The Sale of Data:

Learning Synergies Before M&As*

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June 17, 2022

Abstract

Firms may share information to discover potential synergies between their data sets and algorithms, which eventually may lead 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. Because more sharing of information may increase industry expected profits both when there is head-to-head competition and when there is an M&A, the presence of a regulator who can prevent or allow the M&A can decrease or increase the level of information sharing, as well as consumer surplus, with respect to the no-regulator case. A regulator who can also control the level of information sharing will allow firms to share information.

*We would like to thank Stefan Bechtold, Andreea Cosnita-Langlais, Jacques Crémer, David Gilo, Jan Krämer, Mathieu Parenti, Shiva Shekhar, Thibaud Vergé, Patrick Waelbroeck, as well as participants to the 2021 CRESSE conference, the 2022 IIOC conference, and to the Paris Seminar on the Digital Economics for insightful comments and discussions. This project benefited from the financial support from FNRS (Project PDR T.01.47.19) and from the European Research Council (under the European Union's Seventh Framework Program (FP7-IDEAS-ERC), ERC Grant Agreement OIO- 339950). A previous version of this work has circulated under the title "Data-Driven Mergers and Acquisitions with Information Synergies".

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1 Introduction

Mergers fail, acquisitions are reversed, previously acquired assets are divested, and claimed efficiencies are not realized. Is this because firms claim that 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 an M&A. In such an environment, more precise information about the level of synergies that will follow an M&A is valuable not only for the companies involved but also for a regulator who is willing to maximize social welfare.

Firms need to gather many different types of information before an M&A, such as the quality of the other company's infrastructures, its assets and their actual returns, in particular for industrial firms that have asymmetric information about relative productivities. 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 better anticipate the extent of synergies that may arise after an M&A.

Arrow (1962*a*,*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 competitive positions of the firms 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. Our contribution is to show that the competitive disadvantage is balanced by more efficient M&A decisions that benefit the companies involved, and sometimes consumers as well.

For our narrative, we focus on data sharing and the complementarity of data and algorithms that two firms have developed. Important M&As have happened in the past few years that

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

[2] Throughout 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).

seemed motivated by the potential synergies obtained from aggregating and matching data sets. For instance, Facebook acquired WhatsApp to merge phone numbers with the profiles of Facebook users, and Google's acquisition of Fitbit may 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.

Let us think for a minute of Google and Fitbit. Before acquiring Fitbit, Google did not have a competing product nor had it accumulated such data on users. Therefore, Fitbit had a significant competitive advantage over Google for wearable devices or at least a market leadership in the short term. The product value to consumers could be enhanced by leveraging the data that Google has accumulated into the algorithm developed by Fitbit, but this was not a certainty: the synergies between the data and algorithms of Google and Fitbit were still unknown, even if both companies had a good understanding of the likelihood of these synergies.

Therefore, the decision faced by Google was make-or-buy, and because Google and Fitbit's products rely heavily on data to provide consumers with high-quality recommendations, potential information synergies played a central role in Google's final decision. If Google obtained part of the data accumulated by Fitbit, it could develop its own product or algorithm and compete with Fitbit using this data to provide consumers with better personalized recommendations and an overall better product quality. Hence, selling some of its information weakens the competitive position of Fitbit if both firms compete head to head.

We characterize the optimal level of information sharing, and we 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 Google and Fitbit would compete head to head, placing Fitbit in a worse situation than in the absence of information sharing. However, if synergies are high, acquisition becomes beneficial, and the new "Google-Fitbit product" is sold at a monopoly price, a better situation for the industry than in the absence of sharing. Consequently, the equilibrium amount of shared information balances these two opposite effects of information sharing on the profits of the firms. We demonstrate that the expected payoff of Google *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 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 at the time in which 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, the possibility that it prevents an M&A increases with the amount of information shared, which reduces the incentives of firms to share information. Perhaps less obvious, we show that the prospective buyer – Google – may want to acquire more information if there is a risk that the M&A is not allowed. This possibility is more likely when the exploration cost is high.

While information sharing intensifies competition and allows firms to better anticipate the value of synergies, there may also be additional privacy losses for consumers, as their information that has been shared can be used in other markets. For example, Google could use the information shared by Fitbit in the health insurance market, with potential harm for consumers. We show that considering such connected markets can reduce the benefit of information sharing for consumers, and even harm them overall if the information shared is sensitive regarding consumers' privacy. On the contrary, Google has even more interest in acquiring information, as it can leverage it on multiply markets and generate higher profits. Therefore, our results also send a cautionary note on information sharing practices, and emphasize the need to account for broad definitions of relevant markets in digital M&As with cross-market externalities.

