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COLLUSION, MERGERS, AND RELATED ANTITRUST ISSUES

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ABSTRACT

This survey examines recent developments in economic research relating to antitrust, paying specific attention to research in the areas of collusion and merger enforcement. Research relating to both collusion and mergers has made significant advances in the last twenty years. With respect to collusion, this includes important theoretical and empirical work on the sustainability, structure, and impact of collusive schemes. With respect to mergers, this includes important work on the impact of enforcement institutions, both theoretical and empirical work on unilateral effects, and theoretical work on the selection of which mergers get proposed to antitrust agencies and optimal policy in the face of that selection. A feature of recent research is the increasing complementarity between empirical work (ranging from observational studies to model-based measurement) and theoretical work in advancing our understanding of collusive and merger-related phenomena.

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1 Introduction

Many markets are composed of a small number of firms possessing market power and making supra-competitive economic profits.[1] Because of the existence of market power, firms' actions aimed at maximizing their own profits can result in market inefficiencies, reducing consumer surplus and societal welfare. As a result, most countries have enacted 'antitrust' (or competition) laws that limit the actions firms are allowed to take in a market. In contrast to industry-specific regulation, antitrust laws provide generally applicable rules to protect the competitive process across the broad spectrum of economic activity in an economy.

In this chapter, we provide a survey of selected recent advances in the academic literature on antitrust economics. The chapter is geared towards academic researchers rather than antitrust practitioners, but we hope that practitioners find our treatment useful as well.[2]

Because of the vast literature on antitrust economics, we confine our attention to two major areas—collusion and mergers—largely leaving out the literature on exclusionary effects of business practices, among others. Exclusion is at the heart of the chapter "A Primer on Foreclosure" by Rey and Tirole in Volume 3 of this Handbook; it is also a central policy issue covered in the chapter on "Vertical Markets" by Lee, Whinston and Yurukoglu in this volume of the Handbook.[3] The more specialized literature on antitrust issues in high-tech industries and two-sided markets is also not discussed.[4] Even within the areas we do cover—collusion and mergers—the chapter is highly selective and inevitably idiosyncratic. It focuses on important recent contributions, both theoretical and empirical, with particular attention to those in the last ten years. Our chapter is thus complementary to chapters in previous volumes of this Handbook, notably "Cartels, Collusion, and Horizontal Mergers" by Jacquemin and Slade in Volume 1 and, especially, the chapter "Antitrust Policy toward Horizontal Mergers" by Whinston in Volume 3.

Methodologically, the research covered by this chapter is diverse–leveraging observation, theory, and measurement. Collectively the body of research we discuss illustrates the highly productive complementarity of theory and the various modes of empirical work in advancing knowledge in the area of antitrust economics.

Section 2 is devoted to collusion. We begin by asking how pervasive collusive conduct actually is. Drawing on theoretical and empirical work, we then analyze how

[1] Here, when we say a firm possesses market power (in a product market) we mean that it faces a residual demand curve that is not perfectly elastic (market power may also exist in an input market, in which case an analogous definition relating to input supply curves would apply). This is distinct from the use of the term in many applied antitrust contexts where it can also involve an additional notion of dominance or of meeting some threshold of economic significance. See the US DOJ-FTC 2010 Horizontal Merger Guidelines (Department of Justice and Federal Trade Commission, 2010) for an example of the use of market power in such an applied context.

[2] Readers interested in a more practitioner-focused treatment are referred to Department of Justice and Federal Trade Commission (2010), Davis and Garces (2010), Buccirossi (2008) and the many excellent chapters therein, and many publications on legal and economic issues produced by the American Bar Association's Antitrust Section.

[3] Whinston's *Lectures on Antitrust Economics* (MIT Press, 2006) provides an excellent treatment of the antitrust issues arising from exclusive dealing. See also the chapter "Predation, Monopolization, and Antitrust" by Ordover and Saloner in Volume 1 of this Handbook.

[4] See Shapiro (2019) and Rysman (2009) for introductions to this, and other, literature.

collusive schemes operate – how agreements start, how they are structured, how they are enforced, and how they may deal with the threat of entry. Next, we briefly discuss the academic literature on cartel detection and leniency agreements. We conclude the section by examining the impact of collusion on market outcomes.

Section 3 is devoted to mergers. We begin by outlining the fundamental trade-off between the market power effect of (horizontal) mergers and potential merger-induced synergies, and survey the surprisingly sparse empirical evidence on such synergies. We then discuss how thresholds in merger notification requirements may affect the set of proposed mergers, and how proposed mergers may be screened for their potential anti-competitive effects. Next, we survey recent advances in the analysis of the unilateral effects of mergers, which have been at the heart of most merger investigations in recent decades, as well as the (less well-understood) coordinated effects of mergers. We then turn to vertical mergers, studying both their potential pro-competitive effects due to the internalization of (vertical) externalities as well as their potential anti-competitive effects due to foreclosing rivals or facilitating collusion. We also discuss the (surprisingly small) literature on merger remedies, before examining the empirical evidence on the impact of mergers. We conclude the section by discussing emergent issues relating to mergers, notably the recent evidence on the evolution of markups in the US economy, and the extent of common ownership of the economy's productive capacity.

Finally, Section 4 briefly outlines a few promising directions for future research.

2 Collusion

Collusion is usually regarded as the "supreme evil of antitrust," as naked cooperation between competitors on the prices paid by customers is almost always the very antithesis of competition.[5] Hard-core collusion, comprising price fixing, market division, and bid rigging, provides a plethora of compelling examples of unambiguously anticompetitive conduct.[6] Policy toward hard-core collusion is typically harsh, inviting criminal sanctions in many jurisdictions. That said, even a cursory examination of enforcement actions, litigation, and the economic literature reveals that cooperative behavior between competitors is not always inimical to competition. Indeed, in some instances, it is necessary.[7] To that end it is useful to begin with a working definition of the type of cooperative behavior that raises serious competitive concerns, and to balance that with a brief discussion of the types of cooperation that often require a more nuanced view.

Collusion of the sort that raises serious competition concerns generally comprises "agreements among competitors regarding prices or outputs," interpreted with the suppression of competitive rivalry in mind.[8] In the context of price fixing, this would include competitors agreeing on a common price, or production quotas. Market division would include designating specific geographic territories or clients to particular

[5]See *Verizon Communications v. Law Offices of Curtis V. Trinko*, 540 U.S. 398 (2004) at 408.

[6]See OECD (2000) and the examples therein. See also Marshall and Marx (2012).

[7]Prominent court cases in which that conclusion was reached include *Chicago Board of Trade v. United States*, 246 U.S. 231 (1918), *Broadcast Music Inc. v. Columbia Broadcasting System Inc.*, 441 U.S. 1 (1979), and *NCAA v. Board of Regents of the University of Oklahoma*, 468 U.S. 85 (1984). There are also a curious number of qualified exemptions for specific cartel-like activity. See, for instance, Sullivan and Grimes (2006).

[8]See Whinston (2006), and Marshall and Marx (2012).

competitors. Bid rigging would include competing bidders taking turns to 'win' an auction, or using more sophisticated mechanisms to coordinate bidding, perhaps through the use of side payments.[9]

By contrast, some forms of coordination are clearly important for the proper functioning of a market. Coordination between competitors in setting standards that allow for the interoperability of technology across platforms or networks is a prominent contemporary example.[10] More generally, coordination between the producers of complementary products can generate benefits arising from mitigating the adverse impacts of externalities. More difficult issues can arise when coordination is alleged to occur on non-price characteristics, or investments in capacity or production or research joint ventures.[11] Lastly, it is worth noting that the literature contains provocative theoretical counter-examples in which even naked collusion on prices can generate greater social benefits than competition.[12]

In this section, we focus on economic research that has investigated fairly blatant, anticompetitive, manifestations of collusion. We begin by asking the threshold question, 'How much of this conduct occurs?' If society is to allocate resources to policing collusive conduct, we should have a view as to its prevalence. We then attempt to synthesize what is understood regarding the operation of collusive agreements (cartels) with a focus on more recent research. We turn to recent work on cartel detection. Finally, we examine what can be said about the impact of collusive agreements. In all that follows, the focus is on what firms do when they are clearly seeking to subvert the competitive process.

There are several main themes coming out of the research surveyed in this section. First, some forms of collusion are likely to be prevalent in many industries. While it is notoriously difficult to detect illegal cartels, the empirical literature is no longer a mere collection of anecdotes; quite some progress has been made in getting a handle on the extent of collusion in the economy. Second, cartels come in a variety of forms: explicit and implicit price-fixing collusion, bid rotation schemes in procurement auctions, and the like. Researchers have obtained a much richer understanding of the forms that are empirically relevant and in the way cartels work. What is still not very well understood is why verbal communication among cartel members appears to be such a prevalent feature. Third, while the theoretical literature on the factors that facilitate collusion continues to grow, the predictive power of the theoretical framework is poor and the mapping of theory to empirics not very well developed. As a result, we still do not have a good grip on understanding why (and when) some industries are cartelized while others are not. Finally, the impact of cartels varies wildly: the collusion-induced price elevation can be large or small; likewise, the welfare impact can be big or small. The academic literature is getting much better at measuring that impact; merging theory with quantification has been very successful here. But again, why some cartels really

[9] See the discussions of price fixing, market division, and bid-rigging in Section 2.2.2 for specific examples of each.

[10] See Simcoe (2012), Farrell and Simcoe (2012), and Spulber (2019) for more details. Note that the openness of the standard is an important factor in its overall competitive effect.

[11] See, for instance, Bresnahan and Salop (1986) in the context of joint ventures and, in the context of investment, the discussions of the coordination reduction of airline capacities in Blair, Mak, and Bonham (2007) and Kamita (2010). See also Chilet et al. (2021) for a recent empirical investigation in the context of automobile emissions technologies.

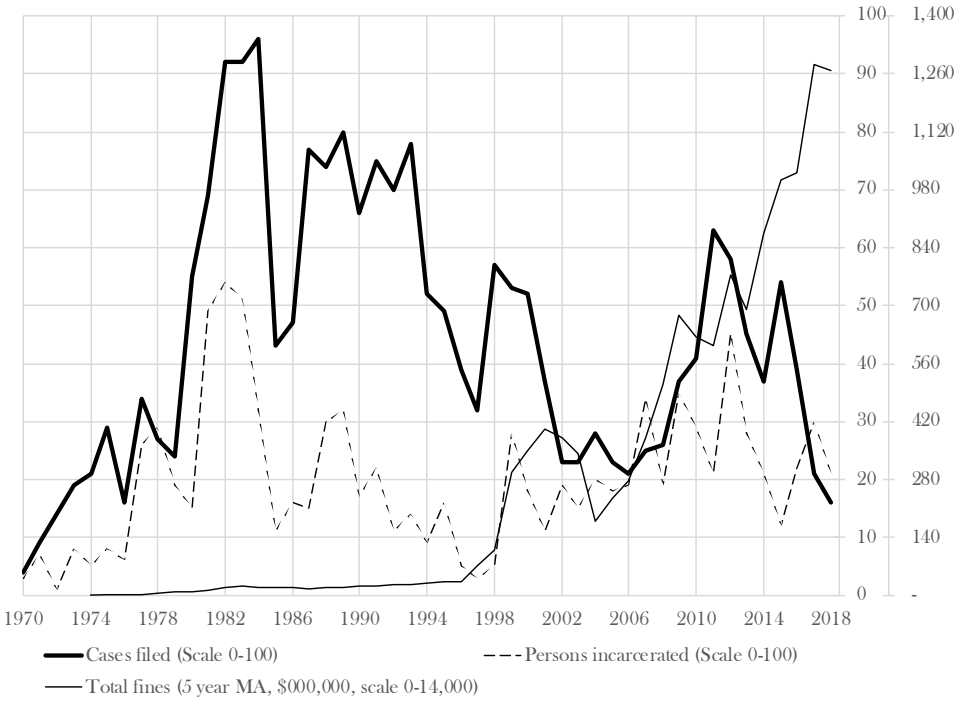
[12] See Whinston (2006), Fershtman and Pakes (2000), and Fershtman and Gandal (1994).

impact markets while others do not is less-well understood.

2.1 How much collusion is there?

Figure 1 shows the number of criminal cartel cases filed by the US Department of Justice's Antitrust Division, by year, from 1970 to 2018 (the heavy solid black line).[13] It also shows the number of persons incarcerated due to cartel conduct (the dashed line) and the extent of imposed fines (the thin solid black line). Counts of cases filed vary considerably over this period. They peak in the early 1980s at over 90 cases a year, with a minimum of under 10 in the early 1970s. Since the early 1980s the number of cartel cases filed has declined somewhat, albeit with considerable year-to-year variation.

Figure 1: Criminal cartel cases filed by US DOJ, persons incarcerated, and fines imposed



Notes: The sources are Antitrust Division Workload Statistics 1970-1979, 1980-1989, 1990-1999, 2000-2009, and 2009-2018 downloaded from `https://www.justice.gov/atr/division-operations` and `https://www.justice.gov/atr/file/788426/download` on 18 May 2020. 'Cases filed' is drawn from 'Restraint of Trade Criminal (Sherman §1) - Filed' for 1990-2018 and from 'Restraint of Trade Criminal - Filed' for 1970-1989. 'Persons incarcerated' is drawn from 'Number of Individuals Sentences (Actual Jail)' for 1970-1989 and 'Number of Individuals Sentenced to Incarceration Time' for 1990-2018. 'Total fines' is a 5 year moving average. For 1970-1989 it is computed from the sum of 'Total Amount Individual Fines ($000)' and 'Total Corporate Fines ($000).' For 1990-2018 it is drawn from 'Total Fines Imposed ($000)'.

The extremely naive conclusion that fewer than 100 cartels exist in the US at any point in time, cannot be right. Cartels are illegal and, by their very nature, do

[13] For a discussion of the analogous European data, see Brenner (2009) and Carree, Günster, and Schinkel (2010). For an expanded discussion of the data on US enforcement, see Ghosal (2008).

not publicize their existence. Consequently, the DOJ enforcement statistics represent a heavily selected sample, comprising cartels that were discovered and for whom sufficient evidence could be collected to make filing a case against them worthwhile (see Miller (2009)).

An alternative, but still naive, conclusion, that cartel activity spiked in the early 1980s, and has declined somewhat since, is also almost surely unreliable. For one thing, resource constraints and policy changes at the DOJ have some influence on prosecutorial practice. Perhaps more importantly, the size of the US economy has increased significantly since the 1980s. More firms are doing more things in more industries. This by itself would suggest that the raw count of cartel activity should not have declined. A further confounding factor is that the costs of engaging in cartel activity have likely increased since the 1980s. In 1982, 92 cartel cases were filed, but only $36.8 million in fines was collected. That amounts to $400,000 per cartel filing.[14] Conditional on avoiding jail time, the costs of cartelizing imposed by the DOJ were low at that time. Getting caught mattered less. By contrast, in 2017 21 cases were filed, but fines were collected totaling $2.79 billion, or over $100 million per case filing.[15] The steady increase in fines imposed in cartel cases by DOJ prosectors since the mid-1990s reflects a meaningful change in the cost to firms of collusion.[16] It is reasonable to think that the increased fines would be a deterrent, but also that, in the face of increased fines, colluding firms would invest more in avoiding detection. In 1993, the DOJ also introduced a new leniency program for cartel offenders that gave a form of immunity, in specific circumstances, to conspirators who informed on their collaborators (see the discussion of Miller (2009), below). Drawing inferences on the prevalence of cartel activity from enforcement data and court filings is made difficult by these, and other, complicating factors, many of which pull in opposing directions.[17]

Recognizing these obvious difficulties, some progress has been made in the literature by either attempting to account for these inference issues, or by trying to infer the prevalence of cartel activity more directly.

A startling example of the direct approach is found in Kawai and Nakabayashi (2020).[18] Kawai and Nakabayashi examine construction projects procured by the Japanese national government between April 2003 and December 2006. The procurement process had multiple rounds. In the first round a first-price sealed-bid auction was conducted with a secret reserve price. A second round was triggered if the secret reserve price was not met in the first round. This usually occurred 30 minutes after the first round. In this second round the lowest bid from the first round is revealed, but not the identity of the winner or any other bids. A third round was triggered if the secret reserve was not met in the second round. If the third round did not result in a winning bid below the secret reserve the government entered into bilateral negotiations with the lowest bidder.

[14] In computing this number we ignore the time lags associated with moving cases through the courts. 69 cases were filed in 1981.

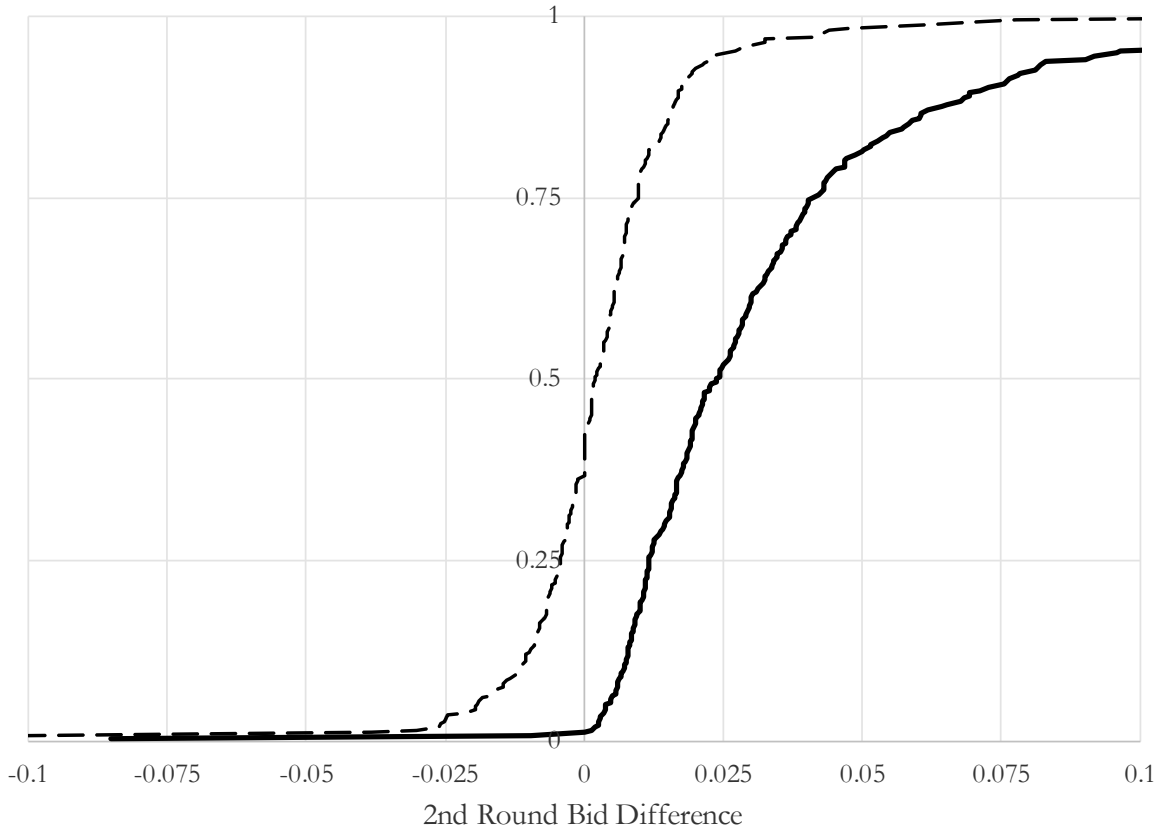
[15] Again, in computing this number we ignore the time lags associated with moving cases through the courts. 39 cases were filed in 2016.

[16] This is true even after accounting for the costs of private civil litigation following the conclusion of a DOJ investigation.

[17] For a general discussion, see Ginsburg and Cheng (2020)

[18] Related, and complementary, analysis is found in Ortner, Chassang and Nakabayashi (2020), Asai, Kawai and Nakabayashi (2018), and Chassang, Kawai, Nakabayashi and Ortner (2018).

Figure 2: Anomalous bidding patterns in Japanese procurement auctions



Notes: CDF of $b^2_{i(2)} - b^2_{i(1)}$ shown by the solid black line. CDF of $b^2_{i(3)} - b^2_{i(2)}$ shown by the dashed line. Constructed from the data underlying Figure 2 of Kawai and Nakabayashi (2020).

Kawai and Nakabayashi catalog evidence of widespread collusion by comparing the subsequent bidding behavior of the lowest , second-lowest , and third-lowest bidders in the first round (denoted $i(1)$, $i(2)$, and $i(3)$ respectively), in the event the auction goes to a second round. Let $b^2_{i(1)}$ be the second-round bid of $i(1)$. Similarly, $b^2_{i(2)}$ and $b^2_{i(3)}$ denote the second-round bids of $i(2)$ and $i(3)$. Kawai and Nakabayashi implement a series of tests that work much like a regression discontinuity. Figure 2 portrays the data underlying one such test. The figure plots the distribution functions of $b^2_{i(2)} - b^2_{i(1)}$ (solid) and $b^2_{i(3)} - b^2_{i(2)}$ (dashed) for all auctions that go to a second round. The central observation is that the distribution of $b^2_{i(2)} - b^2_{i(1)}$ is truncated at zero, whereas the distribution of $b^2_{i(3)} - b^2_{i(2)}$ is not. That is, the winner of the first round is almost always the winner of round 2, whereas the 2nd and 3rd lowest bidders in round 1 often switch order in round 2. This is consistent with the identity of the winner being decided amongst the bidders prior to the auction starting.

Kawai and Nakabayashi conduct a series of tests of this nature and present an analysis of a known cartel to empirically link this pattern to collusive conduct. They then use this approach as a diagnostic tool to infer the extent of collusion in public

procurement in Japan. Over the three and a half years of their data, 970 firms appear to engage in collusive behavior. In the researchers' own words:

> The spread of collusion that we find among construction firms may have economy-wide significance. The total value of public construction projects in Japan (which includes projects procured by both local and national governments) is about $200 billion per year, or about 4% of Japan's GDP. While our dataset accounts only for public construction projects procured at the national level, firms that we identify as uncompetitive are also active in the local procurement auctions. If we simply scale up our estimates by the size of total public construction spending, our results imply that collusive activity by construction firms affects about 0.85% of GDP, or 4% of total national investment.

This direct approach is limited by its focus on a particular line of commerce (in this case Japanese government procurement).[19] A judgment is required as to the extent to which activity in a particular sector (albeit a big one) likely mirrors activity economy wide. In this instance, one might ask whether Japan is unique, and whether public sector procurement of construction is unique. The literature suggests that the answer to both questions is 'not especially.' Decarolis and Conley (2016), for instance, examine the procurement of construction projects by Italian regional governments between 2005 and 2010. They conclude that more than 30 percent of procurements were affected by coordination among bidders. On this basis, Japan does not seem an especial outlier. Similarly, Levenstein and Suslow (2006) describe a range of cartels across a wide range of industries (mostly in the US) spanning beer, bromine, cement, coal, electrical equipment, oil, steel, sugar and tea. Hyytinen et al. (2018) take this one step further, and examine cartel activity in Finnish manufacturing from 1951-1990, a period where cartels were legal, with many being required to register. Using the resulting cartel registry, Hyytinen et al. document 900 cartels, with 364 being in manufacturing and 534 occurring in other industries. The long duration of cartels (upwards of 8 years) coupled with their observed frequency across industries in the registry data, led the authors to conclude that "by the end of the 1980s, almost all Finnish manufacturing was cartelized". While the work of Hyytinen et al. on legal cartels cannot directly speak to the prevalence of collusive activities when those are illegal, it does shed light on the *incentives* to form cartels. Hence, the findings in the literature suggest that enforcers catch only a subset of the cartels present in the economy, and that cartel activity may be large enough, in certain instances, to have aggregate impact.[20]

Complementing this direct approach to understanding the extent of cartel activity, are attempts to disentangle the confounding factors that cloud the inference that can be drawn from the enforcement activity of prosecutorial agencies like the DOJ. This is the approach taken in Miller (2009). Miller investigates the impact of a new cartel leniency program introduced by the US DOJ in 1993.[21] He infers the extent to which this policy change enhanced both the ability of the DOJ to detect cartels and the

[19] Related studies of collusion in Japanese procurement include Ishii (2009), McMillan (1991), and Ohashi (2009).

[20] See Asker et al. (2019, 2021), and Smith (2009). For a discussion of OPEC more generally, see Hamilton (2008).

[21] Many jurisdictions, including the United States and the EU, give immunity from prosecution to the first confessor from each cartel. Depending on the jurisdiction, other limited forms of immunity may exist. A

extent to which the new leniency policy deterred cartel activity. Thus, while Kawai and Nakabayahi can be thought of as trying to infer the true level of cartel activity, Miller's study is directed at understanding the extent to which the trends in Figure 1 are meaningful.

Miller constructs a model of cartel formation and dissolution in which industries' transitions between competition and collusion over time follow a stochastic first-order Markov process. The parameters governing this process are a formation rate, a detection rate, and a dissolution rate. The leniency policy change is interpreted as an innovation that changes these parameters. After the innovation shock the model converges to a new observable steady state. Two testable predictions stem from the model. First, an immediate rise in cartel discoveries suffices to establish an increase in the detection rate. Second, a convergence to a level of expected discoveries lower than the pre-merger one is sufficient to establish a decrease in the formation rate.

The data are the time series of indictments and information reports filed for violations of Section 1 of the Sherman Act between 1985 and 2005. With these data at hand, a reduced-form Poisson regression is used to estimate model parameters. The results imply that the leniency program adoption in 1993 generated a 60% increase in cartel discoveries. This increase is consistent with enhanced detection. The results, interpreted through the model, also imply a greater deterrence probability.[22]

The results underscore the value of leniency programs in both detecting and deterring cartels. They also make the important point that the level of cartel activity at any point in time is a function of policy and that changes in levels are influenced by policy. Reductions in prosecutions, like those seen in Figure 1, may, at least in part, reflect the success of past policy innovations in reducing the extent of collusive activity economy-wide.

2.2 How does collusion work?

Cartels come in a wide variety of shapes and sizes, but they do tend to share some common features. In characterizing the mechanics of how cartels work, it is helpful to have an organizing framework. To that end, consider a set of potential cartel members, $\mathcal{C}$. For each firm $i \in \mathcal{C}$ to be willing to participate, there is an "internal stability condition" (or "participation constraint") which may be written as

$$V_i^{\text{Competition}} \leq V_i^{\text{Collusion}} - F_i. \tag{1}$$

Here, $V_i^{\text{Competition}}$ denotes the firm's net present value from not participating in the cartel, $V_i^{\text{Collusion}}$ is the value from collusion, and F_i represents an irrecoverable one-time cost from joining the cartel, capturing the many frictions that make it hard for firms to organize so as to realize the benefits from coordination. The notation $V_i^{\text{Competition}}$ for the value from non-participation suggests that a cartel is established only if all of the firms in $\mathcal{C}$ participate. However, in principle, a subset of $\mathcal{C}$ may wish to proceed with forming a cartel even if some firms choose not to participate. So, more generally,

precondition of the grant of immunity is typically that the enforcement agency was previously unaware of the cartel. The precise legal institutions around the grant of leniency, and the benefits it conveys, vary by jurisdiction. See American Bar Association (2019) for a treatment. Section 2.3 contains a related discussion.

[22] For closely related work, see Harrington and Chang (2009) and Brenner (2009).

$V_i^{\text{Competition}}$ represents the net present value that firm i would achieve by choosing not to join the cartel when all the other firms in $\mathcal{C}$ choose to participate.[23]

Discussing how firms are transiting from competition to collusion, or finding a way to overcome the frictions to coordination and agree on some mutually understood coordinated action, is the focus of Section 2.2.1 on how cartels start.

In Section 2.2.2, we discuss how collusive agreements are structured, and how the surplus created by a cartel is split. In doing so, we largely ignore (self-)enforcement issues. Issues of enforcement are clearly shaped by cartel structure, and vice versa, but pushing enforcement momentarily to the background allows a discussion of the broad landscape of organizational form, prior to grappling with the self-enforcing nature of the illegal agreement that sits at the heart of most cartel activity.

When a cartel agreement cannot legally be enforced, it must be self-enforcing. No court will enforce an illegal agreement. That is, for any cartel member $i \in \mathcal{C}$, the following "no-cheating constraint" (or "incentive constraint") should hold:

$$V_i^{\text{Collusion}} \geq \pi_i^{\text{Deviation}} + \delta_i V_i^{\text{Retaliation}}, \tag{2}$$

where $\pi_i^{\text{Deviation}}$ denotes the firm's profit in the period in which it chooses to cheat on the agreement, δ_i is the firm's discount factor, and $V_i^{\text{Retaliation}}$ is the firm's continuation value after the deviation.[24]

In Section 2.2.3, we study collusion with an emphasis on such (self-)enforcement issues. Following Stigler (1964)'s seminal work, much of the literature that we discuss there is interested in identifying market conditions or business practices that make it easier (or harder) for the no-cheating constraint (2) to be satisfied.

2.2.1 How agreements start

A notorious invitation to collude was made, in 1982, by Robert Crandall, the CEO of American Airlines, in a telephone conversation with his counterpart at Braniff, a competing airline. Braniff's CEO, Howard Putnam, recorded the conversation and subsequently turned it over to the US Department of Justice. At the time American Airlines and Braniff were competing vigorously on routes out the the Dallas-Fort Worth Airport. The conversation between Crandall and Putnam included the following colorful exchange:[25]

> Crandall: I think it's dumb as hell for Christ's sake, all right, to sit here and pound the shit out of each other and neither one of us making a fucking dime.
>
> Putnam: Well –

[23] In addition, this participation constrain may change over time. As written, it would hold for the decision to join the cartel. The decision to exit a cartel is likely more subtle and would likely depend on the nature of legal penalties, leniency provisions and whether other cartels members had already left the cartel.

[24] This framework can be extended in many directions. For instance, Asmat (2020) considers dynamic considerations that are introduced when learning by doing is present and applies this to an empirical investigation of a cartel active in the DRAM industry.

