( \gamma \).\(^{156}\) Moreover, we have

\[
\lim_{\gamma \to \infty} p_k^* = a - \sum_{j=k+1}^{K} c_j \quad \text{and} \quad \lim_{\gamma \to 0} p_k^* = \sum_{j=1}^{K} c_j.
\]

Firms in layer 1 have all the market power, that is, they extract the entire surplus by setting price \( p_1^* \) equal to \( a \) minus the marginal costs of the other layers. The other layers price competitively, in the sense that they only recover their marginal costs.

Using \( \lim_{\gamma \to \infty} \left( 1 + \frac{\vartheta_i}{n_i} \gamma \right)^\frac{1}{\gamma} = 1 \) and \( \lim_{\gamma \to 0} \left( 1 + \frac{\vartheta_i}{n_i} \gamma \right)^\frac{1}{\gamma} = \exp \left[ \frac{\vartheta_i}{n_i} \right] \), respectively,

\(^{156}\)Take, for example, the case with \( \vartheta_i = 0 \) for all \( i \). Then \( Q^* \) increases (decreases) with \( \gamma \) if \( a - \sum_{k=1}^{K} c_k \) is larger (smaller) than \( b \).
we find

$$\lim_{\gamma \to \infty} Q^* = 1 \quad \text{and} \quad \lim_{\gamma \to 0} Q^* = \begin{cases} 
0 & \text{if } b > a - \sum_{j=1}^{K} c_j \\
\exp \left[ - \sum_{i=1}^{K} \frac{\vartheta_i}{n_i} \right] \frac{1}{\infty} & \text{if } b = a - \sum_{j=1}^{K} c_j \\
\infty & \text{if } b < a - \sum_{j=1}^{K} c_j.
\end{cases}$$

Hence, when demand becomes infinitely concave ($\gamma \to \infty$), the equilibrium quantity is 1, independent of all other parameters. Therefore, when demand becomes infinitely concave ($\gamma \to 0$), the equilibrium price is 0 for all layers, independent of all other parameters. The equilibrium quantity is 0 ($\infty$) when $b > (\leq) a - \sum_{j=1}^{K} c_j$; only when this condition holds with equality, equilibrium quantity is positive and finite.

Collusion in layer $g$ is modeled as an increase in the conjectural variations parameter from $\vartheta_g$ to $\vartheta_g^c \in (\vartheta_g, n_g]$. Cartel quantity and prices are

\begin{align*}
Q^g &= \left[ \frac{1}{b} \frac{n_g + \gamma \vartheta_g}{n_g + \gamma \vartheta_g^c} \left( \prod_{i=1}^{K} \frac{n_i}{n_i + \gamma \vartheta_i} \right) Z \right]^{\frac{1}{\gamma}}, \\
p_k^g &= \begin{cases} 
\left( 1 - \frac{n_g + \gamma \vartheta_g}{n_g + \gamma \vartheta_g^c} \prod_{i=1}^{k} \frac{n_i}{n_i + \gamma \vartheta_i} \right) Z + \sum_{l=1}^{k} c_l & k \geq g \\
0 & k < g,
\end{cases}
\end{align*}

where $Z = \left( a - \sum_{j=1}^{K} c_j \right)$.

The next lemma gives expressions for pass-on & output effects (recall that $\xi_{k+1} = \omega_k$).

**Lemma E.2** The pass-on effect $\omega_k$ for layer $k \geq g$ is given by

\begin{align*}
\omega_k &= \left( \frac{1}{b} \right)^{\frac{1}{\gamma}} \left( \frac{n_g + \gamma \vartheta_g}{n_g + \gamma \vartheta_g^c} \right)^{\frac{1}{\gamma}} \left( \frac{\gamma \vartheta_g^c - \gamma \vartheta_g}{n_g + \gamma \vartheta_g^c} \right) \left( \prod_{i=1}^{K} \frac{n_i}{n_i + \gamma \vartheta_i} \right) \\
&\quad \times \left( \prod_{i=1}^{K} \frac{n_i}{n_i + \gamma \vartheta_i} \right)^{\frac{\gamma+1}{\gamma}} \left( a - \sum_{j=1}^{K} c_j \right),
\end{align*}

and $\omega_k = 0$ for every $k \leq g - 1$. 
The output effect for layer $k$ and the output effect for consumers are given as

$$
\sigma_k = \left( \frac{1}{b} \right)^{\frac{1}{k}} \frac{\gamma \vartheta_k}{n_k} \left( 1 - \left( \frac{n_g + \gamma \vartheta_g}{n_g + \gamma \vartheta_c} \right)^{\frac{1}{k}} \right) \left( \prod_{i=1}^{k} \frac{n_i}{n_i + \gamma \vartheta_i} \right) \left( a - \sum_{j=1}^{K} c_j \right) \right)^{\frac{\gamma+1}{\gamma}},
$$

(E.10)

$$
\sigma_C = \left( \frac{1}{b} \right)^{\frac{1}{k}} \left( \frac{\gamma}{n_g + \gamma \vartheta_g} \right)^{\frac{\gamma+1}{\gamma}} - \left( \frac{n_g + \gamma \vartheta_g}{n_g + \gamma \vartheta_c} \right)^{\frac{1}{k}} \left( a - \sum_{j=1}^{K} c_j \right)^{\frac{\gamma+1}{\gamma}},
$$

