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The Sale of Data: Learning Synergies Before M&As*

Antoine Dubus[†] Patrick Legros[‡]

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Abstract

Firms may share information to discover potential synergies between their data sets and algorithms, eventually leading to more efficient mergers and acquisitions (M&A) decisions. However, as pointed out by Arrow, information sharing also modifies the competitive balance when companies do not merge, and a firm may be reluctant to share information with potential rivals. Under general conditions, we show that firms benefit from (partially) sharing information. More information sharing may increase industry expected profits when there is head-to-head competition and a M&A. Compared to a laissez-faire situation, a regulator allowing or refusing the M&A may decrease or increase information sharing and consumer surplus.

Keywords: Synergies; Mergers; Sale of Data; Incomplete Information; Antitrust; Privacy.

JEL: G34; K21; L1; L21; L24; L5; L86.

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Mergers fail, acquisitions are reversed, previously acquired assets are divested, and claimed efficiencies are not realized. Is this because firms claim M&As will yield efficiency gains in the hope of convincing authorities? Is it because firms did not do their homework and incorrectly evaluated the extent of synergies? Or is it because synergies exist only “on average,” therefore that there is a probability that synergies may not be realized after the M&A?

These questions are relevant in a world where firms are uncertain of the extent of synergies at the time of a M&A. In such an environment, more precise information about the synergies that will follow a M&A is valuable for the companies involved and a regulator willing to maximize social welfare.

Firms must gather many different types of information before a M&A, such as the quality of the other company’s infrastructures, its assets, and their actual returns, particularly for industrial firms with asymmetric information about relative productivity. In addition, in the digital economy where products rely heavily on algorithms and data, the sale (potentially at a zero price) of data between merger participants can allow a firm to anticipate better the extent of synergies that may arise after a M&A.

[Arrow \(1962a,b\)](#) famously pointed out the benefits and the difficulty of inducing such collaborations among competitors, especially if what is sold can be replicated at no cost.¹ But even if there is a cost to replication, providing assets to competitors enhances their ability to compete, and sharing its assets can be costly for a firm.² Sharing information changes the firms’ competitive positions if the M&A does not go through, and also changes the desire of a regulator – who is aware of this information or can infer it from the decisions of firms to merge – to allow the M&A. We contribute to showing that the competitive disadvantage is balanced by more efficient M&A choices that benefit the companies involved and sometimes consumers.

For our narrative, we focus on data sharing and the complementarity of data and algorithms that the two firms have developed. Important M&As have happened in the past few years that seemed motivated by the potential synergies from aggregating and matching data sets. For instance, Facebook acquired WhatsApp to merge phone numbers with the profiles of Facebook

¹[Anton and Yao \(2002\)](#) similarly show the risk of expropriation for inventors who must reveal their inventions’ inner workings before a sale.

²Throughout the article, we use equivalently the terms information “sharing” and “selling,” consistently with the literature ([Hörner and Skrzypacz, 2016](#)) and with the definitions adopted in recent data protection laws (see for instance the [California Consumer Privacy Act](#)).

users. Google has acquired Fitbit to complement the high-precision profiles that Google has built thanks to its online services with health data collected by the wearable devices sold by Fitbit.

In these data-driven M&A, the profits of a firm can be enhanced by leveraging the data accumulated by the target into its algorithm, but this is not a certainty: the synergies between the data and algorithms of firms are unknown before the M&A, even if both companies have a good understanding of the likelihood of these synergies. Because digital products now rely heavily on data to provide consumers with a high-quality experience, potential information synergies play a central role in the M&A decision of digital firms such as Google and Facebook. At the same time, a firm that shares its data usually weakens its competitive position, especially if the merger does not go through and firms compete. In the case of Google and Fitbit, if Google obtained part of the data accumulated by Fitbit, it could develop its product or algorithm and compete with Fitbit using this data to provide consumers with better personalized recommendations and overall better product quality.

We characterize the optimal level of information sharing and show that, while sharing will reduce the extent of inefficient M&As, firms do not always find it profitable to share information. If, after exploration, synergies are learned to be low, an acquisition is not beneficial, and firms compete, placing the firm that has shared its data in a worse situation than in the absence of information sharing. However, if synergies are high, acquisition becomes beneficial, and the total industry profits may be greater than when there is no sharing. The equilibrium amount of shared information balances these two opposite effects of information sharing on the firms' profits.

Central for the decision of firms to share data before the M&A is the impact of data sharing on their competitive profits when synergies are low. All other things equal, the lower the competitive loss in case of low synergies, the higher the expected payoff of the industry, and the greater the equilibrium amount of information shared by firms. This novel effect has important implications for understanding the choice of a target by a prospective buyer. In the case of quality competition to which we apply our general framework, the expected payoff of the information receiver *increases* when the value of low synergies *decreases*, as it also reduces the intensity of competition in case the merger does not go through. This reverses the standard analysis where the expected payoff of a firm increases when the loss in case of low synergies becomes smaller.

A regulator such as a competition authority will have a lenient view on information sharing

practices: competition between firms will be fiercer after the information is shared, to the benefit of consumers. However, for this reason, the regulator will be tempted not to encourage M&As even if synergies are high. Assuming that the weight placed by a regulator on consumer surplus is uncertain when firms engage in M&A proceedings, we show that the presence of a regulator has an ambiguous impact on the equilibrium amount of information shared by the companies. If the regulator values competition between firms, a M&A is more likely to be refused when shared information increases. This weakens the incentives for firms to share information. Perhaps less obvious, we show that the prospective buyer may want to acquire more information if there is a risk that the M&A is not allowed.

The remainder of this article is organized as follows. We review the literature on M&As in Section 1, we describe the model in Section 2, and we characterize the equilibrium in Section 3. We analyze in Section 4 how regulation would shape information sharing and welfare. We extend the model in several directions in Section 5. We conclude in Section 6.

1 Literature

Information sharing and competition policy. Competition policy for the digital era has been the object of growing attention in the past few years. While [Scott Morton, Bouvier, Ezrachi, Jullien, Katz, Kimmelman, Melamed and Morgenstern \(2019\)](#) and [Shapiro \(2019\)](#) call for a tightening of merger policy to fight abuses of dominant position, [Cabral \(2021\)](#) suggests caution so as not to discourage innovation. The role of data is central to this debate, as the success of digital companies is primarily built upon the collection, use, sharing, and sale of vast amounts of consumer data ([Varian, 1989](#); [Bergemann and Bonatti, 2015](#)). However, data are a competitive asset ([Hagiu and Wright, 2020](#)), and because of the non-rival nature of information, firms are reluctant to share data with their competitors.

Consequently, the literature sees information sharing between companies as a way to promote competition in digital markets ([Martens, De Streel, Graef, Tombal and Duch-Brown, 2020](#)).³ [Tirole \(2020\)](#) and [Cr mer, de Montjoye and Schweitzer \(2019\)](#), among others, suggest ensuring fair

³Practices of information sharing have been well analyzed in economics ([Vives, 1984](#); [Gal-Or, 1986](#)). It is acknowledged that sharing information can have pro- or anti-competitive effects, in particular depending on the nature of competition (Cournot vs. Bertrand).

and equal access to information between firms following fair, reasonable, and non-discriminatory licensing terms.⁴ By doing so, firms would have equal access to data and could compete on a level playing field.

On the contrary, [Jones and Tonetti \(2020\)](#) argue that companies attempt to prevent competitors from accessing their data to maintain a substantial competitive advantage over a market. The ability to secure exclusive access to high-quality, relevant data is viewed by many as a cause for the domination of digital markets by companies such as Facebook and Google.

An essential way for large companies to maintain their data-based competitive advantage is by acquiring new sources of information. For this reason, and since combining data sets can yield essential information synergies, the merger of two firms' data sets can motivate M&As ([Stucke and Grunes, 2016](#)). The European Commission investigated this possibility in the acquisition of WhatsApp by Facebook ([Argentesi, Buccirosi, Calvano, Duso, Marrazzo and Nava, 2019](#)).⁵ More recently, the European Commission gave its green light for Google to acquire Fitbit under the condition that data from both companies would not be merged,⁶ as the resulting information synergies would increase the market power of Google, reducing consumer welfare in turn. Microsoft has also recently tried to acquire the large consumer base and the related consumer data of Discord, a fast-growing social media.⁷

Synergies. The literature has extensively studied the sources of synergies resulting from M&As.⁸ [Chatterjee \(1986\)](#) distinguishes three types of synergies: financial, operational, and collusive, and indicates that collusive synergies are associated with the highest value from a M&A, while operational synergies are associated with the lowest value. Nevertheless, [Mukherjee, Kiyamaz and Baker \(2004\)](#) report that operational synergies are provided by firms as the main reason to merge. In contrast, [Gupta and Gerchak \(2002\)](#) quantify operational synergies and highlight the importance of the acquirer's product characteristics and the target for synergies to arise. [Larsson](#)

⁴This suggestion also echoes [Admati and Pfleiderer \(2000\)](#) who analyze the importance of the disclosure of financial information by firms.

⁵Facebook lied to the Commission by claiming that data sets owned by the two companies were impossible to merge, and the Commission eventually fined Facebook for concealing the potential for information synergies of the M&A ([Commission fines Facebook €110 million for providing misleading information about WhatsApp takeover](#), last accessed 04/12/2021).

⁶[Mergers: Commission clears acquisition of Fitbit by Google, subject to conditions](#), last accessed 03/01/2022.

⁷[Microsoft in Talks to Buy Discord for More Than \\$10 Billion](#), Bloomberg 03/23/2021.

⁸[Damodaran \(2005\)](#) reviews different types of synergies considered in the literature and assesses what issues can emerge from misperceptions of the benefits of different synergies.

and Finkelstein (1999) focus on the importance of a common culture between two companies for M&As to succeed, demonstrating that synergy realization is a function of the similarity and complementarity of the two merging businesses and the extent of interaction and coordination during the organizational integration process. Madura and Ngo (2008) reveal that the valuation of synergies by companies and markets is based on synergies measured in recent takeovers in the same industry.

Our focus in this paper will be on uncertain synergies and how the merging parties can anticipate their extent by sharing data. Leccese, Sweeting, Tao and Yao (2022) also start from the observation that synergies (reducing production costs) may not be known before a merger and focus on the informational rents that firms will obtain since the regulator is uninformed.

This literature does not consider information synergies, probably because data have only recently become essential for many business models. As Parker, Petropoulos and Van Alstyne (2021) emphasize, information synergies naturally arise depending on the complementarity of data sources, and they have become essential elements of M&As between digital companies. A firm has incentives to learn the potential for complementarity before engaging in data-driven M&As, and we will show how companies can use information sharing to assess information synergies.

By contrast, the literature on information theory has long acknowledged the importance of information synergies. A recent trend in the literature has focused, in particular, on quantifying unique, redundant, and synergistic information when considering two data sets. For instance, Bertschinger, Rauh, Olbrich, Jost and Ay (2014), Griffith and Koch (2014), and Olbrich, Bertschinger and Rauh (2015) discuss how information synergies can arise when merging data sources. This literature is the theoretical starting point of our interest in information synergies from M&As. Moreover, Sootla, Theis and Vicente (2017) empirically measures the synergistic coefficient of two data sets. This last article supports several hypotheses that we use in our model. In particular, an ‘exploration’ cost is required to learn synergies between data sets.

Selling innovation and information. This article is closely related to the literature on the sale of technology. d’Aspremont, Bhattacharya and Gérard-Varet (2000) focus on a problem in which a seller can disclose verifiable knowledge used for contracting. Anton and Yao (2002)

analyze how inventors can reveal part of their innovations to prospective buyers to signal their quality. In their article, the inventor cannot sell its product to consumers, a case nested in our model when the incumbent makes zero profits under competition.

These questions have recently been revisited by a growing literature on the sale of information (Bergemann and Bonatti, 2015; Kastl, Pagnozzi and Piccolo, 2018; Bergemann and Bonatti, 2019; Bounie, Dubus and Waelbroeck, 2021). In particular, Hörner and Skrzypacz (2016) analyze sequential information disclosure by a privately informed agent when the receiver can expropriate the shared information. We contribute to this literature by considering the possibility of the information receiver using the information to compete with the sender and by showing how this competitive effect impacts equilibrium information sharing.

Data-driven M&As. We also overlap with recent literature that analyzes the competitive impacts of data-driven M&As.⁹ De Corniere and Taylor (2020) characterize whether data is pro or anti-competitive, while Bounie, Dubus and Waelbroeck (2023) analyze mergers between data intermediaries and their competitive impact on product markets. Chen, Choe, Cong and Matsushima (2022) consider an environment where data-driven mergers increase consumer surplus as long as competitors remain in the market. These articles focus on the consequences of M&As assuming perfect information on their potential outcomes. By contrast, we assume that participants usually do not know the extent of their complementarities, particularly regarding information synergies. They can discover this synergistic value and make better decisions by sharing information before the M&A occurs.