[25] Extracted from the complaint filed by the US Department of Justice in *US v American Airlines and Robert Crandall*, CA 3-83-0325-D, July 12, 1985, available at `https://www.justice.gov/atr/case/us-v-american-airlines-inc-and-robert-l-crandall`. Notably, Aryal et al. (2021) present contemporary evidence of communication facilitating coordination among airlines via statements in earnings calls.

> Crandall : l mean, you know, goddamn, what the fuck is the point of it?
>
> [· · ·]
>
> Putnam: Do you have a suggestion for me?
>
> Crandall: Yes. I have a suggestion for you. Raise your goddam fares twenty percent. I'll raise mine the next morning.
>
> Putnam: Robert, we –
>
> Crandall: You'll make more money and I will too.
>
> Putnam: We can't talk about pricing.
>
> Crandall : Oh bullshit, Howard. We can talk about any goddamn thing we want to talk about.

This explicit invitation to collude solves many of the problems of forming a cartel. In this conversation, Crandall is clear as to what price points are to be coordinated on and why. The threat of continued vigorous competition in the absence of an agreement is transparent, albeit implied. Given the plethora of equilibria feasible under the supergame strategies possible in the type of structure underlying equation (2) above, Crandall supplies some helpful clarity in defining the possible cartel. By contrast, in the absence of this kind of direction, settling on a (tacit) understanding of how to coordinate pricing is likely to be much more difficult. Indeed, in a seminal contribution, Green and Porter (1984) remarked that:

> It is logically possible for this agreement to be a tacit one which arises spontaneously. Nevertheless, in view of the relative complexity of the conduct to be specified by this particular equilibrium and of the need for close coordination among its participants, it seems natural to assume here that the equilibrium arises from an explicit agreement.

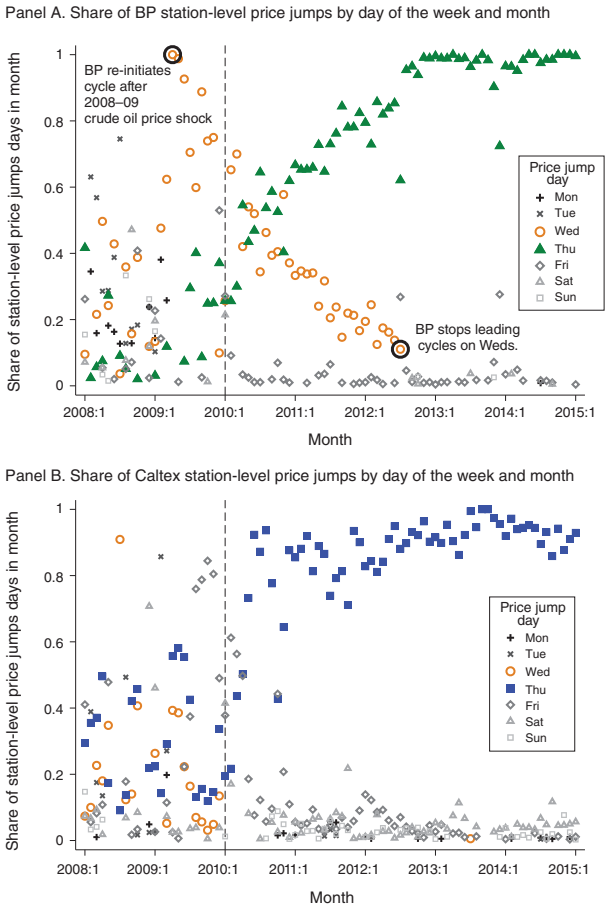
That tacit collusion can erupt spontaneously remains a somewhat unsatisfactory conjecture. While a tacit understanding may be supportable as an equilibrium, in the sense that the incentive constraint in equation (2) is satisfied, how a collection of independent firms may arrive at any specific understanding remains underdeveloped.

An important exception is Byrne and De Roos (2019). Byrne and Do Roos examine the market for petrol (gasoline) in Perth, Australia, between 2001 and 2015. Starting in 2009, and ending in 2013, one chain of stations (BP) leads the market in transitioning to a new equilibrium characterized by higher profit margins and better synchronized price adjustments.

Byrne and De Roos use data on the daily prices of petrol stations. During this time petrol stations were required to commit to prices a day ahead and post those prices to a central, government-operated website called Fuelwatch. The purpose of the Fuelwatch site was to make prices transparent, allowing consumers to better search for the cheapest gasoline. Ironically, it would appear that this greater transparency also allowed stations to effectively monitor coordination.[26]

[26]This might be viewed as government-assisted information sharing between firms. Information sharing can give rise to concerns closely related to collusion, albeit with ambiguous market impact. See, for instance, Shapiro (1986) and Gal-Or (1985) for early theoretical discussions, Kühn and Vives (1995) for related policy discussion, and Doyle and Snyder (1999) and Albaek, Møllgaard and Overgaard (1997) for empirical studies. Empirical work by Luco (2019), again on gasoline markets, and computational work by Asker et al. (2020) are examples of more recent contributions.

Figure 3: Tacit coordination via price leadership in a gasoline market (Bryne and De Roos, 2019)



Notes: Insert here.

Figure 3 shows the market interactions documented by Byrne and De Roos. Like many petrol (gasoline) markets in the world, the Perth market is characterized by sudden price jumps followed by gradual price decreases, creating periodic price cycles. Panel A of Figure 3 shows the share of BP stations that have price jumps on each day of the week. Prior to 2009 jumps occurred on a variety of days of the week. Starting in 2009 BP begins to lead pricing on Wednesday, with a high percentage of their stations engaging in price jumps on Wednesday and most of the remainder adjusting on Thursday. Caltex, the next-largest chain, gradually picks up on this pattern and by mid 2010 is following BP's Wednesday jump with a jump on Thursday (panel B). Over time BP decreases the proportion of stations that jump on Wednesday (the circles in panel A) and increases the proportion that jump on Thursday. That is, they gradually decrease the extent of price leadership (and consequently the cost from foregone sales) as the market learns to coordinate on Thursday jumps. Byrne and De Roos show several periods of experimentation by BP, in which BP stops leading on Wednesday to test whether the market is ready to coordinate on Thursday adjustments without BP

leadership. Eventually, as shown in Panels A and B together, the market is able to settle on Thursday adjustments of 2 cents per litre.

One way to distill the analysis in the Byrne and De Roos study is that market interaction itself may provide sufficient communication for coordination to be feasible. The scope for communication may be very limited, however, and the transition to coordination may be very slow.[27] As a corollary, as communication becomes more direct, and richer, the ease with which collusion can be realized might be expected to increase. Cooper and Kühn (2014) provide support for this intuition in an experimental setting. Cooper and Kühn consider a two-period game that is a reduced form of an infinitely repeated symmetric Bertrand pricing game. The first stage has payoffs mirroring a Bertrand game in which prices can be low, medium, or high. The second stage is a coordination game that has three Nash equilibria (in each, players set matching prices) with the payoff being Pareto ranked from low, to medium, to high. In stage 2, the equilibrium in which both matched subjects charge the high price generates the largest payoffs.[28] Communication was allowed in four ways, with no communication being the fifth setting (a control). The communication treatments were (*i*) simple declaratory statements prior to play, (*ii*)) as in (*i*), but also with 'if' statements, (*iii*) unrestricted chat prior to play, and (*iv*) unrestricted chat prior to play and prior to round 2. The results show that as communication becomes easier and less restricted, the ability to coordinate on a high price in period 1 dramatically increases.[29] With no communication, a high price is reached in fewer than 10% of instances. With limited communication, a high price is reached not more than 50% of the time (this probability declines to below 20% as players become more familiar with the game). As communication becomes easier and less restricted, the probability of realizing a high price increases, exceeding 80% in the least restrictive treatment.[30]

Overall, communication (at least in some limited form) is an important feature of those instances of cartel formation that economists know about. For cartels that already exist, communication continues to be central to the ability of cartels to coordinate on an ongoing basis, with many cartels engaging in a surprising amount of ongoing internal communication.[31] We unpack this observation further in Section 2.2.2, on the structure of cartels, below.

Against this broad characterization of the literature, an emerging literature on collusion via algorithms stands to expand our understanding of tacit collusion and challenge the notion that communication is a recurrent feature of cartel formation.[32]

[27]By contrast, Cabral et al. (2021) examine the German gasoline market following the introduction of price matching guarantees. They argue that this created conditions amenable to the emergence of tacit collusion, and that the transition to a collusive state was fast relative to that observed in Byrne and De Roos. For additional examples of coordination despite a limited scope for communication, see Cramton and Schwartz (2000) and Bajari and Yeo (2008) (both in auction settings).

[28]Subjects played 20 rounds of this game, with random allocation of opponents in each round.

[29]See Figure 1 of Cooper and Kühn (2014).

[30]Harrington et al. (2014) conduct a related experiment with complementary findings.

[31]This is a point underscored in recent theoretical work by Awaya and Krishna (2016), who illustrate the value of cheap talk in facilitating coordination among cartel members in settings where prices and quantities are not readily observable.

[32]It is possible that tacit collusion is not the right term here. We use the term to distinguish methods of initiating collusion that are distinct from explicit communication, of which the discussion between Crandall and Putnam at the start of this section is an example. It seems likely that a richer taxonomy would be useful.

A small number of papers have sought to explore the extent to which, when agents delegate the play of repeated pricing games to algorithms, supra-competitive pricing emerges. The algorithms vary, but can be grouped into those that are 'crude' in the sense of comprising a commitment to a specific strategy (e.g., Brown and MacKay, 2020, investigate algorithms that determine the frequency at which firms adjust their prices and, via internal optimization, by how much), and those that are 'sophisticated' in the sense of not restricting the actions of an algorithm beyond articulating a state space shaping how the algorithm 'conceptualizes' the game (e.g., Calvano et al., 2020, investigate the play of agents in a repeated Bertrand game who learn to play via a reinforcement learning algorithm).[33] Preliminary results from this line of research suggest that agents that play games via algorithms can realize outcomes generating supra-competitive pricing, in the 'crude' and 'sophisticated' lines of enquiry. This opens potentially productive lines of research informing judgements as to the general conditions under which this might be more readily achieved.[34] Assad et al. (2020) provide an empirical example in which the inferred adoption of an algorithmic approach to pricing by German gasoline retailers appears to have coincided with an increase in margins of up to 28%.

Another issue that deserves more attention is whom to invite into the cartel. The issue of who participates in a cartel has real economic content. This can be seen by considering a model in which six firms compete in a Cournot market. All firms have the same constant marginal costs of c and face an industry demand curve of $p = a - bq$. If we let $A = \frac{(a-c)^2}{b}$, it is easy to show that each firm's profits are equal to $\frac{A}{49}$. If all firms were able to collude perfectly, and split the resulting profits equally, they would each get $\frac{A}{4} \div 6 = \frac{A}{24}$. However, consider the scenario in which one of these six firms simply refused to be part of the cartel. It would still make sense for the remaining five firms to collude as they would each get $\frac{A}{9} \div 5 = \frac{A}{45} > \frac{A}{49}$, but note that now the outsider, who did not join the cartel, would enjoy profits of $\frac{A}{9}$, which is considerably more than it would get from joining a cartel that split its surplus equally.[35]

This example makes it clear that the negotiations around who is in, who is out, and who gets what, are likely to be vexed, complicated, difficult to model, and sensitive to the specific features of the market at issue. In this exemplar market, a threat to not join a cartel unless some extra payment is made is entirely credible – every firm would be happy to be the one firm that is outside the cartel. But if every firm wants special treatment, then reaching any agreement will likely be hard. Further, over time, this market will likely look very attractive to entrants, and those entrants may well prefer to be outside the cartel. Whether, and how, to bring an entrant into the cartel is obviously a difficult issue for any cartel.[36]

Work that models who enters, and who opts out of, a cartel is currently limited.

[33] We do not mean the term 'crude' in any pejorative sense, and recognize that a 'cruder' implementation may be easily implemented, and might be more empirically relevant, at least in some settings.

[34] Recent work in this area includes Salcedo (2015), Miklós-Thal and Tucker (2019), O'Connor and Wilson (2019), Hansen et al. (2020), and Asker et al. (2021). The notion that delegation to an agent can lead to supra-competitive prices has been well understood in industrial organization since at least Fershtman and Judd (1987) and Sklivas (1987).

[35] This mirrors the 'Cournot paradox' relating to mergers discussed in Salant et al. (1983) and Perry and Porter (1985), among others, and dates back informally to at least Stigler (1950).

[36] See Wiseman (2017), Morton (1997), Genesove and Mullin (2006), Heeb et al. (2009), and the discussion in Section 2.2.4 below.

Most theory papers consider cartels involving a full set of active firms, and rarely delve into the actual process of negotiating the composition of a cartel. Empirical papers, lacking direction from theory, typically take the composition of a cartel as exogenous. Bos and Harrington (2010) is a good example of that rare set of papers that do consider cartel formation among ex ante heterogenous firms. Bos and Harrington endogenize the cartel-formation process, showing that smaller firms (in the sense of having less production capacity) are more likely to remain outside the cartel, with colluding firms setting a price that serves as an umbrella, and noncartel firms pricing below it and producing at capacity.[37]

2.2.2 How agreements are structured

Our experience is that researchers who have worked on collusion quickly become entranced with the infinite variety of organizational forms that cartels adopt. No cartel is quite like another. In part this is a function of institutional features of the industry in which they operate, but it is equally a function of the idiosyncratic creativity with which they solve the myriad problems involved in coordinating action among participants to overcome that instinctive inclination to compete. As Marshall and Marx (2012) have remarked, "The successful suppression of competition is a thing of economic beauty."

Organizational beauty does not tend to arise spontaneously. Again drawing from Marshall and Marx (2012),"Successful explicit collusion requires planning, investments in administration, clear thinking, and hard work." The product of this hard work and planning is an organizational structure. This organizational structure varies widely across cartels. Despite the (extremely) wide range of organizational structures that arise in practice, a taxonomy of canonical forms has emerged that provides a useful framework for sorting through the world as we find it.

The legal and economics literatures provide a number of excellent extended discussions of the organization of cartels.[38] We provide an abbreviated exposition below, with the aim of providing a rough map of this landscape.

Price Fixing.

A price-fixing agreement is an intuitive form of cartel. Firms agree on a certain price and the market allocates customers to the firms via the usual market-clearing mechanism. Ideally the price(s) corresponds to that charged by a hypothetical (multi-product) monopolist. In the context of a demand and supply diagram, this is a simple thing.

In practice, it is rare to find a price fixing agreement that is that simple. Many firms sell many different products at many different prices, making it helpful to employ a rule of thumb approach. Consider the proposal of Crandall in the American Airlines-Braniff example in section 2.2.1. Airlines offer many different flights out of the same airport, and many prices for seats on the same flight. It is no accident that Crandall proposed that American and Braniff "[r]aise [·] fares twenty percent." This sort of rule of thumb removes the need for complicated joint planning.

[37]Related papers include Nocke (1998), Escrihuela-Villar (2008a), Escrihuela-Villar (2008b), Harrington and Chang (2009), and Bos and Harrington (2015).

[38]Marshall and Marx (2012), and Levinson and Suslow (2006) are good places to start. The many cartel determinations of the EU's DG Comp, available at `https://ec.europa.eu/competition/cartels/cases/cases.html`, which tend to be remarkably detailed, are also a valuable resource.

The coordination of petrol pricing examined in Byrne and De Roos (2019) in Section 2.2.1 is another example of the type of conduct that might be considered price fixing. In this instance coordination occurred on both the size and timing of price increases. Again, crude patterns (Thursday jumps of 2 cents per litre) arose. Crude patterns might be helpful, in that they are clear and allow deviations to be detected at possibly lower cost, but they leave the firms vulnerable to demand fluctuations that may be better dealt with through more flexible pricing. Other cartel inefficiencies can also arise.

Product differentiation, and related asymmetries in the market position of participants, can also add complications to a price-fixing agreement.[39] The core issue is how to reconcile the disparate interests and incentives of parties within the cartel in a way that preserves the returns from coordination. Clarke and Houde (2013) bring these issues to the fore in an examination of price-fixing cartels in the Canadian gasoline markets during 2005-2006, in which participants had to reconcile their highly asymmetric market positions of participants. In contrast to the Australian petrol market examined in Byrne and De Roos (2019), price coordination in this Canadian gasoline market was explicit.[40] The data are drawn from four markets in which the Candian Competition Bureau succesfully prosecuted cartels.[41] In total, 128 stations and 64 firms were active in these interrelated cartels.[42]

The problems overcome by these cartels can be understood by focusing on the Victoriaville market. Victoriaville had 25 stations in the cartel. Four belonged to the cartel leader (a Shell franchise), and two belonged to Ultramar (a vertically integrated chain that has centralized control of pricing and guarantees to provide the lowest prices in a neighborhood). Three large retail big box or grocery stores operated another 5 stores in total. The remainder were owned by small operators. The Ultramar and the big box stores tended to have larger stations, Ultramar had lower costs, and the big-box stores had an incentive to price low to attract customers to their stores. Some of the smaller operators also had a meaningful competitive presence.

Clark and Houde draw on documentation prepared by the Canadian Competition Bureau (CCB) in the course of investigating and prosecuting this cartel. Among other things, this contained detailed information relating to wiretaps that the CCB used to collect information on the cartel. Clark and Houde report that the cartel typically worked by the leader communicating with a subset of the cartel to decide on a new price to set for the next week or two, and a time at which to raise the price to that level (t_0).[43] Once an agreement was reached among this group, the leader would reach out to Ultramar and the big-box retailers and propose a time ($t_1 > t_0$) at which these large conspirators were supposed to increase their prices. The interval between t_0 and t_1 varied from less than 30 minutes to up to 5 hours. Following agreement on the price and the delay in implementation that applied to the large firms, the leader would

[39] On the added complication of price fixing with asymmetric participants see Harrington (1991) and, more recently, Miklós-Thal (2011). Note that in some theoretical environments greater product differentiation may make it easier to sustain collusion. See, for instance, Chang (1991) on collusion in a Hotelling-style model.

[40] The reader may well remark on the apparent attractiveness of gasoline (petrol) markets for studying price coordination. We suspect data availability may be at least part of the story.

[41] The markets were the cities of Victoriaville, Thetford Mines, Sherbrooke, and Magog in Quebec.

[42] Cartel activity in these four cities was prosecuted in a single case brought by the CCB.

[43] The length of time that price levels was sustained before a new round of coordination was needed appears to vary.

directly, or via proxies, reach out to other market participants to announce the coming price increase.

At least two features of this way of organizing the cartel are notable. First, larger conspirators (Ultramar and the big-box stores) are allowed to delay price increases. The purpose of this delay is to transfer rents to them. Effectively, the delay allows the market to transfer a form of side-payment to these firms. In this way, the asymmetry between the cartel participants is accommodated and the distribution of cartel rents is adjusted to keep them content. A practical implication of this is that side-payments between cartel members need not take the form of literal transfers of cash, but can be synthesized via appropriate coordination of the market operations of the cartel members.

Second, this cartel engaged in a lot of communication. On average, coordination on a price increase involved 65 phone calls between the cartel members.[44] Coordination on price decreases, on average, involved 26 phone calls. Communication was central to the successful operation of this price fixing conspiracy.

The explicit coordination on prices cataloged by Clark and Houde (2013) contrasts with the care taken by the Sugar Institute, between 1927 and 1936, to collude on everything but prices, as described by Genesove and Mullin (2001). A striking intensity of communication between cartel participants is a shared feature of the cartels described in Clark and Houde and Genesove and Mullin. In almost every other respect, one could not find more different price-fixing conspiracies. The Sugar Institute was established in 1927 by the 14 major sugar refiners in the United States. The members of the organization met weekly. The focus of the organization was to formulate and enforce rules that had the effect of standardizing the sale and distribution of sugar across its members. Genesove and Mullin study the notes of a cartel member's representative at the organization's meetings, and supplement them with attention to the prosecution of the cartel by the US Department of Justice. The US Supreme Court found, in 1936, that the Sugar Institute's practices violated antitrust laws.

Genesove and Mullin (2001) describe the Sugar Institute's system as "combin[ing] implicit collusion on price with explicit collusion on business practices. The latter complemented the former – the ultimate goal – by making price cuts more transparent." The organization had extensive rules about the minutiae of trading in sugar. For instance, it prohibited discounts for the sale of water-damaged or frozen sugar without "full details of amount, location, reason and price to be circulated by the Institute." Similarly, it prohibited allowing customers to take delivery after contracted delivery dates. Both of these rules had the effect of limiting the ability to engage in secret price cuts - undamaged sugar could not be easily booked as damaged to cover a discount made to a preferred customer; similarly, delayed delivery (to reduce a customer's inventory costs) could not be made in lieu of a discount. These rules, and the rigorous policing of them, created a forceful backdrop of facilitating practices that made it easy for underlying industry norms around cooperative pricing to persist. The Institute also had a formal grievance process that allowed members to bring concerted action against members that violated the Institute's rules. One wonders whether discussions of pricing occurred at the Sugar Institute's meetings. If so, they were never recorded. Nonetheless, the Sugar Institute's rules effect, and their clear purpose, was to facilitate coordination on pricing. The Sugar Institute example indicates that in some instances,

[44]Typically all this communication occurred on the same day as the t_0 price increase.

finding the price on which to coordinate is less of a problem than removing the incentive of conspirators to deviate. In this case, the effort of the cartel appears to have been directed at policing deviations, as opposed to selecting a price to coordinate on.

The Sugar Institute did not arise spontaneously. It was merely one of a series of incarnations of cartel activity in the sugar industry. Sugar refiners had been coordinating, with varying degrees of success and regulatory intervention, in North America since at least 1887. See Genesove and Mullin (2006) for more on the US sugar markets, and Asker and Hemphill (2020) for coordination in the Canadian markets.

Quantity Setting.

Quantity setting, in a simple model, would amount to firms agreeing on how much to sell, rather than the price to sell it. If the product is homogeneous, it amounts to much the same thing, but allows the division of surplus among the cartel to be controlled with precision, rather than being left to the will of the market-clearing mechanism. In this sense, quantity-setting arrangements are a better way to keep co-conspirators content. It is perhaps unsurprising then that, at least in cartels in commodity markets, quantity-setting arrangements are very common.[45]

Unsurprisingly, the exact implementation of quantity setting varies across cartels. Broadly, agreements tend to refer to specific quantities or market shares. For example, in the Lysine cartel firms were assigned output levels, and a sales quota scheme was implemented in the citric acid cartel (see Harrington and Skrzypacz, 2011, Connor, 2001, and Levenstein and Suslow, 2006). Where output levels are assigned, they are often set with reference to historical market shares (see the study of the international coffee cartel by Igami (2015). That said, the production assigned to cartel members can also be the result of heated arguments and negotiations.[46] Other notable quantity setting cartels that have been examined in the literature include OPEC (see Asker et al., 2019 and 2021), the Norwegian cement cartel examined by Röller and Steen (2006) and the German cement cartel examined by Harrington et al. (2015).

A striking feature of many cartels that use some form of quantity setting is the length to which they go to verify that set quantities are adhered to. In some instances, this extends to retaining external consultants to both coordinate activity and conduct independent audits on production. A notable example of such a facilitator is AC-Treuhand, a Swiss-based consultancy that came to the attention of regulators during the course of various cartel investigations related to the European chemical industry and was ultimately prosecuted in relation to services it provided to the heat-stabilizers cartel.[47]

Market Division.

A market division scheme is, in principle, a simple thing. In the abstract, a specific geographic territory is given to each co-conspirator and the conspirators agree to not sell into the territory of a co-conspirator. Beyond that, in their own territory, each conspirator can do as they wish. At this level of abstraction, market division schemes have an attractive simplicity. In practice, implementations of market division schemes

[45]Quantity-setting schemes are often referred to under the broad umbrella label of price fixing. This is less a comment on the underlying economics than on the fluidity of terminology in describing cartels.

[46]See the DOJ surveillance footage collected during the Lysine cartel investigation available at `https://www.youtube.com/watch?v=ytNI56yzbQg&ab_channel=naserimperial` (youtube: "Lysine Cartel 6").

[47]See Case C-194/14 P, *AC Treuhand v Commission*, ECLI:EU:C:2015:717

range from the simple to the much more complicated.[48] The first point of complication relates to what, exactly, is divided between the conspirators. Markets may be divided on the basis of geography, customer, or even time.[49]

In addition, it is not uncommon to see market division schemes combined with other organizational forms.[50] A good example is the German cement cartel that operated from at least 1991 to February 2002. Harrington et al. (2015) study this cartel and its ultimate collapse.[51] This cartel involved the six largest cement companies in Germany, with a combined share of 86%. The cartel divided Germany into four regional sub-cartels, with membership in these sub-cartels based on the location of each member's production plants. Within these market divisions, the sub-cartels operated using sales quotas. Compliance monitoring was facilitated by the industry trade association.[52] Harrington et al. (2015) show that when this cartel structure fell apart, prices dropped by at least 20%, suggesting that this was likely a reasonably successful cartel structure.[53]

Bid Rigging.

Bid rigging is a generic term that is applied to cartel activity that occurs in an auction setting. Auctions are a distinct environment in that, often, only one bidder can win. Hence, deviations from cartel activity are easy to detect, in that if the wrong conspirator wins the auction, someone must have deviated. Because of the structured nature of auction markets, bidding rings can be quite intricate. Following McAfee and McMillan (1992), it is helpful to subdivide bidding rings into those that employ side-payments and those that do not.

A famous example of a bidding ring that did not use side-payments was the 'Great Electrical Conspiracy' of the 1950s.[54] This conspiracy actually involved collusion in many product markets that collectively comprised the heavy electrical equipment industry. Baker and Faulkner describe the conspiracy as involving as many as 40 manufacturers and 20 separate product lines. The specific conspiracy in the switchgear market is perhaps the most famous. Switchgear is essential, standardized, equipment in managing electrical transmission. At trial, General Electric's general manager of low-voltage switchgear testified that the senior management of the conspirators would meet to set the cartel's policy, and then delegate the operation of the cartel to lower-

[48] *United States v. Topco Assocs., Inc.*, 405 U.S. 596 (1972) is a good example of a relatively simple geographic market division.

[49] For an example of a customer division that overlaps with bid rigging, see Asker (2010b)'s study of maritime shipping. For an example of a conspiracy that can be framed as a time-based market division, see Hemphill (2006).

[50] This is not peculiar to market division; often organizational forms combine multiple elements of price fixing, quantity setting, market division and, where auctions are used in the market, bid rigging.

[51] The cartel fell apart following over-investment in capacity by Readymix, a large co-conspirator, and the subsequent cheating that this over-investment enabled.

[52] The role of trade associations in facilitating collusive activity is also emphasized by Ale-Chilet and Atal (2020) in the context of the provision of gynecological services.

[53] A roughly 20% overcharge is unremarkable when compared to other cartels (see Section 2.4). Similarly, this market division based cartel structure does not, at a high level, appear particularly unusual. Marshall and Marx (2008) review 20 cartel decisions of the European Commission and find that almost all of them feature either customer, geographic, and/or market-share allocation.

[54] See Smith (1961a, 1961b) and Baker and Faulkner (1993) for detailed histories. Watkins (1961) gives an overview of the related litigation. Baker and Faulkner note that the heavy electrical equipment industry had a history of collusion dating back to the 1880s.

level managers. These lower-level managers would meet and communicate frequently. It was this lower-level 'working group' that invented the notorious 'phases-of-the-moon' system of bid rotation for which this cartel is primarily remembered.[55] This bid rotation system was based on rotating the position of each conspirator every two weeks, with different bidders being allocated different pricing levels to ensure both that the correct bidder won each auction and that the bids of other bidders gave the impression of competition. A detailed code system was devised and used in the documents ('phase-of-the-moon' charts) that the cartel used to coordinate who should bid what and when.

McAfee and McMillan (1992) show, in the context of first-price sealed bid auctions, that a bid rotation scheme (like that observed in the 'Great Electrical Conspiracy') achieves the best outcome possible for a cartel absent side-payments between the conspirators. When the possibility of side-payments is added, a bidding ring can further improve its returns from coordination.

A good example of a bidding ring that made extensive use of side-payments is the stamp cartel described in Asker (2010a). Asker (2010a) describes a bidding ring occurring in the North American market for collectable postage stamps in the 1980s and 1990s.[56] This ring was active in auctions for stamps sold at a set of auction houses, mainly in New York, that specialized in the sale of collectables. The auction houses used ascending price auctions. The members of the ring were only a subset of the bidders that competed for these stamps.

Of particular note is the internal mechanism this ring used to coordinate activity. It provides a canonical example of how a ring operationalizes the use of side-payments via an internal auction or 'knockout' to coordinate bidding.[57] Ring members (located mostly in New York) would send a fax or supply a written bid to an agent (a New York taxi and limousine driver employed by the ring), indicating the lots in which they were interested, and what they were willing to bid for them in the knockout auction. The taxi driver would then collate all the bids, determine the winner of each lot, notify the ring as to the winners in the knockout and send the bids to another ring member who would coordinate the side-payments after the target auction was concluded. Depending on who actually won the knockout, the taxi driver would, usually, either bid for the winner in the target auction, using the bid supplied in that auction as the upper limit, or organize for another auction agent to bid for the winner on the same basis. In the language of auction theory, the knockout was conducted using a sealed-bid format, with the winning bidder getting the right to own the lot should it be won by the ring in the target auction. The winning bid in the knockout set the stopping point for the ring's bidding in the target auction (recalling that the target was an English auction). Since bidding in the target auction was handled by the ring's agent, monitoring compliance with this policy was straightforward.

Sidepayments were used by the ring to compensate ring members for not competing

[55]Kuhlman (1968) contains, and explains, an example of the specific 'phase-of-the-moon' charts that the cartel used to coordinate bidding. The details of the scheme make it clear that the implementation was designed to maintain agreed upon market shares when aggregated over auctions.