The remainder of this article is organized as follows. We review the literature on M&As in Section 2. We describe the model in Section 3, and we characterize the equilibrium in Section 4. Section 5 analyzes the impacts of a regulator on information sharing and welfare. We extend the model in several directions in Section 6, and Section 7 concludes.

2 Literature

Information sharing and competition policy. Competition policy for the digital era has been the object of a 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 largely built upon the collection, use, sharing and sale of huge amounts of consumer data (Varian, 1989; Bergemann and Bonatti, 2015). 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 Crémer, de Montjoye and Schweitzer (2019), among others, suggest to ensure fair 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 strong 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 important way for large companies to maintain their data-based competitive advantage is through the acquisition of new sources of information. For this reason, and since combining data sets can yield important information synergies, the merger of two firms' data sets can be an important motivation for M&As (Stucke and Grunes, 2016). In fact, the European Commission investigated this possibility in the acquisition of WhatsApp by Facebook (Argentesi, Buccirossi, Calvano, Duso, Marrazzo and Nava, 2019).[5] More recently, the European Commission gave its

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

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

[5] Facebook lied to the Commission by claiming that data sets owned by the two companies were impossible

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 sources of synergies resulting from M&As have been studied extensively in the literature.[8] Chatterjee (1986) distinguishes three types of synergies: financial, operational, and collusive, and indicates that collusive synergies are associated with the highest value from an M&A, while operational synergies are associated with the lowest value. Nevertheless, Mukherjee, Kiymaz and Baker (2004) report that operational synergies are provided by firms as the main reason to merge, while Gupta and Gerchak (2002) quantify operational synergies and highlight the importance of production characteristics of the acquirer and of the target for synergies to arise. Larsson and Finkelstein (1999) focus on the importance of 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 of 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.

This literature does not consider information synergies, probably because data have become essential for many business models only recently. As Parker, Petropoulos and Van Alstyne (2021) emphasize, information synergies naturally arise depending on the complementarity of data sources, and they have become important 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 information sharing can be used by companies to assess information synergies.

By contrast, the literature on information theory has long acknowledged the importance

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 from different synergies.

of information synergies. A recent trend of 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 resulting from M&As. Moreover, Sootla, Theis and Vicente (2017) empirically measure the synergistic coefficient of two data sets. This last article supports several hypotheses that we use in our model. In particular, it justifies that synergies are learned when data sets are merged, and require an 'exploration' cost.

Merger failure. We consider mergers that may fail with some probability in case synergies are low, and we analyze how firms can anticipate this outcome. Alternatively, the literature provides explanations for merger failures based on the behavior of merger participants after the M&A process. In Banal-Estañol, Macho-Stadler and Seldeslachts (2008), a company faces a moral hazard issue and under-invests in integration and cooperation with the other firm after a merger. Banal-Estañol and Seldeslachts (2011) introduce conflicts between merger participants, and reveal how they can result in efficiency losses.

Sharing innovation. 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 that is used for contracting. Anton and Yao (2002) analyze how an inventor can reveal part of its innovation to a prospective buyer to signal its quality. Our focus is different since the initial owner can sell its product to consumers, therefore it does not need an information buyer to do so, and the sharing of data allows exploration of potential synergies. We adopt the common view that shared information can be used by the receiver to compete with the sender, resulting in the well-known Arrow information paradox.

Killer acquisitions. The competitive effect of information sharing implies that an M&A will be motivated – at least in part – by a reduction of competition, and for this reason our article also relates to the literature on "killer acquisitions." Cunningham, Ederer and Ma (2021) document this practice of "incumbent firms acquir[ing] innovative targets solely to discontinue the target's innovation projects and preempt future competition" in the pharmaceutical industry.[9]

More generally, Cabral (2021) analyzes the benefits for an incumbent to acquire entrants and to shut down their project when there is a high probability that the new company poses a threat to the incumbent. In particular, he emphasizes the need for incumbents to identify the value of the threat, which is usually uncertain.

We consider a different situation in this article, where a prospective entrant chooses whether to acquire the incumbent, as was the case in recent flagship M&As such as Facebook/WhatsApp and Google/Fitbit. Moreover, we allow for synergies to be realized after an M&A, and the merger decision of the entrant depends on the value of these synergies. The threat posed by the entrant results from the amount of information that is shared by the incumbent, which is used to anticipate the value of synergies and to make a better overall M&A decision. In other words, firms may discover the value of synergies resulting from the M&A by sharing information, but sharing also increases the value of the threat faced by the incumbent.[10] Once information has been shared, the entrant faces a make-or-buy decision, and the M&A takes the flavor of a killer-acquisition at this stage.