2 Model

We consider two firms, indexed by 1 and 2 that are competitors for providing a service or product. The baseline model in Section 3 assumes that if firms decide to merge, no regulator can prevent the M&A. Regulatory oversight is explored in Section 4.

Figure 1 introduces the sequence of events, we then delve into each stage and the variables of interest as well as our main assumptions. The extensive form is given in the Appendix, where

⁹Chirita (2018) calls for accounting for potential privacy loss when assessing the impacts of data-driven M&As.

we also provide a quality competition rationale for the assumptions made below.

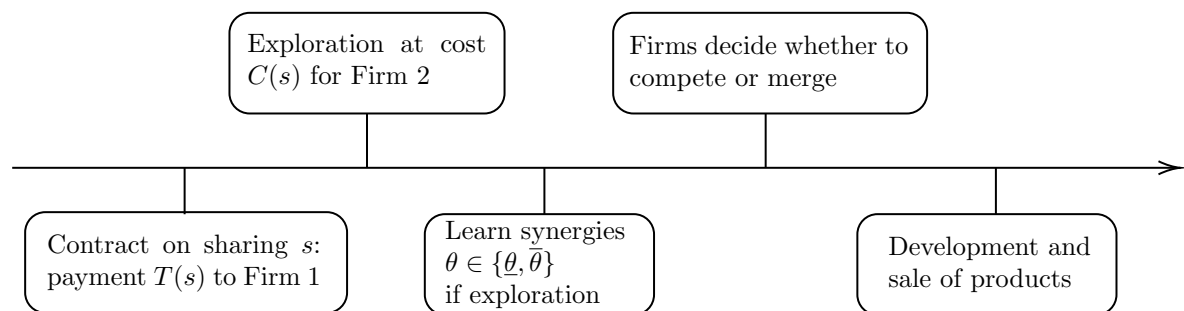


Figure 1: Sequence of events

Sharing and contracting. The firms have a stock of data generated by their activities. Firm 1 can share a proportion $s \in [0, 1]$ of its data with Firm 2 in exchange for a lump sum transfer $T(s)$.

Allowing firms to contract on the amount of data shared s requires Firm 2 to know the total stock of data owned by Firm 1, or at least to have a good estimation of this total amount of information. This is usually the case for digital firms that regularly disclose their number of users, and for which data protection laws require consumers' consent before collecting their data. For instance, a mobile application must ask consumer approval before accessing specific sources of information, such as the microphone, camera, or specific folders, and before collecting the related data (Kesler, Kummer and Schulte, 2020; Affeldt and Kesler, 2021). Overall, in digital M&As, firms now regularly assess which data their potential targets have access to and the size of their data stock. For instance, Facebook had a good idea of the size of the consumer base of WhatsApp and of the type of data collected by the social media before initiating the M&A,¹⁰ and similarly for Google before acquiring Fitbit.¹¹

The assumption of ex-ante payments conditional on the amount of data shared streamlines the main analysis. We show in Section 5.3 that information sharing can occur without money transfer when TIOLI merger offers are replaced by cooperative Nash bargaining.

¹⁰See e.g., [In One Chart, Here's Why Facebook Is Blowing \\$19 Billion On WhatsApp](#). Forbes, February 19, 2014.

¹¹See [Google closes \\$2.1B acquisition of Fitbit as Justice Department probe continues](#). Fierce, January 14, 2021. In general, it is easy for a firm such as Google to reverse-engineer a Fitbit device, identify the different sensors and captors that collect data, and understand the type of data to which Fitbit has access.

Synergies and exploration. Combining data from Firms 1 and 2 will generate information synergies of value $\theta \in \{\underline{\theta}, \bar{\theta}\}$, $\bar{\theta} > \underline{\theta}$, that will impact the profits of the firms and the surplus of consumers. The value of θ is unknown to firms, but each company knows that $\theta = \underline{\theta}$ with probability α , and $\theta = \bar{\theta}$ with probability $1 - \alpha$.¹² The firms may learn the value of the synergies, and Firm 2 will learn how to develop a product that uses the data from Firm 1. This learning entails a cost of exploration of $C(s)$.

To simplify, we assume in the basic model analysis that both firms learn synergies. We show in Section 5.1 that our results are robust to the case where Firm 2 receives this information privately.

It is well documented in the literature on statistics and machine learning that inferring information from missing data is costly and that statistical models perform better when more data is available (see, e.g., [Neiswanger and Xing \(2017\)](#)). (Intuitively, if more data increases the cost of exploration, Firm 2 can always focus on a subset of the database.) For this reason, we assume that the exploration cost $C(s)$ required to learn the level of synergies decreases with s . For simplicity, we also make standard Inada conditions:

$$(H1) \quad \text{Exploration cost: } C(s), C''(s) \geq 0, C(0) = +\infty, C'(0) = -\infty, \text{ and } C'(1) = 0.$$

For developing a product using data from Firm 1, Firm 2 incurs other costs, like structural costs to store and analyze the data, develop new algorithms, and integrate the data into its systems. These costs are usually increasing with the amount of data shared. Our profit functions below are net of these structural costs.

Merger decision. The decision to merge can happen under imperfect information if synergies are not learned (either because no information is shared or because Firm 2 does not explore). If Firm 2 has acquired and explored data from Firm 1, firms can also merge with perfect information about the synergy. Hence, sharing and exploration allow the decision to merge to be contingent on the level of the synergy, thereby increasing the total ex-ante industry expected profit, net of the exploration cost.

¹²Our results also hold for the general distribution of probabilities over a continuous set of outcomes of the type $\theta \in [\underline{\theta}, \bar{\theta}]$. For simplicity, we focus on the binary case.

For a M&A to take place, we focus on Firm 2 making a TIOLI offer to Firm 1 and capturing all industry surplus from the merger. We will see that this bargaining mode yields an equilibrium amount of data shared that also maximizes industry profits. We analyze other distributions of bargaining power in Section 5.3. In particular, we will show that the amount of information shared by Firm 1 depends on the bargaining power of each firm and that a different bargaining power may impact the willingness of Firm 1 to share information and engage in a merger. Hence, the interactions of the firms at the time of the M&A - which firm makes the TIOLI offers and how is the surplus from the merger distributed among the firms - are not neutral and may impact the outcome of the game.

We denote by $\pi^M(s, \theta)$ the profit of the merged firm, which depends on the amount of information explored by the firm after the merger and the value of the synergies. More data *explored* increases the monopoly profit in any state:

$$(1) \quad \pi^M(s, \theta) \text{ is increasing in } s, \theta.$$

Development. If there is development and competition, the firms' profits (which include the development costs for Firm 2) are denoted by $\pi_i(s, \theta)$, continuous in s for any θ , and are net of these structural costs.¹³

Without development, profits under competition are

$$(2) \quad \pi_1^0, \pi_2^0, \text{ where } \pi_i^0 = \pi_i(0, \theta), \forall i, \theta.$$

Integrating data from Firm 1 into its algorithms allows Firm 2 to enhance the consumer value for its product to an extent that depends on the value of information synergies. In a competitive setting, this may negatively impact the profit of Firm 1 (Arrow, 1962a; Anton and Yao, 2002).

The literature has shown that data sharing may increase or decrease a firm's profits that share its information. For instance, information sharing can facilitate coordination between firms and increase the profits of the firm sharing its data. Nevertheless, sharing a valuable asset can reduce a firm's profits, as analyzed by Anton and Yao (2002). Vives (1984) and Gal-Or (1986) have

¹³The profit of Firm 2 may capture potential synergies across products when Firm 2 operates in multiple markets. Hence, our model captures cross-market data externalities.

also shown that firms may lose profits when sharing information on market demand or private cost structures with their competitors. If the first effect dominates, there is no tradeoff between the competitive loss and the merger gain, and our mechanism starts playing a role as long as the profits of Firm 1 decrease for a nontrivial set bounded above by one. For simplicity, we assume that the second effect dominates the first and that data sharing reduces the profits of Firm 1 for all values of s .

$$(H2) \quad \text{Arrow effect: } \frac{\partial \pi_2(s, \theta)}{\partial s} \geq 0 \geq \frac{\partial \pi_1(s, \theta)}{\partial s}.$$

In practice, receiving data allows a firm to personalize its product to customers' needs, improve recommendations, and optimize its advertising campaigns. In the quality competition framework that we analyze in the Appendix, data directly increases the product's quality and the consumers' utility to the detriment of the competitor.

The Arrow assumption is compatible with an industry profit increase in the data shared. We assume that sharing data reduces the industry's total profits when synergies are low, leaving the possibility that industry profit increases with s when synergies are high.

$$(H3) \quad \text{Industry loss with low synergies: } \frac{\partial(\pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta}))}{\partial s} < 0.$$

For ex-ante information sharing to create an option value, we assume that the industry profit is greater under a merger than under competition only if there are high synergies, that is

$$(H4) \quad \begin{aligned} \text{Option value: } \pi^M(1, \bar{\theta}) &> \pi_1(s, \bar{\theta}) + \pi_2(s, \bar{\theta}), \\ \pi^M(1, \underline{\theta}) &< \pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta}). \end{aligned}$$

3 Equilibrium Analysis

Given our assumption that both firms learn the level of synergy if there is exploration, the game is one of symmetric information. Our concept of equilibrium is subgame perfection, and as usual, we proceed backward in our analysis.¹⁴

¹⁴See Appendix A for the extensive form representation of the game.

We first consider Firm 2, which has acquired data from Firm 1, and we characterize the firms' profits if Firm 2 chooses to explore the data and to compete or merge with Firm 1. We then derive the expected payoff of Firm 2 and characterize the optimal amount of information acquired by Firm 2. We show that information sharing allows Firm 2 to avoid the M&A when synergies are low, and, in equilibrium, information sharing is always more profitable for Firm 2 than a M&A under imperfect information.

3.1 Exploration Decision, M&A and Competitive Profits

The profit following a merger $\pi^M(s, \theta)$ depends on the realization of θ and the amount of explored data. Depending on the value of synergies, this profit may be greater or lower than the total industry profits before the merger when firms compete. For instance, in the case of digital products that intensively use consumer data, the developer's identity of a product is not neutral: a product developed by Google has the stamp "Google" on it; in particular, it inherits consumers' concerns about privacy. In the case of Google and Fitbit, the acquisition of Fitbit's data by Google has raised red flags among data protection agencies willing to protect consumer privacy, and many consumers were reluctant to have their health data acquired by a privacy-threatening firm like Google. For this reason, when a company such as Google or Facebook acquires another digital firm, the profits of the merged entity can decrease overall despite positive information synergies. This loss also captures the costs firms incur when they engage in a M&A, and because of this, a merger may generally be detrimental to firms.

We have assumed that product development using data from Firm 1 can happen only if Firm 2 has spent the exploration cost. Nevertheless, it is possible that Firm 2 decided not to develop a product incorporating data from Firm 1 after exploring. For instance, if s is shared and $C(s)$ is spent for exploring, upon learning that synergies are low, if Firm 2 competes with Firm 1, it will develop a new product only if $\pi_2(s, \underline{\theta})$ is greater than π_2^0 . The Arrow hypothesis (H2) together with (2) preclude such possibilities.

Therefore, there are two exclusive cases to consider: when the firms know the synergy before deciding to merge and when they do not.

3.1.1 Firm 1 shares s and Firm 2 spends $C(s)$.

In this case, at the time of a merger, the firms know that they can use all the data post-merger without paying an additional exploration cost. Hence the post-merger profit equals $\pi^M(1, \theta)$ in state θ . Under Assumption (H4), firms are willing to merge when synergies are high but may lose profits if synergies are low, and the industry ex-ante profit if s is shared and exploration happens is

$$(3) \quad \Pi^e(s) := (1 - \alpha)\pi^M(1, \bar{\theta}) + \alpha(\pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta})) - C(s).$$

3.1.2 Firm 1 does not share s or Firm 2 does not explore before the merger.

Absent a merger, the industry profit is $\pi_1^0 + \pi_2^0$. If there is a merger, and the merged firm explores an amount $s \in [0, 1]$ of data, the industry profit is equal to

$$\mathbb{E}[\pi^M(s, \theta)] := \alpha\pi^M(s, \underline{\theta}) + (1 - \alpha)\pi^M(s, \bar{\theta}).$$

Hence, the maximum profit at the time of the merger is $\max_s \mathbb{E}[\pi^M(s, \theta)] - C(s)$. Under assumptions (H1) and (1), if the firm decides to explore, exploring all data after the merger is optimal and the expected payoff of the industry is $\mathbb{E}[\pi^M(1, \theta)] - C(1)$.