[56]Other well-known studies of bidding rings include Pesendorfer (2000), Porter and Zona (1993), and Porter and Zona (1999).

[57]The mechanism was described theoretically by Graham et al. (1990). A strategically equivalent mechanism is discussed in Porter (1992). A characterization of the optimal mechanism under fairly general conditions is provided by Mailath and Zemsky (1991).

for a lot when the ring was successful in winning that lot. The determination of side-payments is explained using the example in Figure 4

Figure 4: Side-payments from a successful acquisition in a target auction, Sotheby's, June 24, 1997, Lot 49 (Asker, 2010a)

Knockout auction	Bid ($)	Sidepayment
Bidder A	9,000	$-\left(\frac{7{,}500-6{,}750}{2}\right)-\left(\frac{8{,}000-7{,}500}{2}\right)=-625$
Bidder G	8,000	$+\left(\frac{7{,}500-6{,}750}{2}\right)\times\frac{1}{2}+\left(\frac{8{,}000-7{,}500}{2}\right)=437.50$
Bidder B	7,500	$+\left(\frac{7{,}500-6{,}750}{2}\right)\times\frac{1}{2}=187.50$
Bidder J	5,100	0
Target auction price	6,750	

Notes: The stamps were purchased at the target auction (Sotheby's) for $6,750.

In Figure 4, the winner of the knockout auction was bidder A, who bid $9,000. The ring was successful in the target auction, winning the lot for $6,750. Since bidder J bid only $5,100 in the knockout auction, he was not eligible for a sidepayment since his bid in the knockout was less than the target auction price. Bidders B and G bid more than the target auction price, and so both are eligible for a sidepayment. The computation begins with bidder B's bid of $7,500. The difference between $7,500 and the target auction price is $750. The knockout winner, bidder A, keeps half this amount. The other half is split equally between bidders B and G, resulting in each getting $187.50. This is the only sidepayment bidder B gets. Bidder G bid higher than bidder B and so is eligible for a further payment. The winner of the knockout, bidder A, keeps half the increment between bidder G's bid and bidder B's bid and gives the balance, $250, to bidder G.

Thus, the side-payments involve ring members sharing each increment between bids, provided that their bids are above the target auction price. Half the increment is kept by the winner of the knockout, and the balance is shared equally between those bidders who bid equal to or more than the 'incremental' bid. The side-payments were aggregated and settled on a quarterly basis.[58]

The evidence on the enforcement of the ring's rules is limited. During the early years of the ring, at least two members were ejected, one for not meeting his financial obligations and another for being felt to be interested only in collecting side-payments.

[58]Prior to the late 1980s, the ring used a slightly different variant of this side-payment system. The difference was that each increment was split equally among all eligible bidders. So, in the above example, the $750 increment between the target auction price and bidder B's bid would have been shared three ways, with the winner, bidder G and bidder B, getting $250 each. This is the same as if they treated the bids as true willingness to pay and gave each ring member his imputed Shapley value (Graham and Marshall (1987) make this point in their theoretical discussion of nested knockouts). That said, it is also clear that ring members were not averse to bickering amongst themselves.

The records of the case indicate that deviant bidding behavior that did not comply with the rules of the ring was either not a problem or not detected by the ring. For instance, there is no suggestion of members bidding and losing in the knockout and then participating in the target auction anyway. Similarly, there is no record of people getting temporarily suspended from ring membership. Instead, all accounts agree that the ring was very stable over the 15 or so years it operated.[59]

This structure gave rise to an incentive for ring members to overbid in the knockout auction. That is, since side-payments increased in a bidder's bid, if the bidder lost the knockout, Asker (2010a) argues that there was an incentive to bid higher than their true valuation in the knockout auction.[60]

This overbidding occasionally benefited the seller by driving up prices, but it imposed damages on non-ring bidders and caused misallocation and, hence, inefficiency. Non-ring bidders suffered damages either by having their prices artificially inflated or by failing to obtain an object that they would have won in a truly competitive bidding environment. The structural model used by Asker (leveraging a minor adaptation of the Guerre et al. (2000) approach to recovering the primitives of an auction model from data) suggests that damages to other bidders were at least as large as the damages to the seller. Interestingly, while efficiency was reduced by the ring's activity, the decrease was not economically significant, at least as compared to the impact of a change in participation.[61]

One might ask where this cartel form came from. The record indicates that it was imported to North America by the cartel's founder, who was a member of a similar cartel in Europe. The European cartel appears to have resulted from a slow evolution of cartel forms over the course of at least two hundred or so years. The historical record indicates that related cartels were active in markets for collectables and art in European markets, likely since those markets first emerged.[62]

Other organizational forms.

The basic typology of price fixing, quantity setting, market division, and bid rigging is hardly exhaustive. As has already been noted, some cartels arguably combine elements of several of these archetype forms. Others are difficult to fit any classification. The decisions of judges in the cartel cases that reach appellate courts can provide good examples of cartel-like arrangements that are difficult to classify.[63] Similarly difficult to classify can be coordinated activity that is explicitly exempt from antitrust

[59]In this setting equilibrium knockout bids exceed values, and if cartel members are ex ante symmetric (i.e., have the same value distributions), then there should be no concern about defections of the form of bidding and losing in the knockout auction and then bidding in the target auction. The target auction is an English auction, and so bidding above the winning knockout bid cannot be a profitable strategy when the internal cartel allocation is efficient. When bidders are asymmetric, as appeared to be the case in this instance, the knockout auction may not be efficient, leading to this reasoning breaking down.

[60]Asker (2010a) uses an IPV framework to model the auction.

[61]In a comforting sanity check, it was found that the ring, while occasionally hurting itself by overbidding, did benefit from coordinating bidding efforts.

[62]Freeman and Freeman (1990) provide a detailed account of a related ring in rare books, and give an account of the broader history of cartel activity in European art, book, and collectables markets.

[63]The fact pattern in *United States v. Apple Inc.*, 952 F. Supp. 2d 638 (S.D.N.Y. 2013) is a good example. In this matter Apple coordinated a form of wholesale price conspiracy among publishers to effectively reduce the competitive pressure that Apple e-books would experience from Amazon e-books and, as a quid-pro-quo, also allow publishers of e-books to make more money.

review or even attracts explicit government assistance (the role of the Federal Maritime Commission in enforcing shipping conference agreements in the 20th century being a notable example).[64]

Overarching themes.

The many organizational structures of cartels can often be understood as being shaped by the institutional features of the co-conspirators' market and the need to solve a series of problems. McAfee and McMillan (1992) describe cartels as solving at least four problems. First, the conspirators must devise some mechanism for dividing the spoils. Second, an agreement is worthless without some means to enforce it. Third, the high profits earned in a successfully colluding industry attracts entrants. Competition from these entrants undermines the efficacy of the cartel. Fourth, the victims of the cartel, and by extension enforcement agencies, may take action to destabilize it. Much of what has been discussed above is primarily about how the cartel distributed the profits. This seems the primary way that cartels can be easily classified. (We turn to questions of enforcement, entry deterrence, and detection in the sections that immediately follow).

Every cartel faces something of a trade-off in how they approach solving these four problems. Good solutions tend to require greater degrees of coordination, and yield greater returns to cartel activity in the first place. But greater coordination tends to require greater communication, which adds to the trail of evidence that may ultimately cause the cartel to end up in court. The precise balance of these factors that any cartel settles on is usually a function of their institutional setting and the personalities involved.

That said, across the heterogeneity of cartel forms, a relatively common feature, empirically, of coordinated activity that seems uncontroversially anti-competitive is communication. Even when communication is obscure and limited (as in the petrol market studied by Byrne and De Roos, 2019), communication can be observed to have occurred. In more explicit cartels, like the gasoline example studied by Clarke and Houde (2013), the sugar example of Gensove and Mullin (2001), or the bidding ring examined by Asker (2010a), the intensity of communication required to make the conspiracy work is significant.

2.2.3 How agreements are enforced

As price fixing and other cartel agreements are generally illegal in most countries, these agreements must be self-enforceable to be effective. Typically this requires that the threat of future punishment must make a unilateral deviation unprofitable.

The literature on the self enforcement of agreements, centered around an infinitely repeated game, is vast.[65] Here we begin by presenting a version of a repeated game with imperfect public monitoring.[66] This model represents the simplest framework, of which we are aware, that unifies many of the intuitions found in the literature. These intuitions are reflected in many influential policy statements discussing the 'plus' factors that contribute to creating environments that facilitate collusion among firms.[67]

[64]See Clyde and Reitzes (1995) for a description of the FMC and its role in shipping conferences.
[65]See Mailath and Samuelson (2006) for a textbook treatment.
[66]This is an extension of the basic repeated game framework sketched at the start of Section 2.2.
[67]See, for instance, Section 7.2 of the 2010 Horizontal Merger Guidelines (DOJ and FTC 2010) in the

To fix ideas, consider a homogeneous-goods industry with n symmetric firms, each having constant unit cost c, and competing in a Bertrand fashion.[68] Time is discrete, and indexed by $t = 1, 2, ...$ Market demand in period t is stochastic and serially uncorrelated; it is given by $\theta_t D(p_t)$, where $\theta_t = 0$ with probability β and $\theta_t = 1$ otherwise. Assume that $(p-c)D(p)$ has a unique maximizer, the monopoly price p^m. Let $\pi^m \equiv (1-\beta)(p^m - c)D(p^m)$ denote the expected monopoly profit. Firms discount profits at factor δ.

We are interested in the conditions under which industry participants can jointly sustain the monopoly outcome through the threat of an infinite "Nash reversion" (where all firms charge a price equal to marginal cost, resulting in zero profit) in case of a deviation.

Suppose that firms never observe the realized demand state θ_t, either before setting prices nor afterwards, and also never observe rival prices. Instead, assume that at the beginning of each period (before prices are set), there is a public signal s_t which takes the value of one if (i) in the previous period $t-1$, at least one firm set a price below p^m or (ii) with probability α if last period's demand state was low ($\theta_{t-1} = 0$) and all firms charged at least p^m, and takes the value of zero otherwise. That is, if $\alpha\beta = 0$, then the realized public signal $s_t = 1$ is perfectly informative of a deviation in the last period; if, however, $\alpha\beta > 0$, the signal is noisy as the realization $s_t = 1$ may also be due to low demand. We assume that $\alpha\beta$ is sufficiently small: $\alpha\beta < 1/n$. For expositional simplicity, suppose also that at the beginning of each period t, there is a public random variable, r_t, uniformly distributed on $[0, 1]$.

Consider now the following strategy profile, $\sigma^m(\rho)$. In $t = 1$, each firm charges the monopoly price p^m (thereby splitting the monopoly profit equally). In any subsequent period $t' \geq 2$, each firm continues to charge p^m *unless* there is a period $t'' \leq t'$ such that $s_{t''} = 1$ and $r_{t''} \leq \rho$, in which case each firm charges the static Nash equilibrium price c. That is, the signal realization $s_t = 1$ triggers an infinite Nash reversion with probability ρ. Once the infinite Nash reversion has been triggered, each firm's continuation value is equal to zero. Before it has been triggered it is

$$\begin{aligned} V(\rho) =& \frac{\pi^m}{n} + \delta(1 - \alpha\beta\rho)V(\rho) \\ =& \frac{\pi^m}{n[1 - \delta(1 - \alpha\beta\rho)]}, \end{aligned}$$

where $\alpha\beta\rho$ is the on-path probability of reverting to the static Nash equilibrium in the next period. If a firm were instead to deviate once and just undercut its rivals, its value would be equal to

$$V^{\text{dev}}(\rho) = \pi^m + \delta(1 - \rho)V(\rho)$$

as the punishment probability is equal to ρ.

The strategy profile $\sigma^m(\rho)$ forms a perfect public equilibrium (PPE) if and only if the no-cheating constraint $V(\rho) \geq V^{\text{dev}}(\rho)$ is satisfied. If $\sigma^m(\rho)$ forms an equilibrium, then so does $\sigma^m(\rho')$ for any $\rho' \geq \rho$. Hence, the critical discount factor, $\underline{\delta}$, above which collusion in $t = 1$ can be sustained is the value of δ at which $V(1) = V^{\text{dev}}(1)$; it is given

United States.

[68] The following model is inspired by Green and Porter (1984); see also Tirole (1988).

by

$$\underline{\delta} = \frac{n-1}{n(1-\alpha\beta)}. \tag{3}$$

If $\delta \geq \underline{\delta}$, the best equilibrium for the firms (and worst for consumers) minimizes the punishment probability ρ subject to the no-cheating constraint $V(\rho) \geq V^{\text{dev}}(\rho)$. The solution equals

$$\rho^* = \frac{1-\delta}{\delta} \times \frac{n-1}{1-\alpha\beta n}. \tag{4}$$

In the best PPE, the per-period value of each firm, $v^* \equiv (1-\delta)V(\rho^*)$, is thus equal to

$$v^* = \left(\frac{1-\alpha\beta n}{1-\alpha\beta}\right)\frac{\pi^m}{n}. \tag{5}$$

(If $\delta < \underline{\delta}$, collusion cannot be sustained and each firm gets its minmax value of zero in any equilibrium.)

In the limiting case of perfect monitoring ($\alpha = 0$), the critical discount factor takes the familiar textbook form $\underline{\delta} = (n-1)/n$ and each firm's per-period value becomes $v^* = \pi^m/n$. Under perfect monitoring, either the "true" discount factor δ is below the critical level, in which case only the per-period value of $v^* = 0$ can be sustained (namely, through the infinite repetition of the static equilibrium), or it is above the critical level, in which case even the monopoly outcome can be sustained in each and every period. When studying the market conditions or business practices that facilitate collusion, most of the IO literature has therefore focused on the comparative statics of the critical discount factor. In the simple model sketched above, for instance, $\underline{\delta}$ is positively related to n. In that sense, an increase in the number of firms makes collusion harder to sustain. However, if the true discount factor is "far away" from its critical level, then a small change in the number of firms has no effect on collusion possibilities. For policy analysis, this can be viewed as a shortcoming of collusion models with perfect monitoring.

By contrast, with imperfect monitoring and uncertain demand ($\alpha\beta > 0$), collusion possibilities may vary from one market to the other even when the discount factor is arbitrarily large as the fraction of time the industry spends in the "collusive state" (in which the monopoly price is charged) varies with parameters (here, with n, α, and β).

Since Stigler (1964)'s seminal paper, the notion that collusion is more likely in markets where prices (and deviations) are more transparent has long been one of the key tenets of antitrust economists. For instance, the current (2010) US Horizontal Merger Guidelines state: "A market typically is more vulnerable to coordinated conduct if each competitively important firm's significant competitive initiatives can be promptly and confidently observed by that firm's rivals." We can see this point in the simple model of collusion with imperfect monitoring sketched above: from equations (3) – (5), a decrease in the value of α – that is, a better observability of deviations – not only reduces the critical discount factor $\underline{\delta}$ but also increases the per-period value of each firm in the best PPE, v^*, by reducing the on-path punishment probability ρ^*. In recent work, however, Sugaya and Wolitzky (2018) point out that some forms of increased transparency may actually hinder collusion, namely when "[m]ore information lets individual firms tailor deviations to current market conditions."[69]

[69]To fix ideas, consider the example of collusion involving the assignment of exclusive territories in a world

Another old idea is that collusion is easier to sustain if firms interact in many markets, rather than just a single market. Bernheim and Whinston (1990) analyze such multimarket contact in a repeated game with perfect monitoring. Under multimarket contact, a deviator in *one* market is punished in *all* markets. With perfect monitoring, a firm that contemplates a deviation therefore optimally deviates in all markets (or none). More formally, if markets are treated as being strategically independent, then to sustain collusion in each of k markets there must be a separate no-cheating constraint for each firm and each market. By contrast, under multimarket contact, each firm's no-cheating constraints from the k markets are pooled, which tends to make it easier to satisfy them (e.g., by using slack from one market to relax the constraint in another).

However, as shown by Bernheim and Whinston (1990), in symmetric and independent Bertrand markets with constant returns to scale (and perfect monitoring), an irrelevance result obtains. This can be seen from our analysis above, assuming $\alpha\beta = 0$: under multimarket contact, the short-run gain from deviating in a single market, $\pi^m - \pi^m/n$, and the long-run loss from foregone collusion, δV, are both multiplied by k, so that the critical discount factor, $\underline{\delta}$, as well as the per-period value of each firm in each market, v^*, are independent of k.

Multimarket contact becomes relevant when markets are asymmetric or firms are heterogeneous, or both. For example, suppose that there are $k = n$ markets. In each market the same set of firms compete in a Bertrand fashion. Suppose also that the only difference between the markets/firms is that each firm has a distinct home market in which it has low marginal cost, c_L, whereas all other firms have high marginal costs, $c_H > c_L$, in that market. Suppose also that $c_H - c_L$ is sufficiently small so that the unconstrained monopoly price with low marginal cost, $p^m(c_L)$, is larger than c_H. Under these assumptions, "efficient collusion" (each firm serving only its home market and pricing at $p^m(c_L)$) could not be supported as an equilibrium outcome, no matter how large the discount factor, if these markets are strategically independent. By contrast, with multimarket contact, the efficient monopoly outcome could be supported for $\delta \geq (n-1)/n$.

Under imperfect monitoring, multimarket contact can help sustain collusion even when markets are symmetric (Matsushima, 2001). To see this, let $s_t^i \in \{0, 1\}$ denote the period-t signal in market $1 \leq i \leq k$. Suppose that the transition from the best PPE (where each firm charges p^m in each of the k markets) to the worst PPE (with marginal cost pricing in each market) occurs only, with probability ρ_k, following the event in which the signal $s_t^i = 1$ in each market i. (For δ sufficiently close to one, this is indeed optimal.) Before this transition occurs, the per-market value of each firm is thus equal to

$$V(\rho_k) = \frac{\pi^m}{n[1 - \delta + \delta(\alpha\beta)^k \rho_k]}.$$

Despite symmetry, there are now k incentive constraints as each firm can decide to deviate in any number $1 \leq l \leq k$ of markets. It turns out, however, that for δ sufficiently large, the binding constraint is the one with respect to deviating in a single market. The value (averaged across the k markets) from the optimal one-shot deviation

where costs are stochastic. If increased transparency would mean that a deviant cartel member would know better in advance what its costs would be if it were to enter a territory assigned to another cartel member, the deviation could be targeted to the event in which its cost is low (and its deviation profit high), thereby making collusion harder to sustain.

in a single market equals

$$V_1^{\text{dev}}(\rho_k) = \left[\frac{n}{k} + \frac{k-1}{k}\right]\frac{\pi^m}{n} + \delta\left[1 - (\alpha\beta)^{k-1}\rho_k\right]V(\rho_k).$$

In the best PPE, for δ large, ρ_k is such that $V(\rho_k) = V_1^{\text{dev}}(\rho_k)$, i.e.,

$$\rho_k = \frac{1-\delta}{\delta} \cdot \frac{n-1}{(\alpha\beta)^{k-1}[k-(k-1+n)\alpha\beta]}.$$

The resulting per-period value (averaged across markets) is thus given by

$$v^* = \frac{k-(k-1+n)\alpha\beta}{(1-\alpha\beta)k} \cdot \frac{\pi^m}{n}.$$

Note that v^* is strictly increasing in the number of markets, k, and converges to π^m/n as k becomes large. Even though the signal realizations are independent across markets and firms can choose in which market(s) to deviate, multimarket contact is beneficial for collusion as it gives rise to an "informativeness effect" (Nocke and Strausz, 2020): pooling such signals allows the firms to focus the punishment on the event in which the signal realization in a sufficiently large number of markets (for large δ: in all markets) is equal to one.

There are quite a few empirical studies documenting a positive relationship between the level of prices and measures of multimarket contact in various industries. For instance, Evans and Kessides (1994) show that airline fares are higher on routes and in periods with a larger number of "average route contacts," controlling for route characteristics and including firm, time, and route fixed effects.[70] One concern with the interpretation of this correlation is that multimarket contact is endogenous. Ciliberto and Williams (2014) take an instrumental variable approach (using data on the number of gates that airlines control at airports) and confirm the finding of Evans and Kessides (1994).[71]

When firms have private information not only about their own actions but also about their costs (or some other payoff-relevant characteristics), another issue arises for a cartel. Productive efficiency requires that a firm with lower (marginal) costs produces a larger share of the cartel output. In the absence of side payments, this would provide cartel members with an incentive to claim that they have low costs even when they do not. In an infinitely-repeated Bertrand game in which firms' (constant) marginal costs are i.i.d., both across firms as well as over time, and all consumers have the same willingness-to-pay p^m, Athey et al. (2004) show that the best symmetric collusive scheme takes an extreme form: all firms' charge the monopoly price p^m, no matter what their marginal cost realization, and thus share the monopoly profit equally in every period. That is, the cartel gives up on efficiency and focuses instead entirely on rent extraction. In a (simpler) model with only two firms and two possible cost realizations, Athey and Bagwell (2001) allow for asymmetric schemes and show that

[70] Suppose a given route is served in a given period by three airlines. Suppose that these three airlines compete in that year on 40, 60, and 110 routes, respectively. Then, the average route contact on that route and year is equal to $(40 + 60 + 110)/3 = 70$.

[71] The validity of their approach rests on the assumption that the number of slots that an airline controls at an airport is correlated with the decision to serve a route linking that airport but that this number cannot easily be adjusted.

productive efficiency and rent extraction can sometimes both be perfectly achieved for sufficiently large discount factors. Key to this result is that continuation payoffs can serve the role of side payments: a firm demanding a larger share of the collusive pie today has to give up some of its continuation payoffs in return.

2.2.4 Cartels and the threat of entry

As noted in McAfee and McMillian (1990), a collusive agreement that results in high prices will likely attract competition. The cartel's high prices may come at the cost of providing outsiders with an incentive to enter the profitable, cartelized market.[72] In response, cartel members will need to decide whether, and how, to respond to this threat of entry. One option open to the cartel is to engage in coordinated predation by starting (or threatening to start) a price war upon entry. The resulting predatory conduct supports the cartel by deterring entry. In this sense, predation and collusion are complements. By contrast, collusion and predation may be substitutes in that a ("strong") firm (or set of firms) may achieve supra-competitive profits either by colluding or by engaging in a price war and driving out its weaker rivals.

Wiseman (2017) analyzes a model in which predation and collusion are substitutes. Wiseman examines an infinite-horizon stochastic game (with perfect monitoring): each firm's state, representing its financial strength, follows a Markov process in which the transition probabilities depend on the firm's profit in the current period. A firm's state does not affect its contemporaneous profit but if it is sufficiently bad, the firm has to exit. Wiseman (2017) shows that if entry is not possible, and some other conditions hold as well, then an anti-folk theorem obtains: for discount factors sufficiently close to one, in every Nash equilibrium, firms engage in a price war until only one firm remains in the market. If entry is possible, firms may instead collude in equilibrium.

On the empirical side, Scott-Morton (1997) studies the behavior of British shipping cartels around 1900 in response to entry on a shipping route. In her dataset, there are 47 entry events – sometimes the cartel responds by acquiescing, sometimes by engaging in a price war. She finds that the cartel is more likely to start a price war if the entrant is "weaker" (smaller and less experienced), consistent with the "long purse" theory of predation (see, for instance, Bolton and Scharfstein, 1990). In a sense, Scott-Morton's study thus reveals a certain complementarity between collusion and (collective) predation. Of course, predation is not the only way to deter entry. Asker and Hemphill (2020) document a similar complementarity to that discussed by Scott-Morton, but in the context of exclusionary vertical arrangements. Asker and Hemphill discuss firm conduct in the Canadian sugar market in the late 1800s, in which refiners and wholesalers leveraged exclusionary vertical arrangements to exclude competition and support existing collusive pricing. Harrington et al. (2018) study a related scheme in which German cement manufacturers paid off intermediaries to incentivize them to restrict market access by East European cement producers between 1991 and 2002.[73]

Economists' understanding of the propensity of cartels to deter entry rests largely on anecdotes, theoretical possibility results (as in Wiseman), and a small number of empirical studies. If entry is commonly deterred by cartels, then the harms from

[72] Carrera and Titov (2019) illustrate this dynamic in the Chilean Nitrate cartels of the early 1900s.

[73] The mechanisms discussed in both Harrington et al. (2018) and Asker and Hemphill (2020) have much in common with the theoretical model of Asker and Bar-Isaac (2014). Harrington et al. is also notable for the many other examples they provide of exclusionary conduct by cartels.

collusion may persist for longer than would otherwise be expected, and it also would change how we view the plausible economic costs likely to arise from collusion. In particular, costs from the misallocation of production to higher-cost producers may be accentuated, to the extent that more efficient producers are deterred, or to the extent that less efficient entrants are able to survive under the umbrella of cartel pricing (see Carrera and Titov, 2019, and Asker et al., 2019). The relationship between collusion and entry remains one of the more significant gaps in economists' understanding of cartel activity.

2.3 Detection

In practice, many cartels are discovered through the help of "whistleblowers." The whistleblower is typically either a firm that is a party to the conspiracy (usually when informing on the cartel in an effort to obtain immunity from prosecution) or disgruntled (former) employees.[74] Many jurisdictions, including the United States and the EU, give immunity from prosecution to the first confessor from each cartel.[75] In theory, the net effect of such leniency may not be clear-cut.[76] For instance, assuming that the cartel detection probability (in the absence of whistleblowing) changes stochastically over time, Harrington (2008) identifies countervailing effects of a leniency program. On the one hand, leniency provides a deviant cartel member that has just undercut its rivals with the incentive to report the cartel to the authorities in return for leniency; this "deviator amnesty effect" tightens the no-cheating constraint and makes collusion harder to sustain. On the other, being more lenient to the first confessor(s) reduces the expected future fines that cartel member have to pay, thereby increasing the value from colluding; this "cartel amnesty effect" facilitates collusion.[77]

A major problem with empirically evaluating the success of leniency programs (or any other policy towards cartels) is that cartel activity is – because of its illegal nature – unobservable to the econometrician. An increase in the number of detected cartels following the introduction of a leniency program could therefore be due to an induced increase in the detection rate but could also (or alternatively) be due to an induced increase in the number of cartels. Miller (2009), confronts these issues in his study of the introduction of a new leniency program in the United States in 1993, concluding that the leniency program has an economically significant and positive impact on cartel discoveries and deterrence (see the discussion in Section 2.1).

Supplementing the discovery of cartels through informants, are statistical detection

[74]Occasionally, a merger investigation may uncover a cartel or an unrelated prosecution may reveal the existence of collusion. See the DOJ's Answering Brief in *US v Christopher Lischewski*, available at `https://www.justice.gov/atr/case-document/file/1349636/download`, for an example. Customer complaints may also give rise to investigations. See Cuddy (2020) for an example in the context of generic drugs.

[75]Depending on the jurisdiction, other limited forms of immunity may exist. A precondition of the grant of immunity is typically that the enforcement agency was unaware of the cartel. The precise legal institutions around the grant of leniency, and the benefits it conveys, vary by jurisdiction. See American Bar Association (2019) for a treatment.

[76]The first theoretical analysis of cartel leniency programs is due to Motta and Polo (2003). Other noteworthy papers include Spagnolo (2004), Aubert, Rey and Kovacic (2006), and Harrington (2008, 2013).

[77]Counteracting the cartel amnesty effect is the "race-to-the-courthouse effect": A more lenient program can, in some states, induce a switch from no firm applying for leniency to all firms racing to the courthouse, thereby increasing the expected fines and decreasing the value from colluding.

methods. An early canonical reference in this literature is Porter and Zona (1993). Using data from highway-paving procurement auctions on Long Island, Porter and Zona (1993) explore differences in bidding behavior between known ring members and nonmembers. Central to the paper is a test based on the extent to which the rank of a bidder in an auction can be predicted by underlying economic fundamentals (including measures of backlog, utilization rates, capacity , and location of the project relative to the bidder's place of business). When rank can not be predicted by these fundamentals, this indicates the possibility of rank being determined by coordination among the bidders. As Porter and Zona note, "In general, finding a single test procedure to detect bid rigging is an impossible goal."[78] Reflecting this, the subsequent literature contributes a variety of tests motivated by particular assumptions about the data generating process underlying collusion, and mostly directed at bid-rigging settings. Notable contributions include Bajari and Yi (2003), Athey, Levin, and Seira (2011), Kawai and Nakabayshi (2018) (discussed in Section 2.1), and Ortner et al. (2020).[79]

2.4 Impact of collusion on market performance

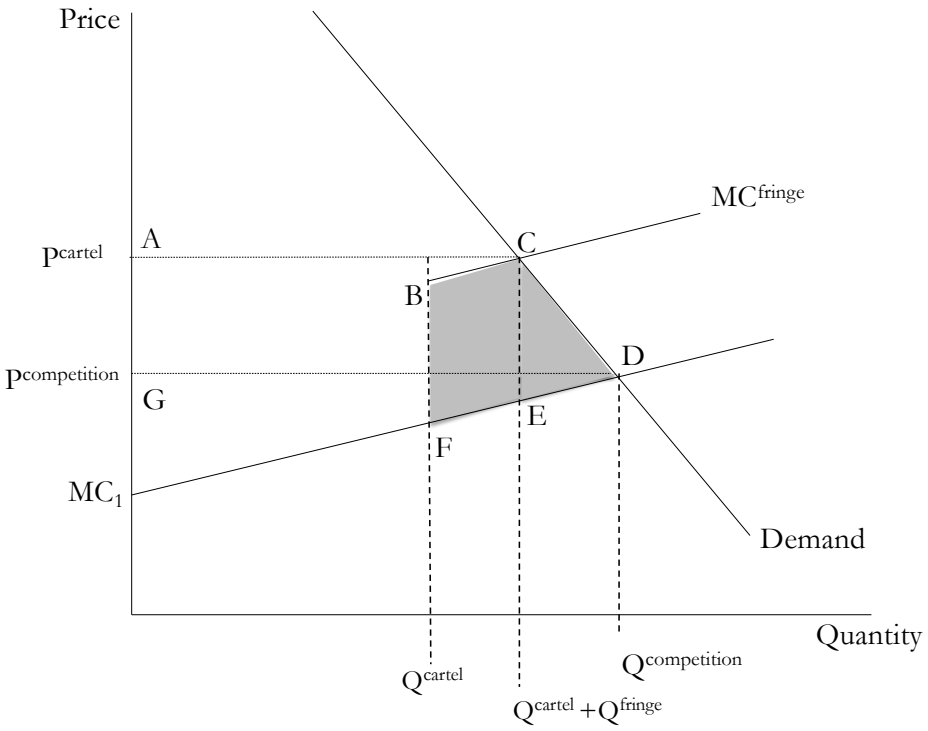
If cartels are the "supreme evil of antitrust." we should see them having a large market impact, at least some of the time.[80] Alternatively, in those instances where they do not have a large impact in the moment, we should expect that they should last a sufficiently long time such that the cumulative impact is meaningful. Forming a picture of the range of market impacts that observed cartels have had is complicated by the various ways that impact can be measured. As a result we begin this section with a brief conceptual detour on measures of market impact, and then attempt to understand the extant literature through this lens.