(E.11)

**Proof:** Straightforward computations show that (for $k \geq g$) we have

$$
p^g_k - p^*_k = \frac{\gamma \vartheta_c - \gamma \vartheta_g}{n_g + \gamma \vartheta_g} \left( \prod_{i=1}^{k} \frac{n_i}{n_i + \gamma \vartheta_i} \right) \left( a - \sum_{j=1}^{K} c_j \right),
$$

$$
p^*_k - p^*_{k-1} - c_k = \frac{\gamma \vartheta_k}{n_k} \left( \prod_{i=1}^{k} \frac{n_i}{n_i + \gamma \vartheta_i} \right) \left( a - \sum_{j=1}^{K} c_j \right),
$$

$$
Q^* - Q^g = \left( 1 - \left( \frac{n_g + \gamma \vartheta_g}{n_g + \gamma \vartheta_c} \right)^{\frac{1}{k}} \right) \times \left[ \frac{1}{b} \left( \prod_{i=1}^{K} \frac{n_i}{n_i + \gamma \vartheta_i} \right) \left( a - \sum_{j=1}^{K} c_j \right) \right]^{\frac{1}{k}}.
$$

Equations (E.9)–(E.10) follow immediately from substituting the above expressions into $\omega_k = Q^g \left( p^g_k - p^*_k \right)$ and $\sigma_k = (Q^* - Q^g) \left( p^*_k - p^*_{k-1} - c_k \right)$. 

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Furthermore, we have
\[
\sigma_C = \int_{Q^g}^{Q^*} \left[ P(Q) - P(Q^*) \right] dQ
\]
\[
= \frac{1}{\gamma + 1} b \left[ (Q^g)^{\gamma + 1} - (Q^*)^{\gamma + 1} \right] + b (Q^*)^\gamma (Q^* - Q^g). \]

Equation (E.11) then follows from substituting \( Q^g = rQ^* \), with \( r = \left( \frac{n_g + \gamma \theta_g}{n_g + \gamma \theta_g^*} \right)^{\frac{1}{\gamma}} \). \( \Box \)

Using Lemma E.2, we can express the measures of harm discussed in Section 6.2.3 in terms of the parameters of the model.

**Proposition E.2** Denote by \( r = \frac{Q^g}{Q^*} = \left( \frac{n_g + \gamma \theta_g}{n_g + \gamma \theta_g^*} \right)^{\frac{1}{\gamma}} \) the fraction by which the cartel reduces output. The damages measures \([6.7]-[6.9]\) are equal to

\[
\lambda_D = \frac{1 - r^{\gamma + 1}}{r(1 - r^\gamma)} \left( 1 - \frac{1}{\gamma + 1} \prod_{i=g+1}^{K} \frac{n_i}{n_i + \gamma \theta_i} \right), \tag{E.12}
\]
\[
\lambda_U = \frac{(1 - r) n_g + \gamma \theta_g}{n_g} \left( \frac{1}{\gamma + 1} \prod_{i=1}^{g-1} \frac{n_i + \gamma \theta_i}{n_i} - 1 \right), \tag{E.13}
\]
\[
\lambda_g = \frac{\gamma \theta_g (1 - r)}{n_g \gamma (1 - r^\gamma) - 1}, \tag{E.14}
\]
\[
\lambda_{g+1} = \frac{\gamma \theta_{g+1}}{n_g + \gamma \theta_{g+1} + \gamma \theta_{g+1} r(1 - r^\gamma)}, \tag{E.15}
\]
\[
\lambda_C = \frac{\gamma (1 - r^{\gamma + 1})}{(\gamma + 1) r (1 - r^\gamma)} \prod_{i=g+1}^{K} \frac{n_i}{n_i + \gamma \theta_i}, \quad \text{and} \tag{E.16}
\]
\[
\lambda_W = \left[ \frac{n_g + \gamma \theta_g^c}{(\gamma \theta_g^c - \gamma \theta_g)} \frac{r^{\gamma} - r^{-1} \left( \prod_{i=g+1}^{K} \frac{n_i}{n_i + \gamma \theta_i} \right) + (r^{-1} - 1)}{\gamma + 1} \right] \times \left( \prod_{i=1}^{g} \frac{n_i + \gamma \theta_i}{n_i} \right). \tag{E.17}
\]