The merged firm may also decide not to explore the data after the merger and make profits equal to $\pi^M(no)$.¹⁵ Hence, if firms merge under imperfect information, the combined firm compares its expected profits with and without exploration to make its exploration decision. A merger under incomplete information is beneficial only if

$$(4) \quad \max[\mathbb{E}[\pi^M(1, \theta)] - C(1), \pi^M(no)] \geq \pi_1^0 + \pi_2^0.$$

a M&A is ex-ante efficient for firms if condition (4) is satisfied and the expected payoff of a merger under imperfect information is greater than total industry profits without information sharing. It is clear that without information, Firm 2 will acquire Firm 1 only when the M&A is

¹⁵These profits may be greater than the industry competitive payoff without sharing $\pi_1^0 + \pi_2^0$ if the merger yields sufficient efficiency gains. It may also be lower in case of high merger costs or strong culture shock between the merging firms.

ex-ante efficient.

Remark 1. *This ignores the possibility for the firms to undo the merger if they lose profits when they merge. This is without loss of generality if divestment is costly, as we show in Section 5.2. Our Google-Fitbit narrative also highlights the difficulties for firms to undo a merger. In particular, assuming that firms can separate in case of low synergies would ignore privacy concerns that play an important role in consumers' valuation of digital products. Such concerns could hardly be forgotten if, after the merger, synergies were low and firms were to separate their activities.*¹⁶

Hence, the value of firms not sharing information or Firm 2 not exploring is

$$\Pi^{no} := \max[\mathbb{E}[\pi^M(1, \theta)] - C(1), \pi^M(no), \pi_1^0 + \pi_2^0].$$

There will be sharing of information if there exists s such that $\max_s \Pi^e(s) \geq \Pi^{no}$.

3.2 Profits with Information Sharing

Suppose Firm 1 shares s with Firm 2, and Firm 2 agrees to pay $T(s)$ to Firm 1 for this amount of data. Upon receiving s , Firm 2 can decide to invest $C(s)$ to learn the value of synergies. In this case, the two firms anticipate payoffs $\pi_i(s, \theta)$ if there is no M&A. Firm 2 can make a TIOLI offer to buy Firm 1's asset at a price $\pi_1(s, \theta)$ that will make Firm 1 indifferent between merging and not merging.

Under Assumption (H4), Firm 2 wants to merge only when synergies are high. Moreover, according to the Arrow effect, Firm 1 incurs a competitive loss from sharing information, and Firm 2 pays $T(s) = \pi_1^0 - \mathbb{E}[\pi_1(s, \theta)]$ to compensate for this loss and to acquire information s .

Lemma 1. *Firm 2 pays $\pi_1^0 - \mathbb{E}[\pi_1(s, \theta)]$ for s and $\pi_1(s, \bar{\theta})$ to acquire Firm 1 when synergies are high.*

Firm 2 is willing to acquire information only if it can recoup the exploration cost and the price of information. The expected value of Firm 2 purchasing information s from Firm 1 is equal to $\Pi^e(s) - \pi_1^0$.

¹⁶See for instance 'Tossed my Fitbit in the trash': users fear for privacy after Google buys a company, *The Guardian*, November 6, 2019.

An increase in the amount of information shared has two opposite effects on the expected profits of Firm 2. On the one hand, more information is costly to acquire from Firm 1, which lowers the earnings of Firm 2. Under Assumption (H3), $\frac{\partial(\pi_1(s,\theta)+\pi_2(s,\theta))}{\partial s} < 0$ and the potential gains for Firm 2 acquiring s information in the competition mode when synergies are low are always dominated by the loss of Firm 1, captured by transfer $T(s)$. To minimize this loss, Firm 2 needs to learn the value of synergies using the smallest possible information.

On the other hand, more information decreases the data exploration cost $C(s)$. Under (H1), using only a small share of data to learn the synergies induces a very high cost, which is not profitable for Firm 2. Overall, the optimal amount of information shared balances these two opposite effects of information acquisition on the profits of Firm 2.

3.3 Ex-Ante Information Sharing

The value of ex-ante sharing will be to improve merger decisions. Under incomplete information, the merger decision is not conditional on the level of synergies. However, merging under low synergies is inefficient, and merging under high synergies can be efficient. Therefore, the sharing of information creates an option for the firms, the value of the option depends on the incomplete information outcome. If competition dominates a merger under incomplete information, sharing can allow merging when synergies are high. If merging dominates competition under incomplete information, sharing will prevent a merger when synergies are low.

Now, the value of merging under incomplete information reflects the desire of the merged entity to explore synergies post-merger. As a reminder, $\pi^M(no)$ is the monopoly profit when there is no exploration, and $\mathbb{E}[\pi^M(1,\theta)] - C(1)$ is the expected monopoly profit when there is exploration. Because $\mathbb{E}[\pi^M(1,\theta)]$ is maximum when the probability of low synergies is zero, there will not be exploration after the merger when $\pi^M(1,\bar{\theta}) - C(1)$ is inferior to $\pi^M(no)$.¹⁷ Under incomplete information about synergies, the value of the merger will be a decreasing function of the probability of low synergies,

With information sharing, the option applies. Whether or not sharing avoids inefficient mergers or allows efficient mergers is related to whether a merger under incomplete information

¹⁷Indeed, if $\pi^M(1,\bar{\theta}) - C(1) \leq \pi^M(no)$, the value under a merger is equal to $\pi^M(no)$ independently of α . Therefore there is no incentive to share information to learn synergies.

dominates the competitive outcome.

There are two drivers for profits under a merger. The usual effect of “avoidance of competition” suggests that even without further synergies, profits are larger than under competition. This will be the case in our notation when $\pi^M(no)$ is greater than $\pi_1^0 + \pi_2^0$. In this case, there is always a merger under incomplete information. Nevertheless, ex-ante sharing has value if the expected benefit of avoiding an inefficient merger under low synergies is large enough.

Due to the (negative) brand image of Firm 2, X-inefficiencies, or other organizational costs, a second effect may negatively impact profits for the merged entity. Therefore, $\pi^M(no)$ could be smaller than $\pi_1^0 + \pi_2^0$. If the effect is large enough, a merger under incomplete information will happen only if the probability of low synergies α is small. Under this scenario, as α increases, sharing first helps prevent inefficient mergers under low synergies. As α becomes larger than the value under which there would be no merger under incomplete information, sharing helps generate mergers under high synergies.

This intuition is formally established in the following proposition.¹⁸

Proposition 1.

- (i) *There is information sharing only if $\pi^M(1, \bar{\theta}) - C(1) \geq \max[\pi^M(no), \pi_1^0 + \pi_2^0]$.*
- (ii) *Under this condition,*
 - (a) *If $\pi^M(no) > \pi_1^0 + \pi_2^0$, there is information sharing if, and only if, $\alpha \leq \alpha_0$, where $\alpha_0 \in (0, 1)$. There is always a merger, and sharing prevents inefficient mergers (when synergies are low).*
 - (b) *If $\pi^M(no) \leq \pi_1^0 + \pi_2^0$, there exists α_1 and α_2 , with $0 < \alpha_1 < \alpha_2 < 1$ such that information sharing happens if, and only if, $\alpha \leq \alpha_2$. Sharing prevents inefficient mergers when $\alpha \leq \alpha_1$ and allows efficient mergers when $\alpha \in (\alpha_1, \alpha_2]$.*

Proposition 1 has interesting implications. First, all things equal, the expected payoff of Firm 2 increases when $\pi_1(s, \underline{\theta})$ increases. Indeed, because Firm 1 loses less when there is competition, Firm 2 can pay a lower price for information. Second, in the extreme case where the competitive loss when data is shared is equal to zero (for all s , $\frac{\partial(\pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta}))}{\partial s} = 0$), Firm 2 acquires all

¹⁸Proofs missing from the text are in the Appendix.

available information and learns the value of synergies at a cost $C(1)$. Hence, its expected profits are equal to those under complete information at the beginning of the game. Finally, information sharing allows for conditionality in merger decisions and when ex-ante mergers are efficient, will prevent inefficient mergers when low synergies exist. Therefore if the industry profit under low synergies increases, the option value of sharing increases. An example may be when information sharing facilitates collusion. In this case, $\pi_1^0 + \pi_2^0$ is not affected, but for any s , the industry profit $\pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta})$ will increase, therefore increasing the likelihood of mergers.

4 Information Sharing in the Shadow of a Regulator

We introduce a regulator in charge of allowing or preventing the M&A. Even if regulators should focus on consumer surplus, as in Europe, their ultimate decision may reflect other political or economic considerations or even the individual bias of the regulator in charge of the M&A case. For instance, the recent decision of the European Commission to prevent the merger between Alstom and Siemens was made in the shadow of intense political lobbying by the French and German governments, and many factors, beyond consumer surplus, were considered by the commission.¹⁹ We will model this by assuming, in the spirit of [Baron and Myerson \(1982\)](#), that the regulator maximizes a welfare function that balances industry profits and consumer surplus.²⁰

We denote by $\rho \in [0, 1]$ the weight the regulator places on consumer surplus and by $1 - \rho$ the weight placed on industry profits.²¹ We assume that firms do not know the value of ρ before sharing information and requesting M&A approval. This model is isomorphic to a setting in which the bias of the regulator ρ is public knowledge but where there is noise on a per-case basis.²² After firms have asked for approval of the merger, the type of regulator is drawn from the distribution $F(\rho)$, and the regulator makes a decision.

Hence, when the firms ask for approval of the M&A, they do not know with certainty which decision the regulator will take; for instance, the composition of the team at the Competition

¹⁹Vestager should stand against Siemens-Alstom M&A; [Financial Times](#), January 17, 2019.

²⁰Additionally, [Grossman and Helpman \(1995\)](#) also consider politically minded governments whose decisions may be influenced by lobbying from the industry.

²¹This weight may be explicit or induced by political lobbying, misinterpretation of the M&A documentation, or ambiguity in other variables used by the regulator to evaluate the M&A.

²²We thank a referee for this alternative interpretation.

Authority is not known ex-ante or the arguments brought by other parties against the merger are not yet known. This assumption seems empirically relevant. It would be otherwise difficult to understand why the parties (and the antitrust authorities) go through a complicated and costly merger approval process with a certain outcome.

Consumer surplus. Without sharing or exploration, CS^0 and CS^M denote, respectively, the consumer surplus when the firms compete and when there is a merger. If there is exploration, consumer surplus depends on the synergies θ . $CS^0(s, \theta)$ and $CS^M(s, \theta)$ are, respectively, the consumer surpluses when a portion s of data has been shared, firms compete, and when there is a merger.

As we have shown in the previous section, if there is exploration, it is optimal for the merged entity to develop a new product using all available data of Firm 1 because $\pi^M(1, \theta) > \pi^M(s, \theta)$ for $s < 1$. In this case, the firms and the regulator, therefore, anticipate that a merger will yield a consumer surplus of $CS^M(1, \theta)$ when synergies are known to be θ or $\alpha CS^M(1, \underline{\theta}) + (1 - \alpha)CS^M(1, \bar{\theta})$ if synergies are unknown.

We assume that consumer surplus under competition increases with the amount of information shared and that a merger harms consumers.

$$(H5) \quad \text{Consumer surplus: for all } (s, \theta), \frac{\partial CS^0(s, \theta)}{\partial s} \geq 0, \text{ and } CS^0(s, \theta) > CS^M(1, \theta).$$

Assumption (H5) is consistent with a narrative where the quality of the products increases with the amount of data received by Firm 2. In this case, consumers benefit from a better product quality sold by Firm 2, and from a higher intensity of competition between firms when s increases. When firms merge, Assumption (H5) implies that the reduction of competition dominates the potential increase of product quality for the merged firm, which is detrimental to consumers.

As industry profits increase when firms merge, a regulator would always allow the merger if consumers were to also benefit from it. Assumption (H5) ensures that a regulator has incentives to block the merger.

4.1 Effect of a Regulator on Information Sharing

To understand the impact of the regulator on the equilibrium amount of information shared by Firm 1, we first consider the case where ρ is common knowledge at the time firms ask for M&A approval. We then consider the case where the value of ρ is unknown to firms.

Assuming that firms do not know the preference parameter ρ allows us to offer novel insights into how regulation affects information sharing. In particular, we will show that firms may share more information when there is a risk that the regulator blocks the merger.

While synergies can arise during the M&A process, they can also be realized under competition when Firm 2 exploits the data provided by Firm 1. Positive synergies create a two-edged sword for the regulator because welfare can increase both under M&A *and* under competition. Consumers benefit if the regulator prevents the M&A, as firms compete more fiercely after sharing information. Therefore, when evaluating a M&A proposal, the regulator will compare the *relative industry gain* weighted by $1 - \rho$ to the *relative loss of consumer surplus* weighted by ρ .

M&A decision without information sharing. Without information sharing, the regulator and the firms have a common interest if the merger increases the expected consumer surplus. In this case, firms ask for approval when the merger yields positive expected gains for the industry, and the regulator always allows a merger to go through. If the merger reduces the expected consumer surplus, the decision of the regulator balances the expected loss of surplus and the expected gains in terms of industry profits.

M&A decision with information sharing and ρ is common knowledge. At the time the regulator has to evaluate a M&A, Firm 1 has already shared s with Firm 2. Hence the exploration cost $C(s)$ is sunk, and both firms know the value of θ . Firms request M&A approval if synergies are high, and the regulator can infer the value of θ from their M&A request. Contrary to the previous case, the objectives of the regulator and the firms are no longer aligned.

