New Tools to Analyze Non-Horizontal Mergers

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Vorgelegt
von
Alessandro Stefano Kadner-Graziano
aus
Fritzlar

Dekan: Prof. Dr. André Meyer (Universität Bayreuth)
Vorsitzender der Prüfungskommission: Prof. Dr. Stefan Napel (Universität Bayreuth)
Erstberichterstatter: Prof. Dr. Fabian Herweg (Universität Bayreuth)
Zweitberichterstatter: Prof. Dr. Armin Schmutzler (Universität Zürich)
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Introduction

1.1 Protecting capitalism from itself, through government intervention, and for the benefit of citizens

> "Capitalism without competition isn't capitalism; it's exploitation."[1] – Joseph R. Biden, 46th President of the United States, 2021

Origins of antitrust rules

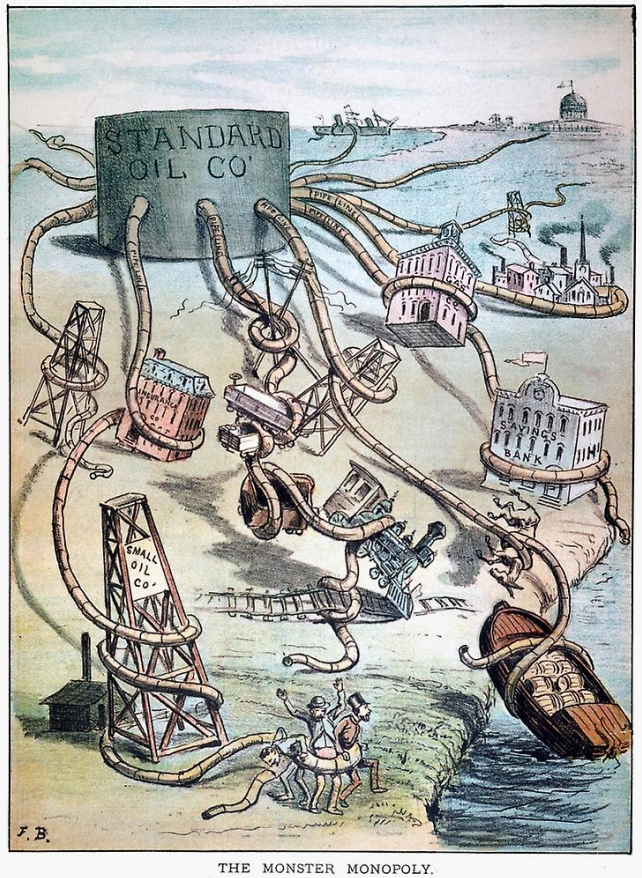
During my bachelor studies, I was surprised when a thought-provoking American professor in cowboy boots taught us that free markets fail. So Americans do not believe that free markets work just great? Surprising and intriguing, I thought at the time. In fact, the first antitrust laws were enacted in the United States: Congress passed the Sherman Act in 1890 nearly unanimously.[2] This was the age of railroads: when capitalism reigned largely free in the New World. Back then, a company named Standard Oil famously purchased rival oil producers and destroyed their production facilities. Standard Oil dominated the oil market. It cut supply to impose high prices. The blatant harm led to public backlash. The Sherman Act outlawed trusts (cartels), made it illegal for corporations to monopolize commerce, and enabled the government to break up existing trusts and monopolies.[3]

[1] See The White House, `https://www.whitehouse.gov/briefing-room/speeches-remarks/2021/07/09/remarks-by-president-biden-at-signing-of-an-executive-order-promoting-competition-in-the-american-economy/`.

[2] See National Archives, "Sherman Anti-Trust Act (1890)", `https://www.archives.gov/milestone-documents/sherman-anti-trust-act`.

[3] *Ibid.* In particular, see sections 1 and 2 of the Sherman Act.

Figure 1.1: “The Monster Monopoly”



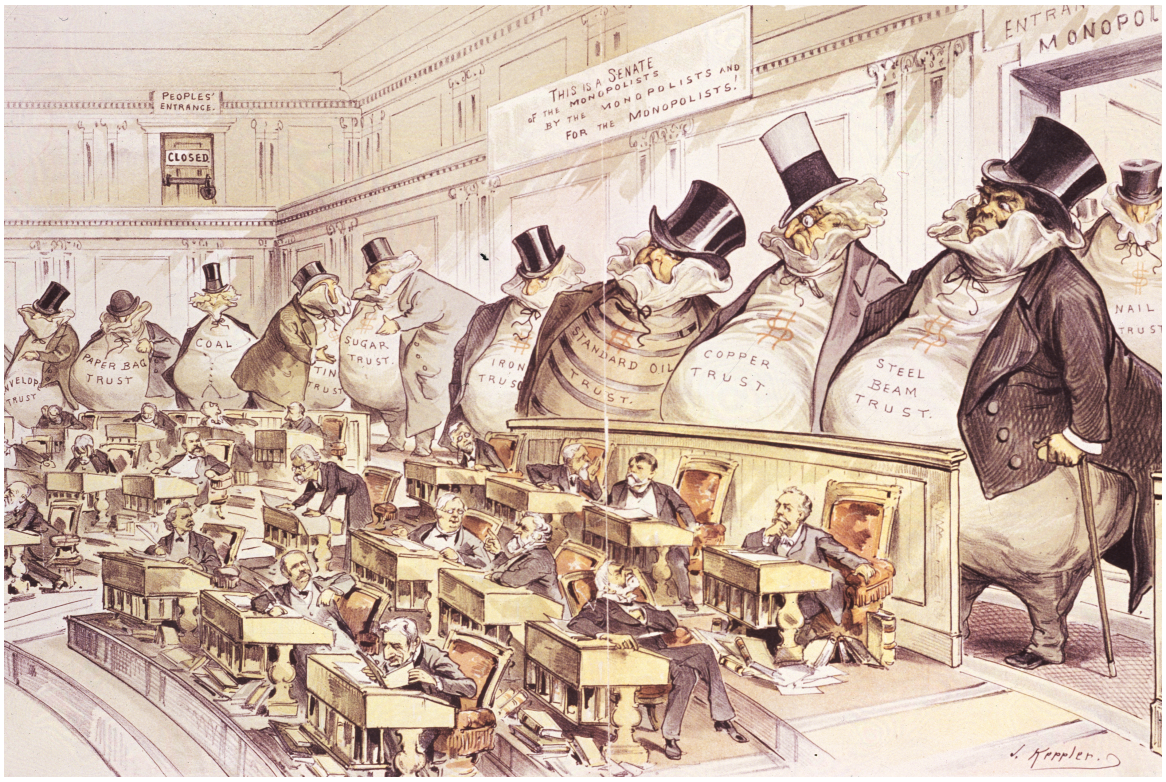
Credit: Frank Beard, appeared in *Judge*, July 19, 1884.

High prices were not the only issue. The United States enjoyed an economic boom in the late 19th and early 20th centuries (when it overtook the UK in economic might), but the concurrent growth of trusts and monopolies across numerous industries led to several problems. Not only did consumers pay monopoly prices in numerous industries, but workers also received low wages. Inequality increased. Corruption in Congress weakened and threatened democracy. In 1888, the then-President of the United States wrote on democracy in his diary,

> “The real difficulty is with the vast wealth and power in the hands of the few and the unscrupulous who represent or control capital. Hundreds of laws of Congress and the state legislatures are in the interest of these men and against the interests of workingmen. These need to be exposed and repealed. [...] This is a government of the people, by the people, and for the people no

longer. It is a government of corporations, by corporations, and for corporations."[4] – Rutherford B. Hayes, 19th President of the United States, 1888

Figure 1.2: "The Bosses of the Senate"



Credit: Joseph Keppler, appeared in *Puck*, January 23, 1889. This image was cropped.

Freedom is not just a political cause but also an economic one. In 1914, a US Representative declared in Congress, on prices and wages,

> "Monopoly has the power to dictate to the producer of the raw material which it must buy, and it has the power to dictate to its labor the wage it will pay for the only commodity labor has to sell, and at the same time it is the absolute dictator of the price which the consumer must pay for the output of the monopolies. Such a centralization of power is a menace to the well-being of all, and, carried to its logical conclusion, it means the enslavement of the

[4]Diary and Letters of Rutherford B. Hayes, Nineteenth President of the United States, edited by Charles Richard Williams (Columbus, Ohio: Ohio State Archaeological and Historical Society, 1922), Volume IV, March 11 1888, p. 374.

masses, the closing of the door of opportunity, and the centralization of all of the wealth earned by the brain and brawn of the American people in the hands of a few monopolists."[5] – Representative Helvering, 1914

Figure 1.3: "Senatorial Round House"

Credit: Thomas Nast, engraving, appeared in *Harper's Weekly*, July 10, 1886.

In this period, a rallying cry for government intervention in the United States can be summarized as: we did not submit to a king; we shall not submit to corporations either! Alternatively, in Senator Sherman's words, "If we will not endure a king as a political power, we should not endure a king over the production, transportation, and sale of any of the necessities of life."[6] Or, in President Woodrow Wilson's statements on freeing the US of monopolies, "This is a second struggle for emancipation".[7]

Because totally free markets fail, governments intervene in markets. In 1911, the US government broke up Standard Oil into numerous (34) smaller entities. Thereby, it

[5]Congressional Record – House, May 23rd 1914, p. 9184.
[6]Congressional Record – Senate, March 21st 1890, p. 2457.
[7]See United States German Embassy, `https://usa.usembassy.de/etexts/democrac/32.htm`.

protected competition and protected consumers from exploitation. After the Sherman Act had outlawed cartels, some firms resorted to mergers to continue coordinating prices. The US government intervened anew. It passed its second major antitrust law in 1914, this time to restrict mergers: the Clayton Act.

Industrial Organization, profit-maximization, and capitalism

In the late 20th century, an academic field of Economics called "Industrial Organization" (or simply "IO") established itself. IO and this thesis are about identifying, understanding, and (at best) finding solutions to problems in market economies. IO economists use mathematics to analyze profit-maximizing strategies of firms and assess effects on consumers (both positive and negative effects).

The role of IO in supporting antitrust intervention is twofold: to inform on the design of laws (rules of the game) and to inform decisions in individual cases. Insights from IO have informed modern antitrust guidelines in the US, EU, UK, Canada, and many more jurisdictions. These guidelines are based on a "more economic approach", whereby firms' conducts are assessed based on their effects on welfare (instead of, e.g., on per se rules). Despite the wealth of available theoretical and empirical research in the highly active field of IO, each new antitrust case is analyzed individually due to its specificities, which typically do not fit neatly with existing models. Therefore, practitioners often do not simply select an existing model from the academic literature that fits their case perfectly but may assess, on the one hand, how existing research can help to understand a case and, on the other hand, may assess how the merger's specificities require further analysis (possibly beyond the research frontier). Because the fit of existing models to new cases is typically imperfect, new academic research that tackles such new cases can have immediate impact on the decisions of authorities.

One assumption underlies practically all IO models: the assumption that firms maximize profits. Profit maximization is a powerful drive for good and bad outcomes. Whereas politicians can write the rules of the game and courts can halt excesses, the profit incentive drives many private entrepreneurs to deliver innovations (developed in universities or private firms) to the masses. Profit maximization is a feature of capitalism. Two persons known for criticizing aspects of capitalism nevertheless recognize,

> "Capitalism does a number of things very well: it helps create an entrepreneurial spirit; it gets people motivated to come up with new ideas, and that's a good thing."[8] – Senator Bernie Sanders, 2009

[8] See Real Clear Politics, `https://www.realclearpolitics.com/video/2009/10/02/sen_bernie_sanders_on_capitalism.html`.

> "Capitalism and market forces are very powerful in producing wealth and innovation."[9] – Thomas Piketty, 2014

However, the profit-maximization motive can also lead to particular problems, e.g., inequality. Famous past economists remarked,

> "Under capitalism, man exploits man. Under communism, it's just the opposite."[10] – John Kenneth Galbraith (1908-2006)

> "Capitalism is the astounding belief that the most wickedest of men will do the most wickedest of things for the greatest good of everyone."[11] – John Maynard Keynes (1883-1946)

IO does not assume that profit maximization delivers "the greatest good". IO is precisely about analyzing whether profit-maximizing firms generate good or bad outcomes for citizens. Across the political spectrum today, politicians recognize the need for regulation (although to varying extents): societies regulate market economies in an attempt to balance ever-better capitalism's definite benefits with reigning in its excesses.

A note on current antitrust laws

There are three major categories of antitrust cases: cartels (where any number of firms agree to fix prices), abuse of dominance (where a single dominant firm exploits its market power), and mergers (where two firms may increase their market power).[12] There are four types of mergers: mergers between direct competitors (horizontal mergers), mergers between a firm and its supplier (vertical mergers), mergers among firms that produce complementary products (mergers of complements), and mergers among firms whose products are essentially unrelated (conglomerate mergers).

The European Union issued its current antitrust laws in 2004:[13] Article 101 of the Treaty on the Functioning of the European Union (TFEU) regulates cartels,[14] Article 102

[9] CBS MoneyWatch Interview, June 5th 2014, https://www.cbsnews.com/news/economist-says-u-s-inequality-reaching-spectacular-heights/.

[10] Quoted in Crook, Clive, "John Kenneth Galbraith, Revisited" in *The Atlantic*, May 2006 issue, https://www.theatlantic.com/magazine/archive/2006/05/john-kenneth-galbraith-revisited/304935/.

[11] Quoted in The Economist, "Capitalism", July 6th 2012, https://www.economist.com/schumpeter/2012/07/06/capitalism.

[12] In the EU, there is a fourth category: the EU brings several "state aid" cases to ensure a level playing field for companies on its internal market.

[13] Individual EU countries have their own antitrust laws and agencies. Several national authorities are very active in addressing antitrust issues that arise domestically but have supranational relevance.

[14] See European Commission, "Antitrust procedures in anticompetitive agreements", https://competition-policy.ec.europa.eu/system/files/2020-12/antitrust_procedures_101_en.pdf.

regulates abuse of dominance,[15] and Council Regulation (EC) No 139/2004 regulates mergers.[16] In addition, the EU issued guidelines for horizontal and vertical mergers.[17]

In the US, the Department of Justice (DOJ) and the Federal Trade Commission (FTC) are two government entities that enforce antitrust laws. The Sherman and Clayton Acts are still in vigor. They have been complemented over the years with changing, sometimes controversial, and heavily-debated merger guidelines.[18] Currently, however, the FTC has no vertical merger guidelines because of disagreements among its commissioners. There, as in Brazil, for example, new vertical merger guidelines are in the works and expected to be published soon.

Neither in the European Union nor in the United States is it illegal to hold monopoly power (despite the Sherman Act). Fair competition can result in a monopoly when one firm caters better to consumers than its competitors. However, the anticompetitive use of monopoly power is illegal. The US Supreme Court ruled in 1948 that "the use of monopoly power, however lawfully acquired, to foreclose competition, to gain a competitive advantage, or to destroy a competitor, is unlawful."[19] Similarly, EU guidelines state, "it is not in itself illegal for an undertaking to be in a dominant position and such a dominant undertaking is entitled to compete on the merits. However, the undertaking concerned has a special responsibility not to allow its conduct to impair genuine undistorted competition".[20]

An overview of current topics

Markets are dynamic. Some firms innovate and grow, while others fail. With technological change, firms develop new strategies in new markets to cater to customers as well as to increase and protect their profit flows. For example, the nature of market interactions is undergoing a profound change. Whereas individuals have set prices for goods and ser-

[15] See European Commission, https://competition-policy.ec.europa.eu/antitrust/legislation/application-article-102-tfeu_en and its guidance, available at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52009XC0224(01).

[16] The text is available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004R0139.

[17] The horizontal merger guidelines (which date from 2004) are available here: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2004:031:0005:0018:en:PDF, and the vertical merger guidelines (which date from 2008) are available here: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2008:265:0006:0025:en:PDF.

[18] For current FTC guidelines, see https://www.ftc.gov/advice-guidance/competition-guidance.

[19] US Supreme Court, *United States v. Griffith*, 334 U.S. 100 (1948), https://supreme.justia.com/cases/federal/us/334/100/.

[20] European Union, Guidance on Article 82, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52009XC0224(01).

vices historically, algorithms increasingly set prices in the 21st century. In light of such changes, there is a broad range of current topics in antitrust. A brief overview of such topics follows below.

- **Algorithms.** Algorithms increasingly set prices for goods and services. When firms use algorithms, prices can reach collusive levels (i.e., the level a cartel would set) even if these algorithms are designed to maximize solely a firm's profits without information on competitors' prices. It is unresolved how authorities can and should intervene when prices equal the collusive level without coordination between humans or algorithms. Intervention could conceivably involve regulated prices or margins, but such intervention is deemed to go too far.

- **Employment.** Uber's business model has been criticized for not treating its drivers as employees and, therefore, not providing them with a range of employment benefits. Uber has argued that its drivers are contractors. Other companies in the gig economy have faced similar criticisms. This is a regulatory or legal issue[21] but it has direct effects on competition, e.g., in the transport sector.

- **Industrial policy.** The Chinese government passed the "Made in China 2025" policy in 2015. The US government passed the "Inflation Reduction Act" and "CHIPS and Science Act" in 2022. The two governments define industries of national priority in these policies and acts; both governments invest heavily in domestic production.[22] The EU is trying to react with the EU chips act,[23], and Germany also subsidizes domestic chip production (e.g., of Intel in East Germany). By design, these enormous public investments impact the global competitive landscapes in specific industries.

- **Killers.** Some old problems reappear. Cunningham, Ederer, and Ma (2021) document killer acquisitions in the pharmaceutical industry where, in the spirit of 19th C. Standard Oil, the acquirer buys a potential competitor and halts (i.e., "kills")

[21] On the decision of, e.g., a Dutch court on the matter, see Haeck, Pieter, "Uber drivers are employees, Dutch judge rules" in *Politico*, September 13 2021, https://www.politico.eu/article/uber-drivers-are-employees-dutch-judge-ruled/.

[22] In China, those industries include New Advanced Information Technology, Artificial Intelligence and Quantum Computing, Automated Machine Tools and Robotics, Aerospace and Aeronautical Equipment, Maritime Equipment and High-Tech Shipping, Modern Rail Transport Equipment, Self-Driving and New Energy Vehicles, Power Equipment, Agricultural Equipment, New Materials, Biopharma and Advanced Medical Products. See Gesellschaft für internationale Zusammenarbeit, https://www.plattform-i40.de/IP/Redaktion/EN/Downloads/Publikation/China/MIC2025_factsheet.pdf?__blob=publicationFile&v=3.

[23] On this, see https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)733596.

their research & development of a competing drug. Some also express concern that acquisitions of tech start-ups are killer or reverse killer acquisitions.[24]

- **Non-competes.** The US Federal Trade Commission (led by Lina Khan) has sought to ban non-compete clauses in employment contracts. Such clauses explicitly limit competition by hindering a company's employees from setting up their own companies or joining competitors for a certain duration. Understandably, an employer does not want to incur costs to train employees and provide them with trade secrets only to see them join competitors. However, there are other laws against sharing trade secrets. The FTC assesses that non-compete clauses in all but some exempt cases should be banned. It estimates that this would boost wages by $300bn per year in the US.[25] The planned ban has received major pushback: it may not be implemented.

- **Ownership.** If investors own shares in competing firms, then, in theory, investors want those competing firms to compete less aggressively in order to maximize their combined (total) profit. Empirical research provides evidence that this phenomenon plays out, e.g., in the US airline industry. In that industry, as in others, investment firms such as Blackrock, Vanguard, and others own substantial shares of competing firms (referred to as "common ownership"). This has been tied to higher prices.[26] Similar effects materialize when a firm buys a minority or partial share in a competitor.

- **Privacy.** There is some, though little, competition among firms on the level of privacy they provide to consumers. Examples of apps that advertise their privacy features include WhatsApp and Telegram; there are also examples of browsers (Firefox, among others). The EU passed the General Data Protection Regulation (GDPR) in 2016 (it has been in force since 2018).[27] This regulation imposes, among others, greater transparency regarding data collected on users online.

- **Security.** Increasingly, countries block attempted acquisitions of domestic companies by foreign (in particular Chinese) entities. This is especially so in high-tech industries or industries that materially impact national security, such as robots and chips (the Committee on Foreign Investment in the United States, CFIUS, blocked

[24] See Caffarra, Crawford, and Valletti (2020).

[25] See FTC, `https://www.ftc.gov/news-events/news/press-releases/2023/01/ftc-proposes-rule-ban-noncompete-clauses-which-hurt-workers-harm-competition`.

[26] See Azar, Schmalz, and Tecu (2018). For a critique, see Dennis, Gerardi, and Schenone (2022), and for a response to this critique, see Azar, Schmalz, and Tecu (2022).

[27] For the GDPR text, see `https://gdpr-info.eu/`.

the acquisition of US-based Qualcomm by Singapore-based Broadcom,[28] and European countries have taken similar actions against attempted Chinese acquisitions).[29] Individual firms are sometimes heavily-exposed to China. Prominently, Apple produced 98% of Macs, 98% of iPads, and 95% of iPhones in 2022 in China.[30]

- **Tech.** The tech industry is characterized by network effects, which tend to favor concentrated industries (or, in the extreme, a 'winner-takes-it-all outcome' of competition). However, durable monopolies are no certain outcome: in practice, new entrants sometimes displace incumbents. The tech industry is also characterized by consumer services that are often free. On the other market side, US giants (e.g., Alphabet, Amazon, Apple, Meta, Microsoft) have fought hard over advertising revenues. In this domain, the European Commission has identified harmful strategies specific to the tech industry and, consequently, has imposed several billion-dollar fines on Google (e.g., for demoting competitors to low rankings in search results). In 2022, the EU parliament passed major new legislation: the Digital Markets Act (DMA). The DMA contains (among others) compatibility requirements forcing gatekeeper platforms to be interoperable. This could mark a significant shift to greater access for new entrants.

- **Unions.** Whereas labor unions are still powerful in several European countries (e.g., France and Germany), unions are less widespread in the United States. This affects firms' costs and how profits are distributed. A much-cited academic study (Barkai, 2020) finds that the share of profits accruing to capital rather than labor has increased substantially.

Recent performance of enforcement, possible solutions, and outlook

Views on the performance of antitrust enforcement over the past decades range from 'all is good' to 'we are heading in the totally wrong direction'. There is heavy criticism (both outside and inside antitrust authorities) of recent antitrust enforcement – or lack thereof. According to the critics, authorities have failed to protect society from harmful mergers, contributing to decades of rising concentration and rising margins across industries (such trends are identified in several academic studies). US President Biden criticized mergers

[28] See Reuters, "President Trump halts Broadcom takeover of Qualcomm", March 12 2018, https://www.reuters.com/article/cbusiness-us-qualcomm-m-a-broadcom-merge-idCAKCN1GO1Q4-OCABS.

[29] See Economist Intelligence Unit, https://country.eiu.com/article.aspx?articleid=1822601765&Country=China&topic=Economy&subtopic=Forecast&subsubtopic=External+sector&u=1&pid=822557665&oid=692556652.

[30] Figures cited in Schönert, Elisabeth, "Knall oder Fall", in *Manager Magazin*, June 2023, p.30.

by big business, "Rather than competing for consumers, they are consuming their competitors."[31] Moreover, antitrust authorities can either approve a merger unconditionally, approve it subject to remedies, or block it,[32] but in practice US and EU authorities block mergers extremely rarely.[33] In addition, there is also criticism of decisions regarding abuse of dominance cases: critics of EU fines on Google for several cases of abuse of dominance bemoan that such fines fail to restore initial, competitive market conditions.

Antitrust enforcement weakened significantly many decades ago. (Some researchers point to the 1960s as the beginning of this weakening, when ideas of the "Chicago School" started spreading.)[34] By the 1980s,

> "Under Ronald Reagan in the United States and Margaret Thatcher in the U.K., there was a rewriting of the basic rules of capitalism. These two governments changed the rules governing labor bargaining, weakening trade unions, and they weakened anti-trust enforcement, allowing more monopolies to be created."[35] – Joseph E. Stiglitz, 2017

How could it come to these trends in concentration? One of several causes is: merger harms are diffuse, whereas benefits are concentrated. Individual consumers do not unite to oppose particular mergers, whereas a monopolist can spend its profits on lobbyists, bankers, lawyers, consultants, and academics. Because this is long-known, antitrust guidelines in the United States and the European Union specify that antitrust authorities must decide cases by considering the welfare of consumers only. In stark words: firms' profits are considered to be socially worthless.

How do we solve the problem? Several suggestions exist. First, authorities can change their stance by litigating mergers more aggressively. The US DOJ with Jonathan Kanter and the FTC with Lina Khan follow this approach, which can be implemented within the current rules.

Second, the burden of proof can be placed on firms rather than on authorities. The EU's DMA is a step in this direction: it requires designated gatekeepers to outline how they plan to comply with the DMA. In a complete reversal of the burden of proof, firms

[31] See The White House, https://www.whitehouse.gov/briefing-room/speeches-remarks/2021/07/09/remarks-by-president-biden-at-signing-of-an-executive-order-promoting-competition-in-the-american-economy/.

[32] For more details on the EU merger procedure, see European Commission, "Competition: Merger control procedures", https://competition-policy.ec.europa.eu/system/files/2021-02/merger_control_procedures_en.pdf.

[33] See Affeldt et al. (2021).

[34] See Lancieri, E. A. Posner, and Zingales (2022) and Stucke and Ezrachi (2017).

[35] Stiglitz, J., "Austerity has strangled Britain. Only Labour will consign it to history" in *The Guardian*, June 7 2017, https://www.theguardian.com/commentisfree/2017/jun/07/austerity-britain-labour-neoliberalism-reagan-thatcher.

would need to prove that their proposed merger raises no antitrust issue. For example, in horizontal mergers, the merging parties would have to demonstrate that they would not raise prices post-merger.

Third, the nature of antitrust rules could be altered significantly. Instead of the current effects-based approach (where each case is tried based on its expected effects, i.e., the "more economic approach"), merger rules could specify per se rules. For example, horizontal mergers in an industry with four firms or less could be prohibited. (This would be a so-called "structural rule".)[36] Opponents argue that per se rules sacrifice efficiency. Proponents respond, in essence, that 'Crimes are illegal even if, in a particular case, a crime might have raised welfare. We should have clear merger rules instead of tediously assessing each case based on its effects.'[37] With per se rules, Economics would still play a critical role: it would inform what those rules should be.

Fourth, authorities may return to breaking up companies.[38] Standard Oil was not the only company to be broken up. More recently, authorities regulated telecommunications markets to promote competition by curtailing the power of monopolists (e.g., of the UK's British Telecom and Germany's Deutsche Telekom). The US Telecommunications Act of 1996 pursued similar aims. It forced interoperability: "Each telecommunications carrier has the duty to interconnect directly or indirectly with the facilities and equipment of other telecommunications carriers".[39] Thus far, authorities have not broken up the contemporary tech giants. In his 1913 New Freedom address, US President "Wilson offered a progressive vision calling for the use of government power to break up monopolies".[40] US President Biden himself has not called for break-ups. Nevertheless, there may be a return to the original interventionist approach during his administration. In January 2023, the US Department of Justice (DOJ) sued Google "for Monopolizing Digital Advertising Technologies":[41] according to the DOJ's complaint, "Through Serial Acquisitions and Anticompetitive Auction Manipulation, Google Subverted Competition in Internet Advertising Technologies".[42] The complainants in the case seek a divestiture by Google of parts of its ad business. Similarly, the EU entered new territory in June 2023: it formu-

[36] At conferences, some proponents of structural rules argue that authorities should protect the competitive process rather than using the welfare standard.

[37] See, e.g., Teachout, Zephyr, "Why Judges Let Monopolists Off the Hook", in *The Atlantic*, October 29 2021, https://www.theatlantic.com/ideas/archive/2021/10/antitrust-facebook-congress-sherman-act/620539/.

[38] On the New Brandeis movement, see Khan (2018).

[39] Federal Communications Commission, Telecommunications Act of 1996, https://transition.fcc.gov/Reports/tcom1996.pdf

[40] National Constitution Center, https://constitutioncenter.org/the-constitution/historic-document-library/detail/woodrow-wilson-the-new-freedom-1913.

[41] US Department of Justice, Press Release, January 14 2023, https://www.justice.gov/opa/pr/justice-department-sues-google-monopolizing-digital-advertising-technologies.

[42] *Ibid*.

lated the potential need to break up Google from one of its key advertising businesses.[43] So, are we heading back to the start?

1.2 This dissertation

How it fits into the field of IO

Practitioners can use the findings of this dissertation within the current antitrust rules. In this dissertation, I use applied IO theory to study the effects of mergers of complements and vertical mergers. I fill two significant gaps in the literature (in chapters 3 and 4) and contribute to the debate on an individual merger case (in chapter 5). Filling these two gaps has practical implications for merger review: practitioners (e.g., antitrust enforcers, lawyers, and consultants) now have additional tools to analyze non-horizontal mergers.

This dissertation contributes to the large body of existing literature on applied theory in IO. Nobel laureate Paul Krugman has criticized IO theory, writing that one can "produce a model to justify anything."[44] He called for more empirical work. But empirical research relies on theory to interpret data. In this dissertation, I develop tools to test long-standing theories against observable data. This allows to identify models that are inconsistent with data. If a model does not fit the data of a particular industry or case, then that model may not apply to that industry or case. In this way, the findings in this dissertation go some way in addressing Krugman's critique.