**Proof:** Substituting equations \([E.9]-[E.11]\) into \([6.7]\) and using \( \left( \frac{n_g + \gamma \theta_g}{n_g + \gamma \theta_g^*} \right)^{\frac{1}{\gamma}} = r \) and
\[
\frac{\gamma^{c}}{\gamma^g} - \gamma^g = 1 - r^\gamma \text{ we obtain}
\]
\[
\lambda_D = 1 + \frac{1 - r}{r (1 - r^\gamma)} \sum_{k=g+1}^{K} \frac{\gamma^d_k}{n_k} \prod_{i=g+1}^{k} \frac{n_i}{n_i + \gamma^d_i} + \frac{\gamma + r^\gamma - (\gamma + 1) r}{(\gamma + 1) r (1 - r^\gamma)} \times \prod_{i=g+1}^{K} \frac{n_i}{n_i + \gamma^d_i}.
\]
Equation (E.12) then follows from using
\[
1 - \sum_{k=l+1}^{K} \frac{\gamma^d_k}{n_k} \left( \prod_{i=l+1}^{k} \frac{n_i}{n_i + \gamma^d_i} \right) = \prod_{i=l+1}^{K} \frac{n_i}{n_i + \gamma^d_i} , \tag{E.18}
\]
which can straightforwardly be shown to hold by induction. Similarly, (E.8) reduces to
\[
\lambda_U = \frac{(1 - r)}{r (1 - r^\gamma)} \sum_{k=1}^{g-1} \frac{\gamma^d_k}{n_k} \prod_{i=k+1}^{g} \frac{n_i}{n_i + \gamma^d_i}.
\]
Equation (E.13) then follows from using
\[
\sum_{k=1}^{g-1} \frac{\gamma^d_k}{n_k} \prod_{i=k+1}^{g} \frac{n_i + \gamma^d_i}{n_i} = \frac{n_g + \gamma^d_g}{n_g} \left( \prod_{i=1}^{g-1} \frac{n_i + \gamma^d_i}{n_i} - 1 \right).
\]
Equations (E.14)–(E.16) are derived analogously. \(\square\)

**Corollary E.1** For linear inverse demand \((\gamma = 1)\), the measures of harm are given as

\[
\lambda_D = \frac{Q^* + Q^g}{Q^g} \left( 1 - \frac{1}{2} \prod_{i=g+1}^{K} \frac{n_i}{n_i + \vartheta_i} \right), \quad \lambda_U = \frac{n_g + \vartheta^c_g}{n_g} \left( \prod_{i=1}^{g-1} \frac{n_i + \vartheta_i}{n_i} - 1 \right),
\]
\[
\lambda_g = \frac{\vartheta_g Q^*}{n_g Q^g} - 1, \quad \lambda_{g+1} = \frac{\vartheta_{g+1}}{n_{g+1} + \vartheta_{g+1}} \frac{Q^* + Q^g}{Q^g}, \text{ and}
\]
\[
\lambda_C = \frac{1}{2} \frac{Q^* + Q^g}{Q^g} \prod_{i=g+1}^{K} \frac{n_i}{n_i + \vartheta_i}.
\]

**Proof.** This follows immediately from substituting \(\gamma = 1\) and \(1 - \frac{r^2}{r(1-r)} = \frac{1+r}{r} = \frac{Q^* + Q^g}{Q^g}\)
and \(\frac{1-r}{r(1-r)} = \frac{1}{r} = \frac{Q^*}{Q^g}\) into equations (E.12)–(E.16). \(\square\)
E.4 Proof of Proposition 6.3

First note that we have \( \lim_{\gamma \to \infty} r = 1 \) and, using \( \lim_{\gamma \to 0} (1 + \alpha \gamma)^{\frac{1}{\gamma}} = \exp[\alpha] \), we have \( \lim_{\gamma \to 0} r = \exp \left[ \frac{\partial_g - \partial^c_g}{n_g} \right] \). Moreover, the following results are useful

\[
\lim_{\gamma \to \infty} r^{\gamma+1} = \lim_{\gamma \to \infty} \left( 1 + \frac{\gamma \partial_g}{n_g} \right) \lim_{\gamma \to \infty} r = \frac{\partial_g}{\partial^c_g},
\]

\[
\lim_{\gamma \to 0} r^{\gamma+1} = \lim_{\gamma \to 0} \left( 1 + \frac{\gamma \partial_g}{n_g} \right) \lim_{\gamma \to 0} r = \exp \left[ \frac{\partial_g - \partial^c_g}{n_g} \right].
\]

Now it follows immediately that

\[
\lim_{\gamma \to \infty} \lambda_D = \lim_{\gamma \to \infty} \frac{1 - r^{\gamma+1}}{r(1 - r^\gamma)} \lim_{\gamma \to \infty} \left( 1 - \frac{1}{\gamma + 1} \prod_{i=g+1}^{K} \frac{n_i}{n_i + \gamma \vartheta_i} \right) = 1.
\]

In order to evaluate \( \lim_{\gamma \to 0} \lambda_D \) first notice that \( \lambda_D \) can be rewritten as

\[
\lambda_D = \frac{1 - r^{\gamma+1}}{r(1 - r^\gamma)} \left( 1 - \frac{1}{\gamma + 1} \prod_{i=g+1}^{K} \frac{n_i}{n_i + \gamma \vartheta_i} \right)
\]

\[
= \frac{1 - r^{\gamma+1}}{r} \frac{n_g + \gamma \vartheta^c_g}{\gamma (\gamma + 1) (\vartheta^c_g - \vartheta_g)} \left( \gamma + 1 - \prod_{i=g+1}^{K} \frac{n_i}{n_i + \gamma \vartheta_i} \right)
\]

\[
= \frac{1 - r^{\gamma+1}}{r} \frac{n_g + \gamma \vartheta^c_g}{\gamma (\gamma + 1) (\vartheta^c_g - \vartheta_g)} \times
\]

\[
\left( \gamma + \frac{\sum_{i=g+1}^{K} \left( \vartheta_i \prod_{j=g+1, j \neq i}^{K} n_j \right) + f(\gamma)}{\prod_{i=g+1}^{K} (n_i + \gamma \vartheta_i)} \right),
\]