Overall, we contribute to this literature by emphasizing how sharing information to learn the values of synergies affects the acquisition decision of the acquirer.

Data-driven M&As. We also overlap with a recent literature that analyzes the competitive impacts of data-driven M&As.[11] De Corniere and Taylor (2020) characterize whether data is pro or anti competitive, while Bounie, Dubus and Waelbroeck (2021) analyze mergers between data intermediaries and their competitive impact on product markets. Chen, Choe, Cong and Matsushima (2020) show that data-driven mergers increase consumer surplus as long as there are still competitors 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 for sure the extent of their complementarities, particularly regarding infor-

[9] A follow-up literature analyzes the implications of these killer acquisitions on start-up creation and innovation, in particular with the emergence of "kill zones" around large companies (Kamepalli, Rajan and Zingales, 2020; Shelegia and Motta, 2021).

[10] Alternatively, Shekhar and Wey (2017) analyze partial ownership as a way for a firm to learn the potential for synergies with a target. The essential difference with our approach is that partial ownership reduces the intensity of competition in the market, while competition becomes more intense after information has been shared in our model.

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

mation synergies. They can discover this synergistic value and make better decisions by sharing information before the M&A takes place.

3 Model

We consider two firms, indexed by 1 and 2, where 2 is a large firm (Google) and 1 is a firm that has developed a new product (Fitbit) and has a stock of data of mass one generated by this activity. There is a mass one of consumers to whom the product of Firm 1 provides a utility level of u. Absent other competition, Firm 1 can impose a price equal to u, making a profit of u.

Synergies. Firm 2 has developed other products and has its own stock of data. Combining data from Firms 1 and 2 will enhance the value to customers to $v \in \{\underline{v}, \overline{v}\}$. The value of v is unknown to firms, but each company knows that $v = \underline{v}$ with probability α, and $v = \overline{v}$ with probability $1 - \alpha$.

We maintain the following assumptions throughout the article.

H1: 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.

H2: $u \leq \overline{v}$.

H3: $u \geq 2\underline{v}$.

Assumption H1 is supported by an important literature on the pricing of information goods (Shapiro and Varian, 1998) that shows how consumers can easily discover their valuation of a product before acquiring it, through sampling, free downloading, freemium, ratings, and reviews. This assumption allows us to focus on strategies of information sharing and to avoid information asymmetries in the product market.

Assumptions H2 and H3 allow for negative and positive synergies. Even if the combination of the two data sets provides a benefit, as already discussed, the good produced after the M&A will inherit the brand image of Firm 2, and if this brand image is negative, the net value of the product to consumers may be lower than when Firm 1 sells the product. For instance, many WhatsApp users migrated to privacy-preserving apps such as Signal and Telegram after WhatsApp updated its terms of services to share user data with Facebook, its parent company.[12] This change of the value of a product after an M&A is supported by the management and economics literature on brand reputations (Fombrun and Shanley, 1990; Tadelis, 1999), on the "shock of cultures" following mergers and change of control, and by the fact that M&As may be accompanied by re-branding of products.

We assume in the main analysis that Firm 2 can neither resell Firm 1 to its previous owner nor can operate it as a separate entity and make profits u. We consider in Section 6.3 the possibility for Firm 2 to resell Firm 1, possibly at a cost, and we show that our results are not affected by this change. H3 is sufficient to ensure that under perfect information, Firm 2 will engage in an M&A only with type $\overline{v}$.[13]

Exploration cost. If Firm 1 does not sell data, the companies may merge under imperfect information. If Firm 1 shares data with Firm 2, the companies may learn the value of the synergies and will merge only if synergies are high, thereby avoiding low valuation M&As. However, there is a cost to use data from third parties to identify synergies, and we denote this cost by $C(s)$. The exploration cost includes the development of new algorithms or code, the matching of data sets, and marketing efforts. We assume that the exploration cost $C(s)$ decreases with s, following the idea that a company can always do at least as good with more data than with less. (If more data increases the cost, Firm 2 can always focus on a subset of the data-base.)