Most merger cases are evaluated using the effects-based framework; this dissertation fits this framework. Whereas horizontal mergers cause well-accepted consumer harm (by removing competitors), mergers of complements and vertical mergers can cause well-accepted consumer benefits (by eliminating double marginalization). In this dissertation, I revisit positive and negative effects of mergers of complements and vertical mergers.

Individual chapters

Chapter 3 deals with mergers of complements. Mergers of complements have been thought to benefit consumers. This is true when the merging parties are monopolists but not when they face perfect competition. In between those competitive extremes, it was hitherto unknown when exactly a merger yields the beneficial Cournot effect (or internalization of double marginalization). The chapter fills this gap: it provides a tool

[43] See European Commission, Press Release, June 15 2023, `https://ec.europa.eu/commission/presscorner/detail/en/ip_23_3207`.

[44] Krugman, Paul, "Jean Tirole and the Triumph of Calculated Silliness", in *The New York Times*, October 14 2014, `https://archive.nytimes.com/krugman.blogs.nytimes.com/2014/10/14/jean-tirole-and-the-triumph-of-calculated-silliness/`.

to determine whether consumers would benefit from such a merger for all competitive landscapes between the polar extremes (of monopoly and perfect competition).

In more detail: Chapter 3 shows pre-merger margins can reveal whether a merger would decrease prices (for general demand functions) in a vertically related industry where every supplier may face competition. Then, the chapter develops a simple, practicable merger test and identifies when the standard prediction of merger benefits is inconsistent with observable facts. Instead of yielding benefits, profitable mergers of complements can cause unambiguous consumer harm. However, the test can also confirm the presence of merger benefits.

Chapter 4 deals with vertical mergers. The typical concern about vertical mergers is the foreclosure of downstream rivals. There already exist tests to identify how big the incentive for foreclosure is, i.e., by how much the merged entity wants to raise the input price of a downstream competitor. Chapter 4 develops a test to identify whether the merged entity has the ability to raise the price of its downstream rival. Without the ability to do so, incentives are inconsequential. Therefore, the test complements existing antitrust tools for vertical mergers. Because one can use the tool to dismiss foreclosure, the chapter also highlights that vertical mergers can harm consumers even absent foreclosure.

In more detail: Chapter 4 shows pre-merger margins can reveal whether, in a vertically related industry, upstream competition constrains a supplier. The chapter develops a test to identify whether a supplier is constrained pre-merger and, consequently, cannot raise input prices post-merger. However, even absent foreclosure, vertical mergers can harm consumers. A merger increases consumer prices and benefits all firms (including downstream rivals) when downstream (horizontal) competition weakens sufficiently. This theory of harm differs markedly from typical theories, which pit the merged entity against downstream rivals.

Chapter 5 deals with an attempted merger in the chip industry. US authorities approved the merger unconditionally, but EU authorities approved it subject to remedies. The chapter develops a formal model and a theory of harm regarding this particular merger. The chapter considers the effects on innovation and consumers. It supports the EU's concerns and the remedies it imposed.

In more detail: Chapter 5 models a merged entity that faces competition in its respective markets. It is well-established that bundling by a monopolist can harm consumers, but bundling is widely considered harmless in competitive markets. The chapter develops a novel theory of harm, which combines a typical concern about vertical mergers (input foreclosure) with a typical concern about mergers of complements (bundling). Whereas bundling alone is loss-making, combined with input foreclosure, it can be profitable. Consumers risk paying higher prices and not benefiting from higher innovation because, in competitive markets, the merged entity appropriates the benefits of its innovation. Be-

cause competition can be insufficient to prevent harm, antitrust intervention can be necessary.

One-sentence summaries of the main contributions follow below.

- Chapter 3 develops a practical tool that one can use to determine whether a proposed merger of complements will yield the long-standing (beneficial) Cournot effect.
- Chapter 4 develops a practical tool that one can use to determine whether a proposed vertical merger will result in (harmful) input foreclosure.
- Chapter 5 develops a case-specific model that supports the EC's concerns and chosen remedies in an attempted $47bn merger in the chip industry.

Chapter 2 provides a technical summary of the two new merger tools. (It is "technical" only in that it includes some algebra.) Hopefully, I managed to write it such that any economist can understand the two tools.

Impact

I presented my research at (a) international academic IO conferences in Europe and the US (e.g., CRESSE 2021, 2022, 2023, EARIE 2022, upcoming in 2023, VfS 2022, IIOC 2023, CLEEN 2023, CEPR 2023), (b) competition authorities of the EU (at DG COMP's Economic Seminar in June 2023), Brazil (to CADE's working group on new vertical merger guidelines in October 2022), and Germany (Bundeskartellamt, upcoming in August 2023), as well as (c) private sector consultancies. The International Journal of Industrial Organization published chapter 3 of this thesis. Chapter 3 also received broader coverage. ProMarket (the publication of the Stigler Center of the University of Chicago Booth School of Business) published my related article "A New Merger Tool Protects Consumers from Limits of the Cournot Effect"; which has been republished on the Oxford Business Law Blog (University of Oxford), and Competition Policy International. Time will tell what the impact of this dissertation will be. The interest of competition authorities reflects demand for this research and development of new, practical tools – it is a good sign.

Bayreuth, 10.07.2023

Chapter 2

New Merger Tools: Technical Summary

New Tools to Analyse Non-Horizontal Mergers

This thesis develops two new tools: one for mergers of complements (mergers between producers of complementary products, e.g., 4G chips and smartphone screens) and one for vertical mergers (mergers between a supplier and its downstream customers, e.g., a producer of smartphone screens and a smartphone manufacturer).

- The first concerns incentives in mergers of complements. One can use the test to determine whether a proposed merged entity will want to reduce prices (i.e. whether the merger will result in the "Cournot effect").
- The second concerns ability in vertical mergers. One can use the test to determine whether a proposed merged entity will be able to raise rivals' costs.

Both tests are practicable, simple, and transparent. They are robust: they apply to general settings. However, they also face limitations, of course. The aim is that practitioners will find these tools useful in specific merger cases.

Starter model for illustration

Picture successive monopolies: an upstream monopolist supplies an input to a downstream monopolist. The upstream firm has a constant unit cost of production c. The downstream firm has a fixed-proportions production technology (e.g., it uses one unit of the input per unit of output). First, the upstream firm sets a unit price v at which it offers to supply any quantity to the downstream firm; second, the downstream firm sets a uniform consumer price P. (Equivalently, one can think of the supplier and the downstream firm as each setting their unit margin.)

The profit of the downstream firm is its unit margin m_D (the consumer price it sets minus its unit input cost) times the quantity sold Q:

$$\Pi_D = (P - v) \times Q(P) = m_D \times Q$$

The profit of the upstream supplier is its unit margin m_U (the price it obtains minus its unit input cost) times the quantity sold:

$$\Pi_U = (v - c) \times Q(P^*(v)) = m_U \times Q$$

(Stars refer to optimal values: values in equilibrium.)

The optimal margin downstream m_D^* and the monopoly margin upstream m_U^M are determined by the downstream and upstream firms' respective profit maximisations (first-order conditions):

$$m_D^* \times \frac{\partial Q}{\partial P} + Q = 0$$
$$m_U^M \times \frac{\partial Q}{\partial P} \times \frac{\partial P}{\partial v} + Q = 0$$

Therefore, there exists a relation between the two margins:

$$m_U^M \times \rho = m_D^* \tag{2.1}$$

where ρ is the pass-through rate $\frac{\partial P}{\partial v}$.

Constrained versus unconstrained

Imagine a second producer of the input exists, with constant unit production cost $\overline{c} > c$. The most efficient upstream producer now selects its optimal margin m_U^*

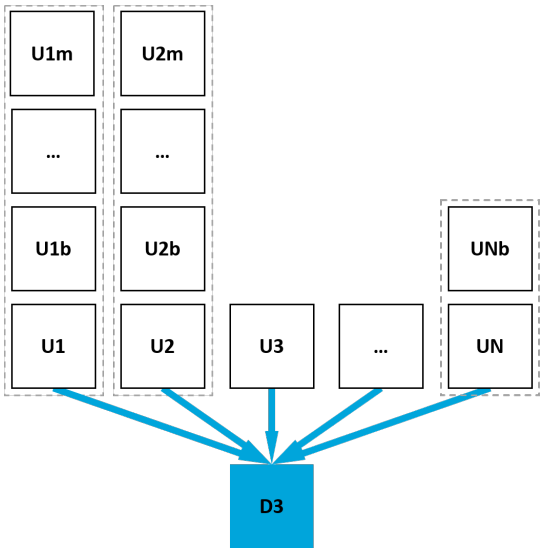
$$m_U^* = \min\{m_U^M, \overline{c} - c\} \tag{2.2}$$

A simple and central result developed in the thesis is: if $m_U^* \times \rho < m_D^*$, then the supplier is constrained by an outside option that the downstream firm has. The constraint prevents the supplier from pricing as high as it would were it free (or "unconstrained") to obtain any price v.

General relation of downstream to upstream monopoly margins

The two tests are useful because they apply to general settings. This thesis shows that (2.1) holds under the following generalisations: (a) when the downstream firm uses any number of different inputs (in some fixed proportion), (b) when there is any number of producers of those different inputs, (c) whether each input is homogeneous or differentiated, (d) when the downstream firm can produce the input in-house at a constant unit cost, and (e) when inputs are not essential (in the sense that above a cutoff price, the downstream firm prefers to produce without one or more inputs). The figure below illustrates this more general setting.

Figure 2.1: Setting with multiple inputs and competition upstream



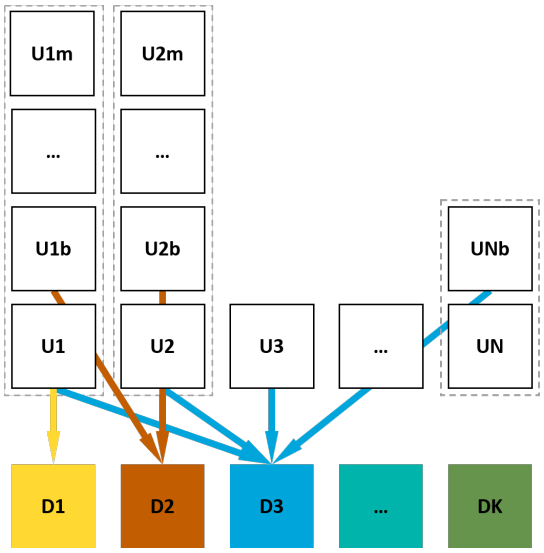
In addition, the thesis shows that the following slightly different condition

$$m^{M}_{Ui,Di} \times \rho_{Di} \geq m^{*}_{Di} \tag{2.3}$$

holds (where $m_{Ui,Di}$ is the merging supplier's margin on downstream firm i, ρ_{Di} is downstream firm i's pass-through rate, and m_{Di} is downstream firm i's margin on sales of its consumer product), (f) when there is differentiated Bertrand competition downstream among any number of firms, where upstream producers can price discriminate across downstream firms, (g) when downstream firms need the same or different sets of inputs, (h) with either incomplete information (in that downstream firms do not know each others' costs) or complete information (though this necessitates some restrictions on demand

functions), and (i) where the same upstream producer may have a different costs to supply different downstream firms. The figure below illustrates this more general setting.

Figure 2.2: Setting with competition upstream and downstream



Mergers of complements

Mergers of complements are typically thought to benefit consumers, via the Cournot effect. Suppose two suppliers to downstream firm i, firms U1 and U2, propose to merge. Then:

Test 1. *If* $(m^*_{U1,Di} + m^*_{U2,Di}) \times \rho_{Di} < m^*_{Di}$ *pre-merger, the merged entity will not decrease prices.*

Intuitively: if the merging parties are constrained to a sufficient degree pre-merger, the merged entity will not want to decrease price post-merger simply because it does not want to further reduce its already small margin. Chapters 3 and 5 also develop theories of harm: they show instances where mergers of complements can lead to higher prices.

Vertical mergers

The typical concern about vertical mergers is raising rivals' costs (a form of foreclosure). Suppose firms U1 and D1 propose to merge. Then:

Test 2. *If* $m^*_{U1,Dj} \times \rho_{Dj} < m^*_{Dj}$ *pre-merger, the merged entity cannot obtain a higher input price from firm Dj post-merger.*

Intuitively: if firm U1 was constrained in the price it set to downstream firm Dj ($j \neq 1$) pre-merger, then it already wanted to obtain a higher price pre-merger but could not. The merged entity faces the same constraints and cannot obtain a higher input price from firm Dj post-merger. (The merged entity may or may not be able to raise its rivals' cost by stopping to supply firm Dj, and such a strategy may or may not be profitable.)

Limitations

Though the two tests apply to general settings, they do not apply to all. The central idea of the test is that margins can reveal information about pricing power. Therefore, the tests do not apply to settings where margins do not reflect such power. For example, when suppliers set two-part tariffs (then suppliers extract substantial profits via fixed fees). In addition, mergers may weaken constraints: in some cases, an upstream supplier may be constrained pre-merger but not (or less so) post-merger. Chapters 3 and 4 discuss several such different settings.

However, the two tests inform on incentives independently of the price formation process that determines input prices. Independently of the price formation process that determines input prices, the condition in test 1 identifies whether a merged entity (in a merger of complements) has an incentive to reduce or raise prices. Similarly, independently of the price formation process that determines input prices, test 2 identifies whether the upstream merging party has an incentive to obtain a higher price pre-merger.

Implications for merger review

In a proposed merger of complements, parties favourable to the transaction may argue that the merger leads to Cournot effects, that these benefit consumers, that those benefits exceed any possible harm antitrust authorities may think of, and that, therefore, the proposed merger should be cleared. An antitrust authority, and ultimately the courts, can use test 1 presented above to assess whether Cournot effects would materialise. Absent consumer benefits from the merger, and if the authority has a theory of harm, there is no trade-off: the merger would be unambiguously harmful. Consequently, the authority would have clear grounds to act against the proposed merger. Of course, for any given case, test 1 might not rule out Cournot effects and a merger of complements might benefit consumers, in which case antitrust authorities should clear the merger.

In a proposed vertical merger, parties favourable to the transaction may use the second test presented above to rule out particular foreclosure effects. They may argue that, therefore, the proposed merger should be cleared. An antitrust authority, and ultimately the courts, can use the second test presented above to confirm that the merger would not result

in raising rivals' costs. However, a vertical merger can harm consumers even without foreclosure (if downstream competition weakens sufficiently relative to any benefit from the elimination of double marginalisation). An antitrust authority can therefore have grounds to act against a proposed vertical merger even absent foreclosure, for the same reason it would act against a proposed horizontal merger: weakened horizontal competition. Of course, for any given case, test 2 might rule out foreclosure, and the vertical merger might benefit consumers, in which case antitrust authorities should clear the merger.

Chapter 3

Mergers of Complements: On the Absence of Consumer Benefits[1]

3.1 Introduction

Absent anticompetitive effects, mergers of complements are typically thought to benefit consumers through the Cournot effect (Etro, 2019). According to this effect (sometimes referred to as the 'internalisation of double markups'), mergers of complements eliminate negative externalities and decrease consumer prices.[2] Antitrust authorities acknowledge this benefit (in particular, the United States Department of Justice, the Federal Trade Commission, and the European Commission in its merger guidelines).[3]

Meanwhile, mounting evidence of insufficient antitrust enforcement has fuelled widespread concerns that merger policy is too lax.[4] This calls for re-examining what are deemed to be merger benefits. In this paper, I show how to identify whether a merger of complements does – or does not – yield the beneficial Cournot effect. This can help antitrust authorities identify mergers that do not yield this benefit and help detect mergers that harm consumers.

Cournot's (1838) now standard argument can be synthesised as follows. Suppose that two monopolists each supply one input to downstream consumers, that each monopolist sets the unit price for the input it supplies, and that the two inputs are perfect complements.

[1] This chapter has been published as Kadner-Graziano, Alessandro S (July 2023), "Mergers of Complements: On the Absence of Consumer Benefits", *in International Journal of Industrial Organization*, Vol. 89, Article 102935.

[2] Alternatively, these externalities are referred to as horizontal double marginalisation (Reisinger and Tarantino, 2019). These externalities are (alongside, e.g., essential patents) a "tragedy of the anticommons" (Buchanan and Yoon, 2000; Heller, 1998).

[3] See, e.g., European Commission (2014), p.212.

[4] See, e.g., Shapiro (2018, 2019). On increasing margins, see De Loecker, Eeckhout, and Unger (2020).

Then, the two suppliers each set their unit price without considering that a higher price diminishes the profit of the other firm (through a lower, common demand). If the two monopolists merge, this negative externality is internalised. After the merger, prices fall and demand increases.[5] This benefits all: the merging parties and downstream consumers.

In contrast, when there is perfect competition in each input market (and with constant returns to scale), suppliers earn zero profit pre-merger. Post-merger, the merged entity does not decrease price (doing so would be unprofitable). Hence, the Cournot effect does not materialise.

For all competitive landscapes in input markets between the two polar extremes (of monopoly and perfect competition), there is no general result on whether the Cournot effect materialises. This gap is problematic for antitrust authorities and applied theorists alike. During a merger review, an antitrust authority needs to weigh positive merger effects against negative effects from any theories of harm it may have. However, it may lack data to ascertain the net impact. More fundamentally, it does not have a test or tool to determine when exactly it can outright dismiss positive Cournot effects. The problem for an applied theorist is knowing how to recognise whether a model correctly predicts that a merger benefits consumers via Cournot effects or whether that prediction is inconsistent with observable facts.

I re-examine the Cournot effect in a vertically related industry. In my baseline model, a downstream firm needs different inputs to manufacture a consumer good. Each of those inputs is produced by one or more upstream producers. In stage 1, each upstream producer sets the unit price (the bid) at which it offers to supply an input to the downstream firm.[6] In stage 2, based on input prices, the downstream firm selects its suppliers and sets the price of its consumer product. This model differs from Cournot's original model (Cournot, 1838, p.112-7) in two crucial ways. First, whereas Cournot exclusively modelled suppliers, I consider both upstream and downstream firms as profit-maximising entities. This enables me to obtain results on upstream versus downstream margins. Second, I allow for any number of producers of each input. This captures the polar cases of monopoly and perfect competition but also intermediate cases of competition. With this model, I develop solutions to the problems laid out in the previous two paragraphs.

Theorem 1 closes the gap in the literature: it can be used to determine whether a proposed merger among suppliers of complements would benefit consumers for all competitive landscapes, from the polar extreme of monopoly to the polar extreme of perfect competition. Theorem 1 can also be used to identify whether particular models of mergers

[5] A merger of complements can also lead to higher investment levels by the merged parties (see Etro, 2019).

[6] When suppliers set two-part tariffs and prices equal marginal costs, there are no negative externalities pre-merger such that, trivially, there is no Cournot effect. On this, see Karlinger et al. (2020).

of complements, and their predictions, are consistent with observable facts of an industry under analysis.

The test, a corollary of Theorem 1, constitutes a practicable new merger tool.[7] Antitrust authorities can use it to determine whether proposed mergers would benefit consumers. If a particular merger would not yield the Cournot effect, an antitrust authority can dismiss claims that the merger would benefit consumers via this effect. Absent other claimed benefits, and if the antitrust authority has a theory of harm, the authority would then have unambiguous grounds to act against the proposed merger.

The intuition for the test goes as follows. When a downstream firm passes through to consumers less than 100% of an input price increase (i.e. when it "absorbs" some of the increase[8]), the elasticity of demand upstream is lower than it is downstream. Consequently, by the intuition of the Lerner index,[9] any supplier's unit dollar margin must exceed the downstream firm's margin.[10] If a suppliers' unit dollar margin is smaller than that of the downstream firm, then the supplier must be constrained (by some outside option of the downstream firm). Such alternatives can, for example, be to source the input from an alternative supplier, to produce the input in-house, or not to purchase and use the input at all. A constrained supplier maximises profit by maximising price: it sets its unit price to the level beyond which the downstream firm would resort to an outside option. In contrast, an unconstrained supplier does not maximise price; it trades off an increase in the unit price it charges with a decrease in consumer demand. J. Lerner and Tirole (2004), who analyse patent pools, refer to the former case as "the competition margin is binding" and to the latter as "the demand margin is binding".

The test comes down to a comparison of pre-merger margins. It states that if the merging suppliers earn a combined unit dollar margin smaller than the downstream firm's unit dollar margin, then prices would not decrease post-merger. Hence, consumers would not benefit from the merger. Effectively, the test verifies and reveals whether the merging suppliers are collectively, sufficiently constrained pre-merger to rule out a price decrease post-merger. (It is necessary but insufficient that each merging party is constrained: the merging parties need to be sufficiently constrained.) Margins can contain sufficient information on outside options to predict merger effects.

As a practical illustration: data shows that Apple earns more dollars of profit per iPhone sold than all of its suppliers combined. (The price of an iPhone, e.g. the iPhone 11, is around $1100, whereas its total unit cost to Apple is estimated at $490: less than

[7] The test is valuable precisely because of its simplicity and generality. It is "transparent", "simple and speedy": it meets criteria for a useful merger test listed by Farrell and Shapiro (2010).

[8] See Amir, Maret, and Troege (2004) and Adachi and Ebina (2014b).

[9] See A. P. Lerner (1934) and Elzinga and Mills (2011).

[10] Adachi and Ebina (2014b) obtain this result for the special case of single-product successive monopolies.

half.)[11] Hence, according to the test, if any two of Apple's suppliers were to merge – or even if all of its suppliers were to merge – the merged entity would not find it profitable to lower input prices.[12]

Theorem 1 and the test can identify the absence of consumer benefits but not the presence of harm. In section 3.4, I augment the model to allow for profitable strategies that harm consumers. I present two distinct theories of harm. In the first theory, I add a compatibility parameter to the model. In the second, I apply a central idea from Whinston (1990). In each, the merged entity weakens the downstream firm's outside options. Consequently, the merger relaxes price constraints, raises the consumer price, and causes unambiguous consumer harm.

The results I develop are useful precisely because they are robust to extensions which capture the intertwined nature of real supply chains. Among others, results continue to hold with downstream competition and when upstream firms supply multiple competing downstream firms.

The remainder of the paper is structured as follows. After a literature review, I describe the baseline model and develop the main results in section 3.2. Section 3.3 addresses the robustness of the results. In section 3.4, I deal with merger harm (in addition to the absence of benefits). In section 3.5, I discuss settings in which my results do not apply. Finally, I conclude in section 3.6. The appendix contains proofs. The supplementary material contains workings for section 3.5 as well as additional results.

Literature review

The present paper primarily relates to the literature on mergers of complements where Cournot effects do appear. Since Cournot (1838), many others have modelled mergers of suppliers of complements as resulting in the Cournot effect, e.g. Choi (2008), Quint (2014a), and Etro (2019). The effect appears in the latter two papers because upstream firms are assumed to be monopolist (unconstrained) suppliers of essential inputs.[13] More broadly, the effect appears in all three aforementioned papers because, when setting a unit price, a supplier is assumed to trade off the price it sets with aggregate consumer demand. The three papers model upstream suppliers as strategic actors, whereas the downstream level is not explicitly modelled. In contrast, I explicitly model both upstream and downstream firms as profit-maximising entities.

The key idea I develop is that margins, thanks to their endogenous nature, convey information on whether firms are constrained and that, consequently, margins can reveal

[11] See Yang, Wegner, and Cowsky (2019) and Rosalsky (2021).

[12] This holds even if the price formation mechanism were bargaining. I discuss bargaining in section 3.3.

[13] In contrast, Reisinger and Tarantino (2019) model suppliers of essential inputs (patents) as being constrained by some inefficient outside technologies.

whether Cournot effects would materialise.[14] This idea is new. There exists a debate and literature on whether margins should inform antitrust review, but the discussion focuses on horizontal mergers. Inderst and Valletti (2011), who analyse vertical mergers, consider pre-merger margins of the merging parties and argue these are insufficient to predict post-merger incentives. Bresnahan and Reiss (1985) compare upstream to downstream margins (as I do) but not in a merger setting.

The key idea, that a merger of complements does not necessarily lead to lower consumer prices if the merging producers are constrained, carries over to single-layer industries.[15] Masson, Dalkir, and Eisenstadt (2014) analyse single-layer industries and criticise what they perceive as a strong presumption of competition authorities that mergers of complements can benefit consumers. They show that Cournot effects "do not exist" for specific consumer preferences.[16] However, my main result relies on comparing upstream to downstream margins. In this comparison, many variables become redundant (they cancel out); consequently, the comparison is simple and practical.

The existing toolbox of antitrust authorities includes tools to estimate the extent of price increases due to horizontal mergers (Farrell and Shapiro, 2010; Moresi and Salop, 2009) and due to vertical mergers (Moresi and Salop, 2013). These tools require data on margins but also on diversion rates. In contrast, I provide a test for mergers of complements. This test provides a binary prediction and only needs data on margins of the merging suppliers and the downstream firm.[17]

The theories of harm laid out in section 3.4 are akin to "raising a rival's cost" (RRC) via tying. See Whinston (1990) for an early and seminal exposition of harmful tying.[18] Carlton and Waldman (2002) as well as Choi (2004) consider how a monopolist in one market can leverage its monopoly power to monopolise a second market. In the present paper, a constrained firm provides the tying good instead of a monopolist. Here, it is precisely because the merging parties lack monopoly power that they have the incentive

[14] Other than competition, contractual features can be the source of constraints: Karlinger et al. (2020) mention contracts that fix prices, these preclude price changes post-merger.

[15] A broad literature explicitly analyses complementary goods sold directly to consumers, with a focus on compatibility. Matutes and Regibeau (1988, 1992) explain why competing firms may want to offer compatible products, Farrell, Monroe, and Saloner (1998) and Denicolo (2000) consider why competing firms would benefit from a lack of interoperability.

[16] Similarly, Alvisi, Carbonara, and Parisi (2011) study the tragedy of the anticommons in a setting where producers of complements sell directly to consumers.

[17] Though margin data is typically sensitive confidential information and though it might not be possible to always ascertain the exact level of margins in practice, antitrust authorities can demand data from the merging parties to estimate the relevant figures and typically collect margin data (see Sheu and Taragin, 2021). There is a debate as to whether margins should play a more prominent role in horizontal merger review, see Caffarra, Latham, et al. (2018), Padilla (2018), and Valletti and Zenger (2018).

[18] He argues against the Chicago school one-monopoly-profit theorem (on this, see R. A. Posner (1976), Bork (1978)). Akgün et al. (2020) dispute that mergers of complements create harm.

to engage in anticompetitive bundling. Here, unambiguous consumer harm results from the interplay of two factors: the absence of Cournot effects and bundling.

3.2 No merger benefit

In this section, I address the following question: would a proposed merger among suppliers of complementary inputs benefit consumers (as a result of the Cournot effect)?

3.2.1 Baseline model

I model a vertically related industry. The downstream market is monopolised. The downstream monopolist needs $K \geq 2$ different inputs to manufacture a consumer product. It requires one unit of each input per unit of output. (It has a Leontief production function.) Let K also denote the set of inputs. Each input is produced by two firms upstream. The more efficient of the two has constant unit marginal cost of production $c_i \geq 0$, $i \in K$, and the other has constant unit marginal cost $\overline{c}_i > c_i$.

There are two stages. In the first stage, all $2K$ upstream firms simultaneously submit an offer to the downstream firm. Each upstream firm submits a unit price at which it offers to supply any quantity of its input. The downstream firm then selects its suppliers; it single-sources each input from the firm which offered the lowest price, v_i, for $i \in K$.[19] Its unit cost is the sum of unit input prices $\sum v_i$. Effectively, the two producers of each input compete à la Bertrand. (In equilibrium, the supplier of an input is the most efficient producer of that input.)

In the second stage, the downstream firm sets uniform consumer price P. The product market clears and determines the quantity $Q(P)$ demanded by consumers. The downstream firm has profit $\Pi_D = (P - \sum v_i)Q$. Supplier $i \in K$ has profit $\Pi_i = (v_i - c_i)Q$.

I assume demand induces the following. First, the downstream firm and each of its suppliers have a twice differentiable strictly quasi-concave profit function. Second, the pass-through rate is non-decreasing.[20] Intuitively, non-decreasing pass-through ensures that a supplier's profit does not keep rising in the price it sets. In the supplementary material, I provide example demand functions (both log-concave and log-convex functions) which induce these two characteristics. Finally, the baseline model features complete information but this is not necessary.[21]

[19] I assume that bidding is costless; that no firm bids below its cost; and that, at equal bids, the most efficient producer is selected.

[20] Non-decreasing pass-through is sufficient but not necessary for the results to hold. See the remark after Theorem 1. In the supplementary material, I show that most standard distributions induce non-decreasing pass-through. On increasing and decreasing pass-through, see also Chen and Schwartz (2015).

[21] See footnote 24. See also Remark 1.

3.2.2 Equilibrium

The game is solved by backwards induction. In the second stage, the downstream firm maximises its profit $\Pi_D = (P - \sum_{i=1}^{K} v_i)Q(P)$. The first-order condition determines the optimal price P^* and yields the downstream firm's unit dollar margin m_D^*:

$$P^* - \sum_{i=1}^{K} v_i = -\frac{Q(P^*)}{Q'(P^*)} \tag{3.1}$$

Applying the implicit function theorem to the downstream firm's first-order condition yields the pass-through rate ρ (as a function of the consumer price P^*)

$$\rho(P^*) := \frac{\partial P^*}{\partial v_i} = \frac{1}{2 - \frac{Q''(P^*)Q(P^*)}{Q'(P^*)^2}}$$

Weak log concavity of demand is equivalent to $Q'(P)^2 \geq Q''(P)Q(P)$. Hence, for any weakly log-concave demand $\rho \in (0,1]$.[22] On the pervasiveness of the log concavity assumption across Microeconomics, see Bagnoli and Bergstrom (2005).[23] In contrast, for any weakly log-convex demand $\rho \geq 1$. Theorem 1 below will hold if (but not only if) the pass-through rate is non-decreasing, i.e., $\frac{\partial^2 P^*}{\partial v_i^2} \geq 0$.