Firm 2 asks for merger approval only when $\theta = \bar{\theta}$, and the industry gain if the M&A is allowed is $\pi^M(1, \bar{\theta}) - \pi_1(s, \bar{\theta}) - \pi_2(s, \bar{\theta})$. The difference of consumer surplus after and before the merger is equal to $CS^M(1, \bar{\theta}) - CS^0(s, \bar{\theta})$ and depends on the amount of data shared s . Under Assumption (H5), this difference is always negative and the merger is detrimental to consumers.

Hence, the regulator balances the gains in industry profits and the losses of surplus when making its merger approval decision. Overall, the regulatory welfare gain from the M&A is:

$$(5) \quad W(s, \rho) := (1 - \rho) \underbrace{(\pi^M(1, \bar{\theta}) - \pi_1(s, \bar{\theta}) - \pi_2(s, \bar{\theta}))}_{\text{Industry gains}} + \rho \underbrace{(CS^M(1, \bar{\theta}) - CS^0(s, \bar{\theta}))}_{\text{Surplus loss}}.$$

At the time Firm 2 acquires information, it anticipates the decision of the regulator and chooses s accordingly. There are two cases to consider depending on the sign of $W(s^*, \rho)$, where s^* is the optimal amount of information shared in the no-regulator case. If $W(s^*, \rho) \geq 0$ the regulator allows the merger to go through and the amount of information shared is equal to the unconstrained optimum s^* . If $W(s^*, \rho) < 0$ the regulator would block the merger if s^* is shared, and the firm must change the amount of information shared for the merger to be accepted.

The variation of the welfare gains from regulation with respect to s is

$$\frac{\partial W(s, \rho)}{\partial s} = -(1 - \rho) \frac{\partial(\pi_1(s, \bar{\theta}) + \pi_2(s, \bar{\theta}))}{\partial s} - \rho \frac{\partial CS^0(s, \bar{\theta})}{\partial s}.$$

and has an ambiguous sign. Indeed, we have made no assumption on the value or the variation of industry profits when data has been shared and synergies are high. Hence, $\frac{\partial(\pi_1(s, \bar{\theta}) + \pi_2(s, \bar{\theta}))}{\partial s}$ can be positive or negative. Under Assumption (H5), $CS^0(s, \bar{\theta})$ increases with s , and more data shared increases the loss of surplus in case the merger goes through, therefore the total variation can be positive or negative.

M&A decision with information sharing and ρ is not realized. We now consider the case where firms do not know the value of ρ before asking for merger approval. We show that this uncertainty creates a new effect that increases the willingness of firms to share information.

We note $G(s) = \pi^M(1, \bar{\theta}) - \pi_1(s, \bar{\theta}) - \pi_2(s, \bar{\theta})$ the industry gains and $L(s) = CS^M(1, \bar{\theta}) - CS^0(s, \bar{\theta})$ the loss of consumer surplus in case of high synergies. By (H4), $G(s) > 0$ so that Firm 2 is willing to merge, and by (H5), $L(s) < 0$ so that the merger reduces consumer surplus and may not be approved by the regulator depending on the value of ρ .

As ρ is unknown by firms, the impact of regulatory oversight on the amount of information shared by Firm 1 becomes elastic, as stated in Lemma 2.

Lemma 2. *There exists a function $\rho^*(s)$ such that the regulator authorizes the M&A if, and only if, $\rho \leq \rho^*(s)$. Hence, the probability of a M&A is $F(\rho^*(s))$, with:*

$$(6) \quad \rho^*(s) = \frac{G(s)}{G(s) - L(s)}.$$

Simple computations show that $\rho^*(s)$ increases with s if and only if $\frac{L'(s)}{L(s)} > \frac{G'(s)}{G(s)}$, that is when the loss elasticity is greater than the gain elasticity with respect to s .

When $\frac{L'(s)}{L(s)} < \frac{G'(s)}{G(s)}$, the probability $F(\rho^*(s))$ that a M&A is allowed always decreases with s . Companies compete more fiercely when more information is shared, which benefits consumers, and this effect always dominates the benefits of a merger for industry profits. The opportunity cost of a M&A is thus larger for higher values of s and a M&A is beneficial only if ρ is large enough.

Consequently, with the presence of the regulator, the expected payoff of Firm 2, net of the no-sharing payoff π_2^0 , when purchasing information s from Firm 1 is:

$$(7) \quad \begin{aligned} u_2(s) = & (1 - \alpha) [F(\rho^*(s)) \underbrace{(\pi^M(1, \bar{\theta}) - \pi_1^0 - \pi_2^0)}_{\text{Industry gains if the merger is approved}} \\ & + (1 - F(\rho^*(s))) \underbrace{(\pi_2(s, \bar{\theta}) + \pi_1(s, \bar{\theta}) - \pi_1^0 - \pi_2^0)}_{\text{Industry profit change if the merger is blocked}}] \\ & + \alpha \underbrace{(\pi_2(s, \underline{\theta}) + \pi_1(s, \underline{\theta}) - \pi_1^0 - \pi_2^0)}_{\text{Industry competitive loss if synergies are low}} - C(s). \end{aligned}$$

While it is immediate that Firm 2's expected payoff decreases in the presence of a regulator, it does not follow that the marginal incentives for information sharing decrease. Using (3) and (7), we can write for $s \in [0, 1]$:

$$(8) \quad \begin{aligned} u_2(s) = & \Pi^e(s) - \pi_1^0 - \pi_2^0 - (1 - \alpha)K(s) \\ \text{where } K(s) := & (1 - F(\rho^*(s))) \underbrace{(\pi^M(1, \bar{\theta}) - \pi_1(s, \bar{\theta}) - \pi_2(s, \bar{\theta}))}_{\text{Industry profit loss from merger prevention}} \end{aligned}$$

and $\Pi^e(s)$ is the industry profit when there is no regulator (see (3)). The additional marginal

incentives for information sharing are positive if $K(s)$ has a negative variation. This happens if and only if the following condition holds:

$$\text{(Hazard)} \quad \frac{f(\rho^*(s))}{1 - F(\rho^*(s))} < \frac{G'(s)}{\rho^{*'}(s)G(s)}.$$

Proposition 2. *Companies exchange more information under regulatory oversight if and only if condition (Hazard) holds.*

The relative magnitudes of the two effects lead either to an increase or a decrease in information sharing with respect to the situation of no regulation.

On the one hand, more data shared changes the probability that the merger will be blocked, which is captured by the term $1 - F(\rho^*(s))$. When $\rho^*(s)$ increases with s , sharing more information increases the chances of approval, and the presence of the regulator positively impacts the firms' incentives to share information.

On the other hand, more data shared also changes the profits of the industry $\pi_1(s, \bar{\theta}) + \pi_2(s, \bar{\theta})$ when synergies are high and the merger is blocked. If $\pi_1(s, \bar{\theta}) + \pi_2(s, \bar{\theta})$ increases with s , more data shared increases the competitive payoffs of the industry and in this case, the presence of the regulator can increase the incentives of the firms to share data according to this effect. As sharing data increases the profits of the firms when synergies are high and they compete, the fact that the merger can be blocked induces them to *share more data* to increase their aggregate profits $\pi_1(s, \bar{\theta}) + \pi_2(s, \bar{\theta})$ if they compete. If $\pi_1(s, \bar{\theta}) + \pi_2(s, \bar{\theta})$ decreases with s , the presence of the regulator hurts the incentives of firms to share information according to this effect.

4.2 The Impact of the Regulator on Consumer Surplus

As we have just argued, firms can share more or less information with than without the regulator. When more information is shared, consumer surplus is higher when synergies are low and firms compete under Assumption (H5). Moreover, the regulator can also prevent M&As when synergies are high to force companies to compete and maintain a high level of consumer surplus. In both cases, the presence of the regulator increases consumer surplus compared to a laissez-faire situation.

Proposition 3. *Suppose that condition (Hazard) holds and that information sharing is profitable. Then, the presence of the regulator increases the expected consumer surplus.*

If we are outside the scope of the conditions of Proposition 2, the presence of a regulator lowers the incentives of Firm 2 to acquire information and has ambiguous effects on consumer surplus. On the one hand, a lower amount of shared data reduces consumer surplus when low synergies exist. On the other hand, by preventing some mergers from going through, the regulator increases the expected consumer surplus when synergies are high.

4.3 Regulating Pre-M&A Information Sharing

Another tool for the regulator is to allow or prevent Firm 2 from purchasing information from Firm 1. To simplify, let us assume that a regulatory authority allows information sharing in an industry with a bias equal to ρ_0 . We distinguish between the authority, such as the DG Competition in Europe, and its regulatory agents, for instance, the various teams in charge of M&A review. Regulatory agents will offer advice for a M&A, and they have potentially different views on the importance of industry profits compared to consumer surplus. For example, each agent can be subject to greater or lesser intense lobbying or have different ideological opinions affecting their final decision. The decision to allow or prevent information sharing is not case-specific but holds for all industries, and we assume that the regulatory authority makes it.²³

This regulatory authority compares welfare with and without information sharing and chooses whether to allow companies to share. As the regulator has ρ_0 close to 1 and is mainly concerned with consumer surplus, not allowing information sharing yields a zero surplus to consumers. By contrast, information sharing yields positive consumer surplus whenever synergies are low, or synergies are high, but the M&A is refused. Therefore, a regulator concerned about consumer surplus will allow information sharing in our environment.

Proposition 4. *As ρ_0 gets close to 1, authorizing information sharing is weakly optimal for the regulator. It is strictly optimal if firms choose to share information when they can.*

A regulatory authority strongly oriented toward consumer surplus sees information-sharing practices keenly, as they lead to a higher consumer surplus if the M&A is prevented. However, we

²³A special case is when the authority is representative of the regulators who will decide on M&As, i.e., when $\rho_0 = \mathbb{E}[\rho]$.

have seen that Firm 2's expected payoff decreases when the regulator can prevent some mergers from going through. This implies that a strong bias of the regulator toward consumer surplus can discourage companies from sharing information and rather compete or merge under imperfect information.

4.4 Merger Remedy: Data Silos

In recent flagship M&As such as Facebook/WhatsApp and Google/Fitbit, the European Commission implemented a new type of merger remedy, allowing the merger to go through but preventing the combination of data sources from the merging parties (Krämer, Shekhar and Hofmann, 2021). The rationale behind such data silos is to allow for the positive effects of a merger unrelated to data, such as efficiency gains or the complementarity of the companies' patent portfolios, while preventing potential negative impacts of data-driven effects. The latter usually relates to privacy issues and increased market power resulting from the merger of data sources.

We consider such data silos and analyze whether they increase or decrease the willingness of companies to share their data. We introduce an exogenous probability γ under which the data sources of firms cannot be merged in case the M&A goes through and they cannot fully benefit from the resulting synergies. Consequently, a M&A with data silos is motivated only by reduced competition, and $\pi^M(s, \bar{\theta})$ are the profits after the merger when data silos are requested. Another option for the regulator is to block the merger when synergies are high. To simplify, this probability is known to be $\psi \in [0, 1]$.

With probability $(1 - \gamma)(1 - \psi)$ firms merge and make a profit equal to $\pi^M(1, \bar{\theta})$; with probability $\gamma(1 - \psi)$, firms merge, but data remain separated, and the only synergies that take place are those resulting from the data shared before the M&A, yielding industry profits equal to $\pi^M(s, \bar{\theta})$. Therefore, Firm 2 is still interested in acquiring Firm 1 in the case of high synergies. With probability $(1 - \alpha)\psi$, there are high synergies, but the merger is blocked. Hence, the

expected gains of Firm 2 are equal to:

$$\begin{aligned}
(9) \quad \Pi_2^{silo}(s) &= (1 - \alpha)(1 - \psi) \left[\underbrace{(1 - \gamma)\pi^M(1, \bar{\theta})}_{\text{Industry profits if the merger is approved without silos}} + \underbrace{\gamma\pi^M(s, \bar{\theta})}_{\text{Industry profits if silos requested}} \right] \\
&\quad + (1 - \alpha)\psi \underbrace{(\pi_2(s, \bar{\theta}) + \pi_1(s, \bar{\theta}))}_{\text{Competitive payoffs if high synergies}} \\
&\quad + \alpha \underbrace{(\pi_2(s, \underline{\theta}) + \pi_1(s, \underline{\theta})) - \pi_1^0 - \pi_2^0 - C(s)}_{\text{Competitive payoffs if low synergies}}, \\
&= \Pi^e(s) - (1 - \alpha)(\gamma(1 - \psi) + \psi)\pi^M(1, \bar{\theta}) \\
&\quad + (1 - \alpha)[(1 - \psi)\gamma\pi^M(s, \bar{\theta}) + \psi(\pi_1(s, \bar{\theta}) + \pi_2(s, \bar{\theta}))] \\
&\quad - \pi_1^0 - \pi_2^0.
\end{aligned}$$

The main lesson here is that, for a fixed ψ , data silos increase the incentives of Firm 2 to acquire information because, according to (1) $\pi^M(s, \bar{\theta})$ increases with s . While the firms' incentive to share information increases, their surplus decreases when the probability of a data silo remedy increases.