[78] Porter and Zona also note, "Our tests will be poor substitutes for a wiretap or a disclosure by a dissident ring member."

[79] Porter (2005) and Harrington (2008) survey the detection literature.

[80] Even this starting proposition is not without some mild controversy. The economic literature contains provocative theoretical counter-examples in which even naked collusion on prices can generate greater social benefits than competition. See Whinston (2006), Fershtman and Pakes (2000), and Fershtman and Gandal (1994).

Figure 5: The different measures of the impact of a cartel



Notes: The overcharge is distance AG, or when expressed as a percentage is usually $AG/P^{competition}$. Typical antitrust damages are $GA \times Q^{cartel}$. Umbrella damages are $GA \times Q^{fringe}$. The lost consumer surplus due to collusion is area $GACD$. Total welfare loss is area $BFDC$. Productive inefficiency is given by $BCEF$. Deadweight loss is given by CDE.

Figure 5 shows the various measures of a cartel's market impact in a static market model. This figure considers a cartel with (aggregated) marginal costs equal to MC_1, and a competitive fringe with marginal costs represented by MC^{fringe}. When acting competitively, the cartel sets price equal to marginal cost leading to a quantity of $Q^{competition}$ and a corresponding price. When the cartel firms act competitively, the fringe, having higher costs of production, is not active. When the cartel firms coordinate, they supply Q^{cartel}. This withholding of supply leads to the fringe entering, supplying Q^{fringe}. The total amount supplied is still less than that supplied in a competitive market, but the fringes entry mitigates the price and quantity impact of the cartel, at least to some degree.

In this fairly standard cartelized market, an oft-used measure of market impact is the 'overcharge,' or the price impact of the cartel. This is the distance GA in Figure 5. Closely related to the overcharge is a typical measure of antitrust damages, which would be the overcharge, GA, times the amount sold by the cartel, Q^{cartel}, leading to total damages of $GA \times Q^{cartel}$. It is this measure that typically attracts tripling when damages are applied by courts.[81] As is clear in Figure 5, antitrust damages are

[81]See American Bar Association (2010) for an extended discussion of the estimation of overcharges and

only a subset of the loss in consumer surplus from cartel activity. The remainder of the lost consumer surplus comprises what are often called 'umbrella damages,' which is the appropriate overcharge applied to quantity sold by firms outside the cartel. Here, umbrella damages would be $GA \times Q^{fringe}$. This captures the idea that less competition by a cartel will lead firms outside the cartel to raise prices under the umbrella of the cartel, which generates a consumer loss.[82] In addition to any umbrella damages, consumers also incur a loss equal to that portion of dead weight loss (CDE) that would be captured by consumers in a competitive market.

The measures of impact above are linked to notions of antitrust damages, which are, in turn, closely linked to the loss in consumer surplus ($GACD$). Of course, much of the loss in consumer surplus is captured by the cartel, resulting in a transfer. For an economist interested in impact as measured by the impact on total surplus, these measures are imperfect. In this market, the impact on total surplus is given by the area $BFDC$. This can be decomposed into dead weight loss (CDE), or the lost surplus on production that does not occur, and productive inefficiency ($BCEF$), or the increase in the resource cost of production that does occur. Different studies measure different combinations of these objects.[83]

Whichever metrics are examined, the basic problem with measuring market impact is working out what is attributable to cartel activity and what is not (bearing in mind that multiple distortions can be happening at the same time). This problem of identification gives rise to both conceptual and implementation issues.

To see the conceptual issues with decomposing the impact of cartel activity in the presence of other distortions, consider the following example:

Example 2.1 *Consider a market in which all firms sell a homogenous good and can collude perfectly (that is, replicate a monopolist), and in which there is a unit tax of t. Let demand be given by $p = a - bq$, and every firm has a constant marginal cost of c. In this setting, assuming that firms compete as in Bertrand, it is a standard exercise to derive the following prices:*

1. *The competitive price: $p^c = c$*
2. *The price, absent a cartel, but with a tax: $p^t = c + t$*
3. *The price, absent a tax, but with a cartel: $p^k = \frac{a+c}{2}$*
4. *The price in the presence of both a tax and a cartel: $p^{t+k} = \frac{a+c+t}{2}$*

Now consider the exercise of decomposing the total effect of the tax and cartel on prices into that attributable to the tax and that attributable to the cartel. One way to proceed might be to consider the tax being imposed first, followed by the cartel. This would lead to the price impact of the tax being $p^t - p^c = t$ and the price impact of the cartel being $p^{t+k} - p^t = \frac{a-c-t}{2}$. Alternatively, we might proceed by considering the cartel forming first, followed by the tax. In this alternate narrative, the price impact

related damage concepts.

[82] Caoui (2020) provides an empirical analysis of umbrella damages arising from the Texas school milk cartel that operated between 1980 and 1992. Caoui finds that umbrella damages comprised more than 35% of total cartel damages.

[83] Additionally, one might also wish to account for the exclusion of rivals or the delay of innovation or investment, or impacts on product variety, or other metrics related to distributive concerns. For an example in which dealing with dynamics is a first-order issue, see Asker et al. (2019).

of the cartel would be $\frac{a-c}{2}$ and the price impact of the tax would be $\frac{t}{2}$. These two approaches to decomposing the net price impact both have the virtue of the impact of the cartel and tax adding to the total impact, but they result in different attributions. In one, the impact of the cartel is $\frac{a-c-t}{2}$, while in the other it is $\frac{a-c}{2}$.[84]

The issue is a difference in the thought experiment that underlies the attribution of impact. When the motivating narrative is 'tax first, then cartel,' what is being measured is the marginal impact of the cartel, holding all else fixed. This mirrors the general approach to measurement in second-best worlds discussed in Lipsey and Lancaster (1956). Alternatively, when the motivating narrative is 'cartel first, then tax,' what is being measured is the infra-marginal impact of the cartel, or the impact of the cartel absent any other distortions.[85] In some instances the marginal approach is obviously the more desirable object to measure, while in others it is not so obvious. When measuring damages that might arise in an antitrust enforcement setting, where the but-for world holds all else constant, the marginal approach to measurement is almost always the right approach. When trying to answer the more academic question of how much of the total distortion in the market is attributable to cartelization, the correct approach is less obvious (as is made clear in the simple example above). Often, the conceptual approach is dictated by limitations imposed by data availability. However, occasions arise in which the researcher has a real choice to make.

Continuing to use example 2.1 for the purposes of illustration, there are usually two types of ways the impact of a cartel is measured using data. The first is to employ a reduced form 'treatment' and 'control' style approach. This will often use some benchmark market as the 'control,' perhaps from a prior clean period, or an adjacent market, and use that to compare the 'treated' cartel period, perhaps using an RDD or differences-in-differences approach. The second is to use a model to arrive at a prediction of what the world absent the cartel would look like. Model-based methods can take many forms, but here we will discuss unambiguously structural approaches that involve estimating the parameters of an explicit theoretical model.

The treatment and control approach will almost always seek to measure the marginal impact of the cartel. This is because the point of the control is to inform a judgement as to what the cartelized market would look like absent the cartel. By construction, the argument is that the control is informative as to what would happen if everything in the cartelized market were to be held constant and the cartel were removed.

Similarly, structural approaches that leverage price and quantity data to estimate demand (or in the auction setting, bid distributions), and then infer marginal costs (or in the auction setting, valuations) from first order conditions, also naturally lend themselves to the estimation of marginal impacts. This is because costs (or in the auction setting, valuations) are typically latent and the first order conditions used to recover them take other distortions (like taxes) as given. The researcher has some flexibility in choosing the model of industry conduct absent the cartel (oligopolistic, competitive, leader-follower, or some other game theoretic framework), but the researcher rarely has

[84]This example can be recrafted to make the same point with any of the welfare metrics discussed earlier in relation to figure 5.

[85]The marginal and infra-marginal language is taken from Asker et al. (2019), in which a measure of both the marginal and inframarginal impact of OPEC on productive inefficiency is estimated. Asker et al. (2021) develop additional methods that allow them to assess the marginal and inframarginal impact of OPEC on total welfare.

any flexibility as to how they engage with the conceptual issues discussed above.[86,87]

By contrast, when first order conditions are not used to infer latent model objects, the researcher can often measure impacts using both the marginal and inframarginal approaches. Asker et al. (2019) provide an example in which both approaches are used to assess the productive inefficiency (area $BCEF$ in figure 5) arising from the cartel activity of OPEC from 1970-2014. They leverage granular cost data, at the oil field level, to estimate the global supply curve of oil. This means that they can compare the actual supply curve to a counterfactual supply curve. Using figure 5 as illustration, this means the line BC is observed in data, and FE is produced via a counterfactual model of perfect competition. By using the data and known market institutions to guide the modeling of different counterfactuals, they are able to estimate both the inframarginal and marginal impacts of OPEC on productive inefficiency. They find that the impact is large (total distortions amount to 744 billion US dollars in net present value terms, with 14-22% of that attributable to market power on the part of OPEC). The marginal and inframarginal measures, in this instance, do not vary meaningfully. By contrast, Asker et al. (2021) find that when total welfare is measured, the inframarginal and marginal approaches yield extremely different results. This reflects the sensitivity of deadweight loss to changes in the equilibrium quantities in different counterfactual scenarios.

Against this backdrop, it is easy to appreciate that unifying the many forms of estimates of impact in the literature is not entirely straightforward. Nonetheless, two features of the literature are striking. First, the impact of cartels varies widely. Some cartels appear to have relatively little market impact, while others have an economically significant impact, regardless of the metric employed.[88] Second, at their worst, cartels can have a profound impact on individual's welfare and may even be able to impact the economy in the aggregate.

Connor (2006) performs the heroic task of compiling a meta-analysis of cartel overcharges, drawing on "peer-reviewed academic journals, dissertations, court and commission decisions, OECD reports, books, government publication, working papers, and other sources." The utilized documents reach back as far as 1770, while others are as recent as 2004. Connor accurately describes this as a "catholic" approach to data collection. He then codifies, as well as possible, the overcharge implied by the documentation in each case. This results in 395 cartel episodes for which overcharges are available. The median overcharge in this sample is 19% and the mean is 29%. Underlying these moments are a wide range of overcharges - with a minimum overcharge of -10% (suggesting some particularly incompetent cartels can exist) and a maximum overcharge of 322%.[89] This heterogeneity in the price impact generated by cartels is

[86]Bergquist and Dinerstein (2020) exploit this classic first order condition approach in estimating the impact of coordination among intermediaries in the Kenyan Maize market. They are aided by experimental variation, which provides a set of particularly compelling instruments. Röller and Frode (2006) is a notable example in which the institutional features of the cartel and market allow marginal costs to be recovered from a first order condition, without reference to demand conditions. Asker (2010a) provides an example of the measurement of marginal impacts in the context of a bidding cartel.

[87]Similar issues would arise if markups (overcharges) derived from input-output elasticities and cost shares, as in De Loecker et al. (2016).

[88]There is also marked heterogeneity in cartel duration. See Levenstein and Suslow (2006).

[89]This maximum overcharge is likely an underestimate. Asker et al. (2019) present evidence consistent with the OPEC overcharge exceeding 700% around 1980.

generally remarked on in the literature (see, for instance, Levenstein and Suslow, 2006, and Whinston, 2006, for surveys).

Of course price impact, by itself, is relatively uninformative as to welfare impact. That is, a small price increase may have a large impact on welfare if quantities are significantly distorted (and vice versa). A particularly attractive way to cut through this empirically is to study cartels in markets where unambiguously adverse welfare outcomes can be measured directly. Cartel activity in developing countries provides a setting where this can be done, at times, effectively due to the low (or non-existent) level of resources allocated to enforcement, and the remarkably pernicious nature of cartels that can arise in these settings. [90] Barkley (2020) studies a cartel that operated among the four largest generic insulin manufacturers in Mexico, between 2003 and 2007. Bid rigging among the cartel members resulted in very stable drug prices prior to the procurer (a large Mexican health care provider) instituting a series of market design changes that destabilized the cartel and induced competitive bidding. This, in turn, more than doubled the supply of insulin to the patients covered by the health care provider. The health impacts of this quantity expansion, following the collapse of the cartel, were profound. Patients with access to insulin increased by 42%. Diabetes-related complications among patients fell by 25%. Perhaps most importantly, diabetes-related deaths decreased by 3.4%. Barkley provides the most disturbing evidence to date of the potential for cartels to profoundly affect the welfare of individual consumers.[91]

Other studies have shown that even the purely 'financial' impact of cartels can be substantial. Kawai and Nakabayashi (2018), discussed in section 2.1, suggest that the cartel activity they document impacts close to 1% of Japan's GDP. Asker et al. (2019, 2021) find that, between 1970 and 2014, the OPEC cartel generated 148-233 billion in productive inefficiency and between 700 billion and 5.7 trillion in total welfare losses (all in 2014 US dollars).[92] The largest of these estimates is approximately 0.15% of global GDP between 1970 and 2014.[93] Clearly, when it is at its most effective or pervasive, collusion is capable of having an effect large enough to impact the aggregate economy.

3 Mergers

We now turn our attention to the recent research on the antitrust treatment of mergers. Here, we focus primarily on horizontal mergers between firms selling substitutable goods.[94] The merger of two car manufacturers (for example, a merger of the Ford Motor Company and Daimler AG) would be horizontal in nature. We also consider

[90] Another notable example of cartel activity in developing countries has been provided by Bergquist and Dinerstein (2020).

[91] Cuddy (2020) raises related concerns in the US market for generic drugs.

[92] The range in the total welfare estimates is a function of the difference between taking the marginal and inframarginal approaches to measurement. Productive inefficiency estimates are inframarginal, where the range reflects different assumptions about the impact of OPEC on the internal efficiency of OPEC members' production.

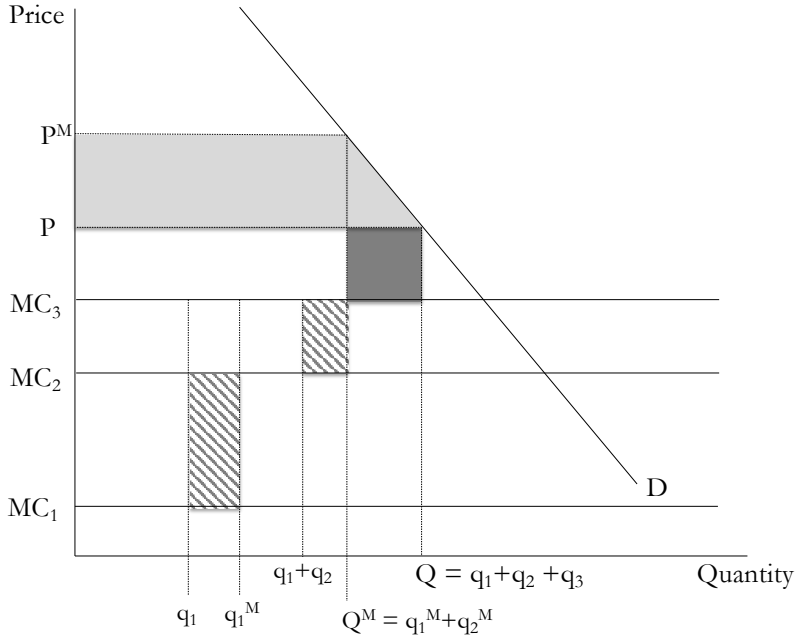
[93] Moreau and Panon (2020) make a similar case for the capacity of cartels to have an aggregate impact, using a macro approach.

[94] The combination of firms selling complements might be viewed as a type of vertical merger.

work relating to vertical mergers. The merger of a car manufacturer and an auto-parts supplier would be an example of a vertical merger. A vertical merger is distinct in that, often, the products being sold by the merging parties are in some way complementary.

To cement ideas, let us focus on horizontal mergers and consider Figure 6, which considers the impact of a merger in a three-firm Cournot market, following the analysis of Farrell and Shapiro (1990).[95] The three firms have different marginal costs and no capacity constraints. Firm 1 has the lowest marginal cost at MC_1. In the absence of a merger, the market clears at a price of P and a combined quantity of Q.

Figure 6: Mergers in Cournot equilibrium (Farrell and Shapiro 1990)



Notes: Welfare costs are indicated by solid shading. Welfare benefits are indicated by hatched shading.

If firms 2 and 3 were to merge, such that the merged firm had marginal costs equal to MC_2, then price would rise from P to P^M and output would decrease from Q to Q^M. The impact on aggregate surplus of the merger would be: a loss in consumer surplus equal to the light grey trapezoid; an additional loss in gains from trade equal to the dark grey rectangle (that portion of firm 3's output in the absence of a merger that is not produced); and a welfare gain from the decrease in production costs (equivalently, increase in productivity) from no longer allocating production to firm 3 and reallocating production among firms 1 and 2 (represented by the hatched rectangles). In this instance prices rise and quantity falls. This follows from the results in Farrell and Shapiro (1990), who derive a simple test for the price impact of a merger in Cournot based on the margins of the firms with and without merger. They establish that if the margin of the merged firm is less than the sum of the margins of the constituent firms, holding production fixed at the no-merger levels, then prices must rise. This is the case

[95]The Farrell and Shapiro analysis, in turn, builds on the foundational framework in Williamson (1968).

in Figure 6. Thus, in this instance, the merger is undesirable when judged against a consumer surplus standard. By contrast, the net impact of welfare is less clear, as the mitigating benefit from reallocating production may be enough to offset welfare losses, even if prices rise (although perhaps not in the specific case illustrated in Figure 6).

Sticking with the Cournot model underlying Figure 6, Farrell and Shapiro (1990) also establish that if the merged firm were able to raise merger-specific synergies such that the merged firm's marginal costs dropped significantly, to say the level of MC_1, then prices would fall.[96] Thus, a sufficiently large drop in marginal costs can mitigate any upward price effects of a merger.[97]

While the Farrell and Shapiro results are derived in the context of a homogeneous goods Cournot model, the basic insights are more general.[98] In particular, conclusions regarding the desirability of any given merger may differ according to whether total welfare or consumer surplus is the metric of interest. Perhaps even more central is the observation that, regardless of the metric, the desirability of a merger turns on the existence and magnitude of mitigating efficiencies (or analogous quality-improvement benefits).

In the absence of any such efficiencies a merger might look like a particularly efficient way to implement collusion.[99] One view would be that bringing all the cartel's activity under one roof may be very helpful in solving many of the incentive problems discussed in the earlier sections on collusion.[100] Indeed, as Stigler (1964) notes,

> Collusion of firms may take many forms, of which the most comprehensive is outright merger.

Given that, in the absence of any efficiencies, a merger and a cartel may look very similar, it is striking that the literature, and policy, tend to position the two phenomena quite differently: cartels are invariably viewed as deserving more severe regulation, presumptions, and punishments.[101] [102]

To the extent that the differential treatment of mergers and cartels has a foundation in economic research, it ideally should rest on a conceptual and empirical foundation

[96] Figure 6 is drawn so that this is true.

[97] Stepping outside the model, any adverse price impact on consumers may also be mitigated by the merger making a higher quality product possible. This would shift the demand curve out, reflecting an increase in the willingness to pay of consumers and a resulting potential for realizing greater gains from trade. Benefits arising from greater investments in R&D, or the ability to realize better R&D outcomes, or the creation of new markets are examples of analogous considerations.

[98] Nocke and Schutz (2019) show that the main insights of Farrell and Shapiro (1990) carry over to the case of differentiated-goods price competition with (nested) CES or multinomial logit demands.

[99] See Dong et al. (2019) for empirical evidence supporting a view that mergers and cartel actvity are somewhat substitutable. They show that, in a cross-country study, the introduction of more effective cartel enforcement (proxied by the introduction of corporate leniency programs between 1990 and 2012) was correlated with more, potentially detrimental, merger activity.

[100] This view is captured in Chapter 7 of the first volume of this handbook (Jacquemin and Slade, 1989, 'Cartels, Collusion and Horizontal Merger'), in which Jacquemin and Slade note, "The corporate merger is the ultimate form of collusion; when two firms merge, they cease to have separate identities and act thereafter as a single unit." Crawford et al.'s (2018) finding of only partial internalization of profits across related business units, within a single company, suggests that even collusion via merger may be a somewhat imperfect solution to the problems of coordination.

[101] If nothing else, in at least several jurisdictions, cartel activity invites criminal prosecution. Similarly, mergers do not invite *per se* treatment in the United States.

[102] See Marx and Zhou (2014) and Davis et al. (2015).

establishing some appropriate magnitude, and frequency, of efficiencies (broadly defined). In the discussion that follows we begin by reviewing the recent contributions to this foundation. There is clear evidence of some mergers leading to efficiencies, but the literature is surprisingly thin given the central position efficiencies have in how we think about mergers.

Another distinguishing feature of merger regulation is the existence of reporting thresholds and, closely related, safe harbors. Mergers that involve payments above certain values are reportable in most jurisdictions, while those falling below the threshold values are not required to be reported to antitrust authorities. Hence, some mergers receive little scrutiny. The impact of these thresholds on the evolution of market structure and the administration of antitrust regulation has been a topic of important work. Similarly, certain types of acquisitions are exempt from scrutiny, most commonly those that are for purely passive investment purposes. Recent work has suggested that these exemptions may deserve further examination. Lastly, HHI thresholds can have a significant influence on subsequent enforcement, and have been the focus of important recent research. In Section 3.2 we collect the research on these institutional features of the regulatory landscape as it applies to mergers. This research collectively questions the way our current enforcement institutions determine which mergers require rigorous scrutiny.

Following that, we discuss work relating to analysis of unilateral and coordinated effects (Sections 3.3 and 3.4). The analysis in Farrell and Shapiro typifies a unilateral effects analysis – the prices that arise in a world with the merger are consistent with static oligopoly behavior. By contrast, one might be concerned that mergers allow the remaining firms in an industry to better coordinate prices at some level over and beyond what one might expect from static oligopoly behavior. Such a concern invites the consideration of coordinated effects.[103]

We conclude by considering research on vertical mergers (Section 3.5), remedies (Section 3.6) and, lastly, the growing literature evaluating the impact of consummated mergers and investigating their impact on markets. Despite obvious issues with selection, this literature on merger 'retrospectives' comprises an important body of work against which economists can judge the efficacy of enforcement and the value of the tools we bring to the table (Section 3.7).

3.1 Efficiencies and other mitigating factors

As noted above, in the absence of efficiencies a merger might look like a particularly efficient way to implement collusion. Given this, well-founded merger policy should rest on a foundation that establishes that, as a general matter, it is not merely fanciful to think that efficiencies may arise from mergers and, ideally, that these efficiencies occur commonly enough to warrant the differential treatment of mergers and cartels. The literature is surprisingly sparse on both these points.[104] Surprisingly little progress has been made in providing empirical characterizations of merger-specific efficiencies. However, there is now at least some empirical basis for claiming that efficiencies *may*

[103]Loosely, most types of coordinated effects ideas have a model of collusion in mind that leverages a continuation value to generate supra-oligopoly pricing.

[104]See Röller et al. (2001) for a helpful overview of the literature prior to 2001 and the related regulatory landscape.

arise from mergers.

Two studies, Ashenfelter et al. (2015) and Braguinsky et al. (2015), provide the clearest examples of merger specific efficiencies leading to the kinds of increases in productivity that might, plausibly, lead to pro competitive outcomes.[105] Ashenfelter et al. (2015) begin by noting that "there is very little direct empirical evidence that efficiencies can offset the incentive to raise prices. This lack of direct evidence is likely due to the inherent difficulties in measuring if (and by how much) mergers lower firms' marginal costs." They then leverage scanner data to examine the 2008 Miller-Coors joint venture (effectively, a merger for the purposes of the United States) in the US brewing industry. [106] The basis for claiming efficiencies in this instance was a reduction in shipping and distribution costs - Coors brewed beer in two locations, while Miller had six locations where they brewed. By expanding Coors' production into Miller plants, beer could be brewed closer to many of the 48 relevant regional markets, thus reducing the cost of shipping beer (recall a cubic meter of beer, like water, weighs, roughly, a metric ton). Ashenfelter et al. (2015) examine the correlation between post-merger price changes and the changes that the merger induced in shipping distances to different markets, and in concentration, finding that larger increases in concentration were correlated with bigger price increases, and larger reductions in shipping distances were correlated with smaller price increases. Interestingly, and consistent with company statements, they find evidence that market power effects of the merger were realized faster than efficiencies, with cost reductions not being "fully incorporated into pricing until about two years after the merger's approval".[107]

Braguinsky et al. (2015) examine the Japanese cotton spinning industry from 1896 to 1920. During this period, 73 acquisitions occurred in a period of marked industrial growth and consolidation. Using extremely detailed data on plant inputs and outputs, Braguinsky et al. show that more profitable firms tended to acquire less profitable firms, despite acquiring and acquired firms having similar physical productivity. Interesting, little evidence is found of market power contributing to higher profitability post-merger. Instead, the evidence points to acquired firms improving in inventory management, accounts receivable, and capacity utilization.[108] Essentially, the acquired firms tended to have better capital but were using it less effectively, hence post merger productivity rose. The pattern in the data indicates that merger activity can have an important role in allocating the means of production to those managers with the greatest talent in using them. This can contribute to increases in the aggregate productive efficiency of the economy. Indeed, during the time studied, the Japanese cotton spinning industry experienced average annual productivity growth of 2.5 per cent.[109]

[105] Ashenfelter et al. (2015) study of the 2008 Miller-Coors merger. They establish the existence of merger-specific efficiencies in that context. In subsequent work, Miller and Weinberg (2017) show that despite these efficiencies the merger coincided with price increases, consistent with an increase in coordination between firms in the industry post merger.

[106] Miller and Coors were the 2nd and 3rd biggest brewers in the US at the time. This merger was approved by the US Department of Justice.

[107] Kim and Singal (1993), in the context of airline mergers, also present evidence that the price effects of a merger can be realized quickly.

[108] Acquired firms tended to have younger capital stock, which accounted for the similarity in overall productivity.

[109] See Eliason et al. (2020) for evidence from the Dialysis Industry. Although less closely related, the kind of allocative gains seen here are also seen in Olley and Pakes (1996), which some view as a study of a sort

It is instructive to contrast the examples provided by Ashenfelter et al. (2015) and Braguinsky et al. (2015). The beer example is a classic technological merger-related efficiency.[110] In the cotton spinning example, by contrast, the source of the efficiency arises from managerial talent rather than some technological feature of the combination.[111]

These two examples can also be used to discuss two important conditions for claimed efficiencies to affect the merger approval decisions by antitrust authorities. First, efficiencies can only be used to counteract the market power effect of a merger if these efficiencies are *merger-specific*, i.e., they cannot be realized through some other arrangement that distorts competition less. For instance, in the beer example of Ashenfelter et al. (2015), the two parties may be able to come to a contractual arrangement whereby each party would agree to brew the other's beer in its plants, while each firm would still price its own beers independently. Second, claimed efficiencies should in principle be verifiable by antitrust authorities at the time of the merger review. In the beer example, this requirement does not appear to be a high hurdle as the induced reductions in transport costs are quite apparent, but it may well be in the cotton-spinning example as managerial efficiencies are hard to prove before they are realized.[112]

Direct evidence informing a judgment as to the frequency with which mergers give rise to efficiencies is even more limited. An interesting contribution in this regard is Geurts and Van Biesebroeck (2019) examining the universe of mergers in Belgium between 2005 and 2012. They find that approximately 80 percent of mergers lead to an increase in employment, which may be consistent with an increase in output.[113] If one is willing to assume that mergers do not affect the mapping from output to employment, then the results would suggest that 20 percent of mergers raise competitive concerns, consistent with claims, on the part of some commentators, of under-enforcement by antitrust agencies.[114] Evidence as to the typical size of merger efficiencies is also

of 'reverse-merger.'

[110]Other examples of technologically related efficiencies include Elliott et al (2021), who study congestion related efficiencies in telecommunications, Yonghong and Zhao (2019), who study the 1997 Boeing-McDonnell Douglas merger in the wide-bodied aircraft manufacturing industry and find evidence of increased learning by doing due to the merger; Genakos et al. (2018), who, in the context of telecommunications mergers, find evidence suggestive of increased investment post-merger; Kalnins et al. (2017), who describe how capacity utilization can increase via scale economies in the hotel industry; Focarelli and Panetta (2003), who find evidence suggesting long-run benefits from mergers due to efficiencies in the Italian banking industry; and Jeziorski (2014) who examines cost efficiencies in the US radio industry.

[111]Eliason et al. (2020) present an analysis of dialysis mergers that provides a similar example to mergers leading to profitable changes in internal firms operations, albeit at the expense of the health outcomes of patients. This indicates that mechanically equating measured productivity gains with actual welfare is ill-advised, without further examination as to why productivity is increasing.