where \( f(\gamma) \) is a function with the property that \( \lim_{\gamma \to 0} f(\gamma) = 0 \). Taking the limit,

\[
\lim_{\gamma \to 0} \lambda_D = \left( 1 - \exp \left[ \frac{\partial_g - \partial^c_g}{n_g} \right] \right) \frac{n_g}{\vartheta^c_g - \vartheta_g} \left( 1 + \sum_{i=g+1}^{K} \frac{\vartheta_i \prod_{j=g+1}^{K} n_j / n_i}{\prod_{i=g+1}^{K} n_i} \right)
\]
\[ h \left( \frac{\vartheta_c - \vartheta_g}{n_g} \right) \left( 1 + \sum_{i=g+1}^{K} \frac{\vartheta_i}{n_i} \right), \]

with \( h(x) = \frac{\exp(x)-1}{x} \). Note that \( \lim_{x \to 0} h(x) = 1 \), \( h'(x) > 0 \) and \( h(1) = e - 1 \). Clearly, the second part of the above expression, \( \left( 1 + \sum_{i=g+1}^{K} \frac{\vartheta_i}{n_i} \right) \), is bounded from above by \( K - g + 1 \). Taken together we find that \( \lim_{\gamma \to 0} \lambda_D \leq (1 + K - g) (e - 1) \), with the upper bound being exact when all downstream layers are monopolized (implying \( \vartheta_i = n_i \) for all \( i \)), and there is full collusion in the colluding layer and perfect competition otherwise \((\frac{\vartheta_c - \vartheta_g}{n_g} = 1)\).

Alternatively, one can consider the relation between total downstream harm and total profit loss (i.e., overcharge plus output effect) of the direct purchasers. That is,

\[ \tilde{\lambda}_D = \frac{d_D}{\xi_{g+1} + \sigma_{g+1}} = \frac{\lambda_D}{\Xi}, \]

where \( \Xi = \xi_{g+1} + \sigma_{g+1} \). Obviously, \( \Xi \geq 1 \). Moreover, if layer \( g + 1 \) is perfectly competitive (that is, \( \vartheta_{g+1} \to 0 \) and/or \( n_{g+1} \to \infty \)) there is no output effect for this layer of direct purchasers, \( \sigma_{g+1} = 0 \). This implies \( \Xi = 1 \) and \( \lambda_D = \lambda_D \). Obviously, the downstream damage multiplier \( \tilde{\lambda}_D \) can, therefore, also take on any value. This holds even if the indirect purchaser layer is imperfectly competitive as the next lemma shows.

**Lemma E.3** For any \( M > 0 \) and any value of \( \vartheta_{g+1}/n_{g+1} \leq 1 \), there exists a market structure such that \( \tilde{\lambda}_D > M \).

**Proof.** First, using Lemma E.2 we find that

\[ \Xi = 1 + \frac{1 - r}{r} \frac{\vartheta_{g+1}}{n_{g+1} + \gamma \vartheta_c} \frac{n_g + \gamma \vartheta_c - \vartheta_g}{n_g}. \]

From the proof of Proposition E.3 we know that \( \lim_{\gamma \to 0} r = \exp \left[ \frac{\vartheta_c - \vartheta_g}{n_g} \right] \). Using \( h(x) = \frac{\exp(x)-1}{x} \) again we can write

\[ \lim_{\gamma \to 0} \tilde{\lambda}_D = \lim_{\gamma \to 0} \frac{\lambda_D}{\Xi} = \frac{h \left( \frac{\vartheta_c - \vartheta_g}{n_g} \right)}{1 + \frac{\vartheta_{g+1}}{n_{g+1}} h \left( \frac{\vartheta_c - \vartheta_g}{n_g} \right) \left( 1 + \sum_{i=g+1}^{K} \frac{\vartheta_i}{n_i} \right)}. \]

Since \( h(x) \) is maximized at \( x = 1 \) and \( h(1) = e - 1 \) we find an upper bound for \( \tilde{\lambda}_D \)
by taking $\gamma \to 0, \vartheta_g = 0, \vartheta^c_g = n_g$ and $\vartheta_k = n_k$ for $k = g + 1, \ldots, K$. This upper bound is given by

$$\frac{e - 1}{e} (1 + K - g).$$

Clearly, any level of $\tilde{\lambda}_D$ can be reached by choosing $K - g$ appropriately. \hfill $\Box$

Moreover, it is easily verified that for the case with $\vartheta_{g+1} = n_{g+1}$, and a perfectly competitive benchmark in the colluding layer, $\vartheta_g = n_g = 0$, we have that $\Xi$ equals 2 for $\gamma = 1$, and $\Xi$ goes to $e$ (1) for $\gamma \to 0 (\gamma \to \infty)$.

E.5 An Example of Upstream “Undercharges”

Following Mandeville Island Farms, direct suppliers to a buyers cartel that colluded to decrease input prices can maintain a treble-damages action for the “undercharge.”\footnote{See Blair and Page (1996), pp. 131–132.} In this paper, we abstract from buyer power effects. Yet, as argued in Section 5.3.2, variations in demand or the cost of production can generate upstream price effects as well. Input prices may increase when the cartel reduces demand. Direct suppliers may also obtain a lower price for their inputs by the cartel members than they would under competition, however, in which case they suffer a straightforward “undercharge.”