Proposition 5. *For a fixed probability of blocking a merger under high synergies, a silo remedy will increase information sharing.*

5 Extensions

In this section, we consider several extensions of the baseline model.²⁴ As in the basic model, we ignore the regulation and show that these alternative scenarios may reduce the competitive impact of information sharing and increase the amount of information shared by Firm 1. While we do not explicitly introduce a regulator in these extensions, it should be clear that the qualitative effects identified in Section 4 will be similar.

In Section 5.1 we show that our results are robust to private learning of synergies by Firm 2 and that the equilibrium amount of information shared is obtained when synergies are publicly learned. We consider the possibility of divestment after a M&A in Section 5.2, and we analyze

²⁴This also corresponds to the case where the regulator is entirely oriented toward the industry ($\rho = 0$).

Nash bargaining on the final value of the M&A in Section 5.3. In Section 5.4 we analyze bilateral information sharing between the firms and characterize market conditions under which firms prefer to purchase or exchange information. Finally, we consider data that depreciate with time in Section 5.5.

5.1 Asymmetric Learning of Synergies

In the primary analysis, we have assumed that Firm 1 and the regulator learn the value of synergies when Firm 2 explores the data. However, Firm 2 can also explore the data privately and then report the value of the synergies. We analyze here the possibility of learning synergies privately, showing that it does not impact information sharing and M&A decisions. The intuition is that for Firm 1 to accept the M&A, Firm 2 must offer a higher price when it has private information, which increases the expected payoff of Firm 1 when sharing information. This change will fully translate into a lower cost of information. Therefore, the expected return of Firm 2 when acquiring data from Firm 1 will equal the expected payoff with public learning of synergies. Hence, companies approach the regulator only when synergies are high and there is no information asymmetry.

Consider the situation where after having acquired s and invested $C(s)$, Firm 2 learns θ privately. As usual, there are three candidates for pure strategy signaling equilibrium by Firm 2: pooling and not offering a M&A, pooling and offering a M&A, and separating by offering a M&A only when synergies are high, equivalent to an excluding equilibrium. However, pooling equilibria are not sustainable as Firm 2 is not interested in acquiring Firm 1 when synergies are low. We will therefore focus on the separating equilibrium.

Let $p(s)$ be the price offered by Firm 2 for the M&A when synergies are high and information sharing is s . When synergies are low, Firm 2 does not make an offer to Firm 1. Firm 2 can deviate from the separating strategy in one of two ways.

A first deviation is not to offer a M&A when synergies are high. Firm 2 obtains $\pi_2(s, \bar{\theta})$ in this case. Therefore, deviation is not profitable if $\pi^M(1, \bar{\theta}) - p(s) \geq \pi_2(s, \bar{\theta})$.

A second deviation is to offer price $p(s)$ when synergies are low. In this case, Firm 1 believes that synergies are high and will accept the M&A when $p(s)$ exceeds the competitive payoff

$\pi_1(s, \bar{\theta})$.

It follows that a separating strategy is incentive-compatible when the acquisition price satisfies the inequality.

$$\pi^M(1, \bar{\theta}) - \pi_2(s, \bar{\theta}) \geq p(s) \geq \pi_1(s, \bar{\theta}).$$

Firm 2 maximizes profits by choosing the lowest price that satisfies incentive compatibility, equal to $\pi_1(s, \bar{\theta})$. Therefore, Firm 1's continuation payoff equals $\pi_1(s, \underline{\theta})$ when synergies are low and $\pi_1(1, \bar{\theta})$ when synergies are high. Hence, the equilibrium level of information is identical to the baseline model with symmetric information about θ .

5.2 Possibility of Divestment After the M&A

Firms may engage in a M&A without sharing information and separate the merged entity if low synergies exist. Assume that Firm 1 can achieve profits π_1^0 by operating its company separately. If synergies are low, the former owners of Firm 1 can make a TIOLI offer to Firm 2 and repurchase their company for a value equal to $\pi^M(1, \underline{\theta}) - \pi_2^0 < \pi_1^0$ (we assume that $\pi^M(1, \underline{\theta}) > \pi_2^0$ for simplicity). As a result, Firm 2 can acquire Firm 1 at a price $p = (1 - \alpha)\pi_1^0 + \alpha(\pi^M(1, \underline{\theta}) - \pi_2^0)$, and make an expected payoff at the time of the acquisition equal to $(1 - \alpha)(\pi^M(1, \bar{\theta}) - \pi_1^0)$. As Firm 2 makes no loss when synergies are low, profits are identical to those with perfect information at the beginning of the game.

However, this reasoning assumes that M&As are costless to realize, which is a far cry from reality. For the same reason, divestitures also entail costs. Assume that the cost of a M&A is $\phi > 0$ and that the cost of divestiture is $\hat{\phi} > 0$. The lack of information about synergies at the time of a merger implies that the cost ϕ is paid at the time of the merger, and there will be divestiture if synergies are low and $\pi^M(1, \underline{\theta}) - \pi_2^0 > \hat{\phi}$. Hence, the expected industry profit is $(1 - \alpha)\pi^M(1, \bar{\theta}) + \alpha(\pi_1^0 + \pi_2^0) - \phi - \alpha\hat{\phi}$, as long as this is greater than the industry profit under ex-ante competition $\pi_1^0 + \pi_2^0$.

By contrast, if Firm 1 shares s , the expected industry profit is $(1 - \alpha)\pi^M(1, \bar{\theta}) + \alpha(\pi_2(s, \underline{\theta}) + \pi_1(s, \underline{\theta})) - C(s) - (1 - \alpha)\phi$ because there is a merger only if synergies are high, in which case there is no further divestiture. When synergies are low, the industry profits are equal to $\pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta})$, which are lower than profits without sharing. Comparing industry profits in both scenarios,

sharing of information emerges whenever

$$C(s^*) + \alpha[\pi_1^0 + \pi_2^0 - \pi_1(s^*, \underline{\theta}) - \pi_2(s^*, \underline{\theta})] < \alpha(\phi + \hat{\phi}).$$

Where s^* maximizes the expected payoff of Firm 2 when acquiring information, this value is the same as that of the baseline model.

5.3 Nash Bargaining

The ability of firms to transfer $T(s)$ may be limited, for instance, if s is observable but not contractible. In this case, Firm 1 must be provided incentives to share information. By contrast, transfer payments for engaging in a M&A are contractible. Despite the lack of ex-ante transfers that compensate Firm 1 for its loss in the event of head-to-head competition, information sharing can occur if Firm 1 has a positive stake in the future M&A.

In this extension, we assume that the spoils of a M&A are shared following the cooperative Nash bargaining solution. Without information sharing, firms merge if the M&A is ex-ante efficient. In this case, Firms 1, 2 have, respectively, threat points π_1^0, π_2^0 and the Nash payoffs under no information sharing are:

$$\begin{aligned}\pi_1^{no} &:= \frac{1}{2} (\mathbb{E}[\pi^M(1, \theta)] - C(1) + \pi_1^0 - \pi_2^0) \\ \pi_2^{no} &:= \frac{1}{2} (\mathbb{E}[\pi^M(1, \theta)] - C(1) - \pi_1^0 + \pi_2^0).\end{aligned}$$

With information sharing s and exploration costs $C(s)$ if synergies are low, there is no M&A. Hence firms compete, and firms make profits $\pi_1(s, \underline{\theta})$ and $\pi_2(s, \underline{\theta})$. If synergies are high, a M&A is efficient, while firms have threat points $\pi_1(s, \bar{\theta})$ and $\pi_2(s, \bar{\theta})$. Hence, the Nash profits when the surplus from M&A is $\bar{\theta}$ are

$$\begin{aligned}\pi_1^*(s) &:= \frac{1}{2} (\pi^M(1, \bar{\theta}) + \pi_1(s, \bar{\theta}) - \pi_2(s, \bar{\theta})), \\ \pi_2^*(s) &:= \frac{1}{2} (\pi^M(1, \bar{\theta}) - \pi_1(s, \bar{\theta}) + \pi_2(s, \bar{\theta})).\end{aligned}$$

The (continuation) expected payoffs at the time information is shared are then

$$\begin{aligned}\pi_1^I(s) &= \alpha\pi_1(s, \underline{\theta}) + (1 - \alpha) \left\{ \frac{1}{2}(\pi^M(1, \bar{\theta}) + \pi_1(s, \bar{\theta}) - \pi_2(s, \bar{\theta})) \right\} \\ \pi_2^I(s) &= \alpha\pi_2(s, \underline{\theta}) + (1 - \alpha) \left\{ \frac{1}{2}(\pi^M(1, \bar{\theta}) - \pi_1(s, \bar{\theta}) + \pi_2(s, \bar{\theta})) \right\} - C(s).\end{aligned}$$

Firm 1 will either not share information or share an amount s that induces Firm 2 to explore. Note that with incomplete contracting on s , Firm 1 chooses s , contrary to the complete contracting situation where Firm 2 makes a TIOLI offer $T(s)$ for s .

A necessary and sufficient condition for information sharing is that there exists s such that $\pi_1^I(s) + \pi_2^I(s)$ is greater than $\pi_1^0 + \pi_2^0$ and that Firm 2 explores, or $\pi_2^I(s) \geq \pi_2^0$. Then Firm 1 chooses s to maximize $\pi_1^I(s)$ subject to $\pi_2^I(s) \geq \pi_2^0$.

5.4 Bilateral Information Sharing

In our analysis, Firm 2 can purchase information from Firm 1. In practice, companies can also engage in the bilateral sharing of information, which we analyze in this section.²⁵ We will show that bilateral information sharing can be more profitable for Firm 2 than information purchasing if the information shared by Firm 2 enhances the quality of the product of Firm 1.

Competition. Firm 1 shares information $s_1 \geq 0$ and Firm 2 shares $s_2 \geq 0$, and we ignore for the moment the possibility of a M&A. Each firm learns the synergy and benefits from the shared data by investing $C(s_2)$ for Firm 1 and $C(s_1)$ for Firm 2. The profits of Firm 1 and Firm 2 after data sharing are equal to $\pi_1(s_1, s_2, \theta)$ and $\pi_2(s_1, s_2, \theta)$, which depend on the amounts of data shared by each firm and on the value of synergies. Consistent with our basic model, we assume that the profits of a firm decrease when sharing its data and increase when it receives data from its competitor.

$$\text{(Profits with bilateral sharing): for } i \neq j \in \{1, 2\}, \quad \frac{\partial \pi_i(s_i, s_j, \theta)}{\partial s_i} \leq 0, \quad \frac{\partial \pi_i(s_i, s_j, \theta)}{\partial s_j} \geq 0.$$

²⁵For instance, [Scaria, Berghmans, Pont, Arnaut and Leconte \(2018\)](#) describe practices of information sharing between companies in Europe. Bilateral information sharing is also reminiscent of cross-licensing of innovation ([Fershtman and Kamien, 1992](#)).

M&A. After both firms have shared information, Firm 2 can make a TIOLI offer to buy Firm 1's asset at a price $p(\theta, s_1, s_2)$ that will make Firm 1 indifferent between merging and not merging, that is

$$(10) \quad p(s_1, s_2, \theta) := \pi_1(s_1, s_2, \theta).$$

Profits with bilateral information sharing. When firms share information, they anticipate their profits if there is competition and a M&A, and they share information accordingly. Firm 1 accepts the exchange if its expected payoff, accounting for the data exploration cost, is greater than π_1 . Hence, we need $(1 - \alpha)\pi_1(s_1, s_2, \bar{\theta}) + \alpha\pi_1(s_1, s_2, \underline{\theta}) - C(s_2) \geq \pi_1$. Sharing its data is costly for Firm 2. On the one hand, a higher value of s_2 increases the profits of Firm 1, increasing, in turn, the price of the acquisition in case synergies are low. On the other hand, under Assumption (H4) $\pi_2(s_1, s_2, \underline{\theta})$ decreases with s_2 , and Firm 2 loses profits by sharing its data also when synergies are low. Hence, Firm 2 will share an amount s_2 so that the participation constraint of Firm 1 is binding. Lemma 3 characterizes the expected payoff of Firm 2 when exchanging information with Firm 1.