In the first stage, the most efficient producer of input i sets its profit-maximising offer price $v_i^* \leq \overline{c}_i$:[24]

$$v_i^* = \min\{v_i^u, \overline{c}_i\} \tag{3.2}$$

where v_i^u denotes the (optimal) unconstrained or monopoly price: the price the supplier would set if it were a monopolist producer of input i. Consequently, the most efficient producer of input i is either constrained in the price it offers or unconstrained.

Definition 1. *Supplier i is **unconstrained** if $v_i^* = v_i^u$ but **constrained** if $v_i^* \neq v_i^u$.*

The unconstrained price maximises the profit

$$\Pi_i = (v_i - c_i)Q(P^*\big(\sum_{j=1}^{K} v_j\big))$$

[22] See Amir, Maret, and Troege (2004) and Weyl and Fabinger (2013).

[23] Log concavity allows for highly convex functions but not for overly convex functions. Amir (2005) writes the limit case takes the form $Q(P) = -\ln(P)$ "which is convex and log linear".

[24] Suppose competing producers of the same input do not know each other's cost and that input prices are determined via second-price auctions. Then, unit prices are still given by (3.2) and therefore, results continue to hold.

The first-order condition is

$$Q + (v_i^u - c_i)\frac{\partial Q}{\partial P}\frac{\partial P^*}{\partial v_i} = 0$$

Rearranging, the producer's unconstrained unit dollar margin m_i^u is:[25]

$$v_i^u - c_i = -\frac{Q(P^*(v_i^u + \sum_{-i} v_j))}{Q'(P^*(v_i^u + \sum_{-i} v_j))} \times \frac{1}{\rho(P^*(v_i^u + \sum_{-i} v_j))} \tag{3.3}$$

Remark 1. *Constrained suppliers need less information than unconstrained suppliers. If each input were supplied by a monopolist, then each optimal input price would depend on other input prices as well as the demand function. (In some sense, a monopolist supplier is "constrained" by the demand function.) In contrast, a supplier who correctly believes it will be constrained by competition in equilibrium needs to know neither something about other inputs nor the demand function. To "know its market" by knowing $\overline{c}_i$ suffices to set its optimal price. This can be interpreted as greatly reducing the information suppliers need to set their optimal price. (However, although pre-merger it is sufficient for each constrained merging party to only "know its market", post-merger this knowledge is insufficient if the merged entity's optimal price lies strictly below the sum of constraints.)*

3.2.3 Identifying constrained suppliers

Comparing (3.1) with (3.3), it immediately follows that

$$m_i^u \times \rho = m_D^* \tag{3.4}$$

Observation 1. *For any log-concave demand function, any unconstrained supplier obtains a (weakly) bigger unit dollar margin than the downstream firm.*

The intuition for this observation is straightforward. For any log-concave demand function, the pass-through rate is less than 100%: the downstream firm absorbs some of an input price increase (Adachi and Ebina, 2014b; Amir, Maret, and Troege, 2004). Consequently, the elasticity of demand upstream is lower than downstream. Therefore, by the intuition of the Lerner index, the margin upstream must be bigger than downstream. If there are several unconstrained suppliers, each earns a higher unit dollar margin than the

[25] All unconstrained suppliers earn the same (unit dollar) margin in equilibrium. Intuitively: at the optimum, each unconstrained supplier trades off earning a higher unit profit with a decrease in the quantity sold. The decrease in the quantity sold is the same whichever particular input price increases; consequently, all unconstrained suppliers earn the same unit profit in equilibrium (independently of their marginal cost).

downstream firm. (Whereas the Lerner index relates percentage margins to the elasticity of demand, I relate upstream to downstream unit dollar margins.)

A supplier is constrained (i.e. it would like to obtain a higher price but cannot) if and only if the product of its margin and the pass-through rate is smaller than the downstream firm's margin.

Proposition 1. *Supplier i is constrained if and only if $m_i^* \times \rho < m_D^*$.*

Proposition 1 follows from two intermediate results. First, at the unique unconstrained price, the difference $\Delta(v_i) = m_i(v_i)\rho(v_i) - m_D^*(v_i)$ equals zero (see (3.4)). Second, the difference strictly increases in v_i.[26]

Empirical facts can reveal whether a supplier is constrained. For any pass-through rate up to 100%, if a supplier's unit dollar margin is smaller than that of the downstream firm, then that supplier is constrained. If the exact pass-through rate is unknown but is known not to exceed 100%, constrained suppliers can be identified via margin data.

Corollary 1. *For any log-concave demand function, if $m_i^* < m_D^*$, then supplier i is constrained.*

3.2.4 Merger effects: equivalence & test

Consider a merger among two or more suppliers (the most efficient producers) of inputs $i \in M \subseteq K$: a merger of complements. As before the merger, in the second stage, the downstream firm sets the optimal consumer price. Post-merger, the downstream firm has the same best response function $P^*(\sum v_j)$ as pre-merger. Thus, if the merger leaves input prices unaltered, the consumer price remains unaltered too. Post-merger, the level of the optimal consumer price changes only if the sum of input prices changes. For a given sum of input prices, which might be different after the merger, the downstream firm's post-merger margin is given by (3.1):

$$m_D^* = -\frac{Q(P^*)}{Q'(P^*)}$$

In the first stage, the merged entity is either constrained in the total unit price it offers for inputs $i \in M$, at $\sum_{i \in M} \bar{c}_i$, or unconstrained. Let v_M denote the total unit price the merged entity offers for the M inputs[27] and let c_M denote the merged entity's total unit

[26] This is shown in the proof of Proposition 1 but can be seen easily for log-concave functions. The margin m_i strictly increases in price v_i, the pass-through rate ρ is non-decreasing, and the margin m_D^* is weakly decreasing in v_i (due to less than full pass-through).

[27] The merged entity's profit depends only on the total unit price it receives.

cost $\sum_{i\in M} c_i$. Then, the merged entity has profit

$$\Pi_M = (v_M - c_M)Q(P^*(\sum_{j=1}^{K} v_j))$$

Similar to (3.3), the first-order condition yields the merged entity's unconstrained unit dollar margin m_M^u:

$$v_M^u - c_M = -\frac{Q(P^*(v_M^u + \sum_{-M} v_j))}{Q'(P^*(v_M^u + \sum_{-M} v_j))} \times \frac{1}{\rho(P^*(v_M^u + \sum_{-M} v_j))} \tag{3.5}$$

Again, for log-concave (log-convex) demands, the merged entity has an unconstrained price at which its dollar margin weakly exceeds (is lower than) that of the downstream firm. Finally, the merged entity sets the optimal total unit price

$$v_M^* = \min\left\{v_M^u, \sum_{i\in M} \overline{c}_i\right\} \tag{3.6}$$

Cournot (1838) shows that a merger of monopolists lowers prices, with $v_M^u < \sum_{i\in M} v_i^u$. In words: the merged entity sets a lower (total) price than the sum of the merging parties' pre-merger monopoly prices.

In Theorem 1, I answer the central question addressed in this paper: yes or no, does a given merger of complements benefit consumers (through the Cournot effect)? In that theorem, I also answer a follow-up question of direct practical relevance. Suppose an antitrust authority reviews a proposed merger for which it has data on margins and the pass-through rate. Does such data reveal whether the proposed merger would decrease prices?

Theorem 1 (No merger benefit)**.** *The merger yields no price decrease if and only if pre-merger* $\rho \times \sum_{i\in M} m_i^* \leq m_D^*$.

Theorem 1 states: a merger among suppliers of complements does not benefit consumers if and only if the product of (a) the combined unit dollar margin earned by the merging suppliers and (b) the pass-through rate is smaller than (c) the unit dollar margin of the downstream firm.[28] A merger between suppliers who face perfect competition does not decrease prices whereas a merger between monopolist suppliers does lower prices. Between these two extremes, the literature has hitherto not provided a result on whether consumers benefit from the Cournot effect. Theorem 1 fills this gap in the literature.

[28] A sufficient condition for Theorem 1 is that the pass-through rate $\rho(P^*)$ is non-decreasing; however, the Theorem also holds if the pass-through rate is decreasing but not overly so (see the proof of Theorem 1).

Remark 2. *If $n \geq 2$ suppliers merge and each input market is symmetric, the condition in the theorem becomes $n \times m_i^* \leq \frac{m_D^*}{\rho}$, where the left-hand side grows with n.*

The condition in Theorem 1, $\rho \times \sum_{i \in M} m_i^* \leq m_D^*$, holds if the merging parties are sufficiently constrained pre-merger. For the condition to hold, it is necessary that each merging party is constrained (because a single unconstrained supplier already has $\rho \times m_i^* = m_D^*$), but it is insufficient that each supplier is constrained. Indeed, if each merging party is constrained, but only slightly so, then the merged entity would find it profitable to decrease price. Theorem 1 identifies the cutoff point where a merger of complements yields no consumer price decrease and therefore does not benefit consumers. The Cournot effect does not materialise when the merging parties are collectively, sufficiently constrained.

Example 1. *Let there be only two inputs, inputs A and B. Let consumer demand be $Q(P) = 12 - P$. The pass-through rate is 50% because demand is linear. The downstream firm's optimal price P^* equals $\frac{1}{2}(12 + v_A + v_B)$. Supplier A's unconstrained input price is $v_A^u = 6 - \frac{1}{2}v_B$, which decreases in input price v_B. (And vice versa for v_B^u.) If both suppliers are monopolists, both input prices equal 4 in the pre-merger equilibrium and the consumer price equals 10. The condition in Theorem 1 is not satisfied, as $0.5 \times (4+4) > 2$. Consequently, a merger decreases the consumer price. Similarly, if both suppliers are constrained but only slightly so, e.g. with $\overline{c}_A = 3.5$ and $\overline{c}_B = 3.5$, the condition in the theorem is not satisfied, as $0.5 \times (3.5+3.5) > 2.5$, and therefore a merger decreases the consumer price. In contrast, with stronger constraints, e.g. with $\overline{c}_A = 4$ and $\overline{c}_B = 2$, supplier B is constrained but so is supplier A (whose unconstrained price now equals 5). The condition in Theorem 1 is satisfied, as $0.5 \times (4+2) \leq 3$. Consequently, a merger does not decrease the consumer price.*[29]

A further, technical intuition for Theorem 1 goes as follows. A monopolist sets its price where its first-order condition equals zero. At this interior solution, a small reduction in its price has no first-order effect on its profit but benefits its merging partners through greater demand. In contrast, a constrained supplier sets its price where the constraint creates a kink in its profit function. At the constraint, a small reduction in price has a first-order effect on its profit, which can outweigh the quantity benefit to its merging partners.

Remark 3. *There are several ways to think of a link between $\overline{c}_i$, the constraint, and the degree of competition. For example, imagine each producer of a given input draws a cost from the same distribution with continuous p.d.f., whose upper bound lies above the*

[29] In this example, one can calculate that the merged entity sets a total unit price of $v_M^u = 6$ if it is unconstrained. Consequently, a merger leads to a lower consumer price whenever the pre-merger prices of suppliers A and B sum to more than 6. However, when one applies the test in practice, it is not necessary to know the post-merger monopoly price (pre-merger data is sufficient).

monopoly price. Then, the greater the number of producers of that input, the more likely the supplier of the input is constrained, and the lower the expected $\overline{c}_i$.

In practice, it might not always be feasible to estimate the precise level of the pass-through rate.[30] Imagine you do not know the pass-through rate but know it lies below 100%. For such a situation, I now develop a new merger test. The test comes in the form of a sufficient condition. It states: if, before the merger, the unit dollar margin of the downstream firm is larger than the combined unit dollar margin earned by the merging suppliers, then the merger of complements does not result in a lower price. For a merger among two firms, suppliers of inputs $A, B \in K$:

Corollary 2 (Test)**.** *For any pass-through rate up to 100%, if pre-merger* $m_A^* + m_B^* \leq m_D^*$*, the merger yields no price decrease.*

Suppose the merging parties earn a combined unit dollar margin smaller than the margin of the downstream firm. This implies not only that all merging parties are individually constrained but also that their combined competitive edge over their competitors is sufficiently small such that, post-merger, the merged entity would not want to decrease price.

The test's simplicity, practicability and transparency render it powerful for use by antitrust authorities. The test requires little data, merely three observable data points. Knowing only pre-merger margin data (and that the pass-through rate lies somewhere below 100%) can suffice to identify whether the merging parties face sufficiently strong constraints pre-merger to exclude a price decrease post-merger.

Remark 4. *Because the quantity sold upstream and downstream is the same, one can compare dollar profits instead of unit dollar margins in Theorem 1 and Corollary 2.*

The following definition is important for potential merger harm, which I consider in section 3.4. The merging parties $i \in M$ are ***collectively constrained*** if (and only if) $\rho \times \sum_{i \in M} m_i^* < m_D^*$. When they are collectively constrained, not only does the merger and the 'internalisation of double markups' yield no price decrease but, to the contrary, the merged entity is constrained and would raise prices strictly (if only it could).

3.3 Robustness

The results developed hitherto are remarkably general. I now show that the theorem and test are robust to a series of extensions.

[30] Several academic studies estimate the pass-through rates for various goods. Whereas the economic literature often assumes log-concave demands, several studies find pass-through rates in excess of 100%, such as Pless and Benthem (2019) for solar panels and Besley and Rosen (1999), Delipalla and O'Donnell (2001), and Kenkel (2005) for several consumer goods.

3.3.1 Input substitution

Suppose input $i \in K$ is heterogeneous.[31] In other words, each producer of input i produces a differentiated version of the input. The theorem and the test apply unaltered. Intuitively, because the theorem relates downstream monopoly margins to upstream unconstrained margins, the theorem does not depend on the constraints (the substitutes). Similarly, results remain unchanged when the downstream firm can produce in-house at a constant unit cost. Substitution to heterogeneous inputs and in-house production merely adds further sources of possible constraints.

3.3.2 Market structure

Consider competition downstream. Let there be several downstream firms that compete with differentiated products. I maintain the assumptions on profit functions (the downstream firm and each of its suppliers have a twice differentiable strictly quasi-concave profit function) and maintain the assumption that the pass-through rate is non-decreasing.[32] If the merging parties supply only one and the same downstream firm pre-merger, Theorem 1 and the test apply unaltered. Intuitively, results continue to hold because the profit function of a supplier does not change due to the merger. Notwithstanding that results still hold, downstream competition may alter the level of the pass-through rate.

Suppose a producer supplies several competing downstream firms. (One may think of this as "overlapping" supply chains.) When that producer increases the input price to a given downstream firm it supplies, that downstream firm raises its consumer price. This diverts some demand to other downstream firms, at least one of which the producer also supplies. Consequently, the supplier benefits from this diverted demand (to some extent). Intuitively, compared to the baseline model, the elasticity of "total" quantity sold upstream (i.e. of the quantity sold to all downstream firms) is lower still than the elasticity of demand downstream. As a result, the unconstrained margin upstream relative to downstream is higher still (higher still than $\frac{m_D^*}{\rho}$). When one or more merging parties supply several competing downstream firms, Theorem 1 provides a sufficient condition rather than an equivalence: if $\rho \times \sum_{i \in M} m_i^* \leq m_D^*$, the merger yields no price decrease.[33] The test already provides a sufficient condition: it remains unchanged.

[31] When different versions of an input i are not equally compatible with other inputs $-i$, then bundling can lead to harm (see section 3.4).

[32] This excludes homogeneous product Bertrand competition downstream, because the pass-through rate in such an environment would be extreme.

[33] For formal workings, see Kadner-Graziano (2023b).

3.3.3 Technology and synergies

In the baseline model, the downstream firm has a Leontief production technology. Instead, suppose some input $i \in K$ is non-essential: the downstream firm can do without it and still produce a valuable consumer product. Then, beyond some limit price for that input, the downstream firm chooses to do without it. An input being non-essential constitutes yet another possible explanation as to what may constrain a supplier. Theorem 1 and the test do not change.

Suppose a merger among suppliers of inputs $A, B \in K$ creates synergies such that the merged entity has a constant unit marginal cost $c_M < c_A + c_B$. If suppliers are monopolists, such synergies lead to a lower price post-merger. (Synergies would then benefit all: suppliers of complementary inputs, the downstream firm, and consumers.) In contrast, when the merging parties are collectively constrained, synergies may or may not be passed on. Consumers benefit from synergies if and only if $v_M^*(c_M) < \sum_{i \in M} \bar{c}_i$. With synergies, Theorem 1 and test change somewhat. Sufficient conditions for consumer benefits not to arise are $\rho \times \sum_{i \in M} v_i^* < m_D^*$ or, in the spirit of the test, $\sum_{i \in M} v_i^* < m_D^*$ for log-concave demands. These conditions ensure that, even if synergies are so extreme as to eliminate the merging parties' costs, the merging parties are sufficiently constrained pre-merger for there to be no price decrease post-merger.

3.4 Merger harm

Mergers of complements can, of course, benefit consumers.[34] In this section, I focus on how profitable mergers can harm consumers. I lay out two example theories of harm. The first relates to compatibility across components, a theme discussed in, e.g., Matutes and Regibeau (1988). The second relates to inducing a competitor to exit the market, as analysed by Whinston (1990). In the baseline model, a merger either is profitable and reduces prices (to the benefit of consumers) or has no effect on prices, profits, and welfare. Intuitively, harm arises when the merging parties are collectively constrained and when the merger weakens constraints.

For both theories of harm, I assume the merged entity can credibly commit to pure bundling (to sell either both of its components to the downstream firm or none at all). This assumption is crucial and typical in theories of harm from mergers of complements.[35] To

[34] Other than through the Cournot effect, Choi (2008) discusses that some consumers benefit from lower prices when the merged entity engages in mixed bundling (such that the merger effect is ambiguous). Furthermore, Brueckner and Spiller (1991) show that a merger with cost complementarities can increase welfare and benefit some consumers. Relatedly, see Anderson, Loertscher, and Schneider (2010).

[35] See Whinston (1990). See Kühn, Stillman, and Caffarra (2005) for factors which influence the credibility of pure bundling and "technical bundling".

simplify the exposition (and without loss of generality), let the consumer product consist of two inputs, A and B. Furthermore, there are two producers of each input: firms A1 and A2, as well as firms B1 and B2.

3.4.1 Example A: Compatibility

As is commonplace in the literature on compatibility, let there be different degrees of compatibility across the complementary inputs (see, e.g., Matutes and Regibeau, 1988). The input produced by A1, the most efficient producer of input A, is perfectly compatible with the input produced by B1 and B2. Similarly, the input produced by B1, the most efficient producer of input B, is perfectly compatible with the input produced by A1 and A2. However, the downstream firm incurs some extra unit cost $x \geq 0$ to overcome compatibility issues if it sources inputs from A2 and B2.

Pre-merger outcomes are the same as in section 3.2. When A1 and B1 are constrained, the downstream firm pays a total unit input price of $\overline{c}_A + \overline{c}_B$. Let A1 merge with B1 and credibly commit to pure bundling. Post-merger, if the downstream firm does not source inputs from the merged entity, it sources from A2 and B2 and incurs the extra cost x. Consequently, the merged entity knows it can obtain a unit price up to $\overline{c}_A + \overline{c}_B + x$ for its bundle. (Pre-merger, firm A1 cannot unilaterally extract any of the surplus x because firm A2's product is equally, perfectly compatible with firm B1's product. If firm A1 raised its bid above $\overline{c}_A$, then firm A2 could undercut that bid and the downstream firm would choose firms A2 and B1 as its suppliers.) Hence, the merged entity can extract a higher unit price post-merger.

Lemma 1 (Ability)**.** *The merged entity has* $v_M^* = \min\{v_M^u, \overline{c}_A + \overline{c}_B + x\}$. *If* $x > 0$ *and pure bundling is credible, the merged entity can raise price beyond* $\overline{c}_A + \overline{c}_B$.

Intuitively, pre-merger, neither merging party can generate a profit from the extra cost x because neither merging party is – alone – necessary to the downstream firm to avoid that cost. However, the merging parties A1 and B1 are – jointly – necessary. Therefore, with pure bundling, the downstream firm's outside option – the constraint on A1 and B1 – is weakened post-merger. The merger harms consumers whenever the merging parties are collectively constrained.

Theorem 2 (Merger Harm)**.** *Let* $x > 0$ *and pure bundling be credible. Then, if and only if pre-merger* $\rho(m_A^* + m_B^*) < m_D^*$*, a merger among suppliers A1 and B1 strictly increases* $v_A + v_B$ *from* $\overline{c}_A + \overline{c}_B$ *pre-merger to* $v_M^* = \min\{v_M^u, \overline{c}_A + \overline{c}_B + x\}$.

Figure 3.1 illustrates Theorem 2. When $x > 0$ and pure bundling is credible, a merger of collectively constrained suppliers no longer leaves prices unchanged. Instead, the merger unambiguously harms consumers.

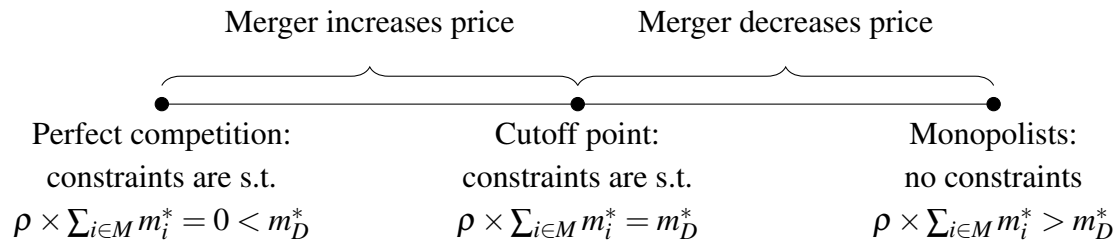


Figure 3.1: Illustration of Theorem 2

3.4.2 Example B: Market exit

In his seminal work on tying, Whinston (1990) finds that if a merged entity can credibly commit to pure bundling, a merger of complements can induce a competitor to exit the market. This way, a merger of complements can reduce competition, lead to higher prices, and harm consumers.

Whinston (1990) does not explicitly analyse supply chains, i.e. vertically related firms. I now make a few changes to the baseline model of section 3.2 to apply, in spirit, his theory of harm to the vertical structure considered in the present paper. Let there be several downstream firms that all compete with one another. Each downstream firm manufactures a differentiated version of the same consumer product. The two producers of A have respective constant unit costs c_{A1} and c_{A2}, where $c_{A2} - c_{A1} > 1$. Each producer of B has a unit cost specific to each downstream firm j. Constant unit costs of the two producers to supply downstream firm j, c_{B1j} and c_{B2j}, are randomly drawn from the same c.d.f. on $[0,1]$. Each producer of B incurs fixed (sunk) costs.

The timing is as follows.[36] First, firms B1 and B2 decide whether to enter and thus incur fixed entry costs. Only a firm which enters can produce B. Second, producers of A and B submit offers to each downstream firm. Third, each downstream firm selects its suppliers, one for every input, and sets the consumer price. Post-merger, an initial stage is added (stage 0), where the merged entity decides whether to engage in pure bundling.

Pre-merger, the more efficient producer of A supplies all downstream firms. B1 supplies those downstream firms for which it is more efficient than B2. Conversely, B2 supplies those downstream firms for which $c_{B2j} < c_{B1j}$. Let A1 merge with any of the producers of B, say with B1, and credibly commit to pure bundling. Post-merger, the non-integrated producer B2 knows it will no longer supply a downstream firm. At best, its cost advantage over B1 is of magnitude 1. However, the cost advantage of A1 over A2 is greater than 1. Therefore, the merged entity can always undercut the total unit price for

[36] The timing is identical to that of Whinston (1990), except here, there is an additional stage because I model both the upstream and downstream levels.

the two inputs offered by B2 and A2. Consequently, post-merger B2 earns no revenue, cannot cover its fixed costs, and exits the market. Thus the market structure for input B changes. This change in market structure allows the merged entity to extract a higher price for inputs A and B than what downstream firms paid pre-merger.[37] The merged entity has an incentive to make use of this gained ability and raise prices post-merger if the merging parties are collectively constrained.

3.5 Different settings

There are settings in which the theorem and test do not necessarily apply. I discuss two such settings below. In both, I consider different ways input prices are formed in the first stage. In both settings, the downstream firm has bargaining power and the merger is typically unprofitable.[38] (Workings and further details are provided in the supplementary material.)

3.5.1 Nash-in-Nash bargaining, with endogenous quantity

Suppose the downstream firm knows the costs of upstream producers. Let the downstream firm bargain with producers over the unit input price in the first stage (before it sets the consumer price in the second stage). To solve the game, I use the Nash-in-Nash bargaining solution.[39] This bargaining solution is well-suited to deal with monopolist suppliers of essential inputs (see Schmidt, 2014; Spulber, 2017). Hence, to begin with, consider the case where each input is produced by a monopolist. In this setting, a merger of complements always decreases input prices, decreases the consumer price, and benefits consumers. Effectively, the main merger effect is a loss of bargaining surplus upstream. (This result goes back to Horn and Wolinsky, 1988.)

With exogenous demand and when suppliers all have the same bargaining power, a merger of complements is never profitable for the merging parties. Intuitively: in the bargaining solution, each essential upstream supplier earns one K^{th} of the total upstream profit. (Suppliers earn the same profit in equilibrium even if their costs differ.) Twice this share, $\frac{2}{K}$, exceeds the share $\frac{1}{K-1}$ the merged entity would receive. Consequently, a merger

[37] After the market exit, the merged entity would act as a monopolist producer of B. However, if there is a competitive fringe of producers of B with unit cost $c_B \geq 1$, the price the merged entity charges for its bundle may increase but nevertheless still be constrained.

[38] The merger may nevertheless be profitable due to, for example, savings in fixed costs.

[39] Harsanyi (1963) extended the Nash bilateral bargaining solution (Nash, 1950) to the $(n+1)$-player case, where a buyer faces n sellers of perfect complements. Collard-Wexler, Gowrisankaran, and Lee (2019) provide non-cooperative micro-foundations for the Nash-in-Nash solution.

diminishes profit upstream.[40] With endogenous demand, the bargaining solution takes into account that lower input prices increase quantity and thus "the size of the pie". This added effect exerts downward pressure on input prices. Post-merger, input prices decrease further and quantity increases. Apart from the most extreme cases (e.g. with very few inputs and extremely convex demand), this quantity effect is insufficient to render the merger profitable.

When there are multiple producers of the same input, algebraic workings become significantly more cumbersome, but the equilibrium price still reflects that a lower price increases quantity. The merger always decreases price. As discussed, the price decrease is not a result of the Cournot effect. Rather, it results from a loss of bargaining surplus. Only in extreme cases would such a merger be profitable.

Consequently, with bargaining and absent anticompetitive effects, mergers of complements always benefit consumers. The theorems and the test do not hold, but because such mergers are mostly unprofitable, such mergers might not occur. Therefore, the question of whether the test and theorems apply to such a proposed merger might not arise in practice.

3.5.2 Auctions with "buyer power"

Loertscher and Marx (2019b) analyse a model with "buyer power": the downstream firm uses an optimal mechanism to procure one unit of an input. Costs of upstream producers are private information. The mechanism is optimal in expectation but risks no trade and inefficient outcomes. It specifies reserve prices; consequently, trade might not occur despite being profitable. With discriminatory reserve prices, the downstream firm might not purchase from the producer who offered the lowest price. Such outcomes result from the buyer's commitment power. In contrast, in the baseline model of section 3.2 (and with second-price auctions, see footnote 24), trade always occurs and is efficient.

Loertscher and Marx (2019b) focus on horizontal mergers but also briefly discuss mergers of complements. They find that a merger between two monopolist suppliers of complementary inputs decreases input prices. In their model, the downstream firm sources a single unit. Consequently, there is no Cournot effect. Instead, the following two features explain their result. First, the convolution of the density functions of the merging parties' costs is such that the downstream firm wants to set a lower reserve price post-merger.[41] Second, the downstream firm has the power to set a lower reserve price: it

[40] This result bears some semblance to Cournot mergers among two firms being strictly unprofitable, for $K \geq 3$ and linear demand. On this, see Salant, Switzer, and Reynolds (1983) and Belleflamme and Peitz (2015), p.374-6. See also Motta (2004), p.243-50. However, for convex demand, Cournot mergers can be profitable.

[41] See the supplementary material to Loertscher and Marx (2019b). The expected price decreases, but quantity can decrease too (when there is no trade post-merger). This differs from the Cournot effect.

(rather than suppliers) makes take-it-or-leave-it offers. In expectation, the merger benefits the downstream firm. However, precisely due to the expected price decrease, the merger can be strictly unprofitable to the merged entity. Unprofitable mergers are tightly linked to downstream (bargaining or buyer) power.

3.5.3 Results on incentives continue to apply

Independently of the price formation mechanism that determines the unit price (whether suppliers set prices, whether second-price or first-price auctions are used, or whether the downstream firm has bargaining or buyer power), the condition in Theorem 1 provides a general test of incentives. If and only if pre-merger $\rho \times \sum_{i \in M} m_i^* \leq m_D^*$, the merged entity wants to obtain a higher unit price. Whether such an incentive materialises into actually obtaining a higher price depends on the price formation process.