Figure 5.1 illustrates an example of input prices in layer $g - 1$ decreasing as a result of a cartel forming in layer $g$ when the marginal upstream costs of production increase in production.

The derived demand for inputs under downstream competition, $p_{g-1}(q)$, turns inwards to $p_{g-1}^g(q)$. Profit maximization given $c_{g-1}(q)$ results in lower input prices to the purchaser cartel, $p_{g-1}^g < p_{g-1}$. As a result, the upstream industry sustains an undercharge of size $\left(p_{g-1} - p_{g-1}^g\right) g_{g-1}^g$ on its actual sales—or area $U$ in the figure.

Given linear demand, upstream prices increase after downstream collusion when costs are concave, and decrease when costs are convex.\footnote{Analytical results quickly become intractable in longer supply chains. From tedious but straightforward computations it follows that in a chain with two layers of production the upstream Cournot equilibrium price decreases with an increase in $\vartheta_2$, whenever}

$$(\Psi_P + \Psi_c) P' (Q) >$$

$$\left(n_2 + \vartheta_2\right) P' (Q) + \vartheta_2 Q P'' (Q) - c_2^g \left(\frac{Q}{n_2}\right) \left(n_1 + 1\right) P' (Q) + Q P'' (Q).$$

$$\Psi_P = \left(n_1 + 1\right) \left(n_2 + \vartheta_2\right) P' (Q) + \left(n_2 + \left(n_1 + 3\right) \vartheta_2\right) Q P'' (Q) + \vartheta_2 Q^2 P''' (Q)$$

and

$$\Psi_c = -n_2 c_1'' \left(\frac{Q}{n_1}\right) - \left(n_1 + 1\right) c_2' \left(\frac{Q}{n_2}\right) - \frac{Q}{n_2} c_2''' \left(\frac{Q}{n_2}\right).$$

If consumer demand is linear and marginal
equal to marginal costs. Decreasing returns to scale result in lower marginal costs of production in equilibrium when the quantity of inputs demanded is reduced. These results carry over to the other forms of imperfect competition upstream in our model.

![Diagram](image)

**Figure AP.2** Direct sellers undercharged by a purchasers cartel.

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costs downstream are constant, this condition reduces to \( c'_1 \left( \frac{Q}{n_1} \right) > 0 \). Furthermore, the class of demand specifications for which there are no upstream price effects when the marginal costs of production are constant both up- and downstream is characterized by

\[
P''(Q)P'(Q) + Q \left\{ P''(Q) P'(Q) - [P''(Q)]^2 \right\} = 0.
\]

Obviously, whereas (6.10) does, many nonlinear demand functions do not satisfy this condition.
E.6 Proof of Proposition 6.5

It is sufficient to prove the proposition for the linear case with $\gamma = 1$. Then we have

$$\lambda_U = \frac{n_g + \vartheta_g}{n_g} \left( \prod_{i=1}^{g-1} \frac{n_i + \vartheta_i}{n_i} - 1 \right).$$

In the extreme case where all upstream layers are monopolized ($\vartheta_i = n_i$ for $i = 1, \ldots, g - 1$) and there is full collusion in the colluding layer ($\vartheta_c^g = n_g$) we obtain

$$\lambda_U = 2 \left( 2^{g-1} - 1 \right),$$

which can reach any finite level as the number of upstream layers $g - 1$ increases. $\square$

E.7 Proof of Proposition 6.6

We show the effects of the location of the colluding layer on total welfare and the different measures of harm. The change in welfare is

$$\Delta W_g = \sum_{k=1}^{K} \sigma_k + \sigma_C = (Q^* - Q^g) \left( P^* - \sum_{k=1}^{K} c_k \right) + \sigma_C$$

$$= \Phi \left[ \left( 1 - \left( \frac{n_g + \gamma \vartheta_g}{n_g + \gamma \vartheta_c^g} \right)^{\frac{1}{\gamma}} \right) - \frac{1}{\gamma + 1} \left( 1 - \left( \frac{n_g + \gamma \vartheta_g}{n_g + \gamma \vartheta_c^g} \right)^{\frac{\gamma + 1}{\gamma}} \right) \prod_{i=1}^{K} \frac{n_i}{n_i + \gamma \vartheta_i} \right],$$

where $\Phi = \left( \frac{1}{b'} \right)^{\frac{1}{\gamma}} \left( \prod_{i=1}^{K} \frac{n_i}{n_i + \gamma \vartheta_i} \right)^{\frac{1}{\gamma}} \left( a - \sum_{j=1}^{K} c_j \right)^{\frac{\gamma + 1}{\gamma}}$. The change in welfare is independent of the location of the cartel. The direct purchaser overcharge is given by

$$\xi_{g+1} = \omega_g = \Phi \left( \frac{n_g + \gamma \vartheta_g}{n_g + \gamma \vartheta_c^g} \right)^{\frac{1}{\gamma}} \left( \frac{\vartheta_g^c - \gamma \vartheta_g}{n_g + \gamma \vartheta_c^g} \right) \prod_{i=1}^{g} \frac{n_i}{n_i + \gamma \vartheta_i},$$

which does decrease in $g$. $\square$
References


Nederlandse samenvatting
[Summary in Dutch]

VERTICALE RELATIES
IN KARTELTHEORIE
Bestuurlijke incentives,
inkoopsamenwerkingen
& kartelschade

Een kartel is een overeenkomst tussen ondernemingen die erop gericht is de onderlinge concurrentie te verminderen. Kartellisten doen dit meestal door prijsspraken te maken, markten te verdelen of af te spreken wie een aanbesteding wint.