When s_1 and s_2 shares of information have been shared, Firm 2 makes the following expected profits:

$$\pi_2(s_1, s_2) = (1 - \alpha)(\pi^M(1, \bar{\theta}) - \pi_1(s_1, s_2, \bar{\theta})) + \alpha\pi_2(s_1, s_2, \underline{\theta}) - C(s_1).$$

And the participation of Firm 1 requires:

$$(1 - \alpha)\pi_1(s_1, s_2, \bar{\theta}) + \alpha\pi_1(s_1, s_2, \underline{\theta}) - C(s_2) = \pi_1.$$

Lemma 3. *The expected payoff of Firm 2 sharing s_2 and investing $C(s_1)$ is:*

$$\pi_2(s_1, s_2) = (1 - \alpha)(\pi^M(1, \bar{\theta}) - \pi_1^0) + \alpha(\pi_1(s_1, s_2, \underline{\theta}) + \pi_2(s_1, s_2, \underline{\theta}) - \pi_1^0) - C(s_2) - C(s_1).$$

Similarly to information purchasing, there are two opposite effects of bilateral information sharing on the profits of Firm 2. Bilateral information sharing allows Firm 2 to incentivize Firm 1 to share information without a transfer of money. Firm 2 shares information s_2 that covers the

loss of Firm 1 from sharing information s_1 , accounting for the data exploration costs incurred by Firm 1. In turn, the higher s_1 the lower the data exploration cost. However, sharing information is costly for Firm 2 as it increases the profits of Firm 1, which increases in turn, the price Firm 2 must pay to acquire Firm 1. It also reduces the competitive payoff of Firm 2 in case synergies are low.

The participation constraint requires that the equilibrium amount of data shared s_2 covers the data exploration cost of Firm 1.

Bilateral information sharing versus information purchasing. We compare profits in equilibrium under bilateral information sharing and information purchasing. The expected profit of Firm 2 purchasing the optimal amount of information s^* from Firm 1 when there is no regulator is $(1 - \alpha)(\pi^M(1, \theta) - \pi_1^0) + \alpha(\pi_1(s^*, \underline{\theta}) + \pi_2(s^*, \underline{\theta}) - \pi_1^0) - C(s^*)$.

Bilateral sharing is more profitable than information purchasing if

$$\alpha(\pi_1(s^*, \underline{\theta}) + \pi_2(s^*, \underline{\theta})) - C(s^*) > \alpha(\pi_1(s_1^*, s_2^*, \underline{\theta}) + \pi_2(s_1^*, s_2^*, \underline{\theta})) - C(s_2^*) - C(s_1^*).$$

Hence, bilateral information sharing can be more profitable than information purchasing. Sharing information with Firm 1 is a way for Firm 2 to learn the value of synergies without requiring a money transfer.

5.5 Depreciation of Data

We have focused our analysis on a one-stage competition model, during which the data shared can be used by Firm 2 to compete with Firm 1. However, data can be short-lived or long-lived, with short-lived data not subject to the Arrow information paradox. In the extreme case where all data used by Firm 1 is short-lived, there would be no competitive cost to data sharing, and Firm 1 would be indifferent to sharing all its data.

There are many ways to model data depreciation,²⁶ but a full analysis is beyond the scope of this paper. Here, we model the durability of information by assuming that the data shared is useful only during a finite time frame. Consider an infinite number of competition stages t , and

²⁶See Valavi, Hestness, Ardalani and Iansiti (2020) for recent work on data depreciation articulating a tradeoff between accumulating stocks or flows of data to maximize the accuracy of machine learning models.

assume that the data shared by Firm 1 gives perfect information about the value of synergies for T periods, and lose all informational value at $T + 1$. Firm 1 makes the following profits where $0 < \delta < 1$ is the discount factor:

$$\Pi_1^0 = \sum_{t=0}^{+\infty} \delta^t \pi_1^0 = \frac{\pi_1^0}{1 - \delta}$$

Information sharing has the same effects as in the main analysis, spread over the T competition periods where data has its informational value and firms know the values of synergies. When sharing s information, Firm 1 makes the following expected payoff:

$$\begin{aligned} \Pi_1(s) &= \sum_{t=0}^T \delta^t ((1 - \alpha)\pi_1(s, \bar{\theta}) + \alpha\pi_1(s, \underline{\theta})) + \sum_{t=T+1}^{+\infty} \delta^t \pi_1^0 + T(s) \\ &= \frac{\pi_1^0}{1 - \delta} - (\pi_1^0 - \mathbb{E}[\pi_1(s, \theta)]) \frac{1 - \delta^{T+1}}{1 - \delta} + T(s). \end{aligned}$$

Hence the equilibrium transfer giving Firm 1 incentive to share data is:

$$T(s) = (\pi_1^0 - \mathbb{E}[\pi_1(s, \theta)]) \frac{1 - \delta^{T+1}}{1 - \delta}.$$

These values correspond to the transfer in the main analysis, summed over the T periods where data has informational value and data sharing induces a competitive loss for Firm 1. Similarly, the gains from a merger are summed over the infinite number of periods where the merged entity would achieve profits, and the resulting expected payoff of Firm 2 when acquiring information s is equal to:

$$\begin{aligned} \Pi^e(s) &= (1 - \alpha) \sum_{t=0}^{+\infty} \delta^t (\pi^M(1, \bar{\theta}) - \pi_1) + \alpha \sum_{t=0}^T \delta^t (\pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta}) - \pi_1) + \alpha \sum_{t=T+1}^{+\infty} \delta^t \pi_2^0 - C(s) \\ &= \frac{\pi_2}{1 - \delta} + (1 - \alpha) \frac{\pi^M(1, \bar{\theta}) - \pi_1^0 - \pi_2}{1 - \delta} + \alpha \frac{1 - \delta^{T+1}}{1 - \delta} (\pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta}) - \pi_1^0 - \pi_2) - C(s) \end{aligned}$$

An increase in T , the duration of data, increases the equilibrium amount of information shared as well as the expected profit of Firm 2.

6 Conclusion

We have analyzed an environment in which information sharing facilitates the discovery of synergies but may also weaken the competitive position of the data owner. Our analysis highlights a potential structural change in M&A practices and regulations. Competition authorities have usually been wary of the exchange of sensitive information about consumers before a merger.²⁷ Yet, governments and regulators are now encouraging information-sharing practices among firms, as they anticipate benefits for all types of industries resulting from information synergies and efficiencies.²⁸ Moreover, the widespread adoption of virtual data rooms also greatly facilitates pre-merger data sharing between participants and with competition authorities.²⁹ We should therefore expect that firms sharing data may learn the complementarity of their data sets with those of other firms and that they make merger decisions accordingly. Our results have shown that this would benefit the firms and sometimes consumers.

Our theoretical analysis calls for empirical evidence on whether firms share information to make better M&A decisions. To assess whether this practice has been adopted by firms, empirical researchers and regulators should identify a potential increase in the amount of data exchanged by firms that ended up merging. Firms can use different ways to share information. Our analysis has shown that because of the risks of expropriation, information sharing may require a contract and a money transfer. Hence, a convenient way to share data is through data marketplaces, enabling contracts between sellers and buyers of large data sets. As these marketplaces are digital platforms, information on the sale of data sets should be freely accessible to academics under the Digital Market act recently enacted in the European Union.³⁰

Firms may also share information without contracting and money transfer, as highlighted by our cooperative Nash bargaining mode analysis. In this case, a simple way for firms to share data is using the virtual data rooms mentioned earlier. Hence, another indication of the practice of pre-M&A data sharing is through changes in the amounts of data shared in virtual data rooms.

²⁷[Avoiding antitrust pitfalls during pre-merger negotiations and due diligence](#), FTC March 20, 2018.

²⁸See for instance the GAIA X project in Europe (GAIA X).

²⁹See for instance [Best practices for the submission of economic evidence and data collection in cases concerning the application of articles 101 and 102](#), DG Competition, last accessed July 11, 2023 and [The Importance Of Online Data Rooms In Mergers And Acquisitions](#), Forbes, August 15, 2016.

³⁰See [The Digital Markets Act: ensuring fair and open digital markets](#), European Commission, last accessed July 23, 2023.

As cloud companies provide these secured storage capacities, the DMA also applies and could allow researchers to observe an eventual increase in the amount of data shared before a merger, suggesting the adoption of pre-M&A information-sharing practices.

Finally, because learning the level of synergies yields more efficient M&As decisions, information sharing can impact firms' willingness to merge and thus market concentration, innovation, and social surplus. In particular, the number of merger failures should decrease if data-driven companies can better anticipate the efficiency of a M&A. The identification of these causal links is a topic for further research.

References

- Admati, A. R. and Pfleiderer, P. (2000), 'Forcing firms to talk: Financial disclosure regulation and externalities', *The Review of financial studies* **13**(3), 479–519.
- Affeldt, P. and Kesler, R. (2021), 'Big tech acquisitions—towards empirical evidence', *Journal of European Competition Law & Practice* **12**(6), 471–478.
- Anton, J. J. and Yao, D. A. (2002), 'The sale of ideas: Strategic disclosure, property rights, and contracting', *The Review of Economic Studies* **69**(3), 513–531.
- Argentesi, E., Buccirosi, P., Calvano, E., Duso, T., Marrazzo, A. and Nava, S. (2019), 'Merger policy in digital markets: An ex post assessment', *Journal of Competition Law & Economics* .
- Arrow, K. J. (1962a), 'The economic implications of learning by doing', *The Review of Economic Studies* **29**(3), 155–173.
- Arrow, K. J. (1962b), Economic welfare and the allocation of resources for invention, in 'The Rate and Direction of Inventive Activity', Princeton University Press, pp. 609–626.
- Baron, D. P. and Myerson, R. B. (1982), 'Regulating a monopolist with unknown costs', *Econometrica: Journal of the Econometric Society* pp. 911–930.
- Bergemann, D. and Bonatti, A. (2015), 'Selling cookies', *American Economic Journal: Microeconomics* **7**(3), 259–94.

- Bergemann, D. and Bonatti, A. (2019), ‘Markets for information: An introduction’, *Annual Review of Economics* **11**, 85–107.
- Bertschinger, N., Rauh, J., Olbrich, E., Jost, J. and Ay, N. (2014), ‘Quantifying unique information’, *Entropy* **16**(4), 2161–2183.
- Bounie, D., Dubus, A. and Waelbroeck, P. (2021), ‘Selling strategic information in digital competitive markets’, *The RAND Journal of Economics* **52**(2), 283–313.
- Bounie, D., Dubus, A. and Waelbroeck, P. (2023), ‘Competition between strategic data intermediaries with implications for merger policy’.
- Cabral, L. (2021), ‘Merger policy in digital industries’, *Information Economics and Policy* **54**, 100866.
- Chatterjee, S. (1986), ‘Types of synergy and economic value: The impact of acquisitions on merging and rival firms’, *Strategic management journal* **7**(2), 119–139.
- Chen, Z., Choe, C., Cong, J. and Matsushima, N. (2022), ‘Data-driven mergers and personalization’, *The RAND Journal of Economics* **53**(1), 3–31.
- Chirita, A. D. (2018), ‘Data-driven mergers under eu competition law’, *The Future of Commercial Law: Ways Forward for Harmonisation*, (eds) J Linarelli & O Akseli (1st ed, Oxford, Hart Publishing, 2019) .
- Crémer, J., de Montjoye, Y.-A. and Schweitzer, H. (2019), ‘Competition policy for the digital era’, *Report for the European Commission* .
- Damodaran, A. (2005), ‘The value of synergy’, *Stern school of Business* pp. 132–146.
- d’Aspremont, C., Bhattacharya, S. and Gérard-Varet, L.-A. (2000), ‘Bargaining and sharing innovative knowledge’, *The Review of Economic Studies* **67**(2), 255–271.
- De Corniere, A. and Taylor, G. (2020), ‘Data and competition: a general framework with applications to mergers, market structure, and privacy policy’.
- Fershtman, C. and Kamien, M. I. (1992), ‘Cross licensing of complementary technologies’, *International Journal of Industrial Organization* **10**(3), 329–348.