[112]Grieco et al. (2018), in studying the merger of Molson and Coors in the North American brewing industry, make some progress in this direction by adapting productivity estimation approaches to the quantification of merger efficiencies. They find evidence of returns to scale in production which they translate into marginal cost reductions. This is closely related to, but distinct from, the sort of measurement likely needed to verify the sort of TFP impacts explored in Braguinsky et al. (2015).

[113]Of course, this may not hold as mergers may affect conditional factor demand functions. Moreover, to the extent that a merger raises monopsony power in the labor market, it may reduce wages and induce a substitution of labor for other inputs. See Prager and Schmitt (2021).

[114]Other papers examining the impact of mergers on employment include Bandick and Gorg (2010), Lehto and Bockerman (2008), and McGuckin and Nguyen (2001). Other, less direct, evidence on the overall impact of mergers is most often found in the productivity and finance literatures. See, for example, Maksimovic

extremely limited.

Admitting the existence of efficiencies gives rise to a subsequent set of difficult questions central to which is "what counts as an efficiency?." A good example of why the economics of this is difficult is considering the case in which a horizontal merger leads to increased bargaining power with upstream suppliers. The merger may lead to the merging parties being able to extract necessary inputs at a lower price than they otherwise would be able to. If so, does this merger enhance competition in a possible upstream market? Perhaps not. However, to the extent that the ability to obtain inputs at a lower price leads to an increase in the total output of the industry, then downstream consumers may in fact benefit. Whether the possible increase in the total surplus created by such a scenario should be regarded as off-setting any perceived loss in competition in a more narrowly defined upstream market is a question that warrants more attention than it has attracted to date (Hemphill and Rose, 2018).[115] This question also overlaps with many issues that arise in the consideration of mergers in vertical markets (see Section 3.5).

Even if merger efficiencies were very small, rare or, indeed, entirely absent, it may be that other mitigating circumstances exist which would lead us to have a permissive policy stance towards mergers. The most obvious of these would be the possibility of entry.[116] As noted by Bork (1978):

> Antitrust is valuable because in some cases it can achieve results more rapidly than can market forces. We need not suffer losses while waiting for the market to erode cartels and monopolistic mergers.

If entry can mitigate the possibly adverse effects of a mergers then enforcement may not be an effective way to allocate regulatory resources. This may happen in one of two ways.

First, an entrant can exert direct competitive pressure on the incumbent. For this form of entry to be effective, entry needs to occur soon after the merger is consummated. This creates the empirical question of how quickly does an anti-competitive merger induce a new firm to enter. Collard-Wexler (2014) considers this question in the context of the US ready-mix concrete industry and finds that it takes between nine and 10 years for an entrant to respond to a merger from duopoly to monopoly. This is a depressingly long time to wait for entry to occur, especially given that ready-mix concrete is an industry that is well-populated by many firms, relatively technologically simple, and has many hundred independent local markets across the United States.

Second, the merger itself may provide the payoff that makes earlier entry more profitable. That is, the possibility of a merger that looks anti-competitive in a static sense, may be the very event that provides the incentive for the initial entry by one of the merging parties. Hence, mergers may provide an important dynamic incentive that enhances competition by providing the payoff (or 'exit strategy') for entrepreneurs that are considering entering an industry. Absent the prospect of a merger, entry would not

and Phillips (2001), and Stiebale and Trax (2011).

[115] Rubens (2020) provides a related empirical study of the Chinese tobacco industry.

[116] One may ask why this would apply to mergers differentially from cartels. To the extent that a satisfactory answer exists it may lie in the fact that most cartels keep themselves secret and so do not attract the attention of potential entrants in the same way that a merger might. This may, in turn, depend on the transparency of prices to market outsiders, among other factors.

occur in the first place - a form of 'entry for buyout' as in Rasmusen (1998). This theme is explored in the context of optimal merger policy by Mermelstein et al. (2020).[117]

Another mitigating factor relevant to mergers is the ability of the regulator to impose remedies that cure a possible competitive harm. We discuss remedies in more detail in Section 3.6.

3.2 Screens

In many jurisdictions, there is a notification requirement for mergers above a certain size threshold. As it is hard for authorities to undo mergers, the aim of such a requirement is to give the antitrust authorities some time to investigate whether a proposed merger may raise (anti-)competitive concerns and potentially block it (or approve it with commitments) *before* it is consummated. The rationale for the exemption of small mergers is presumably that such mergers may be unlikely to harm competition and consumers.[118] If so, a notification requirement for small mergers would seem to impose unnecessary economic costs on the merger partners. However, the cost of notification might also serve a useful purpose in selecting merger proposals that are desirable from the viewpoint of consumers and society.

This idea is formalized in Besanko and Spulber (1993). There are two players, the (horizontal) merger partners and the antitrust authority. The merger partners have private information about the realized merger-specific efficiencies, drawn from some distribution. There is a partial alignment of the interests of the merger partners and the authority: While fewer efficiencies are required for the merger to be privately profitable than for it to raise the authority's objective, larger efficiencies are desirable for the merger partners and the authority. Proposing a merger for approval by the authority involves incurring an irrecoverable fixed cost. Hence, holding fixed the probability that a proposed merger is approved, only a merger with efficiencies above a certain threshold is proposed.[119] In that sense, a positive level of merger proposal costs may benefit consumers and society by inducing a positive selection in merger proposals.[120]

The observation that the notification requirement has an influence in determining which mergers get proposed has empirical support. In a recent empirical study, Wollmann (2019) exploits a 2001 amendment to the 1976 Hart-Scott-Rodino (HSR) *Antitrust Improvements Act* that effectively raised the size threshold below which mergers are exempt from the notification requirement. Not surprisingly, the amendment led to a sharp reduction in both the notifications of newly exempt mergers and also, as shown in the lower right-hand panel of Figure 7, in the agencies' investigations into such

[117] See also Cabral (2003).

[118] Of course, in segmented markets, even a small firm may have significant market power, and the harm of a small merger may be large relative to the size of its market.

[119] Besanko and Spulber (1993) make the extreme assumption that the authority does not observe the efficiencies of a proposed merger. As a result, the only tool the authority has at its disposal is the probability of approving a proposed merger, independently of its efficiencies. But the same mechanism would hold if the authority observed a noisy signal of the efficiencies.

[120] The model of Besanko and Spulber (1993) may also help explain why antitrust authorities are, by and large, apply a consumer surplus rather than aggregate surplus standard. By endowing the authority with an objective that is tougher than its own (in that it puts a smaller weight on profit), the government effectively commits the authority to a tougher policy (a lower probability of merger approval), resulting in a better selection of proposed mergers.

mergers; this reflects the long-standing observation that agencies very rarely investigate mergers that are exempt from the notification requirement.

Figure 7: Notifications and investigations and the amendment of the HSR thresholds (Wollmann 2019)

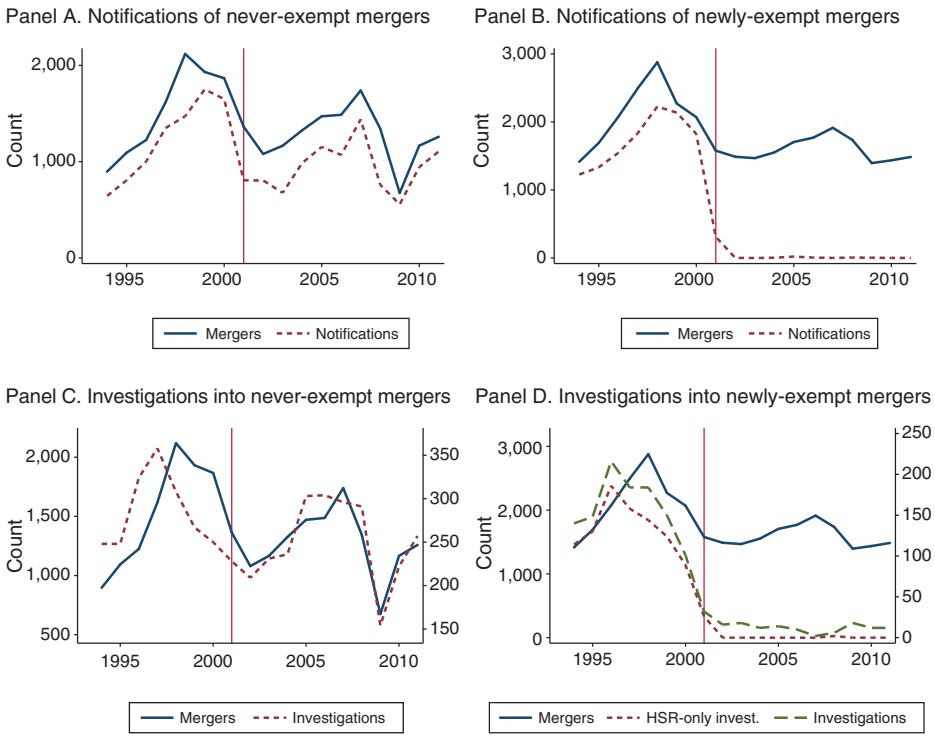


FIGURE 2. NEARLY ALL OF THE DECLINE IN NOTIFICATIONS AND INVESTIGATIONS OCCURS AMONG NEWLY-EXEMPT MERGERS

Notes: Panels A and B plot notifications and mergers over time. Panels C and D plot investigations and mergers over time, with the primary and secondary y-axes counting the former and latter, respectively. Panels A and C are based on never-exempt mergers, while panels B and D are based on newly-exempt mergers. In each, a vertical line marks 2001, the year the Act was amended to raise the size-of-transactions threshold. Note that the vertical distance between the dashed lines in panel D represents non-HSR-related investigations (of which there are few).

More interesting is the question of whether, and if so how, the change in the HSR threshold affected merger activity. To this end, Wollmann uses a difference-in-difference (DD) research design, comparing changes among the newly exempt horizontal mergers to the newly exempt non-horizontal transactions (which are much less likely to cause competitive concerns and, in any event, are almost always approved), as well as a triple-difference (DDD) approach, which controls for shifts among never-exempt mergers (i.e., mergers above the pre-amendment size threshold). Figure 8 shows that the amendment did not differentially affect never-exempt horizontal and non-horizontal mergers but increased the volume of newly exempt horizontal mergers relative to newly exempt non-horizontal mergers. The DD and DDD estimates confirm that the amendment led to a significant increase in newly exempt horizontal mergers. For instance, the

DDD estimates indicate a 50% increase in mergers in the newly exempt horizontal merger categories (324 additional newly exempt horizontal mergers per year on a pre-amendment base of 634 such mergers).

Figure 8: Mergers and the amendment of the HSR thresholds (Wollmann 2019)

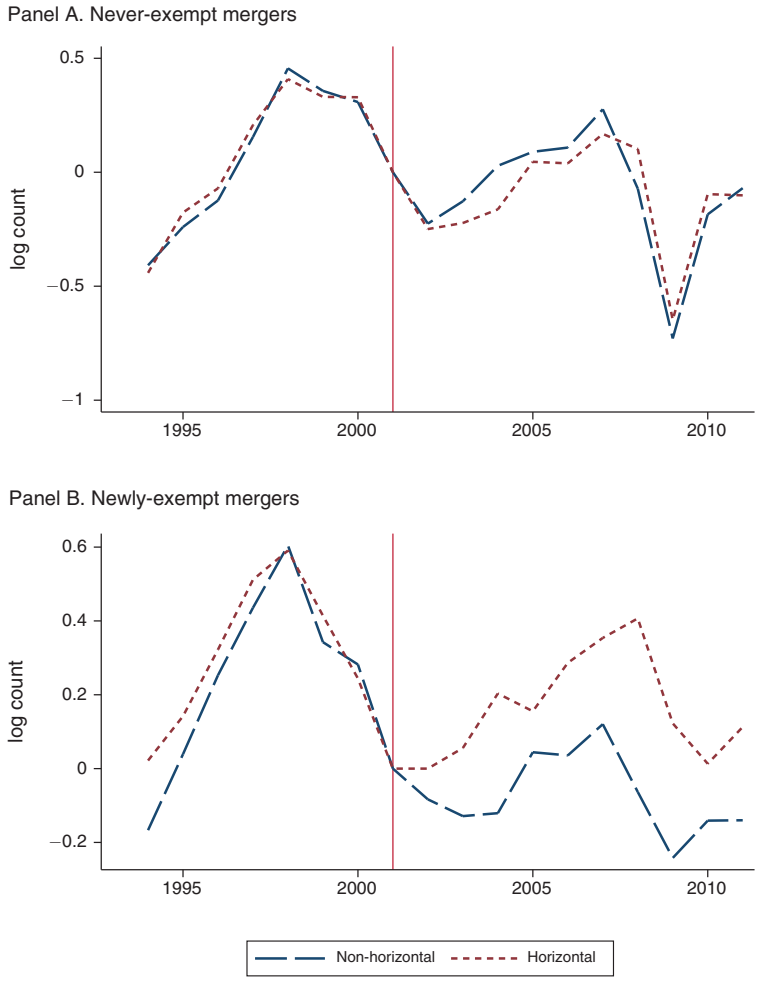


FIGURE 3. NEWLY-EXEMPT HORIZONTAL MERGERS INCREASE FOLLOWING THE AMENDMENT

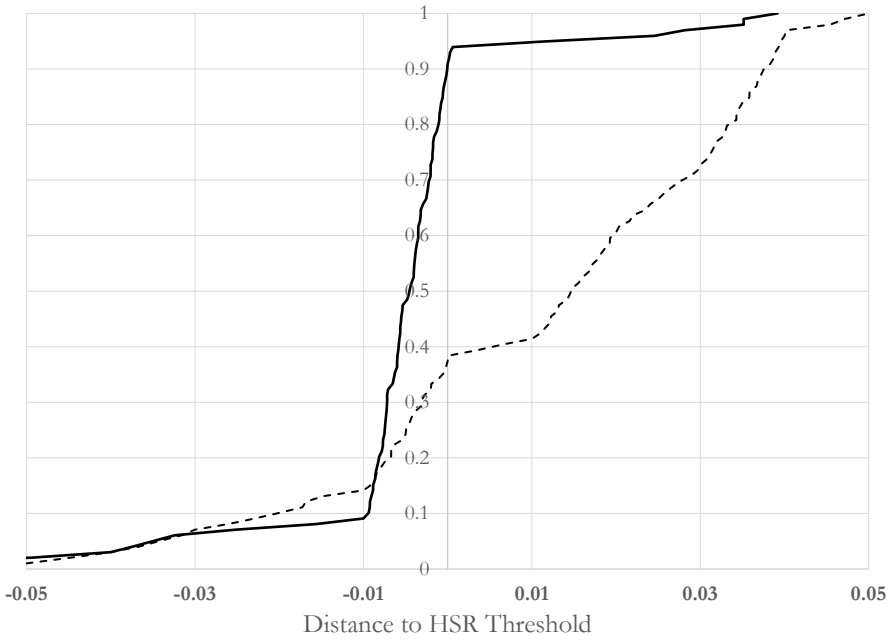
Notes: These graphs plot the log of the number of horizontal and non-horizontal mergers over time. Panel A is based on never-exempt mergers, while panel B is based on newly-exempt mergers. In both, a vertical line marks 2001, the year the Act was amended to raise the size-of-transactions threshold. To facilitate comparisons, all plotted values are reduced by the value they take in that year (so that the lines that connect them intersect $y = 0$ in 2001).

It is tempting to interpret these results through the lens of Besanko and Spulber (1993): The HSR amendment effectively eliminated the merger proposal cost for newly exempt horizontal mergers and reduced the probability of such mergers being blocked (or being approved only under conditions) to zero, thereby making it now profitable for mergers without significant synergies to go ahead. According to that interpretation, the amendment not only increased the number of mergers but also induced a worse

selection.

In another piece of empirical evidence consistent with this story, Cunningham et al. (2021) use data from the pharmaceutical industry to document that pharmaceutical companies regularly engage in what they call "killer acquisitions." These companies acquire innovative rivals engaging in research and development on drugs that would be close substitutes to those developed by the acquirers—only to terminate those acquired drug projects. As shown in Figure 9, there is a bunching of such killer acquisitions just below the HSR size threshold (solid line), whereas there is no such bunching among acquisitions where the drug projects of the acquirer and target do not overlap (dashed line).[121]

Figure 9: Bunching of killer acquisitions just below the HSR threshold (Cunningham, Ederer, and Ma 2021)



Notes: This graph plots the CDF of acquisition size near the Hart-Scott-Rodino review threshold. Acquisitions that fall into the [-5%,5%] around the threshold are kept, and the horizontal axis represents the distance to the review threshold (from -5% to 5%). The CDF of non-overlapping acquisitions are shown using the dashed line, and the CDF of overlapping acquisitions using the solid line. Constructed from the data underlying Figure 3 of Cunningham, Ederer, and Ma (2021).

Once an antitrust agency is aware of a merger, concentration measures such as the Herfindahl-Hirschman Index (HHI) play an important role in the screening of proposed mergers as well as in court proceedings. In the United States, the current *Horizontal Merger Guidelines*—issued in 2010 jointly by the *Department of Justice* (DOJ) and the *Federal Trade Commission* (FTC)—contain both safe harbor presumptions as well

[121]Kepler, Naiker and Stewart (2021) provide related evidence suggesting that, across all industries, a disproportionate number of deals fall just below HSR reporting thresholds.

as presumptions of anticompetitive effects based on the (naively computed) change in the HHI as well as in the (naively computed) post-merger HHI level.[122] Recent work has contributed to the theoretical foundation for expressing these presumptions using HHIs.

For the case of price competition with (nested) MNL or CES demands, Nocke and Schutz (2019) show that—absent merger-specific efficiencies—the merger-induced reductions in consumer surplus and aggregate surplus are both approximately proportional to the (naively computed) change in the HHI, where the approximation is taken around small market shares.[123]

Nocke and Whinston (2020) argue that there is both a theoretical and an empirical basis for focusing on the change (rather than the level) in the HHI in screening mergers for their unilateral effects on consumer surplus.[124] Specifically, they relate the size of the efficiencies necessary for a merger not to harm consumers to both the change and the level of the HHI. They do so theoretically for quantity competition with homogeneous goods as well as for price competition with MNL and CES demands. They also do so empirically for hypothetical mergers in the US beer industry, using the demand and cost estimates from Miller and Weinberg (2017)'s random-coefficient nested MNL model. In a nutshell, Nocke and Whinston (2020) find that the required efficiency gains are larger for mergers that induce a larger change in the HHI, but are independent of the level of the HHI when controlling for the change in the HHI.[125]

The current state of the literature generally supports the use of concentration measures as screens for the presence of potential harms to competition arising from a merger. That said, it underscores the need to apply these screens in a way mindful of their limitations.[126] If information on margins and diversion ratios were available at the screening stage, then Werden (1996), Farrell and Shapiro (2010), and others show how measures of upward-pricing pressure (discussed in Section 3.3 below), as well as required cost synergies, could directly be computed to give additional dimensions of insight at the screening stage.

3.3 Unilateral effects analysis

The unilateral effects of a merger refer to a merger's impact for a given mode of conduct in the industry. In the academic literature, such effects are typically captured by the induced change in the equilibrium outcome of the underlying static competition game (e.g., homogeneous-goods Cournot or differentiated-goods Bertrand).

At the heart of the unilateral effects analysis is the Williamson (1968) trade-off between the *market power effect*, which is due to the internalization of competitive

[122]The computations are performed under the assumption that the market shares of the non-merging outsiders do not change so that the post-merger market share of the merged firm equals the sum of the pre-merger market shares of the merger partners.

[123]The authors also provide an approximation around monopolistic competition conduct.

[124]They also argue that the current presumptions in the US *Horizontal Merger Guidelines* are likely too lax, unless one is crediting large synergies to the typical merger.

[125]The irrelevance of the HHI level would no longer hold if one were willing to accept a small reduction in consumer surplus: The efficiency gain required for consumer surplus not to fall by more than a given (small) fraction, tends to be increasing in the level of the HHI, holding fixed the change in the HHI.

[126]Concentration measures trivially depend on the delineation of the relevant market. To the extent that such a delineation is problematic, so are presumptions based on market shares.

externalities post merger, and the *efficiency effect* that results from potential synergies between the merger partners. Figure 6 at the beginning of Section 3 provides a diagrammatic analysis of this trade-off in the context of a merger in a homogeneous-goods Cournot market, as analyzed by Farrell and Shapiro (1990) in their seminal paper.

3.3.1 The basic theory of unilateral effects

Consider a merger among a subset M of firms. Let q_i^* denote the pre-merger output of firm i, Q^* the aggregate pre-merger output. For simplicity, suppose that $q_i^* > 0$ for all $i \in M$. Further, let $P(\cdot)$ denote the inverse demand function, $C_i(\cdot)$ firm i's (pre-merger) cost function, and $C_M(\cdot)$ the merged firm's cost function.

Prior to the merger, firm $i \in M$ sets its equilibrium output q_i^* such that the profit on the marginal unit of output, $P(Q^*) - C_i'(q_i^*)$ is equal to the reduction in inframarginal revenue induced by the marginal unit of output, $-q_i^* P'(Q^*)$. The market power effect of the merger arises because, after the merger, merger partner i internalizes the effect that this marginal unit has on the inframarginal revenue of its merger partners, $-\left(\sum_{j\in M, j\neq i} q_j^*\right) P^*(Q^*)$, providing it with an incentive to reduce output. To the extent that the marginal unit of output can be produced at lower cost, there is a countervailing efficiency effect.

As shown by Farrell and Shapiro (1990), using the first-order conditions of profit maximization, the merger weakly increases aggregate output, and is thus consumer surplus non-decreasing (hereafter: *CS-nondecreasing*), if

$$P(Q^*) - C_M'\left(\sum_{i\in M} q_i^*\right) \geq \sum_{i\in M} \left[P(Q^*) - C_i'(q_i^*)\right]. \tag{6}$$

The merger is *CS-nonincreasing* if the inequality is reversed, and *CS-neutral* if it is both CS-nonincreasing and CS-nondecreasing. Equation (6) shows that for the merger to be CS-nondecreasing, the merged firm's post-merger marginal cost, evaluated at the combined pre-merger output of the merger partners, has to be less than the pre-merger marginal cost of any merger partner: $C_M'\left(\sum_{i\in M} q_i^*\right) < \min_{i\in M} C_i'(q_i^*)$.

Even if the merger does not generate any synergies (in the sense of Farrell and Shapiro, 1990) so that $C_M(q) = \min\{\sum_{i\in M} C_i(q_i) | \sum_{i\in M} q_i = q\}$ at any output level q, the merger increases productive efficiency if the merger partners are heterogeneous. To see this, suppose that $q_i* < q_j*$ for two merger partners i and j, implying that the smaller merger partner i has higher marginal costs than j: $C_i'(q_i^*) > C_j'\left(q_j^*\right)$. In that case, the merged firm can produce the combined output $q_i^* + q_j^*$ at a lower cost by shifting some output from merger partner i to j. However, an important result of Farrell and Shapiro (1990) is that such output-shifting is not enough for equation (6) to hold: If the merger does not generate synergies, then it is CS-decreasing..

The result extends to settings with multiproduct-firm price competition and (nested) multinomial logit or (nested) CES demands.[127] In such settings, firms can differ in the

[127]Multiproduct-firm pricing games that satisfy certain variants of the *independence of irrelevance alternatives* (IIA) property, share an important feature with the homogeneous-goods Cournot model: They are *aggregative games* in that each firm's profit function depends on the strategic choices of rivals only through some uni-dimensional aggregator, and consumer surplus is a monotonic function of that aggregator; see Nocke and Schutz (2018).

number of products (and in which nests those products are) and the various products can differ not only in their marginal costs but also in their perceived qualities. However, as shown in Nocke and Schutz (2018, 2019), all of the relevant firm-level information can be summarized in a single-dimensional sufficient statistic, the firm's "type," which indicates its contribution to consumer surplus if it were to price at cost. If a merger would not involve any synergies, the merged firm's type would be just equal to the sum of the pre-merger types of the merger partners. Nocke and Schutz (2019) show that a necessary and sufficient condition for the merger to be CS-nondecreasing is that the merged firm's type is above a certain cutoff type that exceeds the sum of the pre-merger types; that is, the merger must involve synergies.[128]

Fully characterizing the conditions under which a merger increases aggregate surplus (hereafter: AS)—the sum of consumer and producer surplus—is more difficult. In the homogeneous-goods Cournot model, assuming that firms have constant returns to scale, Nocke and Whinston (2010) show that a CS-nondecreasing merger is privately profitable in that the merged firm's profit is larger than the sum of the pre-merger profits of the merger partners. As a CS-neutral merger does not affect the profits of the non-merging outsiders, such a merger is therefore AS-increasing. However, aggregate surplus is non-monotonic in a firm's marginal cost; as a result, for a given merger, there may not exist a cutoff for the post-merger marginal cost level below which the merger is AS-increasing and above which it is AS-decreasing.[129]

Farrell and Shapiro (1990) take a different approach: To the extent that a merger is proposed only if it is privately profitable, a sufficient condition for a merger to increase aggregate surplus is that its *external effect*—i.e., the induced change in the sum of consumer surplus and the non-merging outsiders' profits—is positive.[130] For a CS-decreasing merger in the homogeneous-goods Cournot model to have a positive external effect requires that the increase in the outsiders' profit, induced by the reduction in the merging insiders' output, outweighs the decrease in consumer surplus. Farrell and Shapiro (1990) show that this is more "likely" to occur if the outsiders' combined pre-merger market share is larger and more concentrated.[131]

3.3.2 Empirical implementation: Merger simulation and UPP

The state-of-the-art method to quantify the static Williamson trade-off and the merger's welfare impact is a "merger simulation," as pioneered by Hausman, Leonard and Zona (1994), Werden and Froeb (1994), and Nevo (2000).[132] The first step consists in estimating pre-merger demand (e.g., random-coefficient logit, using the methods developed by Berry, Levinsohn and Pakes, 1995). The second step typically involves recovering

[128]Loertscher and Marx (2019) show that the requirement of synergies for mergers not to harm consumers extends to bidding markets where n suppliers with uncertain costs compete in a procurement auction. By contrast, in a Cournot model with vertically differentiated products, Johnson and Rhodes (2019) show that synergies may not be necessary for a merger to increase consumer surplus.

[129]By contrast, in the multiproduct-firm pricing game with (nested) logit or CES demands, there exists a unique post-merger type above which a merger is AS-increasing and below which it is AS-decreasing; see Nocke and Schutz (2019).

[130]In practice, focusing on the external effect may also have the advantage that the antitrust authority does not need to evaluate fully the merger's effect on the merger partners' profits.

[131]Nocke and Schutz (2019) show that these insights are robust in a setting with multiproduct-firm price competition and (nested) logit/CES demands.

[132]See Davis and Garces (2010) for a textbook treatment.

pre-merger marginal costs, using an assumption on pre-merger conduct (e.g., static Bertrand-Nash pricing).[133] In conjunction, the first two steps allow the computation of the pre-merger industry equilibrium and pre-merger welfare. To the extent that the merger affects neither demand nor the set of products offered, the post-merger equilibrium can then be computed at the third step, using assumptions on post-merger conduct and merger-related marginal cost reductions.[134] As the magnitude of the merger efficiencies is most often unknown, one may alternatively compute at the third step the minimum efficiencies necessary for a merger not to reduce a given welfare standard (such as consumer surplus). There is a growing literature assessing the accuracy and robustness of merger simulations, using ex-post evaluations (Peters, 2006; Weinberg, 2011; Weinberg and Hosken, 2013; Björnerstedt and Verboven, 2016).

A simpler quantitative method, often used in antitrust practice where data and resource limitations may impose binding constraints, is based on "upward-pricing pressure" (UPP), a concept proposed by Farrell and Shapiro (2010). Consider a merger between the single-product firms j and k. In its simplest form, the upward-pricing pressure on merger partner j is equal to

$$\text{UPP}_j = d_{jk}(p_k - c_k),$$

where d_{jk} is the diversion ratio from product j to k, evaluated at pre-merger prices, and p_k and c_k are product k's pre-merger price and pre-merger marginal cost, respectively.[135] UPP_j can thus be interpreted as measuring the merged firm's opportunity cost of keeping the price of product j at its pre-merger level. Farrell and Shapiro (2010) view UPP as a simple indicator of the magnitude of the merger-induced change in pricing incentives, which might already be used at an early stage in a merger investigation as it requires only knowledge of diversion ratios and markups.[136] Using Monte Carlo experiments, Miller et al. (2017) evaluate the accuracy and reliability of UPP for measuring the price effects of mergers.[137]

3.3.3 Horizontal mergers under free entry

In our discussion of the Williamson trade-off so far, we took as given the set of active firms in the market. However, as briefly touched upon in Section 3.1 above, the anti-competitive effects of a merger may be mitigated by merger-induced entry.

[133] When reviewing a merger, antitrust authorities may often directly observe something akin to marginal costs, using internal firm documents. If so, they may use the observed marginal costs and an assumption on conduct to recover demand parameters.

[134] Later in this section, we discuss some of the issues that arise when quality or product mix are impacted by the merger.

[135] The diversion ratio d_{jk} is defined as the increase in demand for product k following a small increase in the price of product j, expressed as a proportion of the loss in demand for product j.

[136] Jaffe and Weyl (2013) provide a first-order approximation of the price effect of a merger, which in addition to knowledge of diversion ratios and markups requires estimates of pass-through.

[137] A literature exists that has explored what stock market reactions to merger announcements may be able to reveal about the competitive effects of mergers. See, for instance, Eckbo (1983), Stillman (1983) and more recently Duso et al. (2007). Most authors in this literature are cautious of the ability of an event study to give clear insight into the competitive effects of any specific merger. (As noted by Kaplow and Shapiro, 2007, "[an event study] measures the expectations of investors about merger effects, not the actual effects of mergers.) This approach has been most effective when used to look at patterns across large samples of mergers (see, for example, the paper by Duso et al.).