Een bekend Nederlands voorbeeld is de bouwfraude: bouwbedrijven bepaalden onderling welke aannemer voor welke prijs een aanbesteding van een groot bouwproject won. De Nederlandse Mededingingsautoriteit (NMa) beoordeelde meer dan 1400 ondernemingen in de bouwsector. Daarnaast zijn persoonlijke boetes tot €250.000 opgelegd aan leidinggevenden wegens het hervatten van illegale prijsspraken.

Een voorbeeld van een internationaal kartel met invloed op de Europese markt is het LCD-panelenkartel. Zes producenten van liquid crystal display (LCD) panelen coördineerden hun prijzen tijdens geheime bijeenkomsten in Taiwanese hotels, de zogenaamde Crystal Meetings. De Europese Commissie legde boetes op van in totaal €649 miljoen.

Een berucht kartel actief in de Verenigde Staten was het lysinekartel. Producenten van lysine—een aminozuur in voedsel voor dieren—verdelen de wereldwijde lysinemarkt onder elkaar. De FBI spoorde het kartel op door undercover filmpopnames van kartelbijeenkomsten in hotels. De zogenaamde Lysine Tapes illustreerden de essentie van het kartel wanneer een CEO tegen een bestuurder van zijn grootste concurrent zegt dat “you are my friend” en “our customers are the enemy.” De U.S. Department of Justice vervolging de betrokkenen: drie leidinggevenden werden veroordeeld tot drie jaar gevangenisstraf elk.

159 Het complete bouwfraudedossier is beschikbaar op de websites van de NMa en het Openbaar Ministerie, doorgelinkt via carteltheory.com/references.
160 Zie NMa beslissingen op 29 oktober 2010 in zaken 6494 en 6836 (Limburgse bouwzaken).
161 Zie de beslissing van de European Commission op 8 december 2010 in zaak COMP39309-LCD.
162 De Lysine Tapes zijn online beschikbaar via carteltheory.com/references.
In deze dissertatie bestudeer ik hoe de economische prikkels (incentives) binnen kartels worden beïnvloed door zogenaamde verticale relaties binnen en tussen bedrijven. Met speltheoretische analyses—een modelleermethode om de prikkels achter het gedrag van mensen, bedrijven en instituten beter te begrijpen—tracht ik daarmee bij te dragen aan de theoretische basis van een effectieve mededingingsbeleid.

**Wat zijn verticale relaties in karteltheorie?**

Deze dissertatie bestaat uit vijf studies, gegroepeerd naar drie verschillende typen verticale relaties in karteltheorie: (i) prikkels van managers binnen kartels, (ii) inkoopsamenwerkingen fungerend als kartels en (iii) kartelschade in lange productieketens.

**Het standaard kartelmodel.** Een kartel bestaat meestal uit ondernemingen die zich op hetzelfde horizontale niveau van de productieketen bevinden. Figuur NL.1 geeft een schematische weergave van het standaard kartelmodel: twee bedrijven leveren goederen of diensten aan consumenten en vormen een kartel.

**Prikkels van managers binnen kartels.** In het eerste deel van deze dissertatie onderzoek ik hoe de relatie tussen aandeelhouders en management de prikkels binnen kartels beïnvloedt. Figuur NL.2 illustreert het conceptuele verschil tussen het standaard kartelmodel en mijn benadering: het bedrijf als black box is geopend. Ik bestudeer hoe de stabiliteit en de werking van kartels afhangt van de incentives van managers.

Wordt een kartel stabiel of juist onstabiel van vast of variabel loon (bonussen), tijdelijke of vaste contracten, en aandelen- of optiepakketten? De prikkels om een kartel te vormen kunnen ook afhangen van de mate waarin managers worden gecontroleerd door zogenaamde compliance officers binnen de onderneming. In het eerste deel van deze dissertatie onderzoek ik de impact van dergelijke factoren op de werking van kartels.
Inkoopsamenwerkingen fungerend als kartels. In het tweede deel bestudeer ik hoe een inkoopsamenwerking tussen bedrijven op de input-markt de concurrentie op de eindmarkt voor consumenten beïnvloedt. Figuur NL.3 laat schematisch zien hoe twee detaillisten een inkoopsamenwerking met elkaar kunnen aangaan om gezamenlijk hun inputs van leveranciers te kopen. Een dergelijke inkoopsamenwerking kan de mededinging op de eindmarkt zodanig verstoren dat er effectief sprake is van een kartel.

![Diagram Inkoopsamenwerkingen](image)

**Figuur NL.3 Een inkoopsamenwerking fungerend als een kartel.**

Kartelschade in lange productieketens. In het derde deel wordt onderzocht hoe een kartel binnen een lange productieketen de concurrentie in de verschillende lagen van de keten beïnvloedt. Figuur NL.4 geeft schematisch een productieketen met drie lagen weer, waarbij er een kartel is in de middelste bedrijvenlaag. De verdeling van de economische schade over de verschillende lagen hangt af van de mate waarin de detaillisten de verhoogde kartelprijs doorberekend aan eindconsumenten.