3.6 Conclusion

Standard intuition on Cournot effects; guidelines from antitrust authorities; and many models in the literature suggest mergers of complements can benefit not only the merging parties but also other suppliers, downstream firms, and consumers. Accordingly, when a competition authority reviews a merger of complements, it is thought that any potential negative merger effect ought to be weighed against at least the positive effect from internalising Cournot externalities. This complicates the work of competition authorities. The trade-off can be difficult to ascertain. It may be ambiguous.

In this paper, I develop a tool to identify whether a merger of complements will benefit consumers via the Cournot effect. The main finding, Theorem 1, closes the gap in the literature. It deals with all competitive landscapes between the polar extremes of monopoly and perfect competition. The finding is general. It extends, among others, to downstream competition and non-essential inputs.

Antitrust authorities can use the tool developed herein to inform merger reviews. For example, when a merger-related price decrease can be dismissed, any theories of harm need not be weighed against positive Cournot effects. Absent benefits, the merger can unambiguously harm consumers. The authority may then have clear grounds to act against a proposed merger.

If the tool developed herein indicates that the Cournot effect does materialise, then absent anticompetitive behaviour, the merger benefits consumers. However, accounting for anticompetitive behaviour, the merger may be harmful overall. Thus, the tool cannot provide a free pass to a merger.

Further helpful work would encompass empirical studies comparing manufacturers' and their suppliers' margins in various industries. In addition, helpful empirical studies would assess to what extent Bertrand competition among suppliers accurately characterises competition for supply contracts in various industries.[42]

In short, this paper shows that observable data can reveal information (i) to fact-check existing theory and (ii) to predict merger effects of consequence to consumers.

3.7 Proofs

Proof of Proposition 1. I use two intermediate results for the proof. I lay these out now. First, at supplier i's unique unconstrained price v_i^u, the condition $m_i^u \times \rho - m_D^* = 0$ holds (see equation (3.4)). Second, the difference $m_i \times \rho - m_D^*$ strictly increases in v_i. I show this below:

$$m_i \times \rho - m_D^* = (v_i - c_i) \times \rho - \left[P^*\left(\sum v_j\right) - \sum v_j\right]$$

Differentiating this difference with respect to v_i yields

$$\begin{aligned} &\rho + (v_i - c_i)\frac{\partial \rho}{\partial v_i} - \frac{\partial P^*}{\partial v_i} + 1 \\ &= 1 + (v_i - c_i)\frac{\partial \rho}{\partial v_i} \\ &> 0 \end{aligned}$$

because (by assumption on the demand function) the pass-through rate is non-decreasing. It follows that v_i^u is the unique price v_i at which the difference equals zero.

I now use these intermediate results. If $m_i^* \times \rho < m_D^*$, then it must be that $v_i^* < v_i^u$. If $v_i^* \neq v_i^u$, then by definition the supplier is constrained.

Proving the other direction: if supplier i is constrained, then $v_i^* \neq v_i^u$. The constraint $\bar{c}_i$ cannot lie above the supplier's unconstrained price, for if it did, the supplier could set its unconstrained price. Therefore $\bar{c}_i$ must lie below supplier i's unconstrained price: $\bar{c}_i < v_i^u$. From the intermediate results above we know that at any such input price $v_i^* < v_i^u$, the inequality $m_i^* \times \rho < m_D^*$ holds. □

Proof of Corollary 1. The pass-through rate $\rho \in (0, 1]$ for any log-concave demand. Consequently, Corollary 1 follows directly from Proposition 1. □

Proof of Theorem 1. The proof is mostly identical to the proof of Proposition 1. I begin by listing the three intermediate results used for the proof. First, the profit of a supplier

[42] For related and ongoing empirical research, see Alexandrov, Pittman, and Ukhaneva (2018).

(e.g. the merged entity) is single-peaked, and strictly increasing up to that peak. Second, at the merged entity's unconstrained price v_M^u the condition $m_M^u \times \rho = m_D^*$ holds (see equation (3.5)). Third, the difference $m_M \times \rho - m_D^*$ strictly increases in the price v_M. This is shown below:

$$m_M \times \rho - m_D^* = (v_M - \sum_{i \in M} c_i) \times \rho - \left[P^*\left(\sum v_j\right) - \sum v_j\right]$$

Differentiating the difference with respect to v_M yields

$$\begin{aligned} &\rho + m_M \frac{\partial \rho}{\partial v_i} - \frac{\partial P^*}{\partial v_i} + 1 \\ =&1 + m_M \frac{\partial \rho}{\partial v_i} > 0 \end{aligned} \tag{3.7}$$

as (by assumption on the demand function) the pass-through rate is non-decreasing. It follows that, for any given sum of prices of the non-merging suppliers $\sum_{j \in K, j \notin M} v_j$, the price v_M^u is the unique price where the difference equals zero.

Proving one direction: suppose that pre-merger $\rho \times \sum_{i \in M} m_i^* \leq m_D^*$. Imagine the merged entity were to fix its price at $v_M = \sum_{i \in M} v_i^*$. At this price, in equilibrium $\rho \times m_M \leq m_D^*$. (This immediately shows that the price $v_M = \sum_{i \in M} v_i^*$ is not the unconstrained price.) Therefore, given the direction of the inequality, the unconstrained price v_M^u must lie weakly above $\sum_{i \in M} v_i^*$. Given profit is strictly increasing up to v_M^u, it follows that if $\rho \times \sum_{i \in M} m_i^* \leq m_D^*$ the merged entity finds it strictly unprofitable to decrease price; hence it does not decrease price.

Proving the other direction: suppose the merged entity does not decrease price post-merger. This means that $v_M^u \not< \sum_{i \in M} v_i^*$. Instead, it must be that $v_M^u \geq \sum_{i \in M} v_i^*$. Profit is strictly increasing up to its single peak, therefore $v_M^* = \sum_{i \in M} v_i^*$. And for any such $v_M^* \leq v_M^u$, $\rho \times m_M \leq m_D^*$, i.e. $\rho \times \sum_{i \in M} m_i^* \leq m_D^*$ (recall that $m_M = \sum_{i \in M} m_i^*$). □

Remark 5. *Theorem 1 holds when* (3.7) *exceeds zero. Hence, the pass-through rate can be decreasing but not overly so.*

Proof of Corollary 2. The pass-through rate $\rho \in (0, 1]$ for any log-concave demand. Consequently, Corollary 2 follows directly from Theorem 1. □

Proof of Lemma 1. This follows from the text. □

Proof of Theorem 2. By Lemma 1, if $x > 0$ and pure bundling is credible, then the merged entity has the ability to raise price. From the proof of Theorem 1, it follows that the merged entity wants to obtain a higher price if and only if pre-merger $\rho \times \sum_{i \in M} m_i^* < m_D^*$. The merged entity uses its ability to raise price whenever it has the incentive to do so. □

3.A Supplementary material

3.A.1 Workings for section 3.5.1

In section 3.5.1, I discuss results on bargaining without showing formal workings. Here, I provide algebraic workings and results on merger effects when the downstream firm bargains over input prices with its suppliers and when quantity is endogenous.

Let suppliers be monopolists. In stage 1, the downstream firm bargains with all upstream producers simultaneously (I use the Nash-in-Nash bargaining solution with endogenous demand). Let $\beta \in (0,1)$ denote the downstream firm's bargaining power. When the downstream firm bargains with the monopolist producer of input i, the Nash-in-Nash solution yields unit price

$$\begin{aligned} v_i^* &= \underset{v_i}{\operatorname{argmax}}\ \Pi_i^{1-\beta}\Pi_D^{\beta} \\ &= \underset{v_i}{\operatorname{argmax}}\ \Big[v_i - c_i\Big]^{1-\beta}\Big[P^* - \sum_{j=1}^{K} v_j\Big]^{\beta} Q(P^*) \end{aligned} \tag{3.8}$$

(Recall: P^* is a function of input prices, including v_i.) The above shows: the Nash-in-Nash bargaining solution with endogenous quantity accounts for the increase in the size of the "pie" as a result of lower input prices. The first-order condition yields

$$m_i^* = (1-\beta)\Big[\frac{\beta(1-\rho)}{m_D^*} - \rho\frac{Q'(P^*)}{Q(P^*)}\Big]^{-1}$$

Plugging in (3.1) yields[43]

$$m_i^* = -\frac{Q(P^*)}{Q'(P^*)}\frac{1-\beta}{\rho+\beta(1-\rho)}$$

Let suppliers of inputs $A, B \in K$ integrate and form the merged entity M. After the integration, the merged entity obtains unit price

$$v_M^* = \underset{v_M}{\operatorname{argmax}} \left[v_M - c_A - c_B\right]^{1-\beta}\left[P^* - \sum_{j\neq A,B}^{K} v_j - v_M\right]^{\beta} Q(P^*)$$

The first-order condition is identical to (3.8), the only difference is that post-merger there are $K-1$ upstream firms rather than K.

To illustrate intuitions, I use the log-concave demand function $Q = (1-P)^{\gamma}$. This demand function can be highly concave or highly convex. Using (3.8) to calculate equilibrium profits, the merger is strictly profitable when[44]

$$\begin{aligned}
& & \Pi_i(K-1) &> 2\Pi_i(K) \\
\Leftrightarrow & \frac{(1-\beta)(1-c-\sum_i^K c_i)}{(K-1)(1-\beta)+\gamma+\beta}\left[\frac{\gamma(\gamma+\beta)}{\gamma+1}\frac{1-c-\sum_i^K c_i}{(K-1)(1-\beta)+\gamma+\beta}\right]^{\gamma} &> 2\frac{(1-\beta)(1-c-\sum_i^K c_i)}{K(1-\beta)+\gamma+\beta}\left[\frac{\gamma(\gamma+\beta)}{\gamma+1}\frac{1-c-\sum_i^K c_i}{K(1-\beta)+\gamma+\beta}\right]^{\gamma} \\
\Leftrightarrow & \left[\frac{K(1-\beta)+\gamma+\beta}{(K-1)(1-\beta)+\gamma+\beta}\right]^{\gamma+1} &> 2
\end{aligned}$$

For small K, low β, and highly convex demand the merger can be profitable. Equal

[43] Section 3.2 shows that, with log-concave demand, an unconstrained supplier earns a larger margin than the downstream firm. This is not the case here. Comparing the downstream margin to the unconstrained (monopoly) upstream margin yields $m_D^* > m_i^*$ if

$$\begin{aligned}
1 &> \frac{1-\beta}{\rho+\beta(1-\rho)} \\
\Leftrightarrow\ \rho &> \frac{1-2\beta}{1-\beta}
\end{aligned}$$

For the Laplace and Exponential distributions of consumers' willingness-to-pay, the pass-through rate equals one (see Table 3.2). Hence, for those distributions, the downstream firm's margin exceeds any upstream margin for any $\beta \in (0,1)$.

The comparison of pre-merger upstream and downstream margins is less insightful with bargaining. Not only does the pass-through rate play a role but so does the level of the bargaining power, which may be unknown in practice.

[44] When P and thus Q are treated as fixed a merger of two suppliers is never profitable:

$$\begin{aligned}
& \Pi_i(K-1) &&< 2\Pi_i(K) \\
\Leftrightarrow\ & \tfrac{1}{K-1}(1-\beta)(P-c-\textstyle\sum_i^K c_i) &&< \tfrac{2}{K}(1-\beta)(P-c-\textstyle\sum_i^K c_i) \\
\Leftrightarrow\ & 0 &&< (K-2)(1-\beta)+\beta
\end{aligned}$$

The merger solely leads to lower input prices.

bargaining powers ($\beta = 0.5$) suffices to render the merger unprofitable, as does large K. This is shown in the table below.

Table 3.1: Merger profitability with bargaining, $Q = (1-P)^{\gamma}$

K	10	10	10	3	3
β	0.5	0.5	0.01	0.5	0.1
γ	1	10	10	100	4
$\Pi_i(K-1) - 2\Pi_i(K)$	$-0.8 < 0$	$-0.6 < 0$	$-0.2 < 0$	$-0.4 < 0$	$0.03 > 0$

Source: own workings.

3.A.2 Additional results on demand functions

In section 3.A.2, I show that the pass-through rate is non-decreasing for standard log-concave demand functions. Workings are provided in section 3.A.2. In section 3.A.2, I discuss the log-convex Pareto distribution in more detail.

Non-decreasing pass-through

I assume demand induces non-decreasing pass-through: $\rho' := \frac{\partial^2 P^*}{\partial v_i^2} \geq 0$. In the rightmost column of the table below, I show that this assumption is satisfied for standard log-concave distributions.[45] This can also be satisfied for log-convex distributions, as shown in section 3.A.2.

[45] Let each consumer have unit demand with utility $x - P$, where x represents an individual consumer's willingness-to-pay for the consumer good. A consumer buys when $x - P \geq 0$, where $F(x)$ is the c.d.f of consumers' willingness-to-pay. Demand, then, takes the form $Q(P) = 1 - F(P)$.

That the supports of some of these distributions contain negative willingness-to-pay is not an issue: left-side (and right-side) truncations of the c.d.f. preserve log concavity of the reliability (Bagnoli and Bergstrom, 2005, p.8-9).

Table 3.2: Distributions of consumers' willingness-to-pay, and pass-through

Log-concave distribution	$Q(P)$	ρ	ρ'
Uniform	$1-P$	$\frac{1}{2}$	0
Gaussian	no closed form	$\in [\frac{P^2+1}{P^2+2}, 1]$	≥ 0
Laplace	$\frac{1}{2}e^{-P}$	1	0
Exponential	$e^{-\lambda P}$	1	0
Logistic	$\frac{1}{1+e^{-P}}$	$\frac{1}{1+e^{-P}}$	>0
Extreme value	$1-e^{-e^{-P}}$	$\frac{1}{1-\frac{1}{e^{-P}}-\frac{1}{e^{-e^{-P}}}+\frac{1}{e^{-P}e^{-e^{-P}}}}$	>0
Weibull, $c \geq 1$	e^{P^c}	$\frac{cP^c}{cP^c+c-1}$	>0
Rayleigh	e^{P^2}	$\frac{2P^2}{2P^2+1}$	>0
Power, $\beta > 1$	$1-P^\beta$	$\frac{1}{1+\frac{1}{\beta}+(1-\frac{1}{\beta})\frac{1}{P\beta}}$	>0
Inverse of power reliability, $\beta > 0$	$(1-P)^\beta$	$\frac{\beta}{\beta+1}$	0

Source: own workings on ρ and ρ'.

Workings for Table 3.2

The pass-through rate is

$$\rho = \frac{1}{2 - \frac{Q(P)Q''(P)}{Q'(P)^2}}$$

Let an individual consumer's willingness-to-pay for the consumer good be given by x; $F(x)$ and $f(x)$ denote, respectively, the c.d.f. and p.d.f. of consumers' willingness-to-pay. Then

$$Q(P) = 1 - F(P) \quad Q'(P) = -f(P) \quad Q''(P) = -f'(P)$$

To determine the sign of ρ' it helps to note that

$$\text{sign}\Big\{\frac{\partial^2 P^*}{\partial C^2}\Big\} = \text{sign}\Big\{\frac{\partial \rho}{\partial C}\Big\} = \text{sign}\Big\{\frac{\partial \rho}{\partial P}\frac{\partial P}{\partial C}\Big\} = \text{sign}\Big\{\frac{\partial \rho}{\partial P}\Big\}$$

For the log concavity of the distributions considered below, see Bagnoli and Bergstrom (2005). I now derive the pass-through rate ρ as well as the sign on ρ'.

The uniform distribution has support $[0,1]$ with $F(x) = x$. Hence

$$Q(P) = 1 - P \quad Q'(P) = -1 \quad Q''(P) = 0$$

$$\Rightarrow \quad \rho = \tfrac{1}{2} \quad \text{and} \quad \rho' = 0$$

The Gaussian distribution has support $(-\infty,+\infty)$ with no closed form c.d.f. We can use the bounds on the Gaussian c.d.f. for $Q(P)$, and the p.d.f. $\frac{1}{\sqrt{2\pi}}e^{-\frac{x^2}{2}}$ for $Q'(P)$.[46]

$$\begin{aligned} Q(P) &\in [\tfrac{P}{P^2+1}\tfrac{1}{\sqrt{2\pi}}e^{-\frac{P^2}{2}}, \tfrac{1}{P}\tfrac{1}{\sqrt{2\pi}}e^{-\frac{P^2}{2}}] \\ Q'(P) &= -\tfrac{1}{\sqrt{2\pi}}e^{-\frac{P^2}{2}} \\ Q''(P) &= P\tfrac{1}{\sqrt{2\pi}}e^{-\frac{P^2}{2}} \\ Q'''(P) &= (1-P^2)\tfrac{1}{\sqrt{2\pi}}e^{-\frac{P^2}{2}} \end{aligned}$$

We can then obtain $\frac{Q(P)Q''(P)}{Q'(P)^2} \in [\frac{P^2}{P^2+1}, 1]$ such that

$$\rho \in [\tfrac{P^2+1}{P^2+2}, 1]$$

We can determine the sign of ρ' by determining the sign of the derivative of $\frac{Q(P)Q''(P)}{Q'(P)^2}$.

$$\begin{aligned} \text{sign}\{\rho'\} &= \text{sign}\Big\{\frac{\partial[Q(P)Q''(P)Q'(P)^{-2}]}{\partial P}\Big\} \\ &= \text{sign}\Big\{\frac{Q'''(P)Q(P)}{Q'(P)^2} + \frac{Q''(P)Q'(P)}{Q'(P)^2} - 2\frac{Q''(P)^2Q(P)}{Q'(P)^3}\Big\} \\ &= \text{sign}\Big\{Q'''(P) + \frac{Q''(P)Q'(P)}{Q(P)} - 2\frac{Q''(P)^2}{Q'(P)}\Big\} \end{aligned}$$

Using the lower bound on $Q(P)$ to verify whether the RHS ≥ 0 yields:

$$\begin{aligned} \text{RHS} &= (1-P^2)\frac{1}{\sqrt{2\pi}}e^{-\frac{P^2}{2}} - (P^2+1)\frac{1}{\sqrt{2\pi}}e^{-\frac{P^2}{2}} + 2P^2\frac{1}{\sqrt{2\pi}}e^{-\frac{P^2}{2}} \\ &= 0 \end{aligned}$$

Therefore

$$\rho' \geq 0$$

for the Gaussian distribution.

The Laplace distribution has support $(-\infty,+\infty)$ with $F(x) = 1 - \frac{1}{2}e^{-x}$ for $x \geq 0$.

$$Q(P) = \tfrac{1}{2}e^{-P} \quad Q'(P) = -\tfrac{1}{2}e^{-P} \quad Q''(P) = \tfrac{1}{2}e^{-P}$$

[46] I use the bounds $\frac{1}{\sqrt{2\pi}}\frac{x}{x^2+1}\exp\{-\frac{x^2}{2}\} \leq 1 - F(x) \leq \frac{1}{\sqrt{2\pi}}\frac{1}{x}\exp\{-\frac{x^2}{2}\}$ for $x \geq 0$, from Pishro-Nik (2014).

$$\Rightarrow \quad \rho = 1 \quad \text{and} \quad \rho' = 0$$

The exponential distribution has support $(0,\infty)$ with $F(x) = 1 - e^{-\lambda x}$.

$$Q(P) = e^{-\lambda P} \quad Q'(P) = -\lambda e^{-\lambda P} \quad Q''(P) = \lambda^2 e^{-\lambda P}$$

$$\Rightarrow \quad \rho = 1 \quad \text{and} \quad \rho' = 0$$

The logistic distribution has support $(-\infty,+\infty)$ with $F(x) = \frac{1}{1+e^{-x}}$.

$$Q(P) = \frac{e^{-P}}{1+e^{-P}} \quad Q'(P) = -\frac{e^{-P}}{(1+e^{-P})^2} \quad Q''(P) - \frac{e^{-P}(e^{-P}-1)}{(1+e^{-P})^3}$$

$$\Rightarrow \quad \rho = \frac{1}{1+e^{-P}} \quad \text{and} \quad \rho' > 0$$

The power function distribution has support $(0,1]$ with $F(x) = x^{\beta}$. With $\beta > 1$,

$$Q(P) = 1 - P^{\beta} \quad Q'(P) = -\beta P^{(\beta-1)} \quad Q''(P) = -\beta(\beta-1)P^{(\beta-2)}$$

$$\Rightarrow \quad \rho = \frac{1}{1+\frac{1}{\beta}+(1-\frac{1}{\beta})\frac{1}{P^{\beta}}} \quad \text{and} \quad \rho' = 0$$

The inverse of the power function's reliability is log-concave[47] with $Q(P) = (1-P)^{\beta}$. With support $[0,1)$ and $\beta > 0$

$$Q(P) = (1-P)^{\beta} \quad Q'(P) = -\beta(1-P)^{(\beta-1)} \quad Q''(P) = \beta(\beta-1)(1-P)^{(\beta-2)}$$

$$\Rightarrow \quad \rho = \frac{\beta}{\beta+1} \quad \text{and} \quad \rho' = 0$$

The extreme value distribution has support $(-\infty,+\infty)$ with $F(x) = e^{-e^{-x}}$. With $\beta > 1$,

$$Q(P) = 1 - e^{-e^{-P}} \quad Q'(P) = e^{-P}e^{-e^{-P}} \quad Q''(P) = (e^{-P}-1)e^{-P}e^{-e^{-P}}$$

$$\Rightarrow \quad \rho = \left[1 - \frac{1}{e^{-P}} - \frac{1}{e^{-e^{-P}}} + \frac{1}{e^{-P}e^{-e^{-P}}}\right]^{-1} \quad \text{and} \quad \rho' > 0$$

where ρ was plotted graphically to determine that $\rho' > 0$.

The Weibull distribution has support $[0,\infty)$ with $F(x) = 1 - e^{-x^c}$ for $x \geq 0$. With $c \geq 1$,

$$Q(P) = e^{-P^c} \quad Q'(P) = -cP^{c-1}e^{-P^c} \quad Q''(P) = [cP^c - (c-1)]cP^{c-2}e^{-P^c}$$

$$\Rightarrow \quad \rho = \frac{cP^c}{cP^c+c-1} \quad \text{and} \quad \rho' > 0 \text{ if } c > 1, \text{ else } 0$$

[47] Three equivalent ways to confirm this are the following. First, $\ln Q(P) = \beta \ln(1-P)$ with $(\ln Q(P))'' = -\frac{\beta}{(1-P)^2)} < 0$. Second, $Q(P)Q''(P) - Q'(P)^2 = -\beta(1-P)^{(\beta-2)} < 0$ for $\beta > 0$. Third, $\rho \in (0,1]$.

With the form of the Weibull distribution given above, the Rayleigh distribution is a Weibull distribution with $c = 2$.

Log-convex demand

When consumer valuations are distributed according to the log-convex Pareto distribution, consumer demand is $Q(P) = P^{-\beta}$ (for $\beta > 1$).[48] The associated pass-through rate is non-decreasing (it is constant):

$$\rho = \frac{1}{2 - \frac{Q(P)Q''(P)}{Q'(P)^2}} = \frac{\beta}{\beta - 1}$$

I now show that Pareto demand induces single-peaked profit functions both downstream and upstream.[49] Below I evaluate the second-order condition of the downstream firm.

$$\begin{aligned}
\Pi_D &= (P - \sum_i v_i)P^{-\beta} \\
\frac{\partial \Pi_D}{\partial P} &= P^{-\beta} - \beta(P - \sum v_i)P^{-\beta-1} \\
\frac{\partial^2 \Pi_D}{\partial P^2} &= -2\beta P^{-\beta-1} + \beta(\beta+1)(P - \sum v_i)P^{-\beta-2} \\
\text{sign}\Big\{\frac{\partial^2 \Pi_D}{\partial P^2}\Big\}\Big|_{P=P^*} &= \text{sign}\Big\{-2\beta P^* + \beta(\beta+1)(P - \sum v_i)\Big\}
\end{aligned}$$

Using

$$P^* = \beta(P^* - \sum v_i)$$

[48] See the next footnote.

[49] Either one of the following two adjustments are necessary to avoid the problem of infinite demand as the price P approaches zero. A rightward shift of the Pareto function, of the form $Q(P) = (P+\alpha)^{-\beta}$ for $\alpha > 0$, ensures demand does not approach infinity as the consumer price approaches zero, and ensures that profit is not maximised at a price close to zero. Alternatively, no change to the demand function is required if the supplier has a large enough unit cost, large enough such that it would not set a price close to zero. With either of those two adjustments, the supplier's profit function is indeed single-peaked in the unit price v it sets.

Demand $Q(P) = (P+\alpha)^{-\beta}$ leads the downstream firm to set the optimal consumer price $P^* = \frac{\beta}{\beta-1}v_M^*$, the merged entity has the unconstrained unit price $v_M^u = \frac{\alpha}{\beta-1}$.

to evaluate the sign of the second derivative yields:

$$\begin{aligned}\operatorname{sign}\Big\{\frac{\partial^2\Pi_D}{\partial P^2}\Big\}\Big|_{P=P^*} &= \operatorname{sign}\{-2\beta P^* + (\beta+1)P^*\} \\ &= \operatorname{sign}\{1-\beta\} \\ &< 0 \quad \text{as } \beta > 1\end{aligned}$$

Below I evaluate the second-order condition of a supplier.

$$\begin{aligned}\Pi_i &= (v_i - c_i)P^{-\beta} \\ \frac{\partial\Pi_i}{\partial v_i} &= P^{-\beta} - \beta(v_i-c_i)P^{-\beta-1}\frac{\partial P^*}{\partial v_i} \\ \frac{\partial^2\Pi_i}{\partial v_i^2} &= -2\beta P^{-\beta-1}\rho + \beta(\beta+1)(v_i-c_i)P^{-\beta-2}\rho^2 \\ \operatorname{sign}\Big\{\frac{\partial^2\Pi_i}{\partial v_i^2}\Big\}\Big|_{v_i=v_i^u} &= \operatorname{sign}\Big\{-2P^* + (\beta+1)(v_i^u - c_i)\rho\Big\}\end{aligned}$$

Using the pass-through rate $\rho = \frac{\beta}{\beta-1}$ and the unconstrained margin

$$v_i^u - c_i = \frac{\beta-1}{\beta^2}P^*$$

to evaluate the sign of the second derivative yields:

$$\begin{aligned}\operatorname{sign}\Big\{\frac{\partial^2\Pi_i}{\partial v_i^2}\Big\}\Big|_{v_i=v_i^u} &= \operatorname{sign}\Big\{-2P^* + (\beta+1)\frac{\beta-1}{\beta^2}P^*\frac{\beta}{\beta-1}\Big\} \\ &= \operatorname{sign}\{-2 + \frac{\beta+1}{\beta}\} \\ &= \operatorname{sign}\{1-\beta\} \\ &< 0 \quad \text{as } \beta > 1\end{aligned}$$

Chapter 4

Vertical Mergers: No Foreclosure, Yet Harm to Consumers

4.1 Introduction

Vertical merger policy is hotly debated. In 2020, the Department of Justice (DOJ) & Federal Trade Commission (FTC) released new vertical merger guidelines but rescinded them in 2021 due to disagreements within the FTC.[1] In contrast, in the academic literature, there exists broad agreement on several points. First, vertical mergers can eliminate double marginalisation (Spengler, 1950; Waterson, 1980). The elimination of double marginalisation (EDM) benefits consumers via lower prices.[2] Second, a merged entity may harm its downstream rivals by raising their input costs (Ordover, Saloner, and Salop, 1990, 1992; Salinger, 1988; Salop and Scheffman, 1983, 1987).[3] Raising rivals' costs (RRC) harms consumers via higher prices. It is possible that a merged entity has an incentive to, instead, lower its rivals' costs (Das Varma and De Stefano, 2020; Domnenko and Sibley, 2020). Intuitively: when the EDM effect is very large, the merged entity is more willing to accommodate lower prices of downstream rivals and lowers input prices. Third, vertical mergers can weaken horizontal competition downstream (Baker et al., 2019; Chen, 2001; Moresi and Salop, 2021; Riordan, 1998). After the merger, the merged entity supplies a downstream rival and benefits from its sales. Consequently, the merged entity competes less aggressively downstream. I call this the "stakeholder effect"

[1] See Federal Trade Commission (2021). Salop (2021) lays out suggested guidelines.

[2] Salop (2021) argues, "Pass on of EDM should not be taken as automatic" and that EDM is not necessarily merger-specific. On this, see also Kwoka and Slade (2020).

[3] The post-Chicago literature formalised this argument. RRC can also result from partial vertical integration, see Levy, Spiegel, and Gilo (2018).

because of the close link to the minority shareholding literature.[4] The stakeholder effect harms consumers. Finally, in the literature, the overall merger effect can mostly go either way: it is seldom clear.[5]

Much of the literature on vertical mergers focusses on RRC.[6] Similarly, foreclosure is often the primary concern of antitrust authorities when they review vertical mergers. Foreclosure can come in different forms. (1) The merged entity might set and obtain a higher price from downstream rivals. I call this "direct RRC" because the higher price is paid directly to the merged entity. Alternatively, the merged entity might stop supplying downstream rivals. Consequently, downstream rivals either (2) incur higher costs by sourcing inputs through other means or (3) exit the market.

Whereas much has been written on the *incentive* of the vertically integrated entity to raise rivals' costs, less has been written on the merged entity's *ability* to do so. The presence of upstream competitors may constrain the merged entity in the price it sets to non-integrated downstream rivals. Without the ability to engage in direct RRC, incentives to do so are inconsequential. My two main contributions focus on ability.