To see this, consider the homogeneous-goods Cournot model. To fix ideas, suppose there is a (sufficiently large) number of identical potential entrants, each with constant marginal cost c and facing entry cost ϕ. Ignoring integer constraints on the number of active firms for the moment, the free-entry condition can be written as

$$[P(Q) - c]r(Q; c) - \phi = 0,$$

where Q is aggregate output, and $r(Q; c) = -[P(Q)-c]/P'(Q)$ is the optimal output of a firm with marginal cost c when aggregate output is Q.[138] Under standard assumptions on demand, this condition uniquely pins down the aggregate output level in a free-entry equilibrium. If the free-entry condition holds both pre- and post-merger, a merger among a subset of firms is therefore CS-neutral. To the extent that the merger is privately profitable (due to sufficiently large synergies), it is AS-increasing (Davidson and Mukherjee, 2007).[139]

These conclusions no longer hold once integer constraints on the number of active firms are taken into account: even in a free-entry equilibrium, a merger may increase or decrease aggregate output and thus consumer surplus. However, in the context of the homogeneous-goods Cournot model, Spector (2003) shows that, in the absence of merger-induced synergies, a merger that is privately profitable (when taking into account the merger's effect on entry) necessarily harms consumers; put differently, for it to be both profitable and CS-nondecreasing, a merger needs to induce synergies.[140]

It is important to emphasize though that the assumptions underlying a free-entry equilibrium appear very strong. In most markets, they are unlikely to be satisfied in the short run, not least because entry takes time and because firms that have not yet entered a market are likely less efficient than those that have. As we discuss in Section 3.3.6 below, Mermelstein et al. (2020) provide a dynamic computational framework of (endogenous) mergers with endogenous entry (and investment) that takes such considerations into account.

3.3.4 Dynamic considerations

The analysis of the static Williamson trade-off between the market power and efficiency effects ignores a number of important issues. We begin with the issue that, in many industries, mergers are not one-time events. In a world in which mergers may become feasible over time, the approval decision on a merger today has two types of dynamic effects. First, because of competitive externalities, the decision affects the profitability of potential future mergers involving rivals, and therefore the likelihood of such mergers being proposed. Second, again because of competitive externalities, the decision affects the welfare consequences of potential future mergers, and therefore the likelihood of such mergers being approved by the antitrust authority. This suggests that merger approval decisions based only on current market conditions may be inappropriate.

[138] In the parlance of aggregative games, $r(\cdot; c)$ is the output *fitting-in function*.

[139] The same conclusions hold under differentiated-goods price competition with logit/CES demands where the free-entry condition uniquely pins down the equilibrium value of the aggregator (price index) and thereby consumer surplus; see Anderson et al. (2020).

[140] Using the aggregative-games approach to multiproduct-firm oligopoly of Nocke and Schutz (2018), Caradonna et al. (2021) show that the same conclusion holds under price competition with logit/CES demands. Cabral (2003) considers horizontal mergers in a spatially differentiated oligopoly with free entry (taking integer constraints seriously).

What is the optimal dynamic merger approval policy when merger opportunities arise over time and, in every period, firms with a feasible merger can choose whether to propose it, and the antitrust authority decides which of the proposed merger(s) to approve? While this may seem a hopelessly complicated problem, Nocke and Whinston (2010) show that in some circumstances it has a surprisingly simple solution: An antitrust authority that aims to maximize discounted consumer surplus can achieve its goal by adopting a completely myopic merger approval policy, whereby in every period it approves only the subset of proposed mergers that maximizes consumer surplus in the current period, completely ignoring the possibility of future mergers. In fact, in their model, a myopic policy is dynamically optimal in a strong sense: The authority could not improve upon the induced outcome even if it had perfect foresight about future merger possibilities and even if it had the power to undo previously approved mergers (neither of which it in fact has).

Nocke and Whinston (2010) derive the dynamic optimality result assuming homogeneous-goods Cournot competition, but the result extends to differentiated-goods Bertrand competition with (nested) logit/CES demands (Nocke and Schutz, 2019). The result builds on two key conceptual assumptions. First, merger opportunities do not disappear, so that a merger that is not proposed today (or is proposed but blocked by the authority) can be proposed (and approved) in a future period. Second, mergers are *disjoint*; that is, no firm can be part of more than one (potential) merger.

At the heart of the dynamic optimality result lies a fundamental sign-preserving complementarity in the CS-effect of mergers: If two (disjoint) mergers are CS-nondecreasing in isolation, given current market structure, then each remains CS-nondecreasing if the other merger takes place. Conversely, if two (disjoint) mergers are CS-decreasing, then each remains CS-decreasing if the other gets implemented. This complementarity obtains because any given merger is more likely to be CS-increasing the more intense is competition (as this weakens the merger's market power effect), which it is after a CS-increasing merger. This also means that a CS-increasing merger can change the sign of the CS-effect of a second merger from negative to positive; if so, the first merger remains CS-increasing, conditional on the second taking place. If all feasible and not-yet-approved mergers are always proposed, these arguments imply that the antitrust authority will never regret approving a merger that is CS-nondecreasing at the time of the approval. Because merger opportunities do not go away, the authority also does not regret blocking a merger at a time when that merger is CS-decreasing because it can be approved if and when its CS-effect is positive.

Turning now to the moral hazard problem regarding firms' incentives to propose a feasible (and not-yet-approved) merger, Nocke and Whinston (2010) show that firms' proposal incentives are aligned with the interests of the authority. This follows because any CS-nondecreasing merger is privately profitable in isolation; moreover, it remains profitable even if it induces (directly or indirectly) other mergers to become CS-nondecreasing and therefore to get implemented.

3.3.5 Endogenizing the choice of merger

The simple Williamson trade-off ignores another issue: Merger proposals are endogenous and firms can often choose *which* merger to propose. Nocke and Whinston (2013) show that there is a systematic misalignment of firms' proposal incentives with the interests of consumers: If two alternative mergers were to result in the same non-

negative change in consumer surplus, then the "larger merger" (i.e., the merger with the larger target) would be more profitable. To mitigate these biased proposal incentives, the authority should therefore discriminate between mergers and commit to a tougher standard on mergers involving larger firms.[141]

3.3.6 Investment and innovation

Most of the literature on mergers focuses on the short-run price/quantity effects of mergers, reflecting the emphasis of antitrust agencies and courts. Mergers and merger policy may, however, also affect firms' incentives to invest, to innovate, or to design their product lines. The effects on firms' long-run decisions are much less well understood though, both theoretically and empirically, than those on short-run decisions. Despite this, the impact of mergers on investment have been at the core of some recent merger investigations, including a series of mergers in the mobile telephony industry, both in the EU and the United States.[142] Nonetheless, the academic literature has paid less attention to issues relating to mergers and innovation than is likely warranted.

It is perhaps easiest to analyze this issue in a static model of price or quantity competition and process innovation in which all decisions are taken simultaneously. This is the approach taken in Motta and Tarantino (2019). Specifically, they assume that prior to the merger each firm i offers a single product and chooses two strategic variables: its price p_i and its investment level x_i. The latter means that the firm has to incur a fixed cost $F(x_i)$, increasing in x_i, resulting in a (constant) marginal cost of production $c(x_i)$, decreasing in x_i. On the demand side, they assume that demand has the IIA property.[143] Suppose the merger-induced synergies affect only the production cost and not the investment cost function F. If these synergies are not strong enough so that, at the pre-merger vector of investments (and thus marginal costs) and rivals' prices, the merger partners have an incentive to raise their prices, then they also have an incentive to reduce their investments. The intuition is simple: The incentive to invest in process innovation is positively related to the merged firm's output level; if the merger partners have an incentive to reduce that output level, given their pre-merger marginal costs, they will reduce their effort in keeping marginal costs down. Hence, absent synergies in investment costs, for a merger not to harm consumers requires the same level of production cost synergies as when the effect of the merger on investment is ignored.[144]

Such a static approach to studying mergers and investment has the advantage of

[141] In particular, approving any merger that raises consumer surplus is not an optimal strategy for the antitrust authority. While this seemingly contradicts the conclusion of Nocke and Whinston (2010), note that the choice among alternative merger partners means that the disjointness assumption of Nocke and Whinston (2010) is not satisfied.

[142] The impact of the recent DowChemical/DuPont merger on the incentive of the merging parties to invest in R&D in the pesticide market played a major role in the investigation by the European Commission.

[143] Building on Nocke and Schutz (2018, 2019), they adopt an aggregative games approach and show that firm i's two-dimensional problem of choosing (p_i, x_i) can be collapsed into the single-dimensional problem of choosing price p_i. This follows as for any own price p_i and rivals' price vector p_{-i}, there exists a unique best response x_i.

[144] Bourreau et al. (2019) provide a taxonomy of the effects of a merger among symmetric duopolists in a static model in which firms not only compete in prices but also invest in demand-enhancing innovation. The nature of the investment – demand-enhancing innovation rather than marginal cost reductions – generates a richer set of effects than those identified by Motta and Tarantino (2019).

tractability but also obvious drawbacks, especially for studying optimal policy. What is taken as given in a static model—the initial industry state (e.g., the initial vector of marginal costs)—is endogenous (and affected by policy) in a dynamic model.

Mermelstein et al. (2020) analyze optimal merger policy in a dynamic computational model. In their model, the presence of scale economies allows firms to lower their unit costs through the accumulation of capital; at the same time, these scale economies are also the source of merger-related efficiencies as firms can lower their unit costs by combining their capital stocks through mergers. The paper builds on the computational IO literature, pioneered by Pakes and McGuire (1994) and Ericson and Pakes (1995), adding some innovations that make the model more useful for analyzing mergers.[145] In addition to deciding on capital accumulation, firms can choose to propose a merger, and the antitrust authority—as a strategic player with a given objective function—can choose to block the merger proposal.[146] Once a merger has been proposed and approved, a potential new entrant appears but without capital; the new entrant can subsequently decide if and how much to invest in capital accumulation. The model thus endogenizes entry, investment and mergers, and captures the fact that firm entry and investment are costly, take time and entail uncertain outcomes.

Among other results, Mermelstein et al. (2020) show that the optimal dynamic policy differs markedly from the optimal static policy that considers the effect of the merger only at the current state. They also show that the (in)ability of the authority to commit to its future policy is important: If the true social objective is discounted aggregate surplus, and the authority cannot commit, it may often be better to endow the authority with a tougher standard such as discounted consumer surplus. Indeed, in their baseline specification, a permissive merger policy improves firms' investment incentives in (almost) all states and, yet, leads to lower investment on average as it changes the equilibrium distribution over states: once mergers are allowed, the industry spends much more time in states in which industry concentration is high and firms have weaker incentives to invest. Moreover, a permissive merger policy induces entry-for-buyout behavior: new entrants invest inefficiently much in capital with the sole aim of being purchased by an incumbent.

In innovative industries, mergers and acquisitions are often motivated by the desire of a dominant firm to purchase the technology of a smaller rival. Examples in the digital technology sector might include Facebook acquiring Instagram and WbatsApp, Google acquiring Android, Applied Semantics (Adsense) and YouTube, and Microsoft acquiring Hotmail and Forthought (Powerpoint). Cabral (2018) provides a dynamic model of innovation in continuous time to shed light on the impact of such acquisitions on innovation intensity.[147] In the baseline model, there are two firms—a dominant firm and a fringe firm—who choose at every point in time how much to invest in (incremental) innovation. If one firm successfully innovates, it becomes the current technological leader (and its rival the technological laggard). For a given technology level, the dominant firm makes a larger profit than the fringe firm, and contemporaneous industry profits are larger if the dominant firm rather than the fringe firm is the technologi-

[145] One important difference is in the assumed investment technology, which is approximately "merger neutral" and allows for richer investment dynamics.

[146] Gowrisankaran (1999) also studies mergers in a dynamic computational model but with a simpler investment technology that is not merger-neutral and without the antitrust authority as a player.

[147] See also Segal and Whinston (2007) for a closely related framework to study other aspects of antitrust in innovative industries.

cal leader. An acquisition is modeled as a technology transfer from the technological leader to the laggard by which the latter becomes the new technological leader—with the price of the acquisition being determined through bargaining.[148]

In equilibrium, only the laggard innovates; moreover, technology transfers take place only when the innovator is the fringe firm—that is, the acquirer is always the dominant firm. Cabral shows that allowing such technology transfer through acquisition increases the rate of (incremental) innovation.[149] In an extension, Cabral (2018) introduces the possibility for firms to invest not only in incremental innovation but also in radical innovation: if a firm succeeds in radically innovating, it not only becomes the technological leader but also the (new) dominant firm. Allowing for technological transfer through acquisition in such an environment negatively affects the radical innovation rate by increasing its "opportunity cost" for the technologically lagging fringe firm.[150]

Igami and Uetake (2019) provide a rare empirical study of the impact of mergers on innovation, focusing on in the hard disk industry, which is discussed further in Sections 3.7 and 5.

3.3.7 Product quality and positioning

Another issue ignored by the static Williamson trade-off between the market power and efficiency effects is the impact of the transaction on product quality and positioning. A merger can affect product quality and positioning either directly, through enabling assets to be combined in a way that allows a better product to be produced, or by changing the incentives of market participants via the change in market structure. This second effect has been the focus of recent empirical papers that have sought to adapt the Nevo (2000) merger simulation framework to accommodate product repositioning. How this is done depends on the industry setting that is being studied: Li et al. (2019) examine mergers in the airline industry using a static entry model, attached (as a first stage) to a nested logit demand model. In their setting, the choice is between offering non-stop or connecting service on a route.[151] Wollmann (2018) also uses a first-stage entry model to assess changing product mix following a merger in the US commercial vehicle market. Fan (2013) considers the repositioning of newspapers following a merger, allowing the newspaper to adjust both prices and three dimensions of quality. In this setting, adjusting non-price characteristics essentially involves adding extra first-order conditions to the firm's maximization problem (firms select characteristics, and then choose prices, where characteristics are continuous variables).

Sweeting (2010) provides reduced-form evidence, in the context of mergers between radio station operators, that product repositioning can be a first-order issue in assessing the impact of mergers on consumers. This finding corroborates the simulation-style experiments of Li et al. (2019), Wollmann (2018) and Fan (2013). All of these papers find that mergers can significantly affect the incentives for offering particular product

[148]The technology transfer can equivalently be viewed as a merger, immediately after which a new fringe firms enters the market as a technological laggard.

[149]Cabral (2018) dubs this the *innovation for buyout* effect of technology transfer—which is reminiscent of the *entry for buyout* effect in Mermelstein et al. (2020)

[150]Cabral (2018) dubs this the *complacency* effect of technology transfer.

[151]Benkard et al. (2020) conduct a similar exercise using a conditional choice probability approach based on the Bajari et al. (2007) dynamic game estimator. See also Ciliberto et al. (2021).

mixes and that accounting for product repositioning can have a meaningful impact on the inferred change in consumer welfare. The direction of the bias introduced by not accounting for quality changes varies by paper. This is not surprising, as product entry (or repositioning) by a competitor may increase competitive pressure while product exit (or equivalent repositioning) by the merged entity may further weaken competitive pressure and exacerbate consumer harm; which effect dominates naturally depends on the industry setting.[152]

3.3.8 Bargaining power effects

The last issue ignored by the static Williamson trade-off, which has received notable attention in the recent academic literature, is the impact of horizontal consolidation on the negotiating power of firms in negations with counter-parties at a different level in the vertical chain. As an example, consider a merger of hospitals. At least in the United States, hospitals provide health services to insurers who then sell access to these services (bundled with insurance) to consumers. Hospitals are upstream input suppliers to health insurance companies. When hospitals merge, this changes the composition of options that insurers can negotiate with in forming the network of hospitals that they offer to consumers. The impact of a merger on this negotiation process, and the outcomes that it generates, has been the focus of many papers in the IO-Health literature. A notable example is Gowrisankaran, Nevo, and Town (2015), who adapt a merger simulation framework to this setting (combining the Nevo, 2000, merger simulation with the empirical nash-in-nash bargaining framework of Crawford and Yurukoglu, 2012). They find that the bargaining power of insurers can significantly counteract the market power created by hospital consolidation.

An alternative, mechanism design, approach is taken by Loertscher and Marx (2019). They consider bidding markets with buyer power and study the effects of a merger between bidders. Analogous to Farrell and Shapiro (1990), they show that a horizontal merger harms buyers in the absence of cost synergies – but the effect is mitigated by buyer power. Sufficiently strong cost synergies can eliminate the merger harm but also make otherwise profitable mergers unprofitable.

3.4 Coordinated effects analysis

A merger is typically said to result in coordinated effects when it leads to pricing outcomes that deviate from those that would be predicted by a static Nash equilibrium. That is, situating any coordinated effect theories in a fully specified model requires a continuation value of some form. Typically, the continuation value takes the form of the defect-and-punish dynamic present in most collusion models (see Section 2.2). Hence, any discussion of coordinated effects has a significant overlap with collusion. The primary distinction is that concerns about coordination arising in the absence of explicit communication are typically somewhat heightened in a discussion of coordinated effects.[153]

[152] Mazzeo et al. (2018) provide further guidance in the form of a variety of simulations based on adding a preliminary 'product selection' stage to a standard differentiated products merger simulation framework.

[153] Porter (2020), Fabra and Motta (2018), Ordover (2008), Ivaldi et al. (2003) all provide detailed surveys of the legal and economic aspects of coordinated effects.

It is not unusual for challenges to mergers to employ, as an element, a coordinated effects theory.[154] That said, economists have tended to focus on unilateral effects in the analysis of mergers, at least since the 1980s.[155] We conjecture that the focus on unilateral effects was due to its comparative analytic clarity and the relative absence of clear empirical examples of linking mergers to an increase in the types of conduct contemplated by the coordinated effects label. In the remainder of this section we discuss these features and recent research that speaks to them.

The theoretical foundation for concerns about coordinated effects arise from the standard repeated-game structure used to model cartel behavior in Section 2.2. In a nutshell, the question is whether the merger-induced change in market structure facilitates collusion in the sense discussed in Section 2.2.3. In the infinitely-repeated, homogeneous-goods Bertrand model with n symmetric firms we have seen there that the critical discount factor $\underline{\delta}$ (above which collusion can at least sometimes be sustained) is increasing in n and that, under imperfect monitoring, the time the industry will spend in the collusive state is decreasing in n, assuming the true discount factor is above the critical level (i.e., $\delta \geq \underline{\delta}$). To the extent that a merger reduces the number of players in an industry, this suggests that mergers facilitate collusion.

However, the homogeneous-goods Bertrand model is very special, not least because both the maximal deviation profit (which, in that model, is equal to the monopoly profit) and the profit in the punishment phase (which, in that model, is equal to zero) are independent of n. In richer models, both of these may be decreasing in n, implying that a merger-induced reduction in the number of firms increases not only the left-hand side of the no-cheating constraint (2) but also the right-hand side, so that there are countervailing effects on the critical discount factor. Further, and more importantly, firms are heterogeneous, and a merger is typically more than the elimination of a competitor as the merged firm obtains the tangible (and often also the intangible) assets of the merger partners.

Compte et al. (2002) study this issue in a stylized homogeneous-goods Bertrand setting with perfect monitoring. Market demand takes the form of a step function: it is equal to one at any price less than or equal to the monopoly price of one, and zero otherwise. There are n firms that differ in capacity. Firm i's marginal cost is equal to zero up to its capacity k_i. Firms are labeled in increasing order of their capacity: $k_1 \leq k_2 \leq \cdots \leq k_n$. Let $\widehat{k}_i \equiv \min\{k_i, 1\}$ denote firm i's "effective capacity." Similarly,

[154] According to Richard Gilbert and Hillary Greene (as cited in Miller and Weinberg, 2017) sixty percent of merger complaints filed by the DOJ and FTC between 1990 and 2014 alleged coordinated effects of some form.

[155] Stigler (1964) might be considered the definitive statement of the dominant thinking regarding mergers prior to the mid 1980s. Stigler's central concern is that a merger is just a clean way to replicate a cartel. His use of HHIs was focused on identifying conditions under which a deviation by a conspirator is likely to be detected by co-conspirators. While Williamson (1968), as read by a modern antitrust economist, feels like an early unilateral effects paper, it is important to notice that it is a discussion of a merger to monopoly. Hence, the distinction is somewhat redundant. This view of mergers remained central through the 1970s and was at the heart of the 1982 US Merger Guidelines. Early developments of modern unilateral effects analysis started to emerge in the 1970s, with Cowling and Waterson (1976)'s development of the link between an industry's HHI and the average mark-up, in the context of a Cournot model, being an important contribution. Concurrent development of empirical methods facilitating testing of equilibrium in differentiated products markets (e.g., Bresnahan, 1989) accelerated this transition. Farrell and Shapiro (1990) might be thought of as ending that transition. This transition is marked by the 1992 US Merger Guidelines, in which (at least to our knowledge) the term unilateral effects was first used in a major policy document.

let $K \equiv \sum_i k_i$ denote industry-level capacity, $K_{-n} \equiv \sum_{i<n} k_i$, and $\widehat{K} \equiv \sum_i \widehat{k}_i$ the sum of effective capacities. In their analysis, Compte et al. (2002) focus on "constant share equilibria" in which each firm i has the same market share, α_i, in every period along *any* continuation equilibrium path (even after a deviation). They characterize the critical discount factor above which "perfect" collusion can be sustained. In their setting, a merger $M = \{l, m\}$ between firms l and m allows the two firms to combine their capacities (so that their post-merger capacity is $k_l + k_m$); it has no efficiency effects.

The simplest case arises when $K_{-n} \geq 1$. In this case, the static Nash equilibrium has price equal to marginal cost of zero and gives zero profit to each firm, which is the worst possible punishment. The critical discount factor $\underline{\delta}$ is minimized if the market shares are allocated proportional to firms' effective capacities, i.e., $\alpha_i = \widehat{k}_i/\widehat{K}$. If so, it is given by $\underline{\delta} = (\widehat{K} - 1)/\widehat{K}$. Merger M cannot raise $\widehat{K}$, and so can only make collusion easier. It does so whenever the combined capacity of merger partners l and m is larger than one, $k_l + k_m > 1$.

The analysis is more involved, and the results more surprising, when $K_{-n} < 1$. In that case, the static Nash equilibrium does not yield minmax payoffs.[156] Compte et al. (2002) show that with the optimal allocation of market shares it is always the largest firm whose no-cheating constraint binds. The critical discount factor is given by $\underline{\delta} = \widehat{k}_n/\widehat{K}$. Hence, any merger involving the largest firm hurts the ability to collude; on the other hand, mergers that do not involve the largest firm, and do not create a new largest firm, have no effect.

The analysis of Compte et al. (2002) thus shows that, in a sufficiently rich model with heterogeneous firms, a merger may facilitate or hurt collusion, depending on market and merger characteristics.[157] It is probably fair to say that the conditions under which a merger facilitates (or hurts) collusion are not well understood outside very special models.[158] Moreover, as already discussed in Section 2, there is not yet a robust mapping from theoretical predictions on the critical discount factor to a probability of collusion actually occurring in a market.[159]

It should therefore not be too surprising that in the last twenty years or so courts have been reluctant to block a merger based on potential coordinated effects, at least unless the industry has been known to have been cartelized in the past. On the other hand, if a merger is approved in an industry that is already cartelized, the merger's potential harm may be limited, and – because of efficiencies – may actually benefit society.[160]

[156]The maximal punishment subgame-perfect equilibrium now has two "phases": all firms charge a low price $\underline{p}$ in the first period of the punishment and a high price $\overline{p}$ thereafter.

[157]See Vasconcelos (2005) for a repeated Cournot-model in which marginal costs depend on asset holdings and mergers that induce greater asymmetries in marginal costs make collusion harder to sustain. Similarly, Hatfield et al. (2020) show that increases in concentration in syndicated markets may hurt collusion.

[158]Davis and Huse (2010) and Igami and Sugaya (2020) conduct merger simulations to analyze coordinated effects in richer differentiated-goods settings.

[159]This not-too-optimistic take on the predictive power of collusion models is consistent with the view of Kaplow and Shapiro (2007) that "some important things are missing in models of repeated oligopoly that predict collusive outcomes for a very wide range of market structures and industry conditions. Put simply, supergame theory, at least with sufficiently patient players and without further modifications, is of limited use because it proves too much."

[160]In line with this argument, Röller and Steen (2006) examine a cartel in the Norwegian cement industry

Figure 10: Price movements of beer around the June 2008 Miller-Coors merger

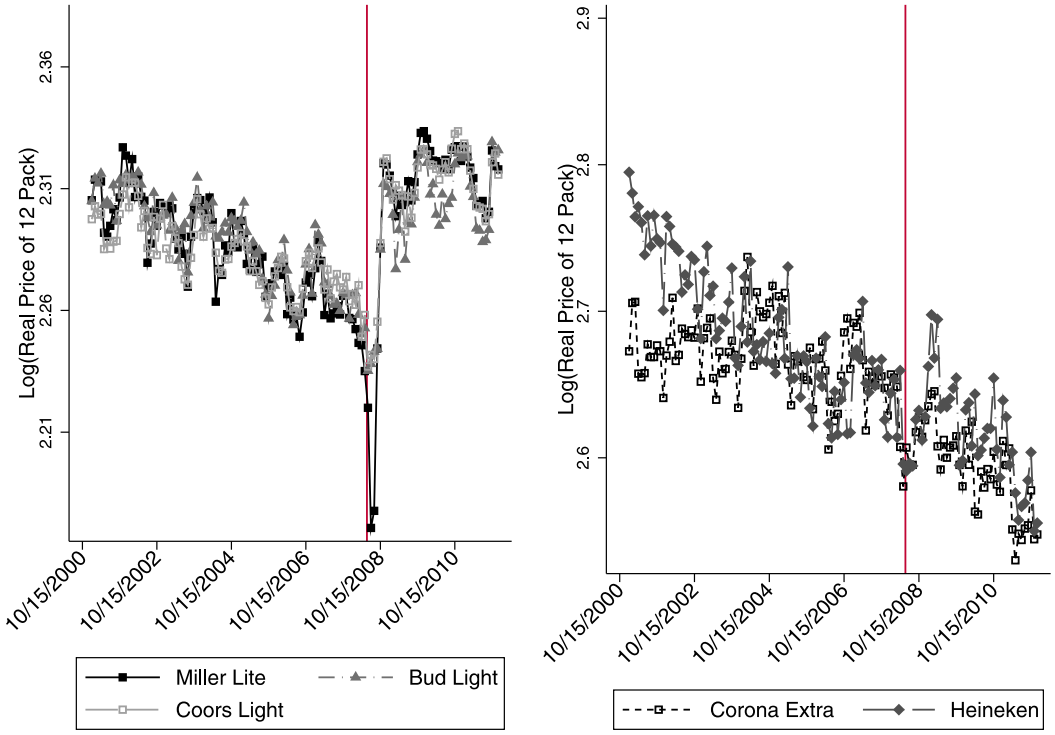


FIGURE 1.—Average retail prices of flagship brand 12 packs. *Notes*: This figure plots the average prices of a 12 pack over 2001–2011, separately for Bud Light, Miller Lite, Coors Light, Corona Extra, and Heineken. The vertical axis is the natural log of the price in real 2010 dollars. The vertical bar drawn at June 2008 signifies the consummation of the Miller–Coors merger.

Notes: Drawn from Miller and Weinberg (2017), Figure 1.

Despite the limited predictive power of collusion models, recent research has started to provide a better empirical foundation for concerns about coordinated effects. A prominent example of this line of work is Miller and Weinberg (2017). Miller and Weinberg examine the effect of the 2008 merger of the US operations of SABMiller and Molson Coors in the US beer market.[161] This merger was let through due to compelling evidence of merger-specific cost efficiencies. Nonetheless, in the investigation

in the period 1955-1968. This cartel operated using a market sharing rule that allocated shares according to capacity, leading to over-investment in capacity. The 1968 merger of the two firms in the industry solved the coordination problem in the industry and removed the incentive to engage in this costly over-investment. As a result, Röller and Steen find that this merger to monopoly delivered a welfare gain relative to the alternative of wasteful collusion. (Röller and Steen do point out that actual competition would have yielded yet greater welfare gains.)

[161]This was part of a joint venture agreement between the two companies. The transaction was approved by the DOJ on June 5th, 2008, on the basis that efficiencies arising from the combination of the brewing operations would outweigh any adverse competitive effect. See the discussion of Ashenfelter et al. (2015) in Section 3.1.

documents surfaced that indicated leader-follower pricing dynamics in the industry. Miller and Weinberg conduct a retrospective which suggests an adverse competitive impact of the transaction, due to coordinated effects.

Figure 10 drawn from Miller and Weinberg shows the path of (log) prices from 2001 to 2011.[162] The left panel shows the price of 12-packs of Miller Lite, Bud Light and Coors Light (domestic beers in the light segment). The right panel are 12-packs of Corona Extra and Heineken (imported beers). All these are 'flagship' brands for their respective brewers.

Curiously, the merger leads to an 8% increase in prices for all brands in the left panel, almost immediately after obtaining merger clearance (indicated by the vertical line at June 2008). By contrast, in the right panel, little to no persistent impact of the merger is evident. The long-term trend of price declines in the left panel is also stopped by the merger.

The price patterns in Figure 10 prompt further examination of the possibility of coordinated effects. While it is possible to construct a demand system that would lead to price patterns like those observed in Figure 10, the extreme strategic complementarity required between Bud and Miller/Coors, together with weak substitution between the domestic and imported segments seem unlikely.[163] To further examine the plausibility of coordinated effects, Miller and Weinberg discuss qualitative evidence of price leadership, which surfaced in other litigation in the beer industry, and then build a structural model which accommodates coordination. The point of this structural modeling is to assess the fit of alternative conduct models to the observed price patterns.[164] The observed price patterns are significantly higher than are predicted by a merger simulation based on known efficiencies and unilateral effects. By contrast, a coordinated-effects model appears to fit the observed price paths.