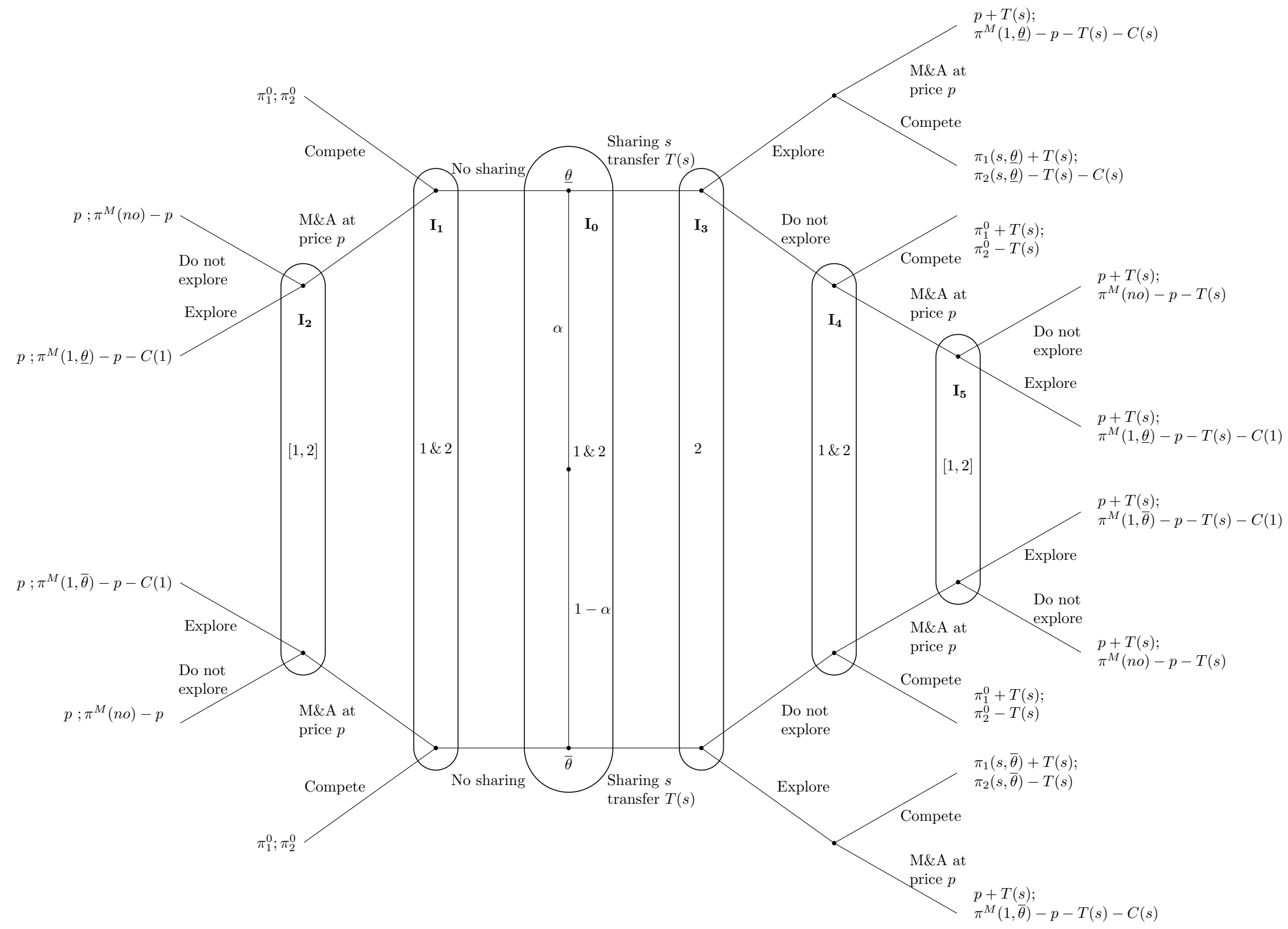
- Gal-Or, E. (1986), ‘Information transmission—cournot and bertrand equilibria’, *The Review of Economic Studies* **53**(1), 85–92.
- Griffith, V. and Koch, C. (2014), Quantifying synergistic mutual information, in ‘Guided Self-Organization: Inception’, Springer, pp. 159–190.
- Grossman, G. M. and Helpman, E. (1995), ‘The politics of free-trade agreements’, *The American Economic Review* **85**(4), 667–690.
URL: <http://www.jstor.org/stable/2118226>
- Gupta, D. and Gerchak, Y. (2002), ‘Quantifying operational synergies in a merger/acquisition’, *Management Science* **48**(4), 517–533.
- Hagiu, A. and Wright, J. (2020), ‘When data creates competitive advantage’, *Harvard Business Review* **98**(1), 94–101.
- Hörner, J. and Skrzypacz, A. (2016), ‘Selling information’, *Journal of Political Economy* **124**(6), 1515–1562.
- Jones, C. I. and Tonetti, C. (2020), ‘Nonrivalry and the economics of data’, *American Economic Review* **110**(9), 2819–58.
- Kastl, J., Pagnozzi, M. and Piccolo, S. (2018), ‘Selling information to competitive firms’, *The RAND Journal of Economics* **49**(1), 254–282.
- Kesler, R., Kummer, M. and Schulte, P. (2020), Competition and privacy in online markets: Evidence from the mobile app industry, in ‘Academy of Management Proceedings’, Academy of Management Briarcliff Manor, NY 10510, p. 20978.
- Krämer, J., Shekhar, S. and Hofmann, J. (2021), ‘Regulating algorithmic learning in digital platform ecosystems through data sharing and data siloing: Consequences for innovation and welfare’.
- Larsson, R. and Finkelstein, S. (1999), ‘Integrating strategic, organizational, and human resource perspectives on mergers and acquisitions: A case survey of synergy realization’, *Organization science* **10**(1), 1–26.

- Leccese, M., Sweeting, A., Tao, X. and Yao, X. (2022), ‘Should we expect uncertain merger synergies to be passed through to consumers?’.
- Madura, J. and Ngo, T. (2008), ‘Clustered synergies in the takeover market’, *Journal of Financial Research* **31**(4), 333–356.
- Martens, B., De Streel, A., Graef, I., Tombal, T. and Duch-Brown, N. (2020), ‘Business-to-business data sharing: An economic and legal analysis’, *EU Science Hub* .
- Mukherjee, T. K., Kiyamaz, H. and Baker, H. K. (2004), ‘Merger motives and target valuation: A survey of evidence from cfos’, *Journal of Applied Finance* **14**(2).
- Neiswanger, W. and Xing, E. (2017), Post-inference prior swapping, *in* ‘International Conference on Machine Learning’, PMLR, pp. 2594–2602.
- Olbrich, E., Bertschinger, N. and Rauh, J. (2015), ‘Information decomposition and synergy’, *Entropy* **17**(5), 3501–3517.
- Parker, G., Petropoulos, G. and Van Alstyne, M. W. (2021), ‘Platform mergers and antitrust’, *Available at SSRN 3763513* .
- Scaria, E., Berghmans, A., Pont, M., Arnaut, C. and Leconte, S. (2018), ‘Study on data sharing between companies in europe’, *A study prepared for the European Commission Directorate-General for Communications Networks, Content and Technology by everis Benelux* **24**.
- Scott Morton, F., Bouvier, P., Ezrachi, A., Jullien, B., Katz, R., Kimmelman, G., Melamed, A. D. and Morgenstern, J. (2019), ‘Committee for the study of digital platforms: Market structure and antitrust subcommittee report’, *Chicago: Stigler Center for the Study of the Economy and the State, University of Chicago Booth School of Business* .
- Shapiro, C. (2019), ‘Protecting competition in the american economy: Merger control, tech titans, labor markets’, *Journal of Economic Perspectives, Forthcoming* .
- Shapiro, C. and Varian, H. (1998), *Information rules: A strategic guide to the network economy*, Harvard Business Press.

- Sootla, S., Theis, D. O. and Vicente, R. (2017), ‘Analyzing information distribution in complex systems’, *Entropy* **19**(12), 636.
- Stucke, M. E. and Grunes, A. P. (2016), ‘Introduction: Big data and competition policy’, *Big Data and Competition Policy, Oxford University Press (2016)* .
- Tirole, J. (2020), ‘Competition and the industrial challenge for the digital age’.
- Valavi, E., Hestness, J., Ardalani, N. and Iansiti, M. (2020), ‘Time and the value of data’, *Harvard Business School Strategy Unit Working Paper* .
- Varian, H. R. (1989), ‘Price discrimination’, *Handbook of industrial organization* **1**, 597–654.
- Vives, X. (1984), ‘Duopoly information equilibrium: Cournot and bertrand’, *Journal of economic theory* **34**(1), 71–94.

A Extensive form

This extensive form is a partial representation. For instance, at I_0 , both firms must agree on the sharing contract $(s, T(s))$ to move to the right. In our basic model with TIOLI offers, we would need to have Firm 2 make an offer $(s, T(s))$, and then Firm 1 accept or reject this offer. Similarly, at information sets I_1, I_4 , Firm 2 proposes a merger at price p and if Firm 1 accepts, the node “M&A at price p ” is selected; otherwise, the default “competition” is selected. The notation “1&2” is a shortcut for this sequence of moves. At information set I_3 , Firm 2 is the only one to decide whether to explore. At information sets I_2, I_5 , the merged firm, denoted $[1, 2]$ in the extensive form, chooses to explore or not.



B A Quality Competition Model

To illustrate our results, we analyze a simple model of information sharing and mergers when firms compete by selling products of different qualities.

Before information is shared, Firm 1 sells a product of quality q_1^0 at a price p_1^0 , and Firm 2 sells a product of quality q_2^0 at a price p_2^0 .

There is a mass 1 of consumers with quasi-linear utility functions $u(q_i, p_i) = q_i - p_i$. Firms compete à la Bertrand to sell their products, and the firm winning the market makes profits equal to $\pi_i = p_i$.

For simplicity, at the beginning of the game, $q_1^0 > 0$, $q_2^0 = 0$, and Firm 1 is a monopolist in the market. Hence, the equilibrium prices and profits are $\pi_1^0 = p_1^0 = q_1^0$ and $\pi_2^0 = p_2^0 = 0$.

Information sharing. Suppose that Firm 1 shares $s > 0$, and, for now, let us ignore the possibility of a M&A. If Firm 2 invests $C(s)$ and learns θ , it can develop a product of quality $q_2(s, \theta) = s\theta$ while the product quality of Firm 1 does not change. We assume for simplicity that when a product is on the market, consumers know its valuation immediately. This holds even if firms do not know the quality of the product at the time they launch it. Indeed, the literature on the pricing of information goods (Shapiro and Varian, 1998) has long pointed out that consumers can quickly discover their product valuation before acquiring it through sampling, free downloading, freemium, ratings, and reviews.

To ensure that the main hypotheses of the baseline model hold in this framework, we assume that $\bar{\theta} > u > 2\theta$, and we discuss these conditions below. Consumers purchase the product that yields the highest utility, and Bertrand's competition implies that the equilibrium profits of the two firms are

$$\pi_1(s, \theta) = 0, \pi_2(s, \theta) = s\theta - u \text{ if } s\theta - u \geq 0,$$

$$\pi_1(s, \theta) = u - s\theta, \pi_2(s, \theta) = 0 \text{ if } s\theta - u \leq 0.$$

The assumptions of our main analysis are satisfied with this quality competition model.

$$(H2) \quad \begin{aligned} \frac{\partial \pi_2(s, \theta)}{\partial s} &= \theta \geq 0 \geq \frac{\partial \pi_1(s, \theta)}{\partial s} = 0 \text{ if } s\theta - u \geq 0, \\ \frac{\partial \pi_2(s, \theta)}{\partial s} &= 0 \geq 0 \geq \frac{\partial \pi_1(s, \theta)}{\partial s} = -\theta \text{ if } s\theta - u \leq 0. \end{aligned}$$

As we have assumed that $u > \underline{\theta}$, when synergies are low the competitive payoffs are equal to $\pi_1(s, \underline{\theta}) = u - s\underline{\theta}$ and $\pi_2(s, \underline{\theta}) = 0$. This ensures that (H3) is satisfied:

$$(H3) \quad \frac{\partial(\pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta}))}{\partial s} = -\underline{\theta} < 0.$$

M&A. When firms merge, the merged entity sells as a monopolist a product of quality equal to $q_2(1, \bar{\theta}) = \bar{\theta}$ if synergies are high and to $q_2(1, \underline{\theta}) = \underline{\theta}$ if synergies are low. As we have assumed that $\bar{\theta} > u$ and $u > 2\underline{\theta}$, Firm 2 is willing to merge only when synergies are high and we recover the option value of the baseline model:

$$(H4) \quad \begin{aligned} \pi^M(1, \bar{\theta}) &= \bar{\theta} > \pi_1(s, \bar{\theta}) + \pi_2(s, \bar{\theta}) = \max[u - s\bar{\theta}, s\bar{\theta} - u], \\ \pi^M(1, \underline{\theta}) &= \underline{\theta} < u - s\underline{\theta}. \end{aligned}$$

Information sharing. The expected profit of Firm 2 purchasing s from Firm 1 is:

$$(1 - \alpha)(\bar{\theta} - u) - \alpha\underline{\theta}s - C(s).$$

By concavity of this expression, the equilibrium amount of information shared is unique and satisfies $\alpha\underline{\theta} = -C'(s^*)$.

Consumer surplus. The surplus of consumers is equal to zero if firms do not share information or if they merge. If firms share information and compete consumer surplus is equal to $\min\{u, \theta s\}$. This weakly increases with s and (H5) is satisfied.