First, I show how to identify whether upstream competition constrains the supplier pre-merger. I use this finding to develop a novel merger test which answers the question: will a proposed merged entity be unable to obtain a higher price from downstream rivals? Even for complex industry structures, the test is practical, transparent, and simple. It uses observable data on margins to predict merger effects. The prediction in existing models that the merged entity can engage in RRC can be consistent or inconsistent with observable data. The test can serve to identify models that are consistent with observable facts of a particular industry. In addition, antitrust authorities can use the test for merger review (they "typically collect [profit margins] as part of merger investigations", see Sheu and Taragin, 2021).

Second, because I provide a test to dismiss particular antitrust concerns, I also show and emphasise that even absent foreclosure, vertical mergers can harm consumers and benefit all firms (not only the merged entity but also its rivals). Precisely when a merged entity wants to but cannot raise its rivals' costs, downstream rivals benefit from weakened downstream competition. In such cases, a vertical merger can increase all consumer prices. Opposite to the typical foreclosure concern, which pits the merged entity against

[4]This effect has no agreed-upon name in the literature. Chen (2001) first identified this effect. He called it the "collusive effect". Moresi and Schwartz (2017) call it the "input supply effect". Moresi and Schwartz (2021) call it the "Chen effect".

[5]For example, Riordan (1998) shows that harmful effects can dominate, whereas Loertscher and Reisinger (2014) show that the EDM effect can exceed foreclosure effects.

[6]I focus on input foreclosure, see Salop (2018) on customer foreclosure. In other theories of harm, vertical mergers facilitate downstream collusion (Biancini and Ettinger, 2017) or upstream collusion (Nocke and White, 2007, 2010). Moreover, a vertical merger can serve to limit arbitrage and better price discriminate across industries (see Perry (1978, 1980) on the classic ALCOA case).

its downstream rivals (raised, for example, in Chen, 2001; Rey and Tirole, 2007), I therefore lay out a theory of harm where the merger benefits all firms and unambiguously harms consumers.

The baseline model I consider is standard. In a vertically related industry, two downstream firms produce a differentiated consumer good. Each downstream firm needs one unit of an input per unit of output. There are one or more upstream producers of that input; each has a constant unit cost of production. In the first stage, each upstream producer set a unit price (a bid) to each downstream firm, at which price it offers to supply any quantity. Producers are permitted to discriminate across downstream firms (i.e. to engage in third-degree price discrimination). In the second stage, each downstream firm sets its consumer price. Finally, consumer demand is determined and downstream firms order inputs. In the baseline model, demand is log-concave. Results are robust to a series of extensions, e.g. to incomplete information and to heterogeneous inputs.

In this paper, the crux is to identify constraints. According to J. Lerner and Tirole (2004), a firm is either constrained by competition ("the competition margin binds") or limited by the demand function ("the demand margin binds"). Thus more specifically, the crux is to identify whether the supplier is constrained by competition (and thus cannot raise price) or whether the supplier is unconstrained by competition, sets its monopoly price, and thus could raise price post-merger.

To construct a novel merger test, I build on a result that relates upstream to downstream margins. In Kadner-Graziano (2023a), I show that an upstream monopolist earns a higher unit dollar margin than the downstream firm it supplies; this holds for any log-concave demand function.[7] Because the pass-through rate is lower than 100% for log-concave demand functions (Amir, Maret, and Troege, 2004), the elasticity of demand is lower upstream than downstream, and consequently, by the intuition for the Lerner markup (A. P. Lerner, 1934), the unit dollar margin upstream must be bigger than downstream.[8]

In the present paper, I find that this relation of margins also holds with downstream competition and when an upstream producer supplies competing downstream firms. With downstream competition, when a monopolist supplier increases the price it sets to some downstream firm A, that downstream firm increases its price and (in equilibrium) firm A's competitors raise their prices as well (downstream prices are strategic complements). Equilibrium price increases by competitors dampen downstream firm A's loss of quantity. Consequently, the elasticity of demand upstream is even lower than downstream.

Moreover, if a producer supplies several competing downstream firms, an input price increase to one downstream firm diverts some demand to other downstream firms it sup-

[7] E.g. the dollars of profit Apple versus one of its suppliers earns per iPhone sold.

[8] Adachi and Ebina (2014b) obtain this result for the case of successive monopolies in a Cournot setting.

plies. Consequently, the supplier's elasticity of total demand (of total quantity sold to downstream firms) decreases further. To summarise, the elasticity of demand upstream is lower than downstream due to three factors: downstream cost absorption (keeping prices at other downstream firms fixed, the pass-through rate is less than 100%); the strategic response of other downstream firms (equilibrium consumer price increases reduce the loss of quantity at downstream firm A); the profit earned on diverted on sales (diverted sales reduce the total loss of quantity upstream relative to downstream).

A monopolist supplier, unconstrained by competition, earns a bigger margin than the margin of any downstream firm it supplies. The test I develop states: if the supplier, on its sales to a downstream firm, earns a smaller margin than that downstream firm, then the supplier is constrained by upstream competition pre-merger and the merged entity cannot obtain a higher price from that downstream firm post-merger. If the merged entity could obtain a higher price, the supplier would have already charged a higher price pre-merger. In this way, margins can reveal the existence of constraints sufficient to rule out direct RRC.

The test is robust to a series of extensions which portray the complexity and intertwined nature of real supply chains. Among others, the relation of margins also holds when there are more than two downstream firms, when downstream firms use any number of different inputs, and when different downstream firms use different sets of inputs. A more general relation between upstream and downstream margins holds with log-convex demand and secret contracts.

Utilising margins to inform on the ability to engage in RRC is new. Bresnahan and Reiss (1985) and Adachi and Ebina (2014a) also compare upstream to downstream margins but not in a merger environment.[9] Inderst and Valletti (2011)[10] also analyse the pre-merger margins of merging parties. They show that these are insufficient to predict post-merger incentives.

Absent foreclosure, the merger can either benefit or harm consumers. The benefit from EDM is small when, pre-merger, the supplier earns a small margin on sales to the downstream firm with which it integrates. Harm from the stakeholder effect is large when, pre-merger and among other factors, the supplier earns a large margin on the non-integrated downstream firm. Consumer harm is clearest when a downstream firm acquires an upstream firm from which it does not source inputs but which supplies a downstream rival. This particular form of a vertical merger is called a "diagonal merger" (see Zenger, 2020). Such a merger generates no EDM; it is simply a credible commitment to compete less

[9] Adachi and Ebina (2014a) analyse a setting with symmetric Cournot competition both upstream and downstream. They find that Cournot competition induces a ratio of margins which depends on the number of upstream and downstream firms.

[10] They use variable proportions, see their production cost function on p.822.

aggressively downstream. Absent foreclosure, the only merger effect is the stakeholder effect. Consequently, all firms benefit, and all consumer prices rise (to the unambiguous detriment of consumers). Contrary to Chen (2001), this theory of harm requires neither efficiency gains nor switching costs,[11] neither for merger profitability nor for consumer harm.

For example, suppose Samsung acquires a supplier of Apple without previously having had any relationship with that supplier. Apple should be worried about an increase in input prices if that supplier has pricing power. However, margin data indicates each Apple supplier is constrained,[12] such that Samsung could not raise prices post-merger,[13] and hence the acquisition would only render Samsung less aggressive on the smartphone market. Consequently, both smartphone makers would benefit, whereas consumers would lose out.[14]

A vertical merger with a constrained supplier is akin to a horizontal merger: it has two countervailing effects that resemble those of horizontal mergers. First, some form of efficiency gain (here, the EDM) versus second, a loss of horizontal competition (here, the stakeholder effect). On similarities to horizontal mergers, see also Riordan (1998), Chen (2001), Baker et al. (2019), Moresi and Salop (2021). Thus, a vertical merger can constitute yet another form of market concentration. This has significant implications for empirical research: estimates of concentration should encompass not only common ownership and cross-ownership but also ownership of suppliers to competitors. See, e.g., Azar, Schmalz, and Tecu (2018) on empirical studies of common ownership. Azar, Raina, and Schmalz (2019) analyse, in addition, cross-ownership.

The remainder of the paper is structured as follows. In section 4.2, I lay out the baseline model and develop a relation of upstream to downstream margins with complete information. In section 4.3, I analyse vertical mergers, develop a novel test, and discuss consumer welfare effects. In section 4.4, I discuss the robustness to extensions. In section 4.5, I discuss alternative models. Section 4.6 contains a brief antitrust discussion. Finally, I conclude in section 4.7 and defer proofs to the appendix.

[11] To incorporate switching costs is non-standard in the literature on vertical mergers.

[12] See Kadner-Graziano (2023a).

[13] Samsung could not raise prices, except if Samsung itself was the constraint on that supplier.

[14] This example applies irrespective of the parts Samsung already supplies to Apple (e.g. screens).

4.2 A relation of upstream to downstream margins

4.2.1 Baseline model

I model a vertically related industry. There are two downstream firms. Each produces a consumer good. The two consumer goods are differentiated. Each downstream firm needs one unit of an essential input per unit of output (each has a Leontief production function). Downstream firm $i \in \{A,B\}$ can produce the input in-house at constant unit marginal cost $c_i \geq 0$.

There are three upstream producers of the input. The second and third-most efficient producers have, respectively, constant unit marginal costs of production $c^{[2]}$ and $c^{[3]}$, with $c^{[3]} \geq c^{[2]} > 0$. Without loss of generality, the most efficient has zero production costs.

There are two stages. In the first stage, all upstream producers simultaneously submit bids to the two downstream firms. To each downstream firm, each upstream producer submits a unit price at which it offers to supply any quantity demanded by that downstream firm. Upstream producers can price discriminate across downstream firms.

In the second stage, the two downstream firms simultaneously set their respective uniform consumer price, P_A and P_B. The product market clears and quantities Q_A and Q_B are determined. Each downstream firm then orders inputs from an upstream producer or produces inputs internally.[15] Downstream firm $i \in \{A,B\}$ pays unit price v_i and earns profit $\Pi_i = (P_i - v_i)Q_i$. In equilibrium, the most efficient upstream producer supplies both downstream firms and earns profit $\Pi_S = \sum_i v_i Q_i$.

Downstream firm i's demand strictly decreases and is weakly log-concave in consumer price P_i: $Q_i' < 0$ and $(\ln Q_i)'' \leq 0$. (In section 4.4, I develop results that allow for log-convex demands.) Downstream products are imperfect substitutes, with $\frac{\partial Q_i}{\partial P_j} > 0$ for $i \neq j$. Moreover, I make the following three assumptions. Assumptions 1 and 2 are standard, see, e.g., Miklós-Thal and Shaffer (2021). Assumption 1 states: at the equilibrium, if all consumer prices rise by the same small amount, then demand for each consumer product decreases.[16]

Assumption 1 (Gross substitutes)**.** *At equilibrium prices P_i^* and P_j^*, $\left|Q_i'\right| > \frac{\partial Q_i}{\partial P_j}$.*

Assumption 2 ensures that, for any v_j, the supplier's profit is strictly concave in v_i.[17]

Assumption 2 (Concave profit)**.** *The Hessian of $\Pi_S(v_i, v_j)$ is negative definite.*

[15] In a tie between two producers, the upstream firm with the lowest cost is chosen.

[16] This assumption ensures sensible comparative statics (in particular, it ensures that a downstream firm raises its consumer price in response to an increase in its unit input cost).

[17] Assumption 2 is not necessary for the results of sections 4.2 and 4.3. It is sufficient to ensure that a constrained supplier prices at the constraint rather than below.

Assumption 3 is not necessary; it is made for conciseness of the algebraic exposition.[18]

Assumption 3 (Additively separable)**.** $\frac{\partial Q_i'}{\partial P_j} = 0$ *for* $i \neq j$.

Finally, I assume complete information in the baseline model (this is not necessary, as shown in section 4.4).

4.2.2 Equilibrium

The game is solved by backwards induction. Once consumer demand is determined, every downstream firm sources inputs from the cheapest source: either it produces internally at c_i or orders inputs from the supplier who offered the lowest unit price. In stage 2, downstream firm $i \in \{A, B\}$ sets price P_i to maximise its profit. At the optimal consumer price P_i^*,[19]

$$\frac{\partial \Pi_i}{\partial P_i} = Q_i\big(P_i^*, P_j\big) + \big[P_i^* - v_i\big] Q_i'\big(P_i^*, P_j\big) = 0 \tag{4.1}$$

In stage 1, upstream producers set offer prices to each downstream firm. The most efficient upstream producer bids unit price v_i to downstream firm i. Let v_i^u denote the monopoly price: the price the most efficient producer would set if it were unconstrained by any outside option of the downstream firm. Then, the most efficient producer sets unit price[20]

$$v_i^* \equiv \underset{v_i}{\operatorname{argmax}}\, \Pi_S = \min\{v_i^u, c^{[2]}, c_i\} \tag{4.2}$$

If the supplier cannot set its monopoly price, it is constrained either at $c^{[2]}$ (the unit cost of the second-most efficient potential supplier) or at c_i (beyond which a downstream firm produces the input in-house).

Definition 2. *Supplier i is* ***unconstrained*** *if* $v_i^* = v_i^u$ *but* ***constrained*** *if* $v_i^* \neq v_i^u$.

The most efficient producer has profit

$$\Pi_S = v_i Q_i\big(P_i^*(v_i, v_j), P_j^*(v_j, v_i)\big) + v_j Q_j\big(P_j^*(v_j, v_i), P_i^*(v_i, v_j)\big) \tag{4.3}$$

[18] Assumption 3 is not necessary: it could be replaced by a weaker though less transparent assumption. It removes a second-order effect. It is satisfied for any demand function where the price of a competing downstream firm enters as an additively separable term. E.g. as in Shubik-Levitan linear demand systems. However, unlike in linear demand systems, I allow for $Q_i'' \neq 0$.

[19] The second-order condition is satisfied: $Q_i'^2 \geq Q_i Q_i''$ because demand is weakly log-concave, and therefore $\frac{\partial^2 \Pi_i}{\partial P_i^2}\Big|_{P_i = P_i^*} = \frac{2Q_i'^2 - Q_i Q_i''}{Q_i'} < 0$. Prices are strategic complements: $\frac{\partial^2 \Pi_i}{\partial P_i \partial P_j} = \frac{\partial Q_i}{\partial P_j} > 0$.

[20] Equation (4.2) can be written as $v_i^* = \min\{v_i^u, \bar{c}\}$ where $\bar{c} \equiv \min\{c^{[2]}, c_i\}$. I distinguish between the two costs because the distinction matters for some merger results.

At the unconstrained (or monopoly) price v_i^u,

$$\frac{\partial \Pi_S}{\partial v_i} = Q_i + v_i^u \left[Q_i' \frac{dP_i^*}{dv_i} + \frac{\partial Q_i}{\partial P_j} \frac{dP_j^*}{dv_i} \right] + v_j \left[Q_j' \frac{dP_j^*}{dv_i} + \frac{\partial Q_j}{\partial P_i} \frac{dP_i^*}{dv_i} \right] = 0 \tag{4.4}$$

4.2.3 Constrained or unconstrained – what margins reveal

I aim to identify whether a supplier is constrained. Rearranging (4.4), the supplier's unit dollar margin on sales to downstream firm i, when it is unconstrained, m_{Si}^u, is[21]

$$v_i^u = -\frac{Q_i}{Q_i' \frac{dP_i^*}{dv_i} + \frac{\partial Q_i}{\partial P_j} \frac{dP_j^*}{dv_i}} - v_j \frac{Q_j' \frac{dP_j^*}{dv_i} + \frac{\partial Q_j}{\partial P_i} \frac{dP_i^*}{dv_i}}{Q_i' \frac{dP_i^*}{dv_i} + \frac{\partial Q_i}{\partial P_j} \frac{dP_j^*}{dv_i}} \tag{4.5}$$

A test that would say the supplier is constrained if and only if $v_i^* < v_i^u$, where v_i^u is given by (4.5), would not be helpful because the numerous derivatives in (4.5) are difficult to estimate in practice.

Instead, to develop a practical test I find a sufficient condition. My approach is to compare the margin of an unconstrained supplier with the downstream margin. Rearranging (4.1), the unit dollar margin of downstream firm i, m_i^*, is

$$P_i^* - v_i = -\frac{Q_i(P_i^*, P_j)}{Q_i'(P_i^*, P_j)} \tag{4.6}$$

To compare margins in (4.5) and (4.6), one can rewrite (4.1) as

$$Q_i\Big(P_i^*(v_i, v_j), P_j^*(v_j, v_i)\Big) + \big[P_i^*(v_i, v_j) - v_i\big] Q_i'\Big(P_i^*(v_i, v_j), P_j^*(v_j, v_i)\Big) = 0 \tag{4.7}$$

and totally differentiate (4.7) with respect to v_i and v_j. Then, one can solve for $\frac{dP_i^*}{dv_i}$ and $\frac{dP_j^*}{dv_i}$, and subsequently plug these two total derivatives into (4.5) and (4.6). Finally, comparing (4.5) with (4.6) yields the following key result on the relation of upstream to downstream margins. When unconstrained, the supplier's unit dollar margin on sales to downstream firm i weakly exceeds downstream firm i's unit dollar margin.

Theorem 3. *(Relation of margins) The margin of an unconstrained supplier, on sales to downstream firm i, weakly exceeds downstream firm i's margin:* $m_{Si}^u \geq m_i^*$.

[21] Because the results relate upstream to downstream margins, the results do not change if the upstream firm has strictly positive unit costs of production and if the upstream firm has different unit costs of production for different downstream firms.

The relation of upstream to downstream margins in Theorem 3 is simple. Nevertheless, the intuition and effects which underlie the result are intricate. In stage 1, the supplier sets its profit-maximising unit input price to each downstream firm by accounting for stage 2 downstream equilibrium effects. Consider an increase in input price v_A. Keeping the price of downstream firm B fixed, downstream firm A passes through less than 100% to consumers (it absorbs some of the input price increase) because demand is log-concave. Holding P_B fixed, the elasticity of demand upstream is therefore lower than downstream and, by the intuition for the Lerner index,[22] the margin upstream must exceed the margin downstream.

In equilibrium, because downstream prices are strategic complements, downstream firm B raises its price. This dampens the supplier's loss of quantity sold to downstream firm A from an increase in v_A. The increase in P_B generates a feedback increase in P_A, but overall, the change in P_B and the feedback effect on P_A necessarily dampen (rather than exacerbate) the loss of demand at downstream firm A (because downstream firm A changes its price only "as a reaction" to downstream firm B's price change). As a result, after accounting for these changes in equilibrium downstream prices, the elasticity of demand upstream is lower still than downstream. And consequently, the unconstrained margin upstream is higher still compared to the margin downstream.

Moreover, because the supplier also supplies downstream firm B, it earns a profit on any sales diverted from downstream firm A to B. This effect further lowers the "total elasticity of demand" upstream (the loss of total quantity sold to downstream firms A and B) relative to the elasticity of demand of downstream firm A, and therefore further increases the unconstrained upstream margin relative to the downstream margin.

From Theorem 3, it directly follows that if $m^*_{Si} < m^*_i$, then the supplier must be constrained in the price it sets to downstream firm i. In words: if the supplier earns a margin on sales to downstream firm i that is smaller than the margin of downstream firm i, then the supplier is constrained. The supplier would like to set a higher price but cannot because of some outside option of the downstream firm.

Corollary 3 (Constrained supplier)**.** *If $m^*_{Si} < m^*_i$, then the supplier is constrained in the price it sets to downstream firm i.*

Corollary 3 provides a sufficient condition to identify a constrained supplier. The condition is transparent, simple, and practical. Even if the supplier earns a large margin (even if it has a large competitive advantage over other potential suppliers or in-house production by the downstream firm), the supplier may be constrained.

[22] Whereas the Lerner index relates a firm's unit percentage margin to the elasticity of demand it faces, Theorem 3 can relate absolute margins because the quantities sold by the upstream and downstream firms are the same – or, more generally with fixed proportions, they are a fixed ratio of each other.

4.3 Vertical merger

I distinguish between two cases of foreclosure. The merged entity can engage in ***direct RRC*** if it can obtain a higher input price from the non-integrated downstream rival post-merger (relative to the price it obtained pre-merger). With direct RRC, the merged entity receives a higher price and thus benefits directly from its rival's higher cost. The merged entity can engage in ***indirect RRC*** if, by stopping to supply the non-integrated downstream firm, the latter's input cost increases (because, for example, it pays a higher price to another supplier or switches to more costly in-house production). With indirect RRC, the merged entity does not receive a direct payment from the downstream rival; instead, the merged entity benefits only indirectly from its rival's higher cost through weakened downstream competition. If stopping to supply causes a sufficiently large cost increase, the rival exits the market.[23]

In this section, I develop a test to identify whether the merged entity cannot extract a higher input price from the downstream rival. In other words, the test serves to answer the question: is the merged entity unable to engage in direct RRC?

4.3.1 Post-merger equilibrium

Consider a merger between the supplier and downstream firm A. If the merged entity M continues to supply the non-integrated firm, its profit is

$$\Pi_M = P_A Q_A + v_B Q_B$$

The profit function of the non-integrated downstream firm B remains unchanged:

$$\Pi_B = (P_B - v_B) Q_B$$

The game is again solved by backwards induction. The non-integrated downstream firm's first-order condition is still given by (4.1). However, the merged entity's first-order condition differs from (4.1). At the optimal consumer price P_A^{*M},

$$\frac{\partial \Pi_M}{\partial P_A} = Q_A\left(P_A^{*M}, P_B\right) + P_A^{*M} Q_A'\left(P_A^{*M}, P_B\right) + v_B \frac{\partial Q_B}{\partial P_A} = 0$$

[23] This is sometimes referred to as "complete exclusion" (Rey and Tirole, 2007). No terms are used uniformly across the academic and legal antitrust literatures to distinguish between direct and indirect RRC. The first case is sometimes referred to as "foreclosure" or "RRC" or also as "partial foreclosure" (Moresi and Schwartz, 2021). The second case is also sometimes referred to as "foreclosure", "RRC", "complete foreclosure" (Rogerson, 2019), or also as "full foreclosure" (Baker et al., 2019). However, "full foreclosure" sometimes refers to the case where the downstream rival exits the market.

For a given v_B, there are two countervailing merger effects on the consumer price P_A. The merged entity competes more aggressively downstream because its unit cost is zero (the EDM effect). In contrast, the merged entity competes less aggressively because it earns v_B per unit sold by the non-integrated firm (the stakeholder effect).[24]

In stage 1, the merged entity sets the optimal input price to the non-integrated downstream firm

$$v_B^{*M} \equiv \underset{v_B}{\operatorname{argmax}}\, \Pi_M = \min\{v_B^{uM}, c^{[2]}, c_B\}$$

where the merged entity sets v_B^{uM} if it is unconstrained (a monopolist supplier). At v_B^{uM},

$$\frac{\partial \Pi_M}{\partial v_B} = Q_B + v_B^{uM}\left(Q'_B\frac{dP_B^*}{dv_B} + \frac{\partial Q_B}{\partial P_A}\frac{dP_A^*}{dv_B}\right) + \frac{dP_A^*}{dv_B}Q_A + P_A^*\left(Q'_A\frac{dP_A^*}{dv_B} + \frac{\partial Q_A}{\partial P_B}\frac{dP_B^*}{dv_B}\right) = 0$$

The FOC of the merged entity differs from (4.4), the FOC of the supplier pre-merger, in two ways. First, the merged entity now earns P_A rather than v_A from each unit of the consumer product A. Second, an increase in v_B allows the merged entity to increase its own downstream price P_A, from which it benefits for any given quantity level Q_A. Algebraically, this refers to $\frac{dP_A^*}{dv_B}Q_A$.[25]

4.3.2 Ability to engage in direct RRC: the test

I now develop a new test for vertical mergers. The test follows from Theorem 3 and Corollary 3. It says: if pre-merger, the supplier's margin on sales to downstream firm B is smaller than downstream firm B's margin, then the supplier is constrained and cannot obtain a higher price post-merger. In other words, the merged entity cannot engage in direct RRC.

Proposition 2 (Test)**.** *If $m_{SB}^* < m_B^*$ pre-merger, the merged entity cannot obtain an input price v_B that is higher than pre-merger.*

The test provides a transparent, simple and practical sufficient condition. It is based on margin data because margins can reveal information on constraints. It suffices to know that the supplier's margin is smaller than that of the non-integrated downstream firm to conclude that the merged entity cannot extract a higher price from the non-integrated

[24] Algebraically, the term $v_B\frac{\partial Q_B}{\partial P_A} > 0$ stands for this effect. The merged entity does not earn a share of profits, its earnings are instead directly proportional to the quantity sold by the downstream rival and customer.

[25] The merged entity has an incentive to engage in direct RRC if and only if $v_B^{uM} > v_B^*$. It has an incentive to raise the input price beyond the pre-merger unconstrained price if and only if $v_B^{uM} > v_B^u$.

downstream firm. If the merged entity could do so, the supplier would have already raised the price pre-merger.[26]

4.3.3 Ability to engage in indirect RRC

If the supplier is constrained at c_B pre-merger and the merged entity stops supplying, the non-integrated downstream firm can switch to in-house production without incurring higher costs. Consequently, the merged entity cannot engage in indirect RRC and finds it profitable to continue to supply. The same holds if the supplier is constrained at $c^{[2]}$, with $c^{[2]} = c^{[3]}$. The condition $c^{[2]} = c^{[3]}$ can be interpreted as the existence of a competitive fringe. Only if $c^{[2]} < c_B$ and $c^{[2]} < c^{[3]}$ does the merged entity have the ability to engage in indirect RRC. But, as is well-known, it may not have the incentive to halt supply.[27]

4.3.4 Consumer welfare

Consider a vertical merger with a constrained supplier. The merger can decrease consumer welfare even without foreclosure (absent direct and indirect RRC). Competition weakens post-merger when the merged entity benefits from sales of the non-integrated downstream firm (when $v_B > 0$); because prices are strategic complements, both consumer prices can increase.

Proposition 3 (Consumer Welfare)**.** *Absent a change in v_B, a vertical merger*

- *increases consumer welfare whenever benefits from the EDM effect outweigh harm from the stakeholder effect but*
- *decreases consumer welfare whenever harm from the stakeholder effect outweighs benefits from the EDM effect.*

Intuitively, if pre-merger $v_A > 0$ and $v_B = 0$, EDM is the only merger effect. Consequently, both consumer prices decrease and consumers benefit from the merger. Conversely, if pre-merger $v_A = 0$ and $v_B > 0$, the stakeholder effect is the only merger effect. Consequently, both consumer prices increase and the merger harms consumers.

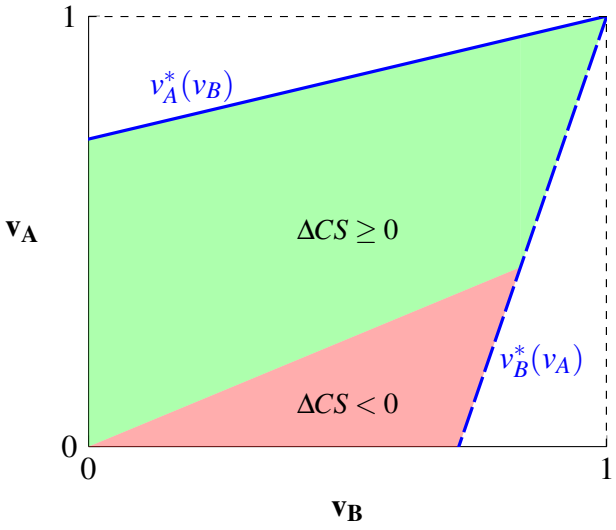
Figure 4.1 below illustrates cases where EDM and the stakeholder effect both materialise (in an example with Shubik-Levitan demand). Pre-merger, if the supplier is unconstrained, it sets $(v_A^u, v_B^u) = (1,1)$. If the supplier is constrained in the price it can charge

[26] Even if the supplier is unconstrained pre-merger, a constraint could lie just above its pre-merger price, such that its ability to engage in RRC may be limited.

[27] "Vertical arithmetic" is an existing tool which practitioners use to assess the incentive of such foreclosure (Zenger, 2020).

to downstream firm B, then its optimal price v_A lies below one. The blue line depicts $v_A^u(v_B)$, the supplier's unconstrained price to downstream firm A for a given level of v_B. Therefore, the supplier never sets v_A inside the top left white triangle. By symmetry, the supplier never sets v_B inside the bottom right white triangle pre-merger, and the dashed blue line depicts $v_B^u(v_A)$.[28] In the green and red areas, the supplier prices at the constraints pre-merger, e.g. $(v_A^*, v_B^*) = (c_A, c_B)$. In the green area, consumer prices P_A and P_B decrease post-merger: consumers benefit unambiguously. In the red area, consumer prices P_A and P_B increase post-merger: the merger unambiguously harms consumers.[29] Consumer harm occurs when the vertical elimination of double marginalisation (related to v_A) is small enough relative to the loss of horizontal competition (related to v_B).

Figure 4.1: Post-merger change in consumer surplus, without foreclosure (example)



Note: Consumer surplus increases post-merger in the green area, whereas it decreases in the red area. Here, consumer demand is $Q_i = 1 - P_i + \theta P_{-i}$ for $i \in \{A, B\}$, with $\theta = 0.5$. Higher θ increases the slope of the cutoff line between the green and red areas and hence the region of consumer harm. Source: own workings.

When a downstream firm integrates with a competitor's supplier without sourcing from that supplier (this corresponds to the case with $v_A = 0$),[30] there is no EDM and the

[28] However, post-merger v_B can lie inside this bottom right triangle. The merged entity's unconstrained input price is $v_B^{uM} = 0.985$. Therefore, foreclosure occurs when the supplier charges less than 0.985 pre-merger and when the constraint on v_B strictly exceeds the pre-merger unconstrained optimum. Finally, for any pre-merger price $v_B > 0.985$, the merged entity lowers its rival's cost.