Miller and Weinberg is a significant paper in establishing the empirical plausibility of coordinated effects in environments where, typically, unilateral effects would be the focus of any merger analysis.[165] That said, it leaves a range of questions open. These include the mechanism of coordination, why coordinated effects arose in this particular instance, or how it could have been predicted that the observed pricing outcomes would occur.[166]

3.5 Vertical mergers

A vertical merger is distinct from a horizontal merger in that it involves the combination of an "upstream" supplier (e.g., manufacturer) with its "downstream" buyer (e.g., retailer) rather than that of firms at the same level of the vertical chain. The core

[162]The underlying data are weekly retail (supermarket) scanner data from IRI.

[163]Miller and Weinberg also recognize other industry factors that could contribute to the patterns observed in Figure 10.

[164]At the core of the model is an estimated demand system, implemented as a random coefficient nested logit model, and a series of models of Bertrand price competition between firms with differentiated products. The key innovation is the introduction of a variable $\kappa \in [0, 1]$, which captures coordination between brands that are not jointly owned. This κ variable enters the ownership matrix in traditional first-order conditions and is estimated. κ is a form of conduct parameter (see Bresnahan, 1989). The estimated value of κ rejects standard models of unilateral price competition.

[165]See Michel and Weiergraeber (2018) for a similar study in the context of the cereal industry.

[166]In follow-on work, Miller et al. (2019) investigate the price leadership mechanism in this industry.

economic distinction between a horizontal and a vertical merger is that the former is a combination of firms offering substitutes whereas the latter involves firms offering complements. This is the main reason why antitrust authorities tend to view vertical mergers more favorably than horizontal mergers: When contemplating an output increase (or price decrease), a firm does not internalize the externality it imposes on another firm. This externality is negative when the other firm offers a substitute but is positive when it offers a complement. Following a merger between the two firms, this externality is internalized—leading (in the absence of merger-induced synergies) to lower output (higher prices) in case of substitutes but higher output (lower prices) in case of complements.

Given this, a stronger presumption in favor of the vertical merger being welfare enhancing exists, and theories of harm focus on concerns around foreclosing rivals and coordinated effects.[167] In light of the excellent existing surveys on vertically related markets, here we provide only a short treatment of vertical mergers.[168] We begin by outlining the fundamental vertical externality that will be internalized by a vertical merger, to the benefit of consumers, and briefly discuss some other efficiencies generated by vertical mergers. We then turn to potential foreclosure effects of vertical mergers, which tend to harm consumers. Finally, we discuss the coordinated effects of vertical mergers.

3.5.1 Vertical mergers and the elimination of double margins

To illustrate the fundamental vertical externality, consider a bilateral monopoly with upstream firm U and downstream firm D. Assume that U produces an intermediate input at constant marginal cost c_U which is transformed by D (using a Leontief technology) into a final good, on a one-to-one basis, at constant marginal cost c_D. That is, the overall marginal cost of supplying the final good is $c_U + c_D$. Consumer demand for the final good is represented by demand $Q(p)$ and inverse demand $P(q)$, satisfying standard assumptions.[169] We consider the following simple two-stage game of complete information. First, U sets a per-unit wholesale price w for the intermediate input. Second, D sets the price p for the final good (or, equivalently, the quantity $q = Q(p)$).

Given its effective marginal cost $w + c_D$, D sets the corresponding monopoly price $p^M(w + c_D)$, where $p^M(c) \equiv \arg\max_p [p - c]Q(p)$. Equivalently, it sets the (monopoly) quantity $q^M(w + c_D)$, which is the solution in q to the first-order condition

$$R'(q) = w + c_D, \tag{7}$$

where $R'(q) \equiv P(q) + qP'(q)$ is marginal revenue. From equation (7), let $W(q) \equiv R'(q) - c_D$ denote D's inverse demand for the input. Instead of maximizing its profit with

[167] Concerns around raising rivals' costs can be considered a weaker version of foreclosure and concerns around information sharing can be thought of as a form of coordinated effects. Salop and Cully (2020) provide a list of US vertical merger cases from 1984, which provides an overview of the many manifestations of these potential harms.

[168] See, in particular, the chapter by Lee et al. in this volume of the Handbook series as well as the chapter by Rey and Tirole in the previous volume. See also Slade (2020) for a complementary, practitioner-focused survey of the empirical literature on vertical mergers.

[169] In particular, we assume that marginal revenue is decreasing: $2P'(q) + qP''(q) < 0$ for all q such that $P(q) > 0$.

respect to w, U's problem can thus be written as one of choosing quantity: $\max_q[W(q)-c_U]q$. Let q^* be the solution to U's problem, which satisfies the first-order condition

$$R'(q^*) + q^*R''(q^*) = c_U + c_D. \tag{8}$$

Hence, under vertical separation, the equilibrium wholesale and final goods prices are given by $w^* = W(q^*)$ and $p^* = P(q^*)$, respectively. Note that $w^* > c_U$ and $p^* > w^* + c_D$; that is, both U and D charge a markup ("double marginalization").

Consider now a (vertical) merger of U and D. Suppose that the merger does not involve any synergies, so that the post-merger marginal cost of producing the final good is $\overline{c} = c_U + c_D$.[170] The post-merger equilibrium quantity $\overline{q}^*$ is the unique solution to the first-order condition

$$R'(\overline{q}^*) = c_U + c_D. \tag{9}$$

Comparing (8) and (9), and noting that $R'' < 0$, we find that the vertical merger raises equilibrium output, $\overline{q}^* > q^*$, and lowers equilibrium price, $\overline{p}^* < p^*$. Hence, even absent merger-induced synergies, the vertical merger is CS-increasing.

Under vertical separation, D does not internalize that U earns $w^* - c_U > 0$ on any additional unit of output.[171] Following a vertical merger, this externality is internalized and the double marginalization eliminated: the merged firm makes its output decision based on the true marginal cost of the vertically integrated structure, $c_U + c_D$. In essence, U's input is a complement in the production of the final good—and the internationalization of externalities in the production (and distribution) of complements is beneficial, for firms and consumers.[172]

While a merger of U and D would indeed lead to the beneficial internalization of the vertical externality, alternative contractual arrangements that fall well short of a merger would induce the same outcome. For instance, instead of a linear wholesale price w, U could charge a two-part tariff (w, F), where w is the wholesale price per unit of input and F is the fixed (or franchise) fee that D has to pay independently of the quantity ordered. By setting $w = c_U$, U would effectively induce D to take the action that maximizes joint profit, and by setting $F = [\overline{p}^* - c_D]\overline{q}^*$ U would extract all of the rents from D.[173] However, the elimination of double marginalization through simple contractual means is unlikely to succeed in richer environments with incomplete information.[174]

Provided that wholesale tariffs are linear (and publicly observable) and the upstream industry is not perfectly competitive, the insight that a vertical merger leads to the elimination of double marginalization continues to hold in richer economic environments—but additional effects may come into play.[175]

[170] As in the case of a horizontal merger, we assume that—following a merger—the merger partners act as a single player, maximizing joint profit.

[171] This conclusion does not hinge on our assumption that U unilaterally decides on the wholesale price w but would continue to hold if the value of w were determined through Nash bargaining or some other (efficient) bargaining process, unless D had all of the bargaining power.

[172] The insight that integration leads to the elimination of double marginalization in a model of successive monopolies is often attributed to Spengler (1950) but goes back to Cournot (1838).

[173] If (w, F) were determined through some efficient bargaining process, the distribution of bargaining power would affect the value of F but not that of w.

[174] See, for example, Nocke and Thanassoulis (2014) and Choné et al. (2021).

[175] See, for example, Westfield (1981) and Salinger (1988, 1991) for early studies.

Consider, for example, the following situation studied by Salinger (1991): there are two symmetric upstream firms, U_1 and U_2, each producing a differentiated product at constant marginal cost c_U and selling through a common downstream retailer, D. Prior to vertical integration, D's marginal cost of selling product i is $w_i + c_D$, where w_i is the per-unit wholesale price charged by U_i. Let $Q_i(p_1, p_2)$ denote the demand for product i and $\partial_j Q_i(p_1, p_2)$ its partial derivative with respect to p_j, satisfying $\partial_j Q_j(p_1, p_2) < 0$ (downward-sloping demand) and $\partial_j Q_{-j}(p_1, p_2) > 0$ (substitute products). In the pre-merger equilibrium, downstream prices satisfy

$$Q_i(p_1^*, p_2^*) + [p_i^* - w_i^* - c_D]\partial_i Q_i(p_1^*, p_2^*) + [p_{-i}^* - w_{-i}^* - c_D]\partial_i Q_{-i}(p_1^*, p_2^*) = 0,$$

where $w_j^* > c_U$ is the equilibrium wholesale price of product j. Consider now a merger of U_1 and D. Evaluated at pre-merger wholesale and downstream prices, the partial derivative of the merged firm's profit with respect to p_1 is now negative,

$$Q_1(p_1^*, p_2^*) + [p_1^* - c_U - c_D]\partial_1 Q_i(p_1^*, p_2^*) + [p_2^* - w_2^* - c_D]\partial_1 Q_2(p_1^*, p_2^*) < 0,$$

whereas that with respect to p_2 becomes positive:

$$Q_2(p_1^*, p_2^*) + [p_2^* - w_2^* - c_D]\partial_2 Q_2(p_1^*, p_2^*) + [p_1^* - c_U - c_D]\partial_2 Q_1(p_1^*, p_2^*) > 0. \qquad (10)$$

The "downward pricing pressure" on p_1 is due to the familiar elimination of double marginalization on that product. The "upward pricing pressure" on p_2 is the flip side of this: because the integrated D now makes a larger profit on every unit of product 1 it sells (when evaluated at pre-merger prices), it has an incentive to increase the price of product 2 so as to steer more consumers toward product 1.[176] However, as these derivatives were evaluated at the pre-merger price levels, this does not mean that post-merger the prices of products 1 and 2 would necessarily decrease and increase, respectively.[177] While it is possible to construct counter-examples, it is reasonable to expect that the vertical merger of U_1 and D does increase consumer surplus (even though some consumers may be harmed).

Luco and Marshall (2020) study this type of situation in the context of the US market for carbonated beverages. This market operates by manufacturers (Coca-Cola, Pepsi, and Dr Pepper) selling concentrate to bottlers, who then constitute and bottle the drink, which is then sold to retailers. Importantly, bottlers have exclusive sales territories in which they are the sole provider of a manufacturer's products to retailers. Coca-Cola and Pepsi never use the same bottler, but a Coca-Cola (or Pepsi) bottler may also handle Dr Pepper products.

During 2009-2010 both Pepsi and Coca-Cola merged with a number of bottlers. This created a form of natural experiment in which different markets and bottlers experienced transitions to and from different vertical configurations. Importantly, the presence of Dr Pepper in the market meant that there was always an unintegrated product being handled by a bottler. Luco and Marshall use the resulting variation, via

[176] Luco and Marshall (2020) dub this upward pricing pressure on p_2 the *Edgeworth-Salinger* effect.

[177] Evaluated at post-merger levels of w_2 and p_1, the left-hand side of equation (10) would be smaller if the unintegrated U_2 finds it optimal to reduce w_2 and, to the extent that prices are "internal" strategic complements, if p_1 is set below its pre-merger level because of the elimination of double margins. In analogy with the Edgeworth paradox, Salinger (1991) argues that, perversely, even both prices may increase after the merger.

a differences-in-differences methodology, to measure the downward and upward pricing pressures.

Luco and Marshall find that both effects are present in their data: when Coca-Cola integrates with a bottler, the price of Coca-Cola products goes down and the price of Dr Pepper products goes up. Importantly, the magnitudes of the effects are roughly equivalent, with a 1.2% price reduction resulting from the elimination of double marginalization and a 1.5% price increase resulting from the upward-pricing pressure on the rival's products.

The results in Luco and Marshall contribute to an increasingly solid empirical foundation for the idea that the elimination of double marginalization is an important differentiating factor justifying the distinct treatment of vertical mergers. Structural work by Crawford et al. (2018) in the context of cable television also finds evidence consistent with the elimination of double margins.[178] At the same time, Luco and Marshall (2020) provide an important empirical basis for being somewhat cautious about drawing a conclusion that a merger between firms making complementary products must necessarily reduce all prices, simply due to the existence of that complementarity. As noted in the theory literature, and supported by the empirical work of Luco and Marshall, off-setting effects may be present in the price impacts on substitute products.

The elimination of double marginalization is an important efficiency-style consideration that arises in the context of vertical mergers. Other potential efficiencies include avoiding hold-up problems and protecting relationship-specific investments, reducing transaction costs, allocating risk more efficiently, and avoiding moral hazard.[179]

More conventional efficiencies can arise in vertical mergers as well, in much the same way that they can in horizontal ones. For instance, the US Federal Trade Commission (2020) points to mergers in which quality improvements result from integration of business tools, and scale and scope economies. Hortascu and Syverson (2007) provide an example of such 'mundane' efficiencies at work in the cement and concrete industries. They find that integrated cement and concrete firms are better able to realize scale economies when the integrated entity operates multiple concrete plants. Given the nature of concrete, which is highly perishable (prior to being set), the logistical coordination of deliveries has significant economic returns. The results in Hortascu and Syversion suggest that vertical integration is a channel through which the managerial expertise required to realize these scale economies may be transmitted. This theme is further developed in Atalay et al. (2014), in which the US Commodity Flow Survey data is used to illustrate that around half of vertically integrated upstream establishments do not make shipments to their downstream counterparts. Rather, evidence is presented consistent with the intangible inputs (equivalently, managerial expertise) being able to be transferred to vertically-related establishments. This mirrors the transfer of managerial talent documented in horizontal mergers in Braguinsky et al. (2015).

[178] In some settings, quality improvements and price reductions can be equivalent. To that end, Gil and Warzynski (2014) find that integrated games developers develop higher quality games, while Ciliberto (2006) finds that integration between doctors' practices and hospital systems increases investment in service quality.

[179] Perry (1989), in volume 1 of this handbook series, provides a concise overview of this literature and much of the early seminal empirical work on vertical integration. Early empirical work includes Monteverde and Teece (1982), Anderson and Schmittlein (1984), Masten (1984), and Joskow (1985).

3.5.2 Foreclosure effects

Foreclosure is the typical unilateral harm of concern in a vertical merger. Rey and Tirole (2007), in an authoritative treatment of the theory of foreclosure in volume 3 of this handbook series, define foreclosure as

> a dominant firm's denial of proper access to an essential good it produces, with the intent of extending monopoly power from that segment of the market (the bottleneck segment) to an adjacent segment (the potentially competitive segment).

Rey and Tirole go on to note that:

> Foreclosure varies in extent. It can be complete, as in the case of a refusal to deal (equivalently, an extravagant price can serve as "constructive refusal") or in the case of technical integration between complementary goods, or partial, as when the bottleneck owner favors some firms or products in the adjacent market to the detriment of other competitors.

In a seminal paper, Ordover et al. (1990) consider a model with two symmetric upstream firms, U_1 and U_2, producing a homogeneous input and competing in (linear) wholesale prices and two symmetric downstream firms, D_1 and D_2, offering differentiated products and competing in prices. Letting w_{ik} denote the wholesale price offered by U_i to D_k, the input price that D_k faces is given by $w_k \equiv \min(w_{i1}, w_{i2})$. Given (publicly observable) wholesale prices, let $p(w_k, w_{-k})$ denote D_k's equilibrium price in the induced subgame; this price function is strictly increasing in both arguments.

Prior to vertical integration, each upstream firm U_i offers the input to each downstream firm D_k at marginal cost: $w^*_{ik} = c_U$. The pre-merger equilibrium prices in the downstream market are thus given by $p^*_1 = p^*_2 = p(c_U, c_U)$.

Consider now a vertical merger of U_1 and D_1, assuming that the merger has no effects on marginal costs (or demand). If the integrated U_1 were to continue to supply the unintegrated D_2 post-merger, the merger would have no effect on the market outcome. Suppose instead that the vertically integrated U_1 withdraws from supplying D_2. As this withdrawal makes U_2 the sole potential supplier of D_2, it provides U_2 with an incentive to charge more: $\overline{w}^*_{22} > c_U$. As the integrated D_1 can obtain the input at marginal cost from its upstream affiliate, the post-merger equilibrium prices in the downstream market are given by $\overline{p}^*_1 = p(c_U, \overline{w}^*_{22}) > p^*_1$ and $\overline{p}^*_2 = p(\overline{w}^*_{22}, c_U) > p^*_2$. Hence, by withdrawing from supplying its input to D_2, the vertically integrated firm effectively softens price competition in the upstream market, which in turn raises its downstream rival's cost—leading to higher prices in the downstream market and harming consumers. It is important to note that the vertically integrated upstream firm does indeed have a strict incentive to withdraw from supplying the input to the unintegrated downstream firm whereas it did not have such an incentive pre-merger.

As pointed out by Reiffen (1992), a drawback of the mechanism proposed by Ordover et al. (1990) is that it relies on the ability of the vertically integrated firm to commit to withdrawing from the upstream market *before* wholesale prices are set: In the absence of such commitment power, the vertically integrated firm would have an incentive to undercut U_2's offer to D_2 as long as $w_{22} > c_U$. A strand of literature has identified conditions under which this commitment is in fact not required for foreclosure to arise. In a setup with endogenous choices of input specifications, Choi and Yi (2000) find that the integrated U_1 has an incentive to make a specialized input for its

downstream division while it would, absent integration, provide a generalized input. Under the assumption that U_1 is more efficient than U_2, Chen (2001) shows that D_2 is willing to pay more for the same input from the integrated U_1 than from the independent U_2, as this softens downstream competition; this results in the integrated U_1 supplying D_2 at a price that exceeds U_2's marginal cost, while U_2 finds itself unable to offer more favorable terms to D_2. In a model where downstream firms make ex-ante investments and upstream firms choose the quality of their input, Allain et al. (2016) show that the integrated U_1 has an ex-post incentive to degrade the quality supplied to the independent D_2; this results in D_2 being unwilling to deal with U_1, and thus being held up by the independent U_2. Finally, in a model with multiple upstream and downstream firms, Hombert et al. (2019) show that a vertically integrated firm may not want to undercut another vertically integrated firm, as this would result in the latter firm becoming more aggressive in the downstream market.

The literature on foreclosure following Ordover et al. (1990) typically relies on wholesale prices (or, more generally, contracts) being publicly observable. Hart and Tirole (1990) propose a very different theory of foreclosure based on a Coasian commitment (or "opportunism") problem that arises when the terms of the contracts between upstream and downstream firms are private information to the contracting parties.[180]

To see the opportunism problem, consider the model of Section 3.5.1 but suppose there are two symmetric downstream firms, D_1 and D_2, that compete in a Cournot fashion in the downstream market. Suppose also that the upstream monopolist, U, offers a two-part tariff (w_k, F_k) to each D_k. One way for U to sustain the monopoly outcome would be to charge $w_k = P(q^M) + (q^M/2)P'(q^M) - c_D$, where q^M is the industry-wide monopoly output level—inducing each D_k to produce $q^M/2$—and extract the remaining rents through the fixed fee $F_k = [P(q^M) - w_k - c_D]q^M/2$. However, if such contracts were signed, then U may have an incentive to secretly renegotiate with each D_k: if D_k expects its downstream rival to sell quantity $q^M/2$, a revised contract entailing a lower wholesale price in return for a higher fixed fee such that D_k's profit remains unchanged would strictly increase U's profit. As this secret contract renegotiation would induce D_k to increase its quantity, it would impose a negative externality on D_k's rival. Anticipating the scope for such opportunistic behavior by U, each downstream firm would not be willing to pay as much for the input in the first place. Hart and Tirole (1990) show that if downstream firms hold "passive beliefs", then the equilibrium quantity in the downstream market would not be q^M but rather the industry-wide quantity arising in a Cournot duopoly in which each duopolist faces the true marginal cost $c_U + c_D$.[181] The opportunism problem gets worse with the

[180] See Rey and Tirole (2007) for an in-depth treatment of the Hart and Tirole (1990) approach to vertical foreclosure.

[181] As downstream firms do not observe the terms of the contract signed by their rival, the Perfect Bayesian equilibrium depends on the beliefs that downstream firms hold about those terms when receiving an out-of-equilibrium offer. Under "passive beliefs" these beliefs are not revised in such an out-of-equilibrium event: each downstream firm continues to believe that its rival has received its equilibrium contract offer. When downstream firms compete in quantities, the equilibrium outcome under passive beliefs coincides with that under "wary beliefs" (McAfee and Schwartz, 1994), under which a downstream firm D_k receiving a deviant offer reasons as follows: (1) when making the offer, the deviant U expected D_k to accept it; (2) U offered to the other downstream firm D_{-k} a contract that is optimal for U, given the offer to D_k; (3) the other downstream firm, D_{-k}, reasons in the same way. Equilibrium outcomes under passive and wary beliefs no longer coincide if downstream competition is in prices (Rey and Vergé, 2004).

number of downstream firms. In the limit as that number becomes large, the upstream monopolist has no market power and the perfectly competitive outcome obtains.[182]

A vertical merger between U and, say, D_1 solves the opportunism problem: post-merger, U would sell the monopoly quantity q^M through its own downstream affiliate D_1 and completely foreclose the unintegrated D_1. Such foreclosure does not require any commitment power as the integrated U fully internalizes the negative externality that selling through D_2 would have on the integrated D_1. [183]

The theoretical literature discussed above focuses on *input* foreclosure in which a downstream firm is (partially or fully) foreclosed access to an input or upstream supplier. In the theoretical models, such input foreclosure may be identified through a merger-induced increase in the wholesale prices faced by unintegrated downstream firms. However, antitrust authorities are also concerned about *customer* foreclosure, which refers to the case in which an upstream firm is (partially or fully) foreclosed access to a customer or downstream firm.[184] By analogy with the case of input foreclosure, customer foreclosure may be identified through a merger-induced decrease in the wholesale price obtained by unintegrated upstream firms.

In Section 3.5.1 we have already seen a simple model (by Salinger, 1991) and an empirical application (by Luco and Marshall, 2020) in which (partial) customer foreclosure is likely to arise: after the vertical merger of U_1 (Coca-Cola) with D (bottlers), the integrated firm has an incentive to steer customers from U_2's (Dr Pepper's) product(s) to its own. As a result, the wholesale price that U_2 charges is likely to decrease. While in this simple situation, the vertical merger is unlikely to harm consumers (in the short run), it may reduce aggregate surplus. Moreover, such customer foreclosure may harm consumers in the long-run if it induces a decrease in (cost-reducing or quality-improving) investments of the (harmed) unintegrated upstream firms.

The empirical literature has tended to look for evidence of foreclosure by examining the extent to which integrated firms favor their own downstream outlets (input foreclosure) or their own upstream products (customer foreclosure). A good example of this approach is Chipty (2001).[185] Chipty investigates vertical integration between content and distribution in the US cable television industry in 1991. Vertically integrated operators tend to reduce content offerings, and in particular owners of premium movie services are less likely to offer a rival basic movie service. The same pattern is observed in shopping channels. Integrated operators are also found to strongly favor carrying their own integrated content. This is consistent with some degree of (customer) foreclosure but also with integration reducing transactions costs and aligning incentives more generally. Perhaps most interestingly, integrated operators are able to see more subscriptions, consistent with the elimination of double marginalization.

[182]Segal and Whinston (2003) show that such competitive convergence obtains more generally when contracts are unobservable.

[183]Nocke and Rey (2018) show that this insight extends to richer environments with differentiated-goods oligopoly upstream: a vertical merger is privately profitable, leads to foreclosure of rival downstream firms (whether integrated or not)—and harms consumers.

[184]This concern is expressed explicitly in the US *Vertical Merger Guidelines* as well as the EU *Non-horizontal Merger Guidelines*.

[185]Related, more recent, empirical work includes Hastings and Gilbert (2005), Suzuki (2009), McGowan (2017), and Boehm and Sontag (2019). Martin et al. (2001) provides a notable experimental contribution to the literature on foreclosure. Waterman and Weiss (1996) provides an early study of vertical integration in cable television.

Chipty also backs out the welfare implications of integration using an elegant and simple structural framework. Vertical integration is found to benefit consumers, although differences between integrated and unintegrated markets are not statistically significant. This suggests that the efficiency effects at least offset any potential harm arising from foreclosure effects. Chipty's paper is important for several reasons, not least for providing the first welfare analysis of vertical integration in an empirical setting.

Following on from Chipty, Crawford et al. (2018) take a more structural approach to the same set of issues. They focus on the integration of Regional Sports Networks (RSNs) with cable television distributors in the US between 2000 and 2010.[186] Over the time interval that they study, they see a series of changes in the carriage agreements, and ownership arrangements, between cable distributors and RSNs. Crawford et al. use an intricate structural model to quantify the incentives on integrated operators to engage in input foreclosure (deprive downstream rivals from access to RSN content), internalize the impact of pricing on related products, and adjust other aspects of their product offerings.

The model they use assumes that in each year (1) channels and distributors bargain bilaterally to decide affiliate fees, and distributors set prices and make carriage decisions for each market in which they operate; (2), households choose which cable operator, if any, to subscribe to in their market; and then, (3), households consume content. The bargaining process in stage (1) adopts the Nash-in-Nash protocol of Horn and Wolinsky (1988), as developed for empirical implementation by Crawford and Yurukoglu (2012) and Grennan (2013), and the subsequent literature.[187]

An important aspect of the model and empirical implementation is that it is not assumed that an integrated division fully internalizes the impact of its pricing (and other) decisions on the rest of the business. Instead, this is an estimated variable. It is estimated that 79 cents of every dollar realized by the RSN is internalized by the cable operator when making its decisions. By contrast, RSNs are found to fully internalize the impact of their decisions on the affiliated operator.

The estimated model is used to simulate the impact of various scenarios involving vertical integration, given the industry structure in 2007.[188] In this sense, Crawford et al. provide a framework for vertical merger simulation that is an analog to that provided by Nevo (2000), in the context of horizontal mergers. The simulation results find evidence of foreclosure, but also reveal that the welfare cost of foreclosure is entirely mitigated by efficiency effects (largely elimination of double marginalization), such that consumers are left weakly better off from vertical integration in all the scenarios and markets that they consider.[189]

Overall, what limited empirical evidence exists points to both the reality of fore-

[186]Crawford et al. (2018) explain that "RSNs carry professional and college sports programming in a particular geographic region. For example, the New England Sports Network (NESN) carries televised games of the Boston Red Sox and the Boston Bruins." These can be valuable content providers.

[187]See the chapter by Lee et al. in this volume of the handbook series.

[188]A key regulatory feature of this industry is program access rules that ensure that non-integrated rival distributors have access to integrated content. Much of the simulation exercise is concerned with the impact of vertical integration with and without these restrictions. What is discussed in the text above are the results in the absence of program access rules.

[189]Lee (2013) conducts a related structural analysis of vertical integration in the video game and console markets. In that setting, estimates point to a significant consumer welfare cost from vertical integration.

closure incentives and the propensity for them to be mitigated by offsetting pro-competitive effects. Quantitatively, the costs of foreclosure and the benefits from vertical integration can clearly be finely balanced. This points to the value of detailed, context-specific enquiry in policy environments. On the research side, expanding the set of well-studied industries beyond the cable television industry seems an obvious point of departure.[190]

3.5.3 Coordinated Effects

An often-raised concern is that a vertical merger may facilitate collusion, especially among upstream firms. For instance, the 2020 US *Vertical Merger Guidelines* explicitly discuss two candidate mechanisms through which a vertical merger may facilitate collusion in the upstream market: by making it potentially easier to monitor prices and by possibly eliminating a buyer ("maverick") that would otherwise disrupt collusion.[191]

In an infinitely repeated game with public monitoring, Nocke and White (2007) analyze the extent to which a vertical merger facilitates upstream collusion. In the upstream market, $n \geq 2$ (symmetric) firms produce a homogeneous good that they offer to $m \geq 2$ downstream firms through (public or private) two-part tariffs. The downstream firms transform this input into a homogeneous or symmetrically differentiated final good and compete in the downstream market in prices or quantities.

Suppose now that the upstream firms collectively attempt (through appropriately designed two-part tariffs) to induce the downstream firms to charge the monopoly price, and to extract all of the rents from the downstream firms, using grim-trigger strategies. Under vertical separation, a deviant upstream firm can obtain the entire monopoly profit by simply undercutting its rivals' contract offers—at the cost of making zero profit in any future period.[192] Suppose now instead that one upstream-downstream pair is vertically integrated, assuming no merger-induced efficiencies. By undercutting its rivals' contract offers, a deviating unintegrated upstream firm can still obtain the business of the unintegrated downstream firms – but not that of the integrated downstream firm, as the latter can obtain the same input at cost from its own upstream affiliate. Nocke and White (2007) dub this the *outlets effect*, as a vertical merger reduces the number of downstream outlets through which an upstream firm can profitably deviate. In a sense, the vertical merger forecloses access to an integrated downstream firm, not on but off the equilibrium path, thereby facilitating upstream collusion. To the extent that an integrated firm is harder to punish than an unintegrated upstream firm (in that the integrated firm's profit in the punishment phase may be strictly positive), there is a countervailing *punishment effect*.[193] However, Nocke and White (2007) show that the outlets effect always dominates the punishment effect so that the net effect of the (first) vertical merger is collusion-facilitating.[194]

[190]The vertical merger retrospective study in Taylor and Hosken (2007) emphasizes the same point.

[191]The 2008 EC *Non-Horizontal Merger Guidelines* also devote an entire section to such coordinated effects.

[192]The resulting critical discount factor is therefore equal to $\widehat{\delta} = (n-1)/n$, as in the textbook model of collusion under Bertrand competition.

[193]Suppose that the punishment phase entails the repeated play of the static Nash equilibrium actions. When offering differentiated products or competing in quantities, downstream firms—whether vertically integrated or not—make strictly positive profits in that phase, whereas unintegrated upstream firms do not.