![Diagram Kartelschade](image)

**Figuur NL.4 Kartelschade in een lange productieketen.**
De economische inzichten resulterend uit mijn onderzoek bieden beleidsmakers en mededingingsautoriteiten een theoretisch kader voor het verfijnen van het mededingingsbeleid. Hieronder beschrijf ik achtereenvolgens de kern van dit beleid gericht op kartels, de onderzoeksmethodologie (speltheorie) en de resultaten van deze dissertatie.

**Mededingingsbeleid**


In Nederland is de Nederlandse Mededingingsauthority (NMa) belast met het opsporen van kartels. Op Europees niveau worden kartels vervolgd door het Directoraat-Generaal Concurrentie van de Europese Commissie (kortweg: de Commissie). Onder leiding van voormalig Eurocommissaris Neelie Kroes heeft het strenge mededingingsbeleid van de Commissie de afgelopen jaren flink aan bekendheid gewonnen.

Mijn onderzoek relateert aan een vijftal beleidsinstrumenten om kartels af te schrikken, op te sporen en te bestrijden. Drie van deze beleidsinstrumenten worden door mededingingsauthority's zelf geïmplementeerd. (1) Bedrijfsboetes: bedrijven riskeren een boete van maximaal 10% van de jaaromzet. (2) Strafrechtelijke vervolging: in de Verenigde Staten worden managers die zich schuldig maken aan kartelvorming strafrechtelijk vervolgd. Zij riskeren zowel gevangenisstraffen als persoonlijke geldboetes. De Europese mededingingswet laat individuen vrijuit laat gaan; een aantal lidstaten van de E.U. hebben echter nationale (mededingings)wetten geïmplementeerd om individuen strafrechtelijk te vervolgen. (3) Clementieprogramma's: de boete van een kartellist wordt kwijtgeschilden wanneer deze het kartel aanhangig maakt bij de NMa of de Commissie.\(^{163}\)

Twee van de vijf beleidsinstrumenten waaraan mijn onderzoek relateert worden direct door civiele partijen uitgeoefend. (4) *Compliance*-programma's: ondernemingen kunnen voorkomen dat managers de mededingingswet overtreden door hun gedrag periodiek te laten controleren door *compliance officers* of mededingingsadvocaten. (5) Civiele rechtszaken: slachtoffers (kopers, afnemers) van een kartel kunnen voor de rechter schadevergoeding eisen van de karteldeelnemers.

\(^{163}\)De NMa heeft een informatiefilm over het clementieprogramma gemaakt; een fictieve karteldeelnemer vraagt daarin clementie aan—zie de link op [carteltheory.com/references](http://carteltheory.com/references).
Methodologie: speltheorie

De onderzoeksmethodologie van deze dissertatie is speltheorie. Speltheorie is een modellermethode om de effecten van (economische) prikkels binnen zogenaamde spelen te isoleren en zodoende het gedrag van mensen, ondernemingen of instituties beter te begrijpen. Binnen de speltheorie is een spel formeel gedefinieerd als een situatie waarbij twee (of meer) spelers een strategische interactie met elkaar aangaan. Dit betekent dat de payoff van de ene speler afhankt van de actie van de andere.

Ondernemingen spelen een spel op de markt: zij voeren competitie en reageren onafhankelijk van elkaar of zij vormen een kartel en coördineren hun acties. De mededingingsautoriteit bepaalt de spelregels op de markt en neemt deel aan het spel door ondernemingen te controleren. Karakterdeelnemers staan voor een aantal speltheoretische dilemma’s: als ik een kartel vorm, komt de mededingingsautoriteit daar dan achter? Hoe weet ik zeker dat mijn medekartellist niet stiekem de prijs verlaagt? Zal mijn medekartellist gebruik maken van het clementieprogramma en het kartel aangeven? Hoe zorg ik dat mijn werknemers zich aan de kartelafspraken houden?

In deze dissertatie bouw ik speltheoretische modellen om de interactie van de onderliggende economische krachten binnen kartels te ontdogen. Ik onderzoek daarmee het effect van verschillende beleidsinstrumenten op het gedrag van ondernemingen en werknemers. In dit kader is het belangrijk om op te merken dat speltheoretische resultaten altijd in het licht van de modelaannames moeten worden geïnterpreteerd. Hoewel de toepassing van speltheorie tot verhelderende nieuwe inzichten kan leiden, dienen deze zorgvuldig te worden afgezet tegen niet-gemodelleerde overwegingen vanuit bijvoorbeeld een sociaal, politiek, juridisch, economisch of psychologisch oogpunt.

Resultaten

Prikkels van managers binnen kartels. Het grootste deel van deze dissertatie gaat over de prikkels van individuele managers om een kartel te vormen. De bestaande literatuur over kartels gaat er over het algemeen vanuit dat een onderneming een winstmaximaliserende black box is (figuur NL.1). Kartels worden juist meestal gevormd door individuele managers die andere incentives kunnen hebben dan de winstmaximaliserende aandeelhouders, zoals conceptueel geïllustreerd in figuur NL.2.