[29] Absent a change in v_B, P_B changes only as a reaction to a change in the best response function $P_A^*(P_B)$. Prices are strategic complements; therefore, consumer prices change in the same direction post-merger.

[30] See the discussion on "diagonal mergers" in Zenger (2020), and in the DOJ's & FTC's Vertical Merger Guidelines, U.S. Department of Justice & The Federal Trade Commission (2020), p.9-10.

merged entity always wants to foreclose its downstream competitor. Absent foreclosure (when $m^*_{SB} < m^*_B$ and when the merged entity continues to supply), the merger solely results in the stakeholder effect: it benefits all firms but harms consumers.

4.3.5 Merger profitability

The merged entity internalises the benefit of an increase in its consumer price P_A on the demand for the consumer product B. Therefore, the merged entity can find it profitable to lose both quantity- and sales-based market share (downstream). It is also possible that, due to the merger, the profit of the non-integrated downstream firm increases by more than the profit of the merging parties.[31]

Proposition 4. *Profitable vertical mergers can*

- *lead the merged entity to reduce output and lose market share downstream. They can also*
- *profit the non-integrated firm more than the merging parties.*

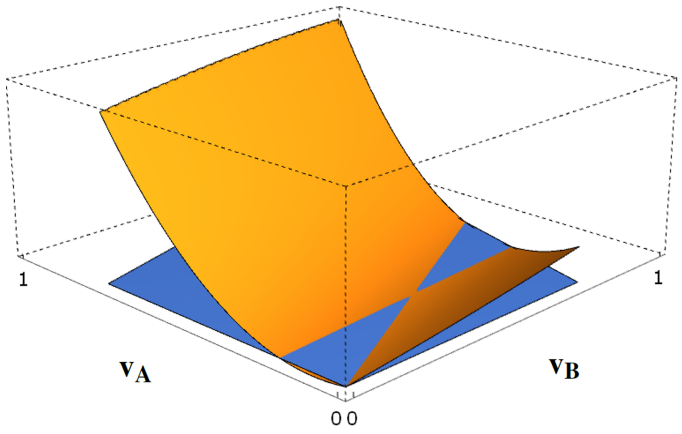
Intuitively, the two points in Proposition 4 occur when the principal merger effect is to reduce the merged entity's aggressiveness downstream. For example, without foreclosure and EDM (e.g. with $m^*_{SB} < m^*_B$ and $c_A = 0$), the only merger effect is to render the merged entity less aggressive downstream. As a result, both consumer prices rise in equilibrium. However, the first-order effect is an increase in P_A with a reduction in Q_A, whereas downstream firm B not only increases P_B but also enjoys an increase in Q_B.

Surprisingly perhaps, a vertical merger is not always profitable.[32] In contrast to the stakeholder effect, EDM commits the merged entity to compete more aggressively downstream. Because downstream firm B knows that the cost of its rival has fallen, downstream firm B behaves more aggressively too. More intense competition downstream is why the merger can be unprofitable. Figure 4.2 below plots the change in the merging parties' profit $\Pi_M - \Pi_S - \Pi_A$ on the z-axis, wherever the constraints bind pre-merger and for the same example demand system as in Figure 4.1. The merger is not profitable where the blue 0-profit plane lies above the orange profit surface.

[31] Ordover, Saloner, and Salop (1990) and Hart and Tirole (1990) pioneered work on endogenous mergers: they analyse which downstream firm has, within their model, the greatest incentive to acquire the supplier. On endogenous mergers, see also Buehler and Schmutzler (2008). In practice, downstream firms A and B may be active on many markets rather than only one, such that there may be incentives to merge related to activities not captured within the present model.

[32] Loertscher and Riordan (2019) show that vertical mergers can be unprofitable when they reduce innovation incentives of non-integrated upstream producers.

Figure 4.2: Change in the merging parties' profit, without foreclosure (example)



Note: The orange surface depicts the post-merger change in profit $\Pi_M - \Pi_S - \Pi_A$ (represented on the z-axis). The blue plane depicts the zero-plane: the merger is unprofitable where the blue plane lies above the orange surface. Here (as in Figure 4.1), consumer demand is $Q_i = 1 - P_i + \frac{1}{2}P_{-i}$ for $i \in \{A, B\}$. Source: own workings.

Remark 6. *The vertical merger would always be profitable if either*

- *the merged entity sets both v_B and P_A in stage 1 and therefore acts as a Stackelberg leader in consumer prices or if*
- *the merged entity sets v_B and v_A in stage 1 and delegates the downstream profit maximisation problem. In stage 2, the downstream delegate chooses P_A to maximise $(P_A - v_A)Q_A(P_A, P_B)$ whereas in stage 1, the merged entity sets v_B and v_A to maximise its total profit upstream and downstream.*[33]

Delegation and Stackelberg leadership lead to identical profits and consumer prices (on this link, see Vickers, 1985 and Moresi and Schwartz, 2017). Seminal work by Schelling (1960) shows instances in which a firm finds it profitable to delegate maximisation problems to elicit less aggressive competition. Related work on delegation within a firm and strategic incentives includes Fershtman and Judd (1987).

[33] Intuitively, with delegation, the merged entity can at least replicate the pre-merger profit by charging its downstream firm the pre-merger input price v_A^*. With Stackelberg leadership, the merged entity can at least replicate the pre-merger profit by setting v_A and P_A to their pre-merger levels. Moresi and Schwartz (2017) explain that the result with delegation requires interim observability of the merged entity's internal price v_A by the non-integrated, and commitment power of the merged entity not to alter that internal price.

4.4 Robustness

Results of sections 4.2 and 4.3 are robust to each of the extensions below.

4.4.1 General model, with incomplete information

Consider the following extensions to the baseline model. First, a downstream firm's demand can now be log-convex in its price P_i. Second, there can be any number of competing downstream firms. Third, each downstream firm may need several different inputs, and the sets of inputs used by different downstream firms can differ. (For now, I maintain the Leontief production function: any input which a downstream firm uses is essential to that downstream firm.) Fourth, each upstream producer can have a different cost to supply each downstream firm (hence the efficiency ranking of producers may differ by downstream firm).

I now formally describe the general model. There is a set X of inputs. There are one or more producers of each input. Producers have a constant unit marginal cost of production. There is a number and a set D of downstream firms, with $\frac{\partial Q_d}{\partial P_j} \geq 0$ for $d \neq j$ and $d, j \in D$. Downstream firm $d \in D$ has a Leontief production technology whereby it needs a set of inputs $x_d \subseteq X$. (Different downstream firms can require different sets of inputs.) The unit cost of producer i to supply downstream firm d is c_{id}.

In stage 1, producers simultaneously submit unit price offers to downstream firms. Supplier i supplies the set of downstream firms $S_i \subseteq D$. In stage 2, downstream firms simultaneously set consumer prices. Let $\mathbf{P}$ denote the D-dimensional vector of consumer prices. I assume (a) the profit Π_d of downstream firm d, $\forall d \in D$, is twice differentiable and strictly quasi-concave in consumer price P_d; (b) the pass-through rate ρ_d of any downstream firm d is non-decreasing in its unit cost; (c) the profit function of any supplier i is twice differentiable and strictly quasi-concave in the S_i-dimensional vector of prices $\mathbf{v}_i$ it sets.

I depart from complete information. Let offers be secret (downstream firms do not observe the input prices of their competitors), let downstream firms form point beliefs about input prices of their competitors, and let these beliefs be correct in equilibrium. I use the "passive beliefs" assumption as laid out by Rey and Tirole (2007) in relation to "secret contracts" and as used by Moresi and Salop (2013). Accordingly, the supplier correctly believes that when it sets the input price v_d to downstream firm d, a change in v_d does not affect downstream firm d's beliefs about the input prices of other firms. In this sense, there are passive beliefs.[34]

[34] This is the key technical and simplifying consequence of such beliefs.

Downstream firm $d \in D$ pays unit price v_{id} for input $i \in x_d$. It has profit

$$\Pi_d = (P_d - \sum_{i \in x_d} v_{id}) Q_d(\mathbf{P})$$

and first-order condition (with respect to P_d)

$$Q_d(\mathbf{P}) + m_d^* Q_d'(\mathbf{P}) = 0 \tag{4.8}$$

where m_d is its unit margin. Supplier i has profit

$$\Pi_i = \sum_{d \in S_i} (v_{id} - c_{id}) Q_d(\mathbf{P})$$

and first-order condition (with respect to v_{id})

$$\begin{aligned}
Q_d(\mathbf{P}) + (v_{id}^u - c_{id}) \frac{\partial Q_d(\mathbf{P})}{\partial v_{id}} + \sum_{j \neq d} (v_{ij} - c_{ij}) \frac{\partial Q_j(\mathbf{P})}{\partial v_{id}} &= 0 \\
Q_d(\mathbf{P}) + m_{id}^u \frac{\partial Q_d(\mathbf{P})}{\partial P_d} \frac{\partial P_d}{\partial v_{id}} + \sum_{j \neq d} (v_{ij} - c_{ij}) \frac{\partial Q_j(\mathbf{P})}{\partial P_d} \frac{\partial P_d}{\partial v_{id}} &= 0 \\
Q_d(\mathbf{P}) + m_{id}^u Q_d'(\mathbf{P}) \rho_d + \rho_d \sum_{j \neq d} (v_{ij} - c_{ij}) \frac{\partial Q_j(\mathbf{P})}{\partial P_d} &= 0
\end{aligned} \tag{4.9}$$

Comparing (4.8) and (4.9),[35]

$$\begin{aligned}
m_d^* &= m_{id}^u \times \rho_d + \frac{1}{Q_d'(\mathbf{P})} \rho_d \sum_{j \neq d} (v_{ij} - c_{ij}) \frac{\partial Q_j(\mathbf{P})}{\partial P_d} \\
\Rightarrow \; m_d^* &\leq m_{id}^u \times \rho_d
\end{aligned}$$

Theorem 4. *With passive beliefs, if $m_{id}^* \times \rho_d < m_d^*$, then supplier i is constrained in the price it sets to downstream firm d, and it cannot raise the input price post-merger.*

The intuition for Theorem 4 is simpler than for Theorem 3 because, with passive beliefs, downstream firms do not react to a change in a competitor's input price (there are no feedback effects downstream.) Intuitively, the monopoly margin of supplier i on sales to downstream firm d is higher (lower) than the margin of the downstream firm because, with log-concave (log-convex) demand, the pass-through rate is below (above) one and therefore, the elasticity of demand upstream is lower (higher) than downstream.

[35] The weak inequality holds with equality if the supplier supplies only one downstream firm or if $v_{ij} = c_{ij}$ for any other downstream firm $j \neq d$ it supplies.

Remark 7. *Suppose upstream producers do not know the unit cost of their competitors. If each downstream firm uses a second-price auction (SPA) for every input $i \in x_d$, producers bid the offered unit price down to* $\min\{v^u_{id}, c^{[2]}_{id}\}$. *Then, each downstream firm has unit cost* $\min\{v^u_{id}, c^{[2]}_{id}, c_{id}\}$. *This outcome is the same as the complete information outcome of section 4.2.*

4.4.2 Input substitution

Suppose the input is differentiated. Product differentiation impacts the constraint: instead of being constrained at $c^{[2]}$, the supplier is constrained at another limit price (at the level of v_i beyond which downstream firm i would switch from its first-ranked to its second-ranked supplier).[36] Because Theorem 3 and Corollary 3 relate the downstream margins to the *unconstrained* upstream margin, both results are unrelated to the degree of upstream product or quality differentiation among producers of the given input. The test (Proposition 2) also remains unaffected.

4.4.3 Multi-product suppliers

Suppose the supplier produces a range of different inputs (rather than quality differences, here I refer to inherently different inputs). Then, when applying the results, one considers the total unit margin a supplier earns on sales to a downstream firm. The results verify whether a supplier is constrained for however many inputs an upstream firm sells to a downstream firm.

4.4.4 Multi-product downstream firms

As is well-known, a vertical merger of single-product successive monopolies eliminates double marginalisation and necessarily decreases the consumer price. Salinger (1991) and Luco and Marshall (2020, 2021) build on Edgeworth's taxation paradox (Edgeworth, 1925) and develop a counterintuitive result. They find that vertical integration by a multi-product downstream firm can lead all consumer prices to increase if some products benefit from EDM ("integrated products") whereas others do not ("non-integrated products"). Surprisingly, costs decrease but prices increase. Intuitively, thanks to EDM, it becomes

[36] The ranking is defined as follows. Suppose all suppliers bid a unit price equal to their unit production cost. At those offer prices, the downstream firm will have a (weak or strict) preference for one supplier. This supplier is the first-ranked supplier, with unit production cost $c^{[1]}$. The second-ranked supplier has unit production cost $c^{[2]}$. In the undifferentiated case, the limit price on the first-ranked is $c^{[2]}$. In the differentiated case, the limit price (greater than $c^{[1]}$) may be greater or smaller than $c^{[2]}$ (for, respectively, a quality advantage or disadvantage).

more profitable to sell integrated products and therefore, the merged entity raises the price of non-integrated products to divert sales to integrated products. The latter effect can be sufficiently large for all downstream prices to rise. This theory of harm does not feature a downstream rival and thus does not feature foreclosure.

In the present paper, all downstream prices can increase after a vertical merger due to the stakeholder effect. If the merged entity sells multiple consumer products (that are substitutes rather than complements), where some benefit from EDM whereas others do not, the merged entity has additional tools (prices of non-integrated products) to raise not only demand for integrated products but also demand for the rival's product. The insights of sections 4.2 and 4.3 continue to apply.

4.4.5 Production technology

The supplier's optimal price function given in (4.2) contains a further limit price if the input is non-essential (i.e. downstream firms can do without the input and still produce a valuable consumer product). Beyond that limit price, a downstream firm chooses not to source the input. This adds a further explanation as to what may constrain a supplier but does not alter results.

4.5 Different settings

The test I develop applies when a supplier's margin reveals information on its pricing power. It does not apply to settings where a supplier's margin does not reflect its pricing power. Two such settings are two-part tariffs and bargaining, which I discuss below. Subsequently, I discuss a setting where the ability to engage in direct RRC is endogenous.

4.5.1 Two-part tariffs

With two-part tariffs and complete information, the supplier may not earn a positive margin and, instead, may extract all industry profits via fixed fees. However, with upstream contractual frictions, a supplier does not extract all profit via fixed fees and sets a price above marginal cost (see Calzolari, Denicolo, and Zanchettin, 2020). Similarly, when a producer supplies several competing downstream firms, it does not necessarily offer each downstream firm a price equal to marginal cost. Instead, the supplier might price discriminate (see Herweg and Müller, 2014, 2016; Inderst and Valletti, 2009). Generally, one should not apply the test to settings with two-part tariffs because comparing upstream to

downstream margins does not necessarily reveal pricing (or "market") power.[37]

4.5.2 Bargaining

The test should not be applied when upstream and downstream firms bargain over prices because, whilst margins do reflect bargaining power, input prices can increase post-merger even if a supplier has little bargaining power. The 2020 U.S. DOJ & FTC vertical merger guidelines explain how, with bargaining, disagreement payoffs change post-merger. The change allows the merged entity's upstream unit to demand a higher input price from non-integrated downstream firms, such that the merger results in RRC and can harm consumers (U.S. Department of Justice & The Federal Trade Commission, 2020, p.7).

Rogerson (2019) develops a tool to estimate the size of such effects, which he calls "bargaining leverage effect", but in a partial rather than full equilibrium model (he leaves out EDM effects).[38] In contrast, Das Varma and De Stefano (2020) show that the merged entity can have the incentive to lower the input price of its downstream rival (and customer) such that the average equilibrium downstream consumer price decreases. Constraints, a focus of the present paper, are less relevant to bargaining but not superfluous. When suppliers are not monopolists, the EDM effect might be small and the merged entity is less likely to lower its rivals' costs. (See Das Varma and De Stefano, 2020 and Zenger, 2020.) Hence, with competition upstream, bargaining models might indeed only yield RRC.

There is a growing literature on vertical mergers with bargaining and incomplete information. In such settings, merger effects can go either way (as with linear pricing and complete information). For example, Choné and Linnemer (2020) find vertical mergers can be anticompetitive even if they eliminate double marginalisation. Similarly, Loertscher and Marx (2022a) find there is no basis for assuming vertical mergers increase social surplus. With bargaining and incomplete information, another reason the test should not be applied is that margins reflect, in part, uncertainties about costs.

4.5.3 Endogenous ability: timing, commitment, and switching costs

In the present paper, constraints ($c^{[2]}$ and c_i) are exogenous. Chen (2001) shows that constraints can be endogenous to the merger. In his model, downstream firms choose their suppliers (and commit to their choice) before setting consumer prices. Pre-merger, downstream firms source from the cheapest supplier but post-merger, for any given v_B,

[37] See Reisinger and Tarantino (2015) for a model of vertical integration with two-part tariffs and incomplete information.

[38] He simplifies the exercise by assuming downstream prices are fixed during input price negotiations. He motivates this assumption by arguing that upstream and downstream prices may be set simultaneously.

the non-integrated downstream firm strictly prefers to source the input from the merged entity at cost v_B (rather than from an alternative supplier or in-house at cost v_B) to elicit weakened downstream competition (the shareholder effect).[39] With this altered timing and the power to commit to a supplier, the merged entity can raise the input price above $\min\{c^{[2]}, c_B\}$. Hence, its ability to engage in RRC is endogenous. This is not foreclosure in the traditional sense: here, the non-integrated firm pays a higher input price to the merged entity due to a self-interested anticompetitive motivation rather than due to the lack of cheaper alternatives. Absent foreclosure and EDM, consumer prices increase not solely because of the stakeholder effect but also because the non-integrated downstream firm chooses to pay a higher input price. This merger effect harms consumers.

Furthermore, Chen (2001) shows that the merged entity can still engage in direct RRC if, instead of being fully committed to its chosen supplier, the non-integrated downstream firm can switch at some fixed cost after consumer prices are set. Similar results materialise if the non-integrated downstream firm has fixed costs to switch to in-house production[40] (such fixed costs are considered in Katz, 1987 and Inderst and Valletti, 2009). The lower the switching costs, the less the merged entity can raise rivals' costs. The results of sections 4.2 to 4.4 can be interpreted as holding when switching costs are negligible.

4.6 Antitrust discussion

4.6.1 The test complements existing antitrust tools

Merger simulation tools developed by DOJ and FTC economists[41] (see Froeb et al., 2018; Sheu and Taragin, 2021), the vGUPPI developed by Moresi and Salop (2013), and vertical arithmetic (VA) are other antitrust tools to assess vertical foreclosure concerns. The test developed herein complements these existing tools. A screening process for vertical mergers could incorporate the following steps. As a preliminary, an antitrust authority can verify whether the merger case under scrutiny fits with the modelling assumptions made herein and if so, it can use the margins test. If the test indicates that the merged entity cannot raise rivals' costs, the merger may still be harmful (see Figure 4.1). Instead, if the

[39] *Ceteris paribus*, the less aggressive the merged entity becomes through the stakeholder effect, the more the merged entity can raise the input price.

[40] In Chen (2001), a downstream firm incurs the switching cost only if it chooses one supplier at the end of stage 1 but orders from another after stage 2. Hence, if downstream firm B decides to source from the second-most efficient firm after the merger and does not change its choice at the end of stage 2 of the post-merger game, downstream firm B incurs no switching cost. This differs from downstream firm B incurring a fixed cost whenever it switches to in-house production.

[41] See the Antitrust R package authored by Taragin and Sandfort as well as the web interface on competitiontoolbox.com authored by Taragin, Rios and Wolak.

merged entity can obtain higher input prices, one can then use merger simulation and the vGUPPI to estimate the extent to which the merged entity wants to raise rivals' costs.[42] In addition, and as is often the case in merger reviews, VA can be used to assess whether the merged entity would find it profitable to stop to supply downstream rivals (on VA, see Zenger, 2020). The test developed herein is relevant to VA because it clarifies whether RRC is possible in the alternative outcome to halting supply. As to data requirements, merger simulation, the vGUPPI, and VA also need margin estimates. Therefore, the test developed herein requires less data than these three existing tools.

4.6.2 Remedies which do not prevent consumer harm

Suppose an antitrust authority imposes a remedy on a proposed merger whereby the merged entity cannot raise v_B beyond the pre-merger level. The remedy precludes RRC.[43] Nevertheless, the stakeholder effect materialises: downstream competition weakens. Consumer prices can increase despite the remedy (depending on the trade-off between EDM and the stakeholder effect). Therefore, such a remedy does not necessarily prevent consumer harm. Instead of such a remedy, if an antitrust review deems that the stakeholder effect would lead to overall consumer harm, then blocking the merger may be necessary.[44]

4.7 Conclusion

A primary focus in vertical merger theory and of antitrust agencies is RRC. Instead of competitors being harmed by RRC, this paper highlights that vertical mergers can benefit all firms – including the non-integrated downstream firms – by reducing competition, increasing prices, and harming consumers. Whereas the underlying premise of numerous theoretical models and their use in practice is that the upstream supplier has pricing power (or "market power") and can raise the input price post-merger, even if it has high margins (or "market power") the merged entity may be unable to engage in RRC.

I develop a general relation between upstream and downstream margins. This relation holds when suppliers set unit prices. Using this relation, I develop a test for vertical mergers. One can use this test to determine whether the upstream firm cannot raise a rival's cost. One can also use the test to identify models in the existing literature that are consistent with data on industries they seek to portray.

[42] The vGUPPI applies to settings with and without input substitution. As discussed in the introduction, the merged entity might want to lower its rivals' costs.

[43] And from any "choice of supplier" effect. On this effect, see section 4.5.

[44] For recent research on mergers that should be blocked, and on divestitures, see Loertscher and Marx (2022b).

Finally, there are significant implications for empirical studies. As is recognised in the literature, a downstream firm which integrates with a rival's supplier gains a stake in that rival and thus behaves less aggressively. Therefore, ownership of competitors' suppliers can also contribute to rising margins. It would be interesting for further empirical work to augment the generalised HHI index to account for such ownership structures (on the GHHI index, see Azar, Raina, and Schmalz (2019)).

4.8 Proofs

In the appendix, where convenient, I use the shorthand notation $r_i = 2 - \frac{Q_i Q_i''}{Q_i'^2}$, with $r_i \geq 1$ because Q_i is log-concave.

Proof of Theorem 3. The theorem states that m_{Si}^u, given in (4.5), weakly exceeds m_i^*, given in (4.6). In a first step, I show that

$$-v_j \frac{\frac{\partial Q_j}{\partial P_j}\frac{dP_j^*}{dv_i} + \frac{\partial Q_j}{\partial P_i}\frac{dP_i^*}{dv_i}}{Q_i'\frac{dP_i^*}{dv_i} + \frac{\partial Q_i}{\partial P_j}\frac{dP_j^*}{dv_i}} \geq 0$$

In a second step, I show that

$$-\frac{Q_i}{Q_i'\frac{dP_i^*}{dv_i} + \frac{\partial Q_i}{\partial P_j}\frac{dP_j^*}{dv_i}} \geq -\frac{Q_i}{Q_i'}$$

As preliminaries to both steps, I solve for $\frac{dP_i^*}{dv_i}$ and $\frac{dP_j^*}{dv_i}$. I totally differentiate the first-order condition (4.7) with respect to v_i. This yields

$$Q_i'\frac{dP_i^*}{dv_i} + \frac{\partial Q_i}{\partial P_j}\frac{dP_j^*}{dv_i} + [P_i^* - v_i]Q_i''\frac{dP_i^*}{dv_i} + \left[\frac{dP_i^*}{dv_i} - 1\right]Q_i' = 0$$

$$\Leftrightarrow \frac{dP_i^*}{dv_i} = \frac{1 - \frac{1}{Q_i'}\frac{\partial Q_i}{\partial P_j}\frac{dP_j^*}{dv_i}}{2 - \frac{Q_i Q_i''}{Q_i'^2}}$$

Similarly, one can calculate the total derivative

$$\frac{dP_j^*}{dv_i} = \frac{-\frac{1}{Q_j'}\frac{\partial Q_j}{\partial P_i}\frac{dP_i^*}{dv_i}}{2 - \frac{Q_j Q_j''}{Q_j'^2}}$$

Solving simultaneously yields[45]

$$\frac{dP_i^*}{dv_i} = \frac{2 - \frac{Q_j Q_j''}{Q_j'^2}}{\left(2 - \frac{Q_j Q_j''}{Q_j'^2}\right)\left(2 - \frac{Q_i Q_i''}{Q_i'^2}\right) - \frac{1}{Q_i'}\frac{\partial Q_i}{\partial P_j}\frac{1}{Q_j'}\frac{\partial Q_j}{\partial P_i}} > 0$$

$$\frac{dP_j^*}{dv_i} = \frac{-\frac{1}{Q_j'}\frac{\partial Q_j}{\partial P_i}}{\left(2 - \frac{Q_j Q_j''}{Q_j'^2}\right)\left(2 - \frac{Q_i Q_i''}{Q_i'^2}\right) - \frac{1}{Q_i'}\frac{\partial Q_i}{\partial P_j}\frac{1}{Q_j'}\frac{\partial Q_j}{\partial P_i}} > 0$$

Both denominators are positive, because $Q_i'^2 > Q_i Q_i''$ (due to log concavity) and because $\left|Q_i'\right| > \frac{\partial Q_i}{\partial P_j}$ (by Assumption 1).[46]

As further preliminaries, I show that $\frac{dQ_i}{dv_i} < 0$ and that $\frac{dQ_j}{dv_i} \geq 0$. Plugging in $\frac{dP_i^*}{dv_i}$ and $\frac{dP_j^*}{dv_i}$ into $\frac{dQ_i}{dv_i} = Q_i'\frac{dP_i^*}{dv_i} + \frac{\partial Q_i}{\partial P_j}\frac{dP_j^*}{dv_i}$ yields

$$\frac{Q_i' r_j - \frac{\partial Q_i}{\partial P_j}\frac{1}{Q_j'}\frac{\partial Q_j}{\partial P_i}}{\left(2 - \frac{Q_j Q_j''}{Q_j'^2}\right)\left(2 - \frac{Q_i Q_i''}{Q_i'^2}\right) - \frac{1}{Q_i'}\frac{\partial Q_i}{\partial P_j}\frac{1}{Q_j'}\frac{\partial Q_j}{\partial P_i}}$$

The fraction above has a positive denominator, because $r_j \geq 1$, $r_i \geq 1$ and, by Assumption 1, $\frac{1}{Q_i'}\frac{\partial Q_i}{\partial P_j}\frac{1}{Q_j'}\frac{\partial Q_j}{\partial P_i} < 1$. Therefore, the sign of the fraction above is equal to the sign of the nominator. Evaluating the sign of the nominator yields

$$\text{sign}\{\text{nominator}\} = -\text{sign}\{r_j - \frac{1}{Q_i'}\frac{\partial Q_i}{\partial P_j}\frac{1}{Q_j'}\frac{\partial Q_j}{\partial P_i}\} < 0$$

Therefore $\frac{dQ_i}{dv_i} < 0$.

Plugging in $\frac{dP_i^*}{dv_i}$ and $\frac{dP_j^*}{dv_i}$ into $\frac{dQ_j}{dv_i} = Q_j'\frac{dP_j^*}{dv_i} + \frac{\partial Q_j}{\partial P_i}\frac{dP_i^*}{dv_i}$ yields

$$\frac{-\frac{\partial Q_j}{\partial P_i} + \frac{\partial Q_j}{\partial P_i} r_j}{\left(2 - \frac{Q_j Q_j''}{Q_j'^2}\right)\left(2 - \frac{Q_i Q_i''}{Q_i'^2}\right) - \frac{1}{Q_i'}\frac{\partial Q_i}{\partial P_j}\frac{1}{Q_j'}\frac{\partial Q_j}{\partial P_i}}$$

[45] As a specific example on the equilibrium pass-through rate: if downstream firms each face the same demand function $Q_i = \alpha - P_i + \frac{1}{2}P_j$, with $\Pi_i = (P_i - v_i)Q_i$, then $\frac{dP_i^*}{dv_i} = \frac{2}{2\times 2 - \frac{1}{2}\times\frac{1}{2}} = \frac{2}{4-\frac{1}{4}} = \frac{8}{15} < 1$.

[46] We have $\left|\frac{dP_i^*}{dv_i}\right| > \left|\frac{dP_j^*}{dv_i}\right|$ because the nominator of the former (weakly) exceeds 1 (due to log concavity of demand) whereas the nominator of the latter lies in $(0,1)$ (as the consumer products are gross substitutes, Assumption 1).

The sign of the above expression is equal to the sign of the nominator.

$$\text{sign}\{\text{nominator}\} = \text{sign}\{(r_j - 1)\frac{\partial Q_j}{\partial P_i}\} \geq 0$$

Therefore $\frac{dQ_j}{dv_i} \geq 0$.

From the preliminaries, it directly follows that

$$-v_j \frac{\frac{dQ_j}{dv_i}}{\frac{dQ_i}{dv_i}} \geq 0$$

because the denominator $\frac{dQ_i}{dv_i} < 0$ and the nominator $\frac{dQ_j}{dv_i} \geq 0$.