[194]When downstream prices or quantities are set only after publicly observing all contract offers, there are two additional effects, a *reaction effect* and a *lack-of-commitment effect*, both of which further facilitate

Introducing heterogeneity among downstream firms, Nocke and White (2010) show that this conclusion carries over to *any* vertical merger, no matter how large (in terms of capacity or size of product portfolio) the integrated downstream firm. Consistent with the idea expressed in the *Vertical Merger Guidelines* that some downstream firms may be more disruptive of collusive schemes than others, Nocke and White show that vertical integration with a larger downstream firm helps upstream collusion more.

Empirical work on the link between vertical mergers and collusion is, at least to our knowledge, largely absent from the modern literature. This strikes us as a gap that, while challenging to fill, may have considerable benefits in providing a set of mappings from theory to observed phenomena and magnitudes of impact.

3.6 Remedies

Compared to blocking a merger, antitrust authorities are much more likely to approve it subject to remedies. For example, in the period from 1990 to 2014, the number of mergers the European Commission approved subject to remedies was about 15 times as large as the number of prohibitions (Affeldt et al., 2018). In the United States, 60% of the mergers that were challenged by the authorities between 2003 and 2012 were later approved subject to remedial commitments. Remedies may be behavioral (e.g., licensing agreements) or structural (e.g., divestiture of physical assets or intellectual property).

In light ot their prevalence, it is surprising how little is known – theoretically and empirically – about merger remedies. One natural question revolves around the extent to which divestitures can eliminate any harm that a merger would otherwise inflict on consumers. It seems that little can be said on this in general unless one is willing to make strong assumptions on how divestitures affect the efficiency of the outsiders receiving the divested assets as well as the efficiency of the merged firm (and how divestitures interact with any merger-related synergies).

Vergé (2010) studies a benchmark case to shed light on this. He considers a homogeneous-good Cournot model in which all firms have the same cost function $C(q,k)$, where q is the firm's output and k its capital stock. C is assumed to be homogeneous of degree one in (q,k) so that marginal cost $\partial C(q,k)/\partial q$ is decreasing in k. In the absence of divestitures, a merger of firms i and j leads to a new firm with capital stock $k_i + k_j$, where k_i and k_j are the merger partners' pre-merger capital stocks. Divestitures involve allocating some of the merger partners' capital stock to non-merging outsiders. Under the assumption of no merger-related synergies (i.e., the merged firm's cost function is $C(q,k)$), a merger is CS-decreasing in the absence of divestitures. Divestitures can mitigate the negative effect on consumer welfare if and only if the re-allocation of capital makes the industry more symmetric. Vergé shows that remedies can never fully eliminate the harm that the merger would otherwise inflict on consumers if there is only one non-merging outsider or if the pre-merger asymmetries in capital holdings are not large enough.[195]

collusion. The reaction effect arises because by vertically integrating an upstream firm effectively hires a downstream enforcer of upstream collusion in that a deviant upstream firm can be punished even within the same period. The lack-of-commitment effect arises because a vertically integrated firm cannot credibly commit not to lower its own downstream price (or increase its own downstream quantity) when deviating in the upstream market, which reduces the maximal deviation profit it can achieve.

[195]The Vergé (2010) results apply to unilateral effects. In mergers with coordinated effects elements the

Nocke and Rhodes (2019) develop a framework to analyze remedies for mergers that may cross many markets. In each market in which they are active, the merger partners have market-specific assets that can be divested to non-merging outsiders, including firms that are not yet active. Nocke and Rhodes impose only relatively mild assumptions on how divestitures affect the marginal costs of the asset-receiving firms (essentially, marginal costs are monotonic in asset holdings) as well as the asset-divesting merged firm and also allow for arbitrary (market-specific) merger-induced synergies. They assume that the set of divestitures is determined through efficient bargaining between the (consumer-surplus-oriented) antitrust authority and the (profit-maximizing) merger partners, subject to two types of constraints. The first are market-specific constraints on the post-merger consumer surplus level – a special case of which would be the requirement that consumer surplus cannot fall after the merger in any market. The second is the merger partners' participation constraint as the merger would not go ahead if it were not privately profitable.

The first part of the analysis is concerned with solving for the best (from the merged firm's point of view) divestitures that meet the market-level consumer surplus constraints. Nocke and Rhodes show that more competitive markets require fewer (if any) divestitures. The second part is concerned with the multimarket bargaining problem. The key concept that helps to characterize the efficient solution is the *remedies exchange rate*, which gives the level of profit that the merged firm would have to give up to achieve an extra dollar in consumer surplus. Nocke and Rhodes show that under some conditions on the curvature of demand the remedies exchange rate improves in a given market the more assets have already been divested in that market. As a result, the bargaining solution has a bang-bang property: It involves maximum divestitures in some markets and minimum divestitures (to meet the market-level constraints) in the remaining markets. Surprisingly, the efficient bargaining solution entails maximum divestitures in markets in which the merger partners face more efficient rivals as the average remedies exchange rate tends to be worse in such markets.

Friberg and Romahn (2015) empirically study the effect of the 2001 merger between Carlsberg and Pripps, two large brewing companies, on the Swedish beer market.[196] The merger was approved subject to the merger partners divesting 18 products (beer varieties) to a small rival firm (Galatea). Using a difference-in-difference approach, with the non-merging outsiders as controls, Friberg and Romahn find that the merger with remedies reduced both the prices of the non-divested beer varieties of the merger partners as well as those of the divested varieties.[197] The former result suggests that the merger-induced synergies were sufficiently strong to outweigh the market power effect of the merger whereas the latter finding is consistent with the notion that the asset-receiving outsider (Galatea) had less market power after the merger than the merger partners did prior to the merger. Friberg and Romahn also perform a structural merger simulation with and without the divestitures, based on random-coefficient MNL demand. Using only pre-merger price data, they find that—compared

results may reverse. See, for instance, Compte et al. (2002).

[196]Lagos (2018) conducts a similar analysis of divestitures in the retail gasoline market, finding the divestures of stations were effective in mitigating harm in very local markets.

[197]One issue with this exercise is the extent to which non-merging outsiders are a valid control group; another is that the merger was endogenous (and perhaps anticipated by various industry players) and quite some time elapsed between the announcement of the merger and its consummation, so that there is no sharp break between "before" and "after."

to a scenario without remedies—the divestitures would have decreased but not eliminated the merger-induced price increases of the non-divested products *if the merger had not affected marginal costs*. Finally, using post-merger price data, they back out the merger-induced marginal cost savings and find that they are quite substantial: 5% for Carlsberg and 10% for Pripps.

3.7 Overall impact and merger retrospectives

Merger retrospectives play an important role understanding how consummated mergers impact competitive conditions in a market. The typical merger review takes a merger and examines the impact of that merger on an outcome variable using some version of a differences-in-differences methodology. Drawing broad conclusions about the impact of mergers from the merger retrospective literature requires grappling with a number of conceptual issues. These issues include:

1. The set of mergers that are studied are selected. Consummated mergers are ones that have typically been cleared by the relevant antitrust authority. This means that mergers that are blocked, or that are deterred from occurring are not part of the studied population.
2. The studied population are mergers that occur in industries where data availability facilitates academic study. This means that the literature is slanted toward industries that are consumer facing or that have specific regulatory features that generate a source of administrative data. Comparatively, few retrospectives consider intermediate goods markets.
3. The set of mergers that are studied tend to be on the larger side, or present the opportunity to study specific economic phenomena of interest. The literature does not study a random sample of all cleared mergers.

None of these issues undermine the value of merger retrospectives. They are, however, worth keeping in mind when thinking about what the literature can teach us.[198]

While specific retrospectives have already been discussed in this chapter, the objective of this discussion is to give a broader sense of the merger retrospective literature. In doing so we are inclined to be cautious - this is a (happily) growing literature, with new insights being generated every year. To aid in gaining an overview of this literature, we surveyed the top-five general-interest journals in economics, and the more central IO journals, and pulled all the retrospectives we could find published between 2000 and 2020.[199] This creates a less clear filter than one might think, in that several papers have the flavor of a retrospective in some respects but, at least to us, seemed to have a

[198]Other issues can arise. For instance, many merger retrospectives pay only limited attention to defining an appropriate market in which competitive harm, relevant to antitrust scrutiny, may arise. This raises the possibility that any measured consumer harm may arise via channels that are outside the scope of antitrust regulation.

[199]The journals we focused on were: American Economic Review, Econometrica, Journal of Political Economy, Review of Economic Studies, Quarterly Journal of Economics, American Economic Journal: Microeconomics, American Economic Journal: Economic Policy, RAND Journal of Economics, Journal of Law and Economics, Review of Economics and Statistics, Journal of Industrial Economics, International Journal of Industrial Organization, Journal of Economics and Management Strategy, Review of Industrial Organization. For a wider selection of retrospectives see the exhaustive catalog compiled by the FTC at `https://www.ftc.gov/policy/studies/merger-retrospectives/bibliography#background`.

central focus that lay elsewhere (for instance, we do not include Nevo, 2000, or Grieco et al., 2018, in our list, despite those papers offering commentary as to the impact of consummated mergers).[200] We are hesitant to describe the list as comprehensive, but we do view it as representative.

The output of this survey is contained in Section 5 of this chapter. This section contains a table in which we collect the date of the transaction(s) studied, the country to which the data relate, the relevant industry, and a citation to the paper. Most importantly we quote a short extract from the paper that we judged to be the clearest expression of the authors' conclusions.[201] Several themes emerge:

1. Studies find a wide range of price impacts. Some price go up, at times by a lot. Others find no impact. Some find prices go down. The wide range of price outcomes reported following a merger is what we find most striking about these studies when examined collectively.
2. Few studies provide estimates of consumer welfare changes. Many assume that price changes are sufficient statistics for welfare.
3. The outcome variables of interest vary across studies. The change in price of the merged products is commonly measured. Some studies also measure the change in the price of competing products. Other studies also consider the change in the volume of trade (quantity or, in some instances, market share).
4. A small number of studies consider longer-run dynamics. Short and long-run prices effects have been compared (Focarelli and Panetta, 2003), and the impact on innovation has also been studied (Igami and Uetake, 2019).
5. Comparatively few retrospectives consider the impact of mergers on product quality or variety, the incentives for entry and exit, or investment.

What merger retrospectives unambiguously provide is a textured picture of the many and varied ways in which a consummated merger can impact a market. The retrospectives collectively provide clear evidence of the capacity for a merger to lead to consumer harm and, consequently, for the value of agency review. Lastly, the range of observed outcomes emphasizes the value of evaluating specific mergers with reference to the specific industry context in which it occurs. This mirrors standard practice in empirical industrial organization more broadly.

3.8 Emergent issues relating to mergers

The discussion of mergers thus far has been centered on the analysis of specific, usually contentious, mergers and the process by which the impact of individual mergers is assessed. At least two developing literatures provide a backdrop to this discussion of merger analysis.[202] These literatures look at more aggregate trends in the economy

[200] For similar reasons, we do not include Ashenfelter et al. (2015), which, while a retrospective, is solely focused on efficiencies (see the discussion in Section 3.1). Miller and Weinberg (2017) provide a more holistic picture of the 2008 Miller-Coors JV.

[201] Other surveys of retrospectives have attempted to summarize results in a more standardized way. We considered, for instance, trying to record price impact in a standardized way. This proves to be hard. Variation in how studies report results, units of measurement, and the focus of different papers made us uncomfortable with this approach. Instead, we felt that simple quotes served our purpose best.

[202] Shapiro (2019) provides an extended overview of these, and other related, issues.

and raise questions as to whether the implementation of merger policy, at least in the United States, can be improved.

The first of these literatures seeks to measure the extent to which markups have changed over time in the US economy. Much of this literature seeks to explore market power based channels that may explain declines in the labor share in the US, but this literature has also fed into discussions about the appropriateness of current merger policy.

A second line of literature documents an increase in the overlap of equity ownership (equivalently, common ownership) of firms, predominately by large financial entities and explores the extent to which this may be affecting firms' conduct in their product markets.

These two lines of research are, at the time of writing, less developed than the topics covered in the rest of this discussion of mergers. That said, they are attracting considerable attention, in both academic and policy discussion. Our objective in this brief section is to focus on the core findings in these literatures. Even more so than is the case elsewhere, we are cautious in our selection of what to discuss. Given that these literatures are in early stages of development, we are less certain of which results are likely to contribute to the consensus view of researchers working on these topics. This makes these literatures particularly exciting for researchers and we, like many in the research community, eagerly await further work in all these areas. We first turn to the literature on markups.

De Loecker et al. (2020) estimate the revenue-weighted average markup of publicly listed firms in the US from 1955 to 2016, where markups are defined as the ratio of price to marginal cost. Figure 11 shows how this estimated average markup increases over time.[203] De Loecker et al. (2020) conduct a range of robustness checks finding similar qualitative results across a variety of specifications. Importantly, reported markups are much more stable for the vast majority of firms than Figure 11 would suggest. In their own words, "Most firms see no increase in markups. For the higher percentiles, markups increase. For the 90th percentile in particular, the increase is sharpest. Between 1980 and 2016, it increases from 1.5 to 2.5. This indicates that the change in average markup is largely driven by a few firms that currently have much higher markups than decades ago." Notably the median markup is flat over this period.

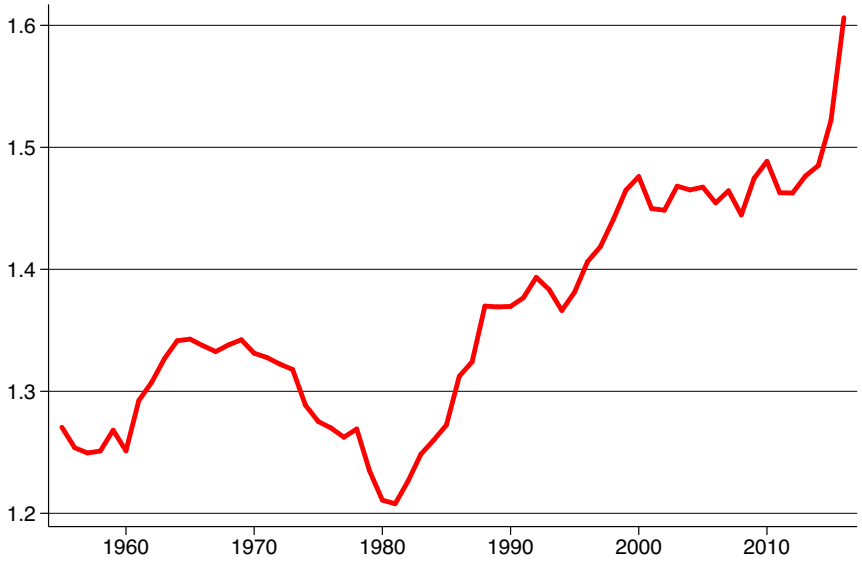
Measurement lies at the core of interpreting the De Loecker et al. (2020) results. Markups, as reported in Figure 11, are derived from Compustat data by taking the ratio of revenue to the costs of goods sold and then applying a measure of the elasticity of output to variable inputs. This follows the approach of De Loecker and Warzynski (2012) and De Loecker (2011).[204] Inevitably, the results will be impacted by the composition of firms in the economy at any point in time and how they engage in production. A shift toward firms with larger fixed costs and (or) lower costs of goods sold will impact the average markup over time.[205] This theme is further explored in

[203]Markups are estimated at the firm level and then averaged.

[204]See also the discussion in the chapter by De Loecker and Syverson in this volume of the handbook series.

[205]De Loecker et al. (2020) do much more in their paper than draw conclusions solely based on Figure 11. In their conclusion they elaborate as follows, "We further establish that the rise in markups is not merely to offset a rise in overhead costs. Although overhead costs have risen, the rise in markups exceeds that of overhead. We thus find that there are excess markups, and that the excess markups are highest for those firms with high overhead costs. This is consistent with the increase in our measure of profits. We also find substantial increases in the market value as a share of sales. All this indicates that the rise in markups is

Figure 11: Revenue-weighted average markups for US publicly listed firms, 1955-2016 (De Loecker et al., 2020)



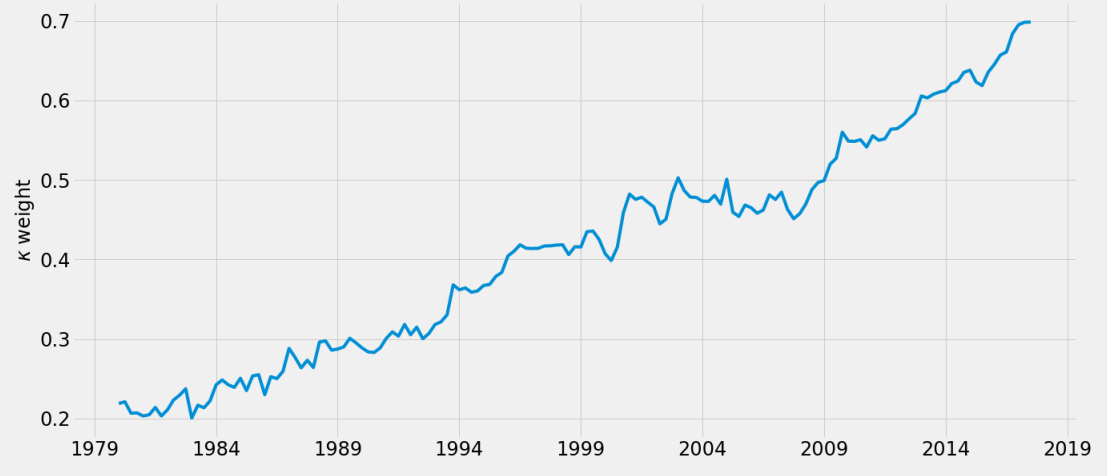
Notes: Markups (on the vertical axis) are defined as price ÷ marginal cost. Firm data is from Compustat.

De Loecker et al. (2021).

evidence of a rise in market power."

Related work has moved the literature in a variety of directions. Edmond et al. (2019), Baqaee and Farhi (2020), and De Loecker et al. (2021) all explore the aggregate implications of changes in markups using different theoretical models. Their work suggests that that the markup changes documented in De Loecker et al. (2020) are of a sufficient magnitude to contribute to broader aggregate effects. Autor et al. (2020) focus specifically on the implications of an increased prominence of large firms in the economy for the labor share. Again, the measured impacts point to meaningful aggregate effects. Complementing these studies, Ganapati (2020) provides a useful descriptive examination of detailed firm-level census data, showing that between 1972 and 2012 concentration increases are positively correlated with productivity and real output growth, uncorrelated with price changes and overall payroll, and negatively correlated with labor's revenue share.[206]

Figure 12: Changing ownership of public companies in the US: Common Ownership Profit Weights 1980-2017 (Backus et al., 2021)



Notes: This figure depicts the mean implied profit weight across all pairs of firms in the S&P 500 index by year, excluding own profit weights, which are normalized to 1. See Backus et al. (2020) for the formula for common ownership weights and its derivation.

The second line of emergent research relating to mergers considers the impact of overlaps in the equity holdings of US financial institutions (equivalently, 'common ownership'). The idea is that if an institutional investor owns equity in two firms that are competitors, this may lead to incentives that, in turn, lead to pressure on managers to ease bilateral competition.[207] A useful starting point in exploring this literature is the raw patterns in the data regarding the extent of common ownership. Backus et al. (2021) compute the weight that each firm in the S&P 500 places on the profits of every other firm in the S&P 500, as implied by a simple model of profit maximization with common ownership, between 1980 and 2017. The average of this statistic is shown in Figure 12.

[206] Berry, Gaynor, and Scott Morton (2019) provide a useful IO-centric perspective on this nascent literature.

[207] This idea dates back to at least Rotemberg (1984) and Bresnahan and Salop (1986). See also Cestone and White (2003).

As seen in Figure 12, in 1980 the average weight that a firm in the S&P 500 put on another firm in the index was around 0.2 (a measure of 0 is equivalent to that predicted by a model with purely unilateral profit maximization, 1 is equivalent to that predicted by a model with full integration). By 2017 this weight had increased to almost 0.7. This represents a significant change in the composition of equity interests in the economy.

Related empirical work has explored the extent to which changes in common ownership can be linked to increases in prices or reductions in quantity or entry in specific industries (see, for instance, Azar et al., 2018, Newham et al., 2019, Xie and Gerakos (2020), and Backus et al., 2021). Other work has attempted to consider the channels through which any adverse impact may be transmitted (see Hemphill and Kahan, 2020, and Antón et al., 2019). In particular, Antón et al. (2019) develop a model in which the incentive for owners to incentivize managers to engage in cost cutting becomes diminished as common ownership increases. This is because owners, when they own equity in competing firms, internalize the competitive externality that cost cutting (and resultant price reductions) impose on competitors. Shekita (2020) grounds much of this discussion by collecting relevant case studies drawn from media coverage, regulatory proceedings, policy groups, and annual stewardship reports. That is, Shekita provides a set of documented instances in which common ownership appears to have impacted firm conduct. Regardless of where this literature ends up, it is clear that even basic patterns relating to common ownership point to possibly important changes in the way the firm sector of the economy might relate to its owners. Given that this transition has occurred via the acquisition of equity, this has potential implications for the range of activity that may usefully invite increased antitrust scrutiny.[208]

4 Conclusion

In this chapter, we have reported on many advances that have been made, both theoretically and empirically, to improve our understanding of antitrust issues relating to collusion and mergers. In doing so, we have left out important chunks of the vast literature, largely because of space constraints. Throughout this chapter we have pointed out issues that are not yet very well understood or strands of literature that are not yet well developed. For instance, more work is needed to understand better why some markets are cartelized while others are not. In the same vein, the potential coordinated effects of mergers are much less well understood than their unilateral effects – to the point that coordinated effects have rarely been at the center of merger investigations (and court proceedings) in the last twenty years or so, at least in the United States. Also, not much is known about "typical" magnitudes of the efficiency effects of horizontal mergers and how they may be related to market structure – despite such efficiencies being at the heart of the Williamson (1968) trade-off. Antitrust authorities are much more likely to approve a merger subject to remedies than to block it; yet, little is known about the effects of divestitures and their optimal design. In sum, while much progress has been made, antitrust economics relating to collusion and mergers will continue to be an exciting research area for many years to come.

[208] Ongoing consideration of the appropriateness of the form of the passive investor exemption under US merger law seems an obvious place to start.

5 Appendix: Summary of Merger Retrospectives

Date of Transaction	Country	Industry/Product	Summary statement	Citation
Studies of a single transaction				
1987	USA	Airlines	"[P]rices rose by 5.0 to 6.0 per cent on routes that one carrier served and the other was a potential entrant. This was more than half the increase on routes where the two carriers had been direct competitors."	Kwoka and Shumilkina (2010)
1990	USA	Hospitals (not for profit)	"[T]he transaction was followed by significant price increases; we reject the hypothesis that these price increases reflect higher post- merger quality."	Vita and Sacher (2001)
1997	USA	Tampons, Sanitary Pads	"After the merger the price of Always pads increased by 8 percent relative to private label pads, and the price of Tampax tampons increased by 5 percent relative to private label tampons. "	Weinberg (2011)
1999	France	Supermarkets	"Our results show a significant post-merger price increase of approximately 2% (between 1.8% and 2.4%) at the rivals' stores affected by the merger ... The merger is also correlated with a 4 to 5% increase in merging firms' prices"	Allain et al. (2017)
1999	USA	Gasoline	"[W]e find no evidence that this acquisition led to higher prices for consumers."	Simpson and Taylor (2008)
2000	France	Parking Facilities	"[T]he merger caused exposed lots - whatever the order of exposure - to increase their price by about 3%."	Choné and Linnemer (2012)
2001	Sweden	Beer	"Average price of beer sold by the merging firms increased some over the pre-merger period but remained largely constant around the merger. The prices of the other main brewers increased somewhat after the merger. The divested beers fell in price compared to the other two groups of beers."	Friberg, Romahn (2015)
2005	USA	Beer	"We document abrupt increases in retail beer prices just after the consummation of the MillerCoors joint venture"	Miller and Weinberg (2017)
2006	USA	Household Appliances	"We estimate price increases for dishwashers and relatively large price increases for clothes dryers, but no price effects for refrigerators or clothes washers. The combined firm's market share fell across all four affected categories and the number of distinct appliance products fell."	Ashenfelter, Hosken, and Weinberg (2013)
2006	UK	Books	"We find that the merger did not result in any price increase either at the local or at the national level."	Aguzzoni et al. (2016)

Date of Transaction(s)	Country	Industry/Product	Summary statement	Citation
Studies of a single transaction (continued)				
2008	USA	Airlines	"[F]ares for airport-pairs where Delta and Northwest competed with each other prior to the merger do not increase by much. In nonstop markets, such price effects are statistically insignificant, whereas in connecting markets, the fare increases by 2.3%."	Luo (2014)
2013	Chile	Retail Gasoline	"[I]n locations impacted by higher market concentration there is an average retail margin increase within the range [0%, 4%] depending on the specification and the location of gas stations. However, stations impacted by the merger that are neighbors of a divested station within a 1 km radius display a significant reduction of retail price margins of about 2%, but only in municipalities with a low density of stations impacted by the merger."	Lagos (2018)
2013	USA	Airlines	"[T]he merger has a significant negative effect on price and that the effect is larger for bigger markets. The effect on price in smaller markets is the opposite of that in larger markets"	Das (2019)
Studies of multiple transactions				
1989-1996	USA	Hospitals	"[H]ospitals increase price by roughly 40 percent following the merger of nearby rivals."	Dafny (2009)
1989-1999	Global	Semiconductor	"[M]ergers and RJVs increase the market shares of participating firms. This points to an efficiency-enhancing role of mergers and RJVs."	Gugler and Siebert (2007)
1990-1998	Italy	Retail Banking	"We find strong evidence that, although consolidation does generate adverse price changes, these are temporary. In the long run, efficiency gains dominate over the market power effect, leading to more favorable prices for consumers."	Focarelli and Panetta (2003)
1993-2000	Canada	Residential Mortgages	"We find that the average effect of the merger yields a statistically significant increase in interest rates. . . . [Borrowers] with high search costs/bargaining abilities, are not affected by the merger, while [all others] are affected. Together these results imply that price dispersion falls as a result of the merger."	Allen, Clark and Houde (2014)

Date of Transaction(s)	Country	Industry/Product	Summary statement	Citation
Studies of multiple transactions (continued)				
1996	USA	Railroads	"[I]n the long run, the mergers have had negligible effects on grain transportation prices and consumer welfare."	Kakikari, Brown, and Nadji (2002)
1996-2006	USA	Radio	"[T]he merger wave resulted in an 11 percent drop in ad quantity and a 6 percent increase in [ad] prices, which translates into an aggregate listener welfare gain of 0.2 per- cent and a 21 percent loss in advertiser welfare."	Jeziorski (2014)
1996-2012	USA	Hospitals	"[C]ross-market, within-state hospital mergers yield price increases of 7%-9% for acquiring hospitals, whereas out-of-state acquisitions do not yield significant increases."	Dafny, Ho and Lee (2019)
1996-2015	Global	Hard Disk Drive	"How far should an industry be allowed to consolidate when competition and innovation are endogenous? . . . We find the current rule-of-thumb policy (which blocks mergers if three or fewer firms exist) is reasonably close to maximizing the discounted present value of social welfare."	Igami and Uetake (2019)
1997-2000	USA	Petroleum Refining	"We do not find evidence of a consistent price [and] concentration relationship."	Hosken, Silvia and Taylor (2011)
1997-2010	USA	Dialysis	"We base our empirical analysis on more than 1,200 acquisitions of independent dialysis facilities by large chains. Acquired facilities converge to the behavior of their new parent companies by increasing patients' doses of highly reimbursed drugs, replacing high-skill nurses with less-skilled technicians, and waitlisting fewer patients for kidney transplants. We then show that patients fare worse as a result of these changes: outcomes such as hospitalizations and mortality deteriorate. Because overall Medicare spending increases at acquired facilities, mostly as a result of higher drug reimbursements, this decline in quality corresponds to an unambiguous decline in value for payers."	Eliason, Heebsh, McDevitt and Roberts (2020)
1997-2012	USA	Hospitals	"Nine of the 28 mergers resulted in statistically significant price increases relative to controls, whereas 6 resulted in statistically significant relative price decreases . . . The mean price change relative to controls across all 28 mergers is 8.9% and the median is 9.6%."	Garmon (2017)
1998-2000	USA	Cereal, Motor Oil, Alcohol, CPG, Food	"[F]our of the five mergers we study resulted in some increases in some consumer prices, while the fifth merger had little effect on prices. The estimated price increases are typically between 3 and 7 percent."	Ashenfelter and Hosken (2010)

Date of Transaction(s)	Country	Industry/Product	Summary statement	Citation
Studies of multiple transactions (continued)				
1998-2006	USA	Health Insurance	"[W]e estimate premiums in average markets were approximately seven percentage points higher by 2007 due to increases in local concentration from 1998-2006. We also find evidence consolidation facilitates the exercise of monopsonistic power vis-a-vis physicians, leading to reductions in their absolute employment and earnings relative to other healthcare workers."	Dafny, Duggan and Ramanarayanan (2012)
2007-2011	USA	Hospitals	"Examining the 366 mergers and acquisitions that occurred between 2007 and 2011, we find that prices increased by over 6% when the merging hospitals were geographically close (e.g., 5 miles or less apart), but not when the hospitals were geographically distant (e.g., over 25 miles apart)."	Cooper et al. (2019)
2007-2008	USA	Grocery Retailing	"We find that five mergers resulted in estimated price increases of more than 2%, and that four of those mergers were in highly concentrated markets. Five mergers resulted in estimated price decreases of more than 2%, and only one of those occurred in a highly concentrated market. The remaining four mergers were associated with relatively little change in price."	Hosken, Olson and Smith (2018)
2013	USA	Cable TV	"I find evidence that station mergers lower retransmission fees. For the most plausibly exogenous set of mergers, a merger between two top-four stations in a market corresponds to basic prices that are on average $3.87 (or 18.9 percent) lower."	Boik (2016)

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