Regulatory oversight. Finally, condition (Hazard) under which companies share more information in the presence of a regulator can be written:

$$(Hazard) \quad \forall s \geq \frac{u}{\bar{\theta}}, \quad \frac{f(\rho^*(s))}{1 - F(\rho^*(s))} < \frac{(\bar{\theta}(1 - s) + 2u)^2}{u(\bar{\theta}(1 - s) + u)}.$$

Where

$$\rho^*(s) = \begin{cases} \frac{1+s-\frac{u}{\bar{\theta}}}{1+2s-\frac{u}{\bar{\theta}}} & \text{if } s \leq \frac{u}{\bar{\theta}}, \\ \frac{1-s+\frac{u}{\bar{\theta}}}{1-s+2\frac{u}{\bar{\theta}}} & \text{if } s \geq \frac{u}{\bar{\theta}}. \end{cases}$$

Condition [\(Hazard\)](#) is satisfied for many distributions, such as when ρ is uniformly distributed for then the hazard rate is $\frac{f(\rho^*(s))}{1-F(\rho^*(s))} = \frac{\bar{\theta}-s\bar{\theta}+2u}{u}$ which is clearly smaller than $\frac{(\bar{\theta}-s\bar{\theta}+2u)^2}{u(\bar{\theta}-s\bar{\theta}+u)}$.

C Proof of Proposition 1

(i) Suppose that $\pi^M(1, \bar{\theta}) - C(1) \leq \max[\pi^M(no), \pi_1^0 + \pi_2^0]$.

If $\pi^M(no) > \pi_1^0 + \pi_2^0$, information sharing and exploration are dominated by merging (and not exploring) under incomplete information.

If $\pi^M(no) < \pi_1^0 + \pi_2^0$, then information sharing and exploration are dominated by competition.

This proves (i).

(ii) Assume now that $\pi^M(1, \bar{\theta}) - C(1) > \max[\pi^M(no), \pi_1^0 + \pi_2^0]$.

To prove points (a) and (b) we first establish the following preliminary result.

Lemma 4. *Suppose that merging and exploring dominate both competing and merging without exploration:*

$$\mathbb{E}[\pi^M(1, \theta)] - C(1) \geq \max[\pi^M(no), \pi_1^0 + \pi_2^0].$$

Then, acquiring the profit-maximizing amount of information before the merger dominates no information acquisition for Firm 2.

Proof. The equilibrium amount of information acquired by Firm 2 maximizes $\Pi^e(s)$ in [\(3\)](#) and belongs to the set :

$$S^* := \operatorname{argmax}_s \alpha(\pi_2(s, \underline{\theta}) + \pi_1(s, \underline{\theta})) - C(s).$$

Under assumptions [\(H1\)](#) and [\(H3\)](#), this set is nonempty and does not include corner solutions. There can be multiple elements in S^* because we have not restricted the shape of $\pi_2(s, \underline{\theta}) + \pi_1(s, \underline{\theta})$. In the quality competition model that we provide in [Appendix B](#), S^* is a singleton.

To show that sharing information dominates a merger under incomplete information, consider the expected industry profits with and without sharing:

$$\text{No sharing: } \mathbb{E}[\pi^M(1, \theta)] - C(1).$$

$$\text{Sharing } s: \Pi^e(s) = (1 - \alpha)\pi^M(1, \bar{\theta}) + \alpha(\pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta})) - C(s).$$

Firm 2 acquires information if the profit difference between sharing and no-sharing is positive. This difference is equal to the option value function $O(s, \alpha)$:

$$(11) \quad O(s, \alpha) := \alpha(\pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta}) - \pi^M(1, \underline{\theta})) - C(s) + C(1).$$

Under Assumption (H4) $O(1, \alpha)$ is positive at $s = 1$. Therefore, for any $s^* \in S^*$, $O(s^*, \alpha)$ is also positive. This establishes that acquiring information strictly dominates merging under incomplete information. Sharing information prevents inefficient mergers when synergies are low. \square

Having established this result, two possible cases emerge, depending on the relative values of $\pi^M(no)$ and $\pi_1^0 + \pi_2^0$.

(a) $\pi^M(no) > \pi_1^0 + \pi_2^0$: mergers are ex-ante efficient. If $\alpha = 0$, the merged firm explores the data as $\pi^M(1, \bar{\theta}) - C(1) > \pi^M(no)$. If $\alpha = 1$, the merged firm does not explore the data.³¹

Hence, by monotonicity in α of $\mathbb{E}[\pi^M(1, \theta)] - C(1) = (1 - \alpha)\pi^M(1, \bar{\theta}) + \alpha\pi^M(1, \underline{\theta}) - C(1)$, there is a unique value $\alpha_- \in (0, 1)$ for which $\mathbb{E}[\pi^M(1, \theta)] - C(1) = \pi^M(no)$. The value of the merger is $\mathbb{E}[\pi^M(1, \bar{\theta})] - C(1)$ for smaller values of α and is $\pi^M(no)$ for larger values of α .

When $\alpha \leq \alpha_-$ we have shown that firms benefit from sharing information before a merger; in particular, the option is to allow efficient mergers. When $\alpha > \alpha_-$, the expected profits with and without sharing are equal to:

$$\text{No sharing: } \pi^M(no).$$

$$\text{Sharing \& exploring: } \Pi^e(s) = (1 - \alpha)\pi^M(1, \bar{\theta}) + \alpha(\pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta})) - C(s).$$

³¹Indeed, under assumptions (H3) and (H4), $\pi_1^0 + \pi_2^0 > \pi^M(1, \underline{\theta}) - C(1)$, and in turn, $\pi^M(no) > \pi^M(1, \underline{\theta}) - C(1)$.

The option value function is now equal to:

$$(12) \quad \hat{O}(s, \alpha) := (1 - \alpha)\pi^M(1, \bar{\theta}) + \alpha(\pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta})) - C(s) - \pi^M(no).$$

This is different from $O(s, \alpha)$ in Lemma 4 because the value of merging under incomplete information is here independent of α when $\alpha > \alpha_*$. Note that this option value is a decreasing function of α . Indeed, $\frac{\partial \hat{O}(s, \alpha)}{\partial \alpha} = \pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta}) - \pi^M(1, \bar{\theta})$ is negative by Assumption H4. Therefore, $\max_s \hat{O}(s, \alpha)$ decreases with α .

We have proved that at α_* , sharing and exploring strictly dominates a merger under incomplete information. Hence, by continuity, there exists a unique $\alpha_0 > \alpha_*$ such that sharing and exploring information before the merger yields greater expected profits than merging and not exploring for $\alpha \leq \alpha_0$. Overall, information sharing prevents inefficient mergers when $\alpha \leq \alpha_0$. This establishes point (a).

Figure 2 illustrates this result. The thick line represents the equilibrium expected profits of the industry. For $\alpha < \alpha_*$ sharing information dominates merging under incomplete information and exploring which constitutes the best outside option: $\Pi^e(s(\alpha)) > \mathbb{E}[\pi^M(1, \theta)] - C(1)$. For $\alpha_* < \alpha \leq \alpha_0$ sharing information dominates merging under incomplete information and not exploring: $\Pi^e(s(\alpha)) > \pi^M(no)$. For $\alpha > \alpha_0$ firms merge under incomplete information and do not explore.

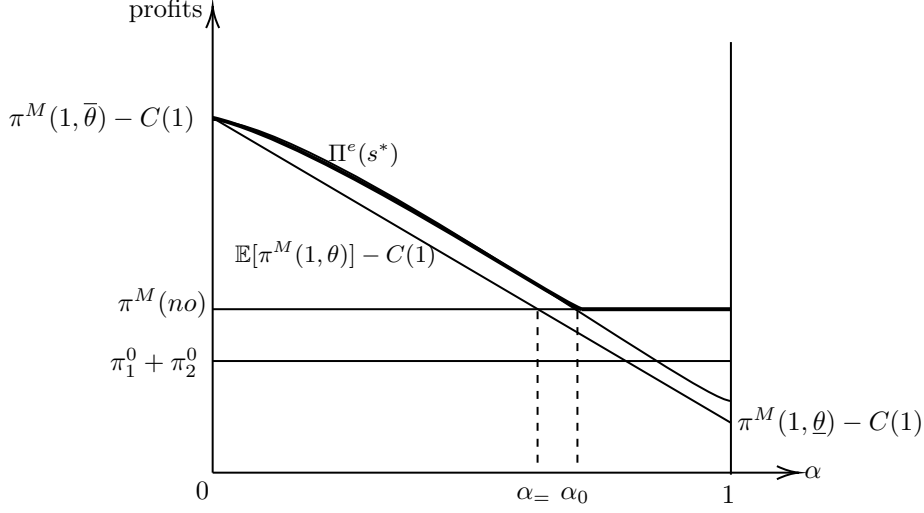


Figure 2: Case $\pi^M(1, \bar{\theta}) - C(1) > \pi^M(no) > \pi_1^0 + \pi_2^0$.

(b) $\pi^M(no) < \pi_1^0 + \pi_2^0$: **either firms compete or they share information.** If $\alpha = 0$, information sharing and exploration is optimal as $\pi^M(1, \bar{\theta}) - C(1) > \pi_1^0 + \pi_2^0$. If $\alpha = 1$, firms compete as $\pi^M(1, \underline{\theta}) - C(1) < \pi_1^0 + \pi_2^0$. Hence, by monotonicity of $\mathbb{E}[\pi^M(1, \theta)] - C(1)$ in α , there is a unique value $\alpha_1 \in (0, 1)$ for which $\mathbb{E}[\pi^M(1, \theta)] - C(1) = \pi_1^0 + \pi_2^0$. A merger is ex-ante efficient for smaller values of α and is ex-ante inefficient for larger values of α .

When $\alpha \leq \alpha_1$, merging under incomplete information dominates competition. Moreover, we have established as a preliminary result that sharing and exploring dominate merging under incomplete information, and so it is also more profitable than competition when $\alpha \leq \alpha_1$. For $\alpha > \alpha_1$, the expected profits with and without sharing are equal to:

$$\text{No sharing: } \pi_1^0 + \pi_2^0.$$

$$\text{Sharing \& exploring: } \Pi^e(s) = (1 - \alpha)\pi^M(1, \bar{\theta}) + \alpha(\pi_1(s, \underline{\theta}) + \pi_2(s, \underline{\theta})) - C(s).$$

In this case, the difference in profits can be written

$$\tilde{O}(s, \alpha) = (1 - \alpha)\pi^M(1, \bar{\theta}) + \alpha(\pi_1(s(\alpha), \underline{\theta}) + \pi_2(s(\alpha), \underline{\theta})) - C(s(\alpha)) - \pi_1^0 - \pi_2^0.$$

Sharing information is profitable if $\tilde{O}(s, \alpha) > 0$, which is true at $\alpha = \alpha_1$. Moreover, $\tilde{O}(s, 1)$ is negative by (H4). As before, the variation of $\tilde{O}(s, \alpha)$ decreases with α . Hence, when $\pi^M(no) <$

$\pi_1^0 + \pi_2^0$ there exists a unique $\alpha_2 > \alpha_1$ such that firms share information when a M&A is ex-ante inefficient if $\alpha \leq \alpha_2$. In this case, information sharing allows efficient mergers to take place. This establishes point (b).

Figure 3 illustrates these results. The thick line represents the equilibrium expected profits of the industry. For $\alpha < \alpha_1$ sharing information dominates merging under incomplete information and exploring which constitutes the best outside option: $\Pi^e(s(\alpha)) > \mathbb{E}[\pi^M(1, \theta)] - C(1)$. For $\alpha_1 < \alpha < \alpha_2$ sharing information dominates competition: $\Pi^e(s(\alpha)) > \pi_1^0 + \pi_2^0$. For $\alpha \geq \alpha_2$ firms compete.

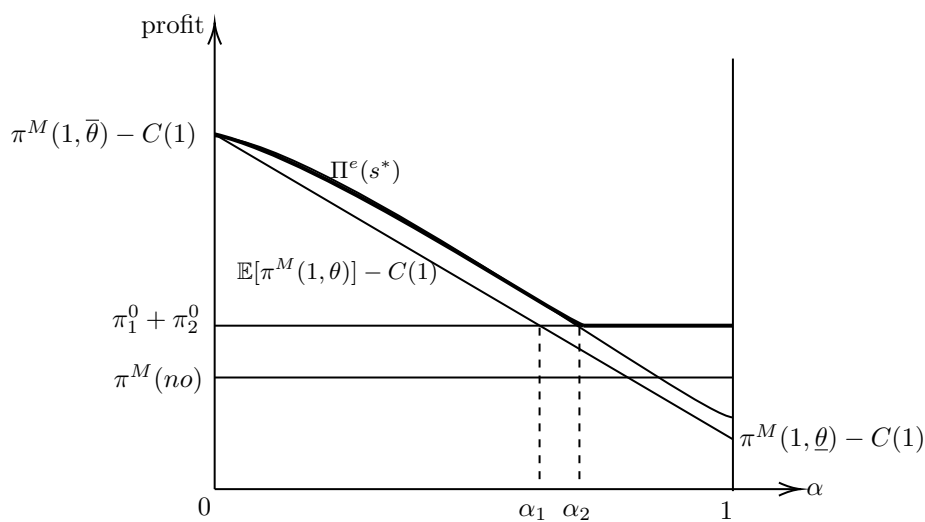


Figure 3: Case $\pi^M(1, \theta) - C(1) > \pi_1^0 + \pi_2^0 > \pi^M(no)$.