Finally, I show

$$-\frac{Q_i}{Q_i' \frac{dP_i^*}{dv_i} + \frac{\partial Q_i}{\partial P_j}\frac{dP_j^*}{dv_i}} \geq -\frac{Q_i}{Q_i'}$$

Rearranging,

$$Q_i' \leq Q_i' \frac{dP_i^*}{dv_i} + \frac{\partial Q_i}{\partial P_j}\frac{dP_j^*}{dv_i}$$

Plugging in $\frac{dP_i^*}{dv_i}$ and $\frac{dP_j^*}{dv_i}$, and simplifying,

$$\begin{aligned} \Leftrightarrow r_i r_j Q_i' - \frac{\partial Q_i}{\partial P_j}\frac{1}{Q_j'}\frac{\partial Q_j}{\partial P_i} &\leq r_j Q_i' - \frac{\partial Q_i}{\partial P_j}\frac{1}{Q_j'}\frac{\partial Q_j}{\partial P_i} \\ \Leftrightarrow r_j Q_i'(r_i - 1) &\leq 0 \end{aligned}$$

because $r_j \geq 1$, $Q_i' < 0$ and $r_i - 1 \geq 0$. Therefore $m_{Si}^u \geq m_i^*$. □

Proof of Corollary 3. By Theorem 3, if $v_i^* = v_i^u$ then $m_{Si}^u \geq m_i^*$. Therefore $m_{Si}^u < m_i^* \Rightarrow v_i^* \neq v_i^u$. □

Proof of Proposition 2. If $m_{SB}^* < m_B^*$, then by Corollary 3 the supplier is constrained pre-merger. If the supplier is constrained it sets $v_B^* = \min\{c^{[2]}, c_B\}$ (rather than $v_B^* = v_B^u$). Therefore, it cannot raise the price beyond $\min\{c^{[2]}, c_B\}$. □

Proof of Proposition 3. The following proves that, absent a change in v_B, the post-merger change in consumer welfare effect can go either way. Consumer welfare increases if the only merger effect is the EDM. This is the case when $v_A > 0$ (the merger results in an

EDM effect) and $v_B = 0$ (there is no weakening of downstream competition). Conversely, consumer welfare decreases if the only merger effect is the weakening of downstream competition. This is the case when $v_A = 0$ (no EDM) and $v_B > 0$. □

Proof of Proposition 4. To prove this Proposition, it suffices to show one example where

- the quantity-based and sales-based market shares of the merged entity's downstream unit decrease, and where
- the profit of downstream firm B rises by more than the combined profits of the supplier and downstream firm A.

I now provide such an example. Let $Q_i = 1 - P_i + \frac{1}{2}P_j$, for $i = \{A, B\}$. For concise workings, let $c_A = 0$. Let $c_B = 0.1$, with $c^{[2]} \geq c_B$.

Pre-merger, the supplier has profit $\Pi_S = v_B Q_B$. And each downstream firm has profit $\Pi_i = (P_i - v_i)Q_i$. The game is solved by backwards induction. The supplier's monopoly price is 0.71. This unconstrained price exceeds c_B, hence the supplier is constrained and sets $v_B = 0.1$. Post-merger, the merged entity unambiguously has an incentive to raise its rival's cost (because there is no EDM). But the merged entity cannot raise v_B beyond c_B. Thus, v_B remains at 0.1.

The table below provides pre- and post-merger figures on prices, quantities, sales (price times quantity), and profits.

Table 4.1: Pre-merger and post-merger values

Variable	Pre-merger	Post-merger	Change
v_A	0	0	none
v_B	0.1	0.1	none
P_A	0.68	0.71	increase
P_B	0.72	0.73	increase
Q_A	0.68	0.66	decrease
Q_B	0.62	0.63	increase
Π_S	0.062	0.063	+0.001
Π_A	0.462	0.464	+0.002
Π_B	0.384	0.393	+0.008

Source: own workings.

From the table, $\frac{Q_A}{Q_A+Q_B}$ and $\frac{P_A Q_A}{P_A Q_A + P_B Q_B}$ decrease, hence the respective market shares of the non-integrated downstream firm increase. Moreover, the quantity Q_A decreases post-merger.

From the table, $\Pi_M - \Pi_S - \Pi_A$ is smaller than the post-merger increase in downstream firm B's profit. □

Proof of Theorem 4. This follows from the text. □

Chapter 5

Foreclosure, Bundling, and Innovation in Competitive Markets

5.1 Introduction

The debate on the effects of bundling (or tying) is not settled. Antitrust authorities agree that bundling can cause harm.[1] However, antitrust decisions sometimes differ across jurisdictions. In the abuse of dominance case against Microsoft regarding the bundling of Windows and Internet Explorer, U.S. and EU authorities agreed[2] but in several mergers of complements, they did not. Most prominently, decisions differed in the attempted GE / Honeywell merger, which was cleared in the United States but blocked in the European Union.[3] More recently, whereas the U.S. Federal Trade Commission cleared the proposed $47bn acquisition of NXP by Qualcomm (in the chip industry) unconditionally, the European Commission cleared the merger of complements subject to remedies.[4] This paper supports concerns that the European Commission raised – on foreclosure, bundling, and innovation.[5]

According to a consensus view in the literature, bundling (or tying) can be harmful only if exercised by a firm with a monopoly (or at least dominant) position in a relevant market (see, e.g. Fumagalli, Motta, and Calcagno, 2018, p. 425). The literature on anticompetitive bundling focuses on whether a monopolist can bundle products to protect

[1] Possible anticompetitive effects notwithstanding, consumers can benefit from bundling, see Fumagalli, Motta, and Calcagno (2018), p. 353-8.

[2] See the U.S. Department of Justice (1998) complaint and the European Commission (2009) decision on remedies.

[3] See U.S. Department of Justice (2001).

[4] See Vandenborre, Sibon, and Hoffmann (2019).

[5] Ultimately, the merger was not consummated because Chinese authorities did not clear the transaction amid the Sino-U.S. trade war (Martina and Nellis, 2018).

its monopoly power from entry or extend its power to other markets. Influential scholars of the Chicago school have argued that a monopolist has no incentive to bundle because increasing sales in the tied market necessarily involves lowering the price in the tying market, such that a monopolist cannot earn more than the (single) monopoly profit from the tying market (R. A. Posner, 1976; Bork, 1978). According to them, tying cannot be anticompetitive. Whinston (1990) revised this view. He shows that a monopolist in one market can bundle its products to deter entry into another market, thereby monopolising that other market too. This theory of harm appears, with some variation, in the subsequent three papers (all related to the aforementioned Microsoft case). For example, Carlton and Waldman (2002) find that a monopolist can use bundling to deter entry into the monopolised market (the tying market) and a newly emerging market. Similarly, Choi (2004) finds that a monopolist can use bundling to commit to more aggressive R&D and deter a rival's investment in the tied market.[6] Choi and Stefanadis (2001) show that a monopolist who faces potential entry in each of its two markets can foreclose entrants by bundling its two products (here again, bundling makes the incumbent more aggressive).[7]

I build on the existing literature, but instead of a monopolist, consider two merging parties who face competition in their respective markets, both pre and post-merger.[8] In this paper, the merged entity has two levers: it can (i) engage in input foreclosure (i.e., stop to supply an input to rivals) and (ii) bundle its two goods. Input foreclosure alone is strictly loss-making. Pure bundling alone is strictly loss-making too (this is in line with the literature).[9] However, a strategy that combines input foreclosure and pure bundling can be profitable: it reduces entry such that the merged entity reaps more of the benefits from its innovation – to the overall detriment of consumers. Therefore, antitrust intervention can be necessary to prevent bundling even in competitive markets.

The model is based on the proposed Qualcomm / NXP merger. In that case, the merging parties supplied complementary components used in smartphones. Qualcomm's and NXP's markets featured different characteristics. Qualcomm was the incumbent producer of high-end LTE connectivity chips (which, among others, manage the data transmission

[6]Earlier papers already establish an incentive for strategic over-investment to deter entry in a market: see Spence (1977, 1979). See Fudenberg and Tirole (1984) for strategic incentives to under-invest.

[7]Choi and Stefanadis (2001) describe this as a "price squeeze" effect, which occurs if there is entry in only one (rather than two) markets. On entry in multiple markets, see also Etro (2019) and Williamson (1979), p.962-3.

[8]Much of the relevant literature does not explicitly consider mergers: whether bundling by a multi-product firm is anticompetitive can be a, theoretically, equivalent question to whether a merger that would lead to bundling by a multi-product firm is anticompetitive. My model yields the same results if, instead of bundling by a merged entity, one considers bundling by a multi-product firm.

[9]Deciding to engage in (pure) bundling can be interpreted as deciding to make one's products (fully) incompatible with those of third-party firms. Matutes and Regibeau (1988) consider the decision of firms to produce compatible or incompatible products and model heterogeneous consumers.

between a smartphone and the cellular network). Its chips were superior to those of its competitors, but Qualcomm risked being displaced if a potential entrant succeeded in innovating. NXP produced secure element chips ("SEs", which, among others, help to store sensitive data on smartphones securely)[10] and owned a non-essential but advantageous technology for SEs (MIFARE, a security technology for contactless payments in, among others, transport systems).[11] NXP licensed MIFARE to rival producers of SEs.[12] Developing an alternative to MIFARE was deemed prohibitively costly.[13] The MIFARE technology can be described as an input or complement to SEs; henceforth, I describe it as an input. The European Commission was concerned, among others, that the merged entity would stop supplying NXP's technology to rivals in the SE market to strengthen Qualcomm's position and, thereby, limit innovation and entry in the LTE chip market.[14]

I model a consumer product that consists of two components (e.g., a smartphone that consists of a connectivity chip and a SE).[15] The two component markets differ. In market A (e.g., the market for SEs), the owner of a non-essential technology (e.g., MIFARE) can either sell component A directly to consumers or, instead, let others sell component A and collect revenues from licensing (i.e., supplying) its technology to competitive fringe producers. In market B (e.g., the market for connectivity chips), an incumbent producer is more efficient than a competitive fringe. It can invest in reducing its cost. However, it faces potential displacement by a potential entrant who can also invest. First, the technology owner in market A decides whether to license. Second, the incumbent and entrant in market B choose their respective investment levels. Third, firms compete on price based on their available production technologies and consumers (e.g., smartphone manufacturers) choose the cheapest of each component.[16]

Pre-merger, the technology owner licenses to rivals whenever they are more efficient at using the technology (this way, it obtains a higher profit via a royalty than if it sells directly). Because the technology is non-essential, the ability of fringe producers to do

[10] SEs are used for, e.g., secure connections, authentication, data protection, and secure key storage, see NXP (2022).

[11] MIFARE is particularly used for contactless payments in transport systems, see European Commission (2018a), p. 29.

[12] European Commission (2018a), p. 48.

[13] *Ibid.*, p. 93-4.

[14] *Ibid.*, p. 131-2.

[15] Though I motivate the model with complementary components, as long as each buyer consumes both goods, they need not be perfect complements and can, as remarked by Whinston (1990), be independent instead.

[16] In the Qualcomm / NXP case, the merging parties were upstream suppliers to a downstream manufacturer (e.g., a smartphone manufacturer). However, the theory of harm remains the same with a downstream firm (that has or does not have bargaining power, see section 5.2.6). Therefore, I do not include a downstream firm in the baseline setup but include it in the supplementary material.

without it constrains the technology owner.[17] In market B, both the incumbent and the potential entrant invest. If the potential entrant, who invests in probabilistic innovation, is unsuccessful in innovating, the incumbent competes against the competitive fringe and wins; otherwise, the incumbent competes against the more efficient potential entrant and loses. Component B is cheaper with entry.

Let the technology owner in market A and the incumbent in market B merge. Imagine the merged entity pursues a strategy that combines stopping to license to rivals in market A (input foreclosure) and pure bundling (of components A and B).[18] Then, the merged entity no longer earns licensing profits. Refusal to license is akin to "burning the bridge" of earning profits when rivals sell. Whinston (1990) shows that when the merged entity bundles, it competes more fiercely because it only earns profits when it sells its bundle. Here also, the merged entity prices more aggressively (relative to the merging parties pre-merger) when entry occurs. This, in turn, implies the potential entrant needs to be not only more efficient than the incumbent in market B to sell but also needs to "make up" the post-merger competitive advantage of the technology owner over the fringe in market A. As a result, the entrant's payoff to innovation decreases. Therefore, it invests less and is less likely to enter. Unlike in Whinston (1990), where the mere threat of aggressive behaviour suffices to foreclose a competitor in market B fully, here, the merged entity has to give up profit (licensing revenues) in market A to become credibly more aggressive. As a result, a strategy that combines input foreclosure and pure bundling is profitable if the loss in market A sufficiently lowers the likelihood of entry into market B.

With full foreclosure (i.e. when the potential entrant in market B decides not to invest at all post-merger), the merged entity competes against the fringes in markets A and B. Prices increase post-merger, to the detriment of consumers. Even if the merged entity invests more than the incumbent did pre-merger, none of the benefits are passed on to consumers because the merged entity prices at the maximum level (determined by the competitive fringes). Thus, the merged entity appropriates a larger share of the benefits of innovation. With partial foreclosure (i.e. when the probability of entry is reduced but not to zero), prices are high with a higher likelihood than pre-merger. However, when entry does occur, prices are lower than pre-merger because competition is fiercer (as the merged entity invests more and is more competitive in market B). The expected price can increase or decrease with partial foreclosure. As a result, consumer welfare effects are ambiguous with partial foreclosure but unambiguous with full foreclosure.

The two most closely-related papers are Whinston (1990) and Etro (2019). Whinston (1990) shows that, contrary to the Chicago school argument, bundling by a monopolist

[17] In this sense, the technology is a non-drastic innovation.

[18] See Choi (2008) on mergers of complements with mixed bundling. (Mixed bundling occurs in settings with heterogeneous consumers, which I do not consider here.)

can be profitable and can harm consumers. In one of the cases Whinston considers, the merging parties are not monopolists but, instead, face competition in both markets pre-merger. In his model, the merged entity can monopolise market B post-merger through bundling (which is not possible here). Among other differences, Whinston (1990) models neither input foreclosure nor innovation. Etro (2019) analyses endogenous innovation[19] and considers a similar setup to the one considered here. However, there is no input foreclosure either in Etro (2019). Moreover, in that paper, the merging parties are monopolists in both markets pre-merger. Therefore, the standard Cournot benefit of mergers of complements (Cournot, 1838) materialises, whereas it does not materialise here.[20] (Indeed, when one or both of the merging parties are monopolists, a merger yields certain benefits to consumers that are absent here because the merging parties face competition.)[21] As a result, in Etro (2019), merger effects are more likely to be beneficial precisely because the merging parties are monopolists.[22]

Because the present paper features refusing to license post-merger, it is also related to the literature on input foreclosure in vertical mergers. On this topic, see Ordover, Saloner, and Salop (1990, 1992), Salinger (1988), and Salop and Scheffman (1983, 1987). In that literature, the merged entity forecloses an input to a downstream rival to harm that same downstream rival, which produces a *substitute* product, whereas here, the merged entity forecloses firms in market A to harm a potential entrant in the *complementary* market B.

The subsequent sections are structured as follows. Section 5.2 lays out the baseline model and merger effects (with full and partial foreclosure). Section 5.3 discusses key features of the model and discusses implications of the model with regards to the European Commission's Qualcomm / NXP case decision. Section 5.4 concludes.

[19] For research specifically on the relation between market structure and innovation, see Schmutzler (2013), Spulber (2013), and Vives (2008).

[20] See Dari-Mattiacci and Parisi (2006) and Kadner-Graziano (2023a) on competition and the lack of merger benefits.

[21] Therefore, the intuition from horizontal mergers that mergers are more harmful the higher the market power of the merging parties (Valletti and Zenger, 2018) does not necessarily carry over to mergers of complements. However, Cournot effects can materialise even with competition: in a differentiated product Cournot model, Economides and Salop (1992) find that prices are lower with competition between producers of systems (where each firm offers components A and B, whether separately or jointly only) rather than with competition between producers of components (where each firm produces only one component) because merged entities internalise Cournot externalities.

[22] A related literature shows that pools of essential patents benefit consumers, see Quint (2014b).

5.2 Model

5.2.1 Baseline setup

Two goods, A and B, are consumed in a one-to-one proportion. There are competitive fringe producers of each good: no seller ever sells good A or B at its monopoly price.

In the market for good A, the owner of a superior technology and competitive fringe producers have constant unit production costs c_{AT} and $\overline{c_A}$ respectively. If any fringe producer has access to the superior technology, its unit cost drops to $\underline{c_A} < c_{AT} < \overline{c_A}$.

In the market for good B, an incumbent and competitive fringe producers have constant unit production costs c_{BI} and $\overline{c_B}$ respectively, where $c_{BI} < \overline{c_B}$. The incumbent can reduce its unit cost deterministically by i_I at investment cost $k(i_I)$. In addition, a potential entrant can choose to innovate with probability $i_E \in [0,1]$ at investment cost $\theta(i_E)$. With probability i_E, it successfully innovates and has zero production cost; otherwise, its investment fails and it cannot produce good B.

There are three stages. In stage one, the technology owner in market A decides whether to license its technology to fringe producers of A at the unit royalty r.[23] In stage two, the incumbent and potential entrant invest in market B. In stage three, producers of each good compete (simultaneously) in posted prices.[24] The producer of $i \in \{A,B\}$ that offered the lowest price v_i sells quantity $Q(v_A+v_B)$ at profit $(v_i-c_i)Q(v_A+v_B)$, where c_i is its unit cost. The table below summarises the timing.

Table 5.1: Timing

Stage	Action
1	In market A, the technology owner chooses whether to license (and, if so, chooses the royalty r).
2	In market B, the incumbent and potential entrant invest.
3	All producers compete (simultaneously) in posted prices.

This paragraph lays out sufficient conditions for a unique interior investment equilibrium pre-merger. Let the investment cost functions of the incumbent and potential entrant

[23] Not licensing is equivalent to setting a prohibitively high royalty. I assume the licensor cannot discriminate: it sets the same royalty for all third-party firms. The licensing contract signed with any third parties stipulates r and is valid for a prolonged time such that if the technology owner decides to license, it is committed to its decision.

[24] At equal bids, the firm with the lowest cost wins.

be strictly convex with $k(0) = \theta(0) = k'(0) = \theta'(0) = 0$,[25] and let $k(c_{BI})$ as well as $\theta(1)$ be prohibitively costly (the incumbent never finds it profitable to reduce its production cost to zero, and the potential entrant never finds it profitable to succeed with certainty). To ensure there exists a unique investment equilibrium pre-merger, I make two assumptions. First, let a producer's profit be concave in its price. This is satisfied, for example, when demand is log-concave (though log-concavity of demand is not necessary). Second, because the convexity of investment costs is insufficient for single-crossing, let $k''' \leq 0$ and $\theta''' \geq 0$.[26] This is satisfied, for example, for quadratic investment costs.[27]

5.2.2 Pre-merger results

The game is solved by backward induction. However, here I provide an intuitive explanation of the pre-merger results by advancing through stages one to three sequentially.

In stage one, the technology owner decides whether to supply fringe producers. Either it licenses its technology and earns licensing revenues or does not license (equivalently, it sets a prohibitively high royalty) and sells good A directly. If it does not license, it earns unit profit $\overline{c_A} - c_{AT}$ in stage three. If it licenses to fringe producers, it can obtain no higher royalty than $r^* = \overline{c_A} - \underline{c_A}$, it extracts a higher unit profit in stage three (because $\underline{c_A} < c_{AT}$). Consequently, the technology owner chooses to license in stage one.

In stage two, the incumbent and potential entrant have respective expected profits

$$\begin{aligned} \Pi_{BI} &= (1 - i_E) \left[\overline{c_B} - (c_{BI} - i_I)\right] Q\Big(\overline{c_A} + \overline{c_B}\Big) - k(i_I) \\ \Pi_{BE} &= i_E \left[c_{BI} - i_I\right] Q\Big(\overline{c_A} + c_{BI} - i_I\Big) - \theta(i_E) \end{aligned} \tag{5.1}$$

They both invest interior amounts in equilibrium.

In stage three, producers compete in posted prices. Competition in market A leads to price $\overline{c_A}$ (fringe producers have cost $\underline{c_A} + r = \overline{c_A}$). The technology owner does not sell but earns unit licensing revenue $r^* = \overline{c_A} - \underline{c_A}$. Competition in market B leads to price $\overline{c_B}$ when the incumbent sells (without entry) and price $c_{BI} - i_I$ when the entrant sells (with entry).[28]

Proposition 5. *In stage 1, the technology owner licenses at $r^* = \overline{c_A} - \underline{c_A}$. In stage 2, the incumbent and the potential entrant both invest strictly positive amounts. In stage 3,*

[25] These assumptions are identical to those of Etro (2019), except that I assume $k(0) = 0$. Assuming otherwise means one or both parties may not invest at all.

[26] It is not guaranteed that there is a unique equilibrium pre-merger if $k'''(i_I) \leq 0$, or $k'''(i_I) \leq 0$ for some $i_I \in [0, c_{BI}]$ but $k'''(i_I) > 0$ for other $i_I \in [0, c_{BI}]$.

[27] See the appendix for a graphical representation.

[28] The technology owner has expected profit $\Pi_{AT} = [\overline{c_A} - \underline{c_A}]\Big[(1 - i_E^*)Q(\overline{c_A} + \overline{c_B}) + i_E^* Q(\overline{c_A} + c_{BI} - i_I^*)\Big]$.

prices are $v_A + v_B = \overline{c_A} + c_{BI} - i_I$ *when the entrant innovates and* $v_A + v_B = \overline{c_A} + \overline{c_B}$ *when it does not.*

Remark 8. *The incumbent's investment does not benefit consumers when the incumbent sells. Instead, the incumbent's investment only benefits consumers when the incumbent does not sell: when competition with the successful entrant drives the price for B below* $\overline{c_B}$.

The intuition for the remark above goes as follows. When the incumbent sells, it competes against the competitive fringe. Because the incumbent is constrained at price $\overline{c_B}$, it never charges a lower price. Therefore, the incumbent's cost does not affect the consumer price: the price equals $\overline{c_B}$ however much the incumbent invests. In contrast, when the incumbent competes against a more efficient entrant, the incumbent competes more fiercely the more efficient it is (consumers then pay $c_{BI} - i_I$ for good B). Therefore, the incumbent's investment benefits consumers when there is competition with the entrant (in which case the entrant sells).

5.2.3 Post-merger strategies

Consider a merger between the technology owner in market A and the incumbent producer in market B. The timing post-merger is identical to pre-merger, except that the merged entity can additionally decide in stage 1 whether to engage in pure bundling (to commit to selling either both its goods jointly or none at all). The timing is shown in the table below.

Table 5.2: Timing, post-merger

Stage	Action
1	The merged entity chooses whether to engage in pure bundling and whether to license (and, if so, chooses the royalty r).
2	In market B, the incumbent and potential entrant invest.
3	All producers compete (simultaneously) in posted prices.

The merged entity has four possibilities in stage one. These are shown in the table below. However, the only post-merger strategy that can be strictly profitable is one that combines input foreclosure with bundling. To see this, consider the three other strategies. Without input foreclosure and without bundling, the merger has no effect. Bundling without input foreclosure is loss-making. The merged entity becomes less (not more) aggressive with bundling and without input foreclosure, because when entry occurs the

merged entity has opportunity cost r of selling (which the incumbent in market B did not have pre-merger). Input foreclosure without bundling is loss-making too. Then, the merged entity loses licensing profits in market A without any gain in market B.

Table 5.3: Expected profitability of post-merger strategies in stage 1

$\Pi_M - \Pi_{AT} - \Pi_I$	No bundling	Bundling
No input foreclosure	$= 0$	< 0
Input foreclosure	< 0	$\lessgtr 0$

Proposition 6. *In stage 1 post-merger, no strategy other than one that combines input foreclosure and bundling can be strictly profitable.*

When the merged entity bundles, effectively, there is competition on the total price $v_A + v_B$ in stage 3. Intuitively, it can be profitable to refuse to license and bundle because the merged entity thereby "burns its bridge" of earning revenue on good A when others sell and, consequently, behaves more aggressively in stage three. (Refusal to license works as a commitment device not to sell via others.) The merged entity will credibly compete more aggressively against the potential entrant by setting a price as low as $c_{AT} + c_{BI} - i_I$ when the entrant succeeds (where the merged entity may select a higher investment than the incumbent in market B pre-merger). As a result, the entrant invests less post-merger. Providing further intuition: post-merger, the potential entrant needs to make up the competitive disadvantage of its "bundle partner" in good A relative to the merged entity's cost for good A, $\overline{c_A} - c_{AT}$, in order to win in stage three. This decreases its incentive to invest and therefore decreases the likelihood with which consumers benefit from lower prices for good B. Limiting competition from the potential entrant can lead the merger to be strictly profitable.

Remark 9. *Refusal to license does not affect the competitiveness (the unit cost) of third-party producers of good A (with or without a license, third-party producers of good A have unit cost $\overline{c_A}$). Instead, refusal to license eliminates the merged entity's outside option of not selling: from earning royalty r^* to zero. In this way, refusal to license increases the bidding aggressiveness of the merged entity.*

The potential entrant is ***fully foreclosed*** if it invests zero. If the potential entrant does not invest, the merged entity invests $i_I^*(0) = k'^{-1}(Q(\overline{c_A} + \overline{c_B}))$. Full foreclosure is an equilibrium if $i_I^*(0)$ is such that

$$c_{BI} - i_I^*(0) - (\overline{c_A} - c_{AT}) \leq 0 \tag{5.2}$$

Intuitively, the condition in (5.2) states: the potential entrant is fully foreclosed if, after accounting for the competitive disadvantage in good A, the entrant would incur a loss were it to sell. Conversely, the potential entrant is ***partially foreclosed*** in any equilibrium where it is not fully foreclosed.

In the subsequent sections, I consider merger results when the merged entity refuses to license and engages in pure bundling in stage 1.

5.2.4 Post-merger results, with full foreclosure

By definition, the potential entrant never enters post-merger when it is fully foreclosed. In stage three, the merged entity obtains a total price of $\overline{c_A} + \overline{c_B}$ with certainty. In stage two, the merged entity chooses investment level i_I to maximise its profit

$$\Pi_M = \left[\overline{c_A} + \overline{c_B} - (c_{AT} + c_{BI} - i_I)\right] Q\left(\overline{c_A} + \overline{c_B}\right) - k(i_I) \tag{5.3}$$

The merged entity invests more post-merger compared to pre-merger because investment yields a benefit with certainty. It reaps all the benefits from its increased investment. Consumers, on the other hand, do benefit from that investment: with full foreclosure, the merger harms consumers unambiguously.

Proposition 7. *When input foreclosure and bundling results in full foreclosure of the potential entrant,*

1. *The potential entrant does not invest (by definition), whereas the merged entity invests more than the merging parties pre-merger.*

2. *The total price rises unambiguously to $\overline{c_A} + \overline{c_B}$: the merged entity reaps all benefits from its increased investment, and the merger harms consumers.*

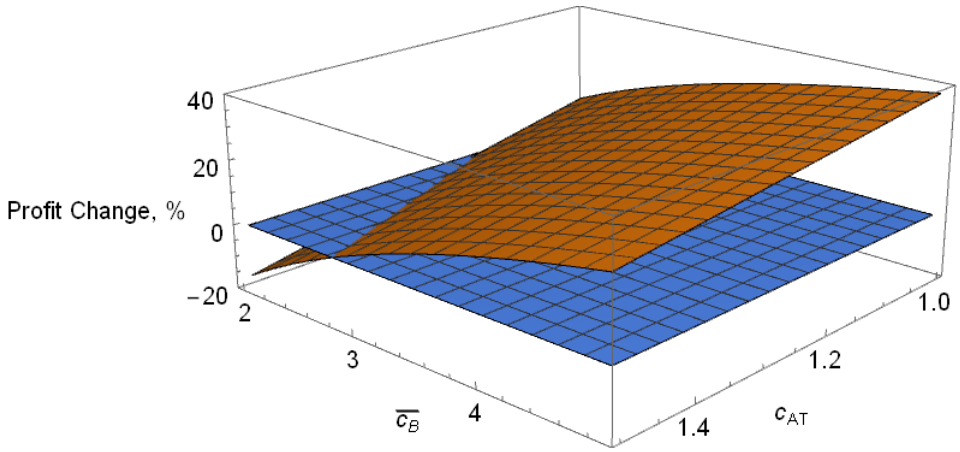
Remark 10. *According to the Cournot effect (Cournot, 1838), a merger of complements can decrease prices. In addition, mergers can raise investment in innovation. Here, in contrast, competition always constrains sellers such that the merged entity sets the maximum price and no benefits from innovation are passed on to consumers.*

The merger is strictly profitable if $\Pi_M > \Pi_{AT} + \Pi_{BI}$. The merger has five effects on the merging parties' joint profit. The merged entity earns a greater profit on good B post-merger than the incumbent did pre-merger because (i) it sells good B with certainty post-merger, and (ii) it has a lower unit cost thanks to its greater investment. These benefits come at (iii) greater investment costs post-merger. The merged entity earns less licensing profit than the technology owner did pre-merger because (iv) it always loses out on extracting licensing profits from the greater efficiency of fringe producers at using

the technology and (v) it misses out on earning licensing revenues on the extra quantity $Q(\overline{c_A} + c_{BI} - i_I^*) - Q(\overline{c_A} + \overline{c_B})$ which was sold in the case of entry pre-merger.

Intuitively (and all else equal), the higher $\overline{c_B}$, the more profitable it is to fully foreclose the potential entrant in market B. Intuitively (and all else equal), the lower c_{AT}, the lower the cost of input foreclosure (of refusing to license). Conversely, the merger is not profitable for sufficiently low $\overline{c_B}$ and sufficiently high c_{AT}. This is illustrated in the figure below.