Hoofdstuk 2 (Monitoring Managers Through Corporate Compliance Programs, co-auteur: Charles Angelucci[1]) bestudeert de effecten van het intern controleren van werknemers met behulp van een zogenaamd compliance-programma. Het model laat zien dat een

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[1]Toulouse School of Economics, Université Toulouse I.
*compliance*-programma een pervers effect teweeg kan brengen: de extra informatie over het werknemersgedrag kan door superieuren juist gebruikt worden om kartelvorming te stimuleren. Onze bevindingen wijken gedeeltelijk af van de huidige clementieprogramma’s en de *U.S. Federal Sentencing Guidelines*. We geven economische argumenten voor (i) gedeeltelijke vrijstelling van boetes voor de onderneming en geen vrijstelling van boetes voor werknemers wanneer de onderneming het kartel aangeeft, (ii) het niet al- tijd vrijstellen van boetes wanneer een werknemer het karteel aangeeft en (iii) het niet automatisch toekennen van een korting op de boete wanneer de onderneming een *compliance*-programma had ten tijde van het kartel.

In hoofdstuk 3 (*Short-Term Managerial Contracts and Cartels*) bestudeer ik het effect van de lengte van arbeidscontracten op kartels. Ik laat zien hoe de stabiliteit van een kar- tel kan worden verhoogd door managers een kortetermijn-arbeidscontract aan te bieden in plaats van een langetermijn-arbeidscontract. Een kortetermijn-contract kan managers een sterke prikkel geven zich aan een kar telovereenkomst te houden. De reden is dat een afwijking van de kar telovereenkomst leidt tot een prijzenoorlog; daardoor neemt de kans toe dat het kortetermijn-contract niet wordt verlengd wegens lage winsten. Daar- naast beargumenteer ik dat kortetermijn-arbeidscontracten kunnen leiden tot patronen van cyclische marktprijzen. Tenslotte interpreteer ik mijn bevindingen in het licht van bedrijfsfinanciering. Ik beargumenteer dat bedrijven gefinancierd met leningen (*debt*) potentieel een stabielere kartel kunnen vormen dan bedrijven gefinancierd met eigen vermogen, vermogen of aandelen (*equity*).


**Inkoopsamenwerkingen fungerend als kartels.** Inkoopsamenwerkingen zijn over- eenkomsten tussen ondernemingen om gezamenlijk hun *inputs* in te kopen; figuur NL.3 geeft hiervan een conceptuele representatie. Een inkoopsamenwerking kan leiden tot een sterkere onderhandelingspositie ten opzichte van leveranciers en zodoende de *input*-prijs reduceren (inkoopmacht). Dit kan vervolgens in het voordeel werken van consumenten, omdat een gedeelte van de kostenreductie naar hen kan worden doorberekend.

Hoofdstuk 5 (*Efficient Cartelization Through Buyer Groups*, co-auteur: Chris Doyle[6]) laat echter zien hoe gezamenlijk inkoopbeleid op de *input*-markt de concurrentie op de

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eindmarkt voor consumenten kan schaden. We beargumenteren dat bedrijven binnen een inkoopsamenwerking hun inkoopcontracten zodanig op elkaar kunnen afstemmen dat de mededinging op de eindmarkt wordt verlaagd naar het kartelniveau. Een inkoopsamenwerking maakt dan gebruik van zogenaamde slotting allowances en vertikale restricties, zoals exclusive dealing of minimum purchase clausules en rebate schemes.

**Kartelschade in lange productieketens.** Slachtoffers (kopers, afnemers) van kartels hebben de mogelijkheid hun geleden schade via de rechter te verhalen bij de karteldeelnemers. In de Verenigde Staten kunnen directe afnemers driemaal de zogenaamde overcharge eisen. De overcharge is gedefinieerd als de prijsverhoging van het kartel, vermengd met het aantal gekochte producten. In een witboek uit 2008 beschrijft de Europese Commissie dat zij voornemens is “vereenvoudigde regels” in te voeren om alle gedupeerden volledig te compenseren voor de geleden economische schade.

Hoofdstuk 6 (The Overcharge as a Measure for Antitrust Damages, co-auteurs: Maarten Pieter Schinkel en Jan Tuinstra) laat zien dat er geen enkelvoudig structureel verband bestaat tussen de overcharge en de werkelijk geleden economische schade in een langere productieketen, zoals afgebeeld in Figuur n.l.4. De schade van iedere laag in de productieketen bestaat uit drie effecten: het zogenaamde overcharge-effect, pass-on-effect en output-effect. Om deze effecten exact te quantificeren is gedetailleerde informatie nodig over bijvoorbeeld de vraag, de marktstructuur en de manier waarop ondernemingen concurrentie voeren. We beargumenteren daarmee dat het voornemen van de Commissie onuitvoerbaar is: zij dient ofwel het doel van “vereenvoudigde regels” ofwel het doel van “volledige compensatie” te laten fieren.

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164 Zie het 2008 Witboek betreffende schadevergoedingsacties wegens schending van de communautaire mededingingsregels van de Europese Commissie.

† Amsterdam Center for Law and Economics (ACLE), Universiteit van Amsterdam (UvA).

§ Center for Nonlinear Dynamics in Economics and Finance (CeNDEF) en ACLE, UvA.
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