Figure 5.1: Change in the merging parties' expected profit (example)



Note: In this example, $\underline{c_A} = 1$, $\overline{c_A} = 3$, $c_{BI} = 2$, $k(i_I) = i_I^2$, $\theta(i_E) = 2i_E^2$, with $Q = 1$ – let there be unit demand $Q(v_A + v_B) \in \{0, 1\}$. The orange surface depicts the change in the merging parties' expected profit post-merger; the blue surface is the 0-plane.

5.2.5 Post-merger results, with partial foreclosure

With partial foreclosure, the merged entity and the potential invest in stage two knowing that, in stage three, prices are $\overline{c_A} + \overline{c_B}$ without entry and $c_{AT} + c_{BI} - i_I^*$ with entry. Therefore, they select their investment levels i_I and i_E to maximise their respective profits

$$\begin{aligned} \Pi_M &= (1 - i_E) \left[\overline{c_A} + \overline{c_B} - (c_{AT} + c_{BI} - i_I)\right] Q\Big(\overline{c_A} + \overline{c_B}\Big) - k(i_I) \\ \Pi_{BE} &= i_E \left[c_{BI} - i_I - (\overline{c_A} - c_{AT})\right] Q\Big(c_{AT} + c_{BI} - i_I\Big) - \theta(i_E) \end{aligned} \tag{5.4}$$

The potential entrant invests less post-merger than pre-merger because it needs to compensate the competitive disadvantage in good A of its bundle partner, which reduces the return on investment. As a result, the merged entity's investment rises in equilibrium (relative to the incumbent's investment pre-merger).

Therefore, the total price for the two goods is more likely to be at the high level of $\overline{c_A} + \overline{c_B}$ post-merger. But when entry occurs, the total price is lower post-merger than pre-merger – for two reasons. First, the merged entity invests more than the incumbent did pre-merger and sets a more aggressive (lower) price post-merger. Second, the price of good A also falls because the merged entity competes on the entire bundle. Surprisingly perhaps, the expected price for goods A and B can decrease post-merger with partial foreclosure. Whether it does depends, among others, on how investment by the potential entrant changes with a decrease in the investment payoff.

Proposition 8. *When input foreclosure and bundling result in partial foreclosure of the potential entrant,*

1. *The potential entrant invests less than pre-merger, whereas the merged entity invests more than the merging parties pre-merger.*

2. *The total price equals $\overline{c_A} + \overline{c_B}$ with a higher likelihood than pre-merger. However, when entry occurs, prices are lower than pre-merger. The merger can lead to a decrease in the expected total price (even with a totally inelastic demand) or to an increase in the expected total price.*

The merger is profitable if the gains from reduced entry exceed the loss of licensing revenues. Intuitively, the merger can be profitable despite that the average price decreases because the merged entity appropriates a larger share of the gains of innovation.

5.2.6 Brief discussion of the model

For conciseness, the model setup does not explicitly include a downstream firm. Imagine a downstream firm consumes the two goods (A and B) as inputs. If suppliers set prices by competing à la Bertrand, then the results described hitherto remain unaltered. If the downstream firm has some bargaining power over prices, then the theory of harm remains unaltered qualitatively too. However, with bargaining and complete information, two differences appear: first, there is investment hold-up[29] and second, the merger can lead to lower expected prices even with full foreclosure.[30] Intuitively, prices can decrease with full foreclosure because the downstream firm benefits from any investment. Intuitively, the merged entity can profit even if expected prices decrease because it appropriates the benefits of its investment with a higher likelihood.

[29] Loertscher and Marx (2019a, 2022a) show that with incomplete information, there is no hold-up with bargaining.

[30] In addition, the technology owner now has an additional incentive to license: by licensing to fringe producers, it avoids bargaining with and losing rent to the downstream firm.

Note that countermergers are no solution: the potential entrant in market B cannot use a countermerger to make up for its competitive disadvantage because there is only one superior technology, which is prohibitively costly to replicate.[31]

Finally, in the baseline setup, the merger does not strictly harm third-party producers of component A. The model can be altered such that these third-party firms earn a positive expected profit pre-merger.[32] Then, input foreclosure would strictly harm these firms.

5.3 Antitrust discussion

In the Qualcomm / NXP merger case, the European Commission imposed a remedy stipulating that the merged entity must continue to supply a technology owned by NXP (MIFARE) to third parties on FRAND terms (fair, reasonable, and non-discriminatory licensing terms).[33] Such a remedy prevents input foreclosure; therefore, no harm occurs in market A. Consequently, the merged entity cannot limit entry in market B. The model developed in the present paper shows that such a remedy effectively prevents the foreclosure of a potential entrant and any associated consumer harm.

Below, I address five questions related to this remedy and to the model. First, why does the merger of complements not yield some benefits to consumers? Mergers of complements can benefit consumers in several ways. A merged entity internalises both a negative externality and a positive externality.[34] It internalises negative pricing externalities and may lower prices (Cournot, 1838). It internalises positive innovation externalities and may invest more in innovation.[35] These benefits materialise when the merging parties are monopolists, but when the merging parties are sufficiently constrained by competition pre-merger, no such benefits materialise:[36] this paper shows that, when competitive constraints bind pre and post-merger, an innovator prices up to the point where it captures all benefits from its innovation, such that no benefits are passed on.

[31] On countermergers in a vertical chain, see Ordover, Saloner, and Salop (1990). On endogenous profitability of horizontal mergers (how one merger may render a series of further mergers to be profitable), see Nocke and Whinston (2010).

[32] E.g. by assuming a producer has cost $\underline{c_A}$ with probability y and cost $\underline{c_A} - x$ with probability $1-y$. For small enough x and large enough y, the technology owner prefers to set $r = \overline{c_A} - \underline{c_A}$ (rather than $r = \overline{c_A} - \underline{c_A} + x$), which leaves a third party producer with unit profit x. Similarly, the model can be adapted such that the technology owner supplies component A directly with some positive probability. For conciseness, this is left out here.

[33] See European Commission (2018b).

[34] According to some practitioners, antitrust authorities have viewed mergers of complements too benevolently, see, e.g., Caffarra, Crawford, and Valletti (2020) and Masson, Dalkir, and Eisenstadt (2014).

[35] See Etro (2019). NXP argued this also: "United in a common strategy, the complementary nature of our technologies and the scale of our portfolios will give us the ability to drive an accelerated level of innovation and value for the whole ecosystem" (NXP, 2016).

[36] See Dari-Mattiacci and Parisi (2006) and Kadner-Graziano (2023a).

Second, must the price of one component depend on the price of complementary components? In its Qualcomm / NXP decision, the EC wrote that it is "non-standard" to assume "that pre-merger the prices for different inputs are [obtained] without taking into account the price of complementary inputs", as it is unclear why the price of "one input would pre-merger not be affected by the price for complementary inputs that are bought by the same buyer and that are needed to produce a given final good".[37] However, with sufficient competition, the price set by one supplier does not reflect the price of other components: even if an incumbent is by far dominant relative to its competitors, the incumbent can be constrained by a (possibly far worse) outside option of the downstream firm. In this case, the seller maximises its price, subject to constraints in its own component market only.

Third, if the technology of the technology owner is described as a "must have" feature,[38] does this alter results? No. If parties describe the licensed technology as "must have", the alternative – which may be far worse – is still the relevant outside option: it is what a consumer (e.g. a downstream firm) would fall back on were it not to obtain that technology. For example, for a downstream smartphone manufacturer to obtain the "best-of-breed" goods can be an equilibrium outcome rather than necessarily a "make or break" condition to produce and release a new smartphone model at all.[39]

Fourth, why does the Single Monopoly Profit Theorem[40] not apply to the present setting? Pre-merger, the technology owner – who has a monopoly over a *non-essential* technology – extracts the maximum surplus it can obtain from component A. Post-merger, the merged entity no longer licenses and loses profit on good A. With bundling and input foreclosure, the merged entity becomes more aggressive, partially or even fully foreclosing a potential entrant in market B. The gain on good B can exceed the loss on good A, depending on how strongly the potential entrant reduces its investment.

Fifth, how important is the commitment to pure bundling? If, after observing the potential entrant's innovation outcome, the merged entity can backtrack on its licensing decision at no cost, the licensing decision is not credible ex ante and has no effect. Several factors influence the ex ante credibility of bundling strategies, e.g. timing and whether the components are physically tied (Kühn, Stillman, and Caffarra, 2005; Whinston, 1990).

[37] European Commission (2018a), p.123-4.

[38] In the Qualcomm / NXP case, MIFARE was described as a "must have" such that some smartphone makers would not consider SE (security element) suppliers who did not provide MIFARE. See European Commission (2018a), p.51.

[39] A "must-have" input would be one without which no new consumer product (e.g., smartphone) would be produced at all. If MIFARE were such a "must-have", then NXP should have earned a far higher margin of its license pre-merger already (see Kadner-Graziano, 2023a).

[40] This is also known in the literature as the "One-Monopoly-Rent Theorem", see Hermalin and Katz (2013). Hermalin and Katz (2013) consider a differentiated duopoly rather than a monopoly in the tying market. The results of the present paper do not rely on differentiation in the tying market.

For example, if the merged entity produces components A and B that are physically tied, unbundling may be very costly or impossible without damaging or destroying the product. Timing also plays a role: changing the licensing decision after observing the entrant's investment outcome may be too late for alternative suppliers of A to develop a functioning product in time for the bidding stage.

5.4 Conclusion

It is well-established that bundling can harm consumers when exercised by a firm with a monopoly in at least one of the two markets. In the present paper, two firms merge and gain an advantage over rivals in two markets without having a monopoly position in either market. The merger can harm consumers due to, first, the absence of standard Cournot benefits and due to, second, anticompetitive strategies. The merged entity uses a strategy that combines (i) input foreclosure in one market with (ii) bundling in order to limit entry into another market.

Pre-merger, licensing is profitable: it allows the technology owner to profit from the greater efficiency of third-party producers of good A. If the merger between the technology owner and the incumbent in market B is strictly profitable, post-merger, the merged entity engages in input foreclosure in market A and bundles. Input foreclosure is costly to the merged entity, as it no longer extracts surplus from more efficient third-party producers of good A. However, the strategy limits entry into market B. Investment by the merged entity increases because it captures more of the social gains from innovation. With reduced competition post-merger, consumers share less in the gains of innovation. Put differently: even if innovation rises post-merger, consumers can be harmed because, with weakened competition, less (or none) of the benefits are passed onto consumers.

In the competitive markets studied here, input foreclosure alone is not profitable. Bundling alone is not profitable either. However, the combination of input foreclosure and bundling can be profitable and harm consumers.

5.5 Proofs

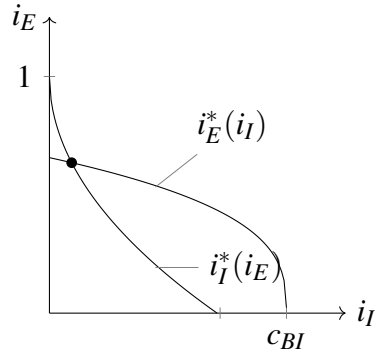
Proof of Proposition 5. In stage 3, the producer of each component $i \in \{A,B\}$ with the lowest cost wins. The two markets can be treated separately. In market A: if the technology owner does not license, it sets $v_A = \overline{c_A}$ and wins. If it licenses at royalty r, it competes price down to $c_{AT} + r$ (its cost, inclusive of the opportunity cost of selling) whereas fringe producers compete down to their cost, which is $\min\{\underline{c_A} + r, \overline{c_A}\}$. In market B: if the potential entrant succeeds in its investment, then it sets $v_B = c_{BI} - i_I$ and wins; if it does not

succeed, the incumbent sets $v_B = \overline{c_B}$ and wins.[41]

In stage 2, the incumbent and the potential entrant select their investment levels to maximise their respective profits given in (5.1); equilibrium investments are characterised by

$$\begin{aligned} i_I^* &= k'^{-1}\left[(1-i_E)Q(\overline{c_A}+\overline{c_B})\right] \\ i_E^* &= \theta'^{-1}\left[(c_{BI}-i_I)Q(\overline{c_A}+c_{BI}-i_I)\right] \end{aligned} \tag{5.5}$$

The investment cost $k(\cdot)$ is strictly convex with $k(0) = k'(0) = 0$. Because $k''' \leq 0$, $k'(\cdot)$ is weakly concave and $k'^{-1}(\cdot)$ is weakly convex. The effect of i_E on $(1-i_E)Q(\overline{c_A}+\overline{c_B})$ is linear, therefore i_I^* is weakly convex in i_E. Similarly, the investment cost $\theta(\cdot)$ is strictly convex with $\theta(0) = \theta'(0) = 0$. Because $\theta''' \geq 0$, $\theta'(\cdot)$ is weakly convex and $\theta'^{-1}(\cdot)$ is weakly concave. Profit $(c_{BI}-i_I)Q(\overline{c_A}+c_{BI}-i_I)$ is concave in i_I. Hence, i_E^* is weakly concave in i_I. Investment costs $k(c_{BI})$ and $\theta(1)$ are prohibitively costly: $i_I^* < c_{BI}$ and $i_E^* < 1$. The unique pre-merger equilibrium in stage 2 is an interior one: it is illustrated below.



In stage 1, the technology owner decides whether to license. If it does not license, it earns unit profit $\overline{c_A} - c_{AT}$ in stage 3. For any fringe producer to license, the royalty must satisfy $r \leq \overline{c_A} - \underline{c_A}$. At any $r \in (\overline{c_A} - c_{AT}, \overline{c_A} - \underline{c_A})$, the technology owner earns a greater profit than without licensing. Consequently, it licenses in stage 1 at the maximum royalty $r^* = \overline{c_A} - \underline{c_A}$. □

Proof of Proposition 6. As a preliminary remark: input foreclosure is economically equivalent to $r > \overline{c_A} - \underline{c_A}$. No input foreclosure (continuing to license) therefore means that $r \leq \overline{c_A} - \underline{c_A}$. However, the merged entity never benefits from charging strictly less than $\overline{c_A} - \underline{c_A}$; hence, without input foreclosure $r^* = \overline{c_A} - \underline{c_A}$.

Of the four feasible post-merger strategies in stage 1, this proof considers each of the following three strategies and shows that each of these three is weakly unprofitable.

[41] With competitive fringes, producers maximise set the highest price possible (i.e., they do not set the monopoly price).

First, consider a strategy whereby the merged entity neither bundles nor engages in input foreclosure. In stage 3, a fringe producer sells at $\overline{c_A}$ and the merged entity earns unit royalty r^* in market A. The merged entity earns price $\overline{c_B}$ without entry and the potential entrant earns price $c_{BI} - i_I$ with entry. In stage 2, profit functions from investment are identical to the pre-merger functions in (5.1). Consequently, investment levels are the same as pre-merger: nothing changes in markets A or B. Hence, the merger has no effect on profits.

Second, consider the strategy of bundling without input foreclosure. In stage 3, the merged entity has unit cost (inclusive of the opportunity cost r)

$$c_{AT} + r^* + c_{BI} - i_I = c_{AT} + \overline{c_A} - \underline{c_A} + c_{BI} - i_I$$

The potential entrant, if it sells, obtains price $c_{BI} - i_I + c_{AT} - \underline{c_A}$, where $c_{AT} - \underline{c_A} > 0$ reflects that it obtains more than pre-merger (see (5.5)). Therefore, for any investment level by the merged entity, the potential entrant has a higher payoff from innovation and thus a higher incentive to invest. In equilibrium, the potential entrant invests more and the merged entity invests less than the incumbent did pre-merger. Therefore, the merger is strictly unprofitable. To see this: for any investment level i_I, the merged entity earns a strictly lower expected profit than the merging parties earned pre-merger, i.e. $\Pi_M(i_I) < \Pi_{AT}(i_I) + \Pi_{BI}(i_I)$. Without entry, the merger is strictly unprofitable as the merged entity earns profit

$$(\overline{c_A} + \overline{c_B} - c_{AT} - c_{BI} + i_I)Q\big(\overline{c_A} + \overline{c_B}\big)$$

where the quantity sold is the same as pre-merger but the unit profit is lower than pre-merger because $\overline{c_A} - c_{AT} < \overline{c_A} - \underline{c_A}$ (the merged entity has higher costs when it sells input A directly). With entry, the merger is strictly unprofitable as the merged entity earns

$$(\overline{c_A} - \underline{c_A})Q\big(c_{AT} + \overline{c_A} - \underline{c_A} + c_{BI} - i_I\big)$$

where the unit profit is the same as pre-merger but the quantity sold is strictly lower than the pre-merger quantity $Q(\overline{c_A} + c_{BI} - i_I)$ because $c_{AT} - \underline{c_A} > 0$. With or without entry, the merged entity earns less than pre-merger (and in equilibrium, the probability of entry increases).

Third, consider the strategy of input foreclosure without bundling. In stage 3, the merged entity sells component A at price $\overline{c_A}$ with unit profit $\overline{c_A} - c_{AT}$. In stage 2, profit functions from investment are identical to the pre-merger functions in (5.1). Consequently, investment levels are the same as pre-merger: nothing changes in market B but the merged entity loses profits in market A. Hence, input foreclosure without bundling is strictly unprofitable. □

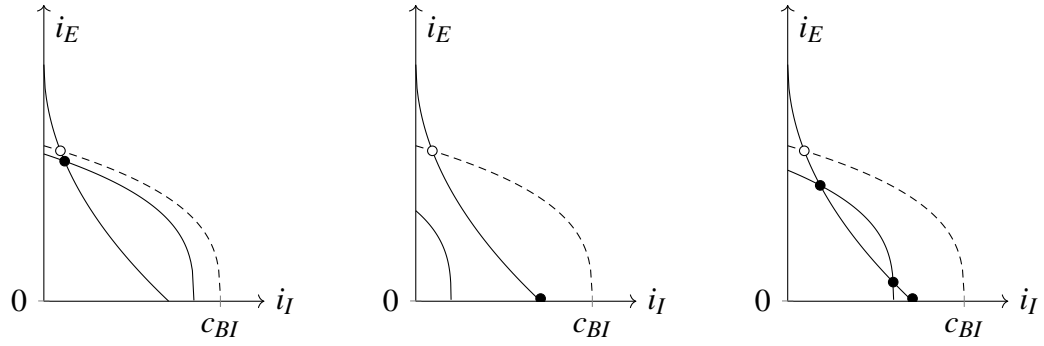
Proof of Proposition 7. In stage 3, the total price is $\overline{c_A} + \overline{c_B}$ with full foreclosure. (With entry, which does not occur, the price would be $c_{AT} + c_{BI} - i_I$.)

In stage 2, the merged entity and potential entrant select their respective investment levels i_I and i_E to maximise their respective profits shown in (5.4) with first-order conditions

$$\begin{aligned} i_I^* &= k'^{-1}\Big[(1-i_E)Q\big(\overline{c_A}+\overline{c_B}\big)\Big] \\ i_E^* &= \theta'^{-1}\Big[(c_{BI}-i_I-(\overline{c_A}-c_{AT}))Q\big(c_{AT}+c_{BI}-i_I\big)\Big] \end{aligned} \tag{5.6}$$

Comparing (5.6) to (5.5): the merged entity's first-order condition is identical to that of the incumbent pre-merger; however, the potential entrant now invests less post-merger for any given level of investment i_I (the price it earns in case of entry drops by $\overline{c_A} - c_{AT}$ post-merger). In equilibrium, the potential entrant invests less than pre-merger and the merged entity invests more than the incumbent did pre-merger. With full foreclosure, condition (5.2) holds: the potential entrant invests zero. □

Remark 11. *Graphically: with an inwards-shift of the entrant's best response function post-merger, there can exist either a unique equilibrium with partial foreclosure or a unique equilibrium with full foreclosure or three equilibria, two of which with partial foreclosure (of which one is unstable) and one with full foreclosure. Each of these possibilities is, respectively, illustrated below. (The dashed lines depict the potential entrant's pre-merger investment best response function. Each white dot depicts the pre-merger Nash equilibrium. Each black dot depicts a post-merger Nash equilibrium.)*



Proof of Proposition 8. In stage 3, the total price is $\overline{c_A} + \overline{c_B}$ without entry and $c_{AT} + c_{BI} - i_I$ with entry.

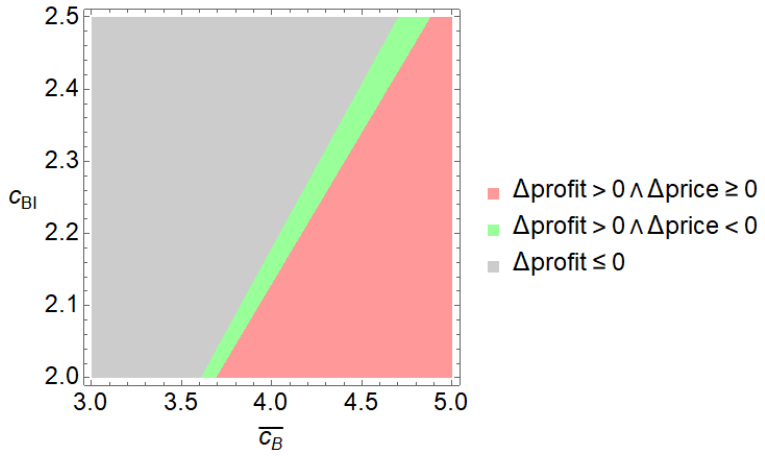
In stage 2, the merged entity and potential entrant select their respective investment levels i_I and i_E to maximise their respective profits shown in (5.4) with first-order conditions given by (5.6). Comparing (5.6) to (5.5): the merged entity's first-order condition is identical to that of the incumbent pre-merger; however, the potential entrant now invests less post-merger for any given level of investment i_I (the price it earns in case of entry

drops by $\overline{c_A} - c_{AT}$ post-merger). In equilibrium, the potential entrant invests less than pre-merger and the merged entity invests more than the incumbent did pre-merger.

Therefore, stage 3 prices equal $\overline{c_A} + \overline{c_B}$ with a higher likelihood than pre-merger, but with entry prices are lower than pre-merger because $c_{AT} < \overline{c_A}$ and because the merged entity's investment is higher than the incumbent's investment pre-merger.

Finally, I prove by example that the expected total price $v_A + v_B$ can increase or decrease. Consider the following example: let $\overline{c_A} = 1.5$, $c_{AT} = 1.4$, $\underline{c_A} = 1.39$, $k(i_I) = 1.25 i_I^2$, $\theta(i_E) = 1.25 i_E^2$, and quantity be fixed at 1. The green area in the graph below depicts a parameter values of $\overline{c_B}$ and c_{BI} for which the merger is profitable and for which the total price $v_A + v_B$ decreases in expectation. (Thus, even with fixed quantity, the expected price can decrease.)

Figure 5.2: Change in the merged entity's expected profit and in expected prices (example)



Note: The merger is profitable but expected prices decrease with, e.g., $c_{BI} = 2$ and $\overline{c_B} = 3.65$.

□

5.A Supplementary material

Here, consider a vertical industry and bargaining. A downstream firm sources one unit of each good, A and B. It has complete information and bargaining power $1 - \beta$, with $\beta \in (0,1)$. It uses the following price formation mechanism here: first, producers of each good compete à la Bertrand (they submit price offers). Subsequently, and for each input, the downstream firm bargains with the producer that offered the lowest price, using the second-lowest offer as the outside option.

Pre-merger results

Pre-merger in market A, the technology owner licenses at $r^* = \overline{c_A} - \underline{c_A}$. Licensing now not only serves to extract profit from the greater efficiency of fringe producers but also serves to avoid bargaining with the downstream firm and sharing rents as a result.

Pre-merger in market B, without entry, the downstream firm and the incumbent maximise the generalised Nash product $[\Pi_D(v_B) - \Pi_D(\overline{c_B})]^{1-\beta} \times \Pi_I(v_B)^{\beta}$. They agree to the price $v_B = c_{BI} - i_I + \beta[\overline{c_B} - (c_{BI} - i_I)]$. (Thus, there is hold-up in investment.) With entry, the downstream firm and the entrant maximise the generalised Nash product $[\Pi_D(v_B) - \Pi_D(c_{BI} - i_I)]^{1-\beta} \times \Pi_{BE}(v_B)^{\beta}$. They agree to price $v_B = \beta(c_{BI} - i_I)$.

Given these price outcomes, the incumbent supplier and the potential entrant choose their investment levels to maximise their respective profits

$$\Pi_I = (1 - i_E)\beta[\overline{c_B} - (c_{BI} - i_I)] - k(i_I)$$
$$\Pi_{BE} = i_E\beta(c_{BI} - i_I) - \theta(i_E)$$

Maximising yields the equilibrium conditions

$$i_I^* = k'^{-1}\left[(1 - i_E)\beta\right] \in (0, c_{BI})$$
$$i_E^* = \theta'^{-1}\left[\beta(c_{BI} - i_I)\right] \in (0, 1)$$

Hold-up reduces equilibrium investment levels.

Post-merger results, with full foreclosure

When the merged entity engages in input foreclosure and bundling, and when this leads to full foreclosure of the potential entrant,[42] the merged entity obtains unit price v, which maximises the Nash product $[\Pi_D(v) - \Pi_D(\overline{c_A} + \overline{c_B})]^{1-\beta} \times \Pi_I(v)^{\beta}$. The bundle price reflects markets for A and B separately:

$$v = \overline{c_A} - (1 - \beta)(\overline{c_A} - c_{AT}) + \overline{c_B} - (1 - \beta)[\overline{c_B} - (c_{BI} - i_I)]$$

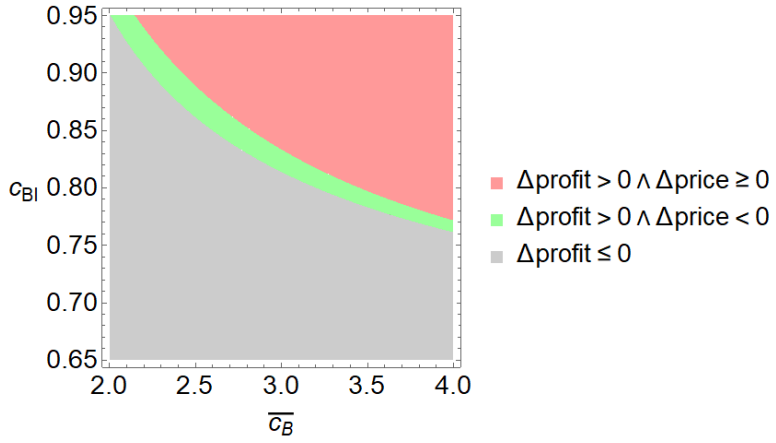
The merged entity's unit profit in market A decreases from $\overline{c_A} - \underline{c_A}$ pre-merger to $\beta(\overline{c_A} - c_{AT})$ post-merger for two reasons. First, when bargaining, it loses a share of the trade-specific surplus to the downstream firm. Second, it no longer benefits from the greater efficiency of other firms. The merged entity's unit profit on good B increases because the potential entrant invests less, and therefore, the merged entity invests more.

As in section 5.2, the total price for goods A and B can increase post-merger. This

[42] The condition for full foreclosure is still given by (5.2).

harms the downstream firm and consumers. Unlike in section 5.2, with bargaining, expected prices can decrease even with full foreclosure. Intuitively, this can happen because the downstream firm captures some of the surplus of the merged entity's larger investment.

Figure 5.3: Change in the merged entity's expected profit and in expected prices, with bargaining and full foreclosure (example)



Note: In this example, $\beta = 0.5$, $\underline{c_A} = 0.29$, $c_{AT} = 0.3$, $\overline{c_A} = 0.66$, $k(i_I) = 0.8i_I^2$, and $\theta(i_E) = i_E^2$.

Chapter 6

Conclusion

In this dissertation, I studied effects of mergers of complements and vertical mergers. I filled two significant gaps in the literature (in chapters 3 and 4). Filling these gaps has practical implications for merger review: practitioners (e.g., antitrust authorities, lawyers, and economic consultants) now have additional tools to analyze non-horizontal mergers.

Mergers of complements have been thought to benefit consumers. This is true when the merging parties are monopolists but not when they face perfect competition. In between those competitive extremes, it was hitherto unknown when exactly a merger yields the beneficial Cournot effect (or internalization of double marginalization). Chapter 3 fills this gap: it provides a test to determine whether consumers would benefit from such a merger for all competitive landscapes between the polar extremes (of monopoly and perfect competition).

The typical concern about vertical mergers is the foreclosure of downstream rivals. There already exist tests to identify how big the incentive for foreclosure is, i.e., by how much the merged entity wants to raise the input price of a downstream competitor. Chapter 4 develops a test to identify whether the merged entity has the ability to raise the price of its downstream rival. Without the ability to do so, incentives are inconsequential. Therefore, the test complements existing antitrust tools for vertical mergers.

Chapter 5 deals with an attempted merger in the chip industry. US authorities approved the merger unconditionally, but EU authorities approved it subject to remedies. The chapter develops a formal model and a theory of harm regarding this particular merger. The theory combines two theories of harm: bundling and input foreclosure. The chapter considers the effects on innovation and consumers. It supports the EU's concerns and the remedies it imposed.

The aim and motivation of this research has been to develop tools to correctly predict merger effects of consequence to consumers. I am therefore glad and grateful that antitrust authorities (CADE in Brazil; DG COMP in the EU; the Bundeskartellamt in Germany;

and the CMA in the UK) and members of the FTC in the US have expressed interest in these new tools.

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