To simplify, we also make standard Inada conditions: $C(s), C''(s) \geq 0$, $C(1) = 0$, $C(0) = +\infty$, and $C'(0) = -\infty$. In equilibrium, Firm 2 will either invest $C(s)$ and learn the value of the synergy or not invest and remain uninformed.[14]

Firm 1 can share a portion of its data $s \in [0, 1]$ with Firm 2, possibly at an agreed-upon price $T(s)$. When $s = 0$, no information is shared, while Firm 1 shares all information when $s = 1$. At the time of sharing, companies do not know the value of synergies, but they know that v can

[12] "WhatsApp delays privacy update over user 'confusion' and backlash about Facebook data sharing," link on CNBC, last accessed June 2, 2021.

[13] We can show that our results hold when $\underline{v} < u < 2\underline{v}$. In this case, Firm 2 may acquire Firm 1 even when synergies are low, and sharing information is less profitable than an M&A under imperfect information.

[14] We could consider alternative data exploration costs. For instance, Firm 2 could learn the value of the synergies with a probability that increases with s. We could also assume that when all information is shared, the exploration cost is positive : $C(1) > 0$. This wouldn't change our main insights, as the important feature of this cost function is that there is a benefit for Firm 2 to obtaining more information from Firm 1, as it improves M&A decision.

be high or low with probabilities $1 - \alpha$ and α. Upon receiving s, Firm 2 can either exert effort greater than $C(s)$, in which case the synergy v is learned with probability 1, and with probability 0 for lower effort levels. To simplify, synergies are learned by both firms. (We show in 6.1 that our results are robust to the case where Firm 2 receives this information privately.)

Product quality. When synergies are learned, firms and consumers know that the product sold by Firm 2 provides value vs to customers when a share s of the data of Firm 1 is used. This specification is consistent with classical assumptions in the theoretical literature on technology transfers (Anton and Yao, 2002). Moreover, considering quality as a function of the amount of information shared is supported by empirical evidence in data-driven industries (Varian, 2019). As the predictive value of a data set increases with its size, the resulting quality of a product, a prediction, or a recommendation to consumers will increase as well. Considering a quality that increases linearly with the amount of data shared simplifies the analysis and does not limit the validity of our results, which would hold under any type of convex and increasing quality function. Moreover, we assume that Firm 2 bears no cost if it enters the market. In our motivating example with Google and Fitbit there might be a cost to enter the connected wearable market, and we show in Section 6.2 that our results are robust with regard to positive entry costs.

If v is known, Firm 2 can make a Take-It-Or-Leave-It (TIOLI) offer to Firm 1 for an M&A, or can use the shared information to compete with Firm 1. If there is an M&A, the product sold to consumers will have value v (since all data from Firm 1 are part of the assets of the merged firm). If the companies do not merge, Firm 2 has a product providing value vs to customers, that it can use to compete with Firm 1.

Regulatory oversight. A regulator can allow or prevent the M&A to maximize a welfare function that is the average of consumer surplus and industry profits. The regulator places a weight $\rho \in [0, 1]$ on consumer surplus, which is unknown by companies when they engage in M&A proceeding, and follows a distribution $F(\rho)$. Even if regulators should focus on consumer surplus, as is the case in Europe for instance, their ultimate decision may reflect other considerations, political or economic, 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.[15] The objective function of the regulator accounts for these additional factors, in the spirit of Baron and Myerson (1982).[16]

At the time the firms ask for approval of the M&A, they do know for certain which decision the regulator will take. For instance, when Google makes an offer to acquire Fitbit, it is not clear what the decision of a competition authority will be: the M&A may increase product quality and industry profits, but the firms may compete if the M&A is prevented, thereby increasing consumer surplus. The decision of the regulator balances these two effects depending on the weight ρ they put on consumer surplus, and we assume that firms do not know this value before sharing information and requesting M&A approval. After firms have asked for approval of the merger, the regulator observes a draw ρ from distribution $F(\rho)$ on $[0, 1]$ and makes a decision. (Beyond approval for an M&A, a regulator may decide ex-ante to allow information sharing in the industry. We will show that it is always beneficial for a regulator to approve information sharing, as it yields a more intense competition if the M&A is prevented.)

Timing. To summarize, the timing of the game is the following:

Stage 1: Firm 2 either remains uninformed, or purchases s information from Firm 1 for transfer $T(s)$, invests $C(s)$ and learns v or does not invest and v remains unknown.

Stage 2: Firm 2 makes a TIOLI offer to Firm 1 for an M&A. If Firm 1 declines the offer, firms compete.

Stage 3: Firms go to the regulator to have the M&A allowed, the regulator learns ρ and decides to allow or prevent the M&A.

Stage 4: Depending on the regulator's decision, firms compete or merge and profits are realized.

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

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

4 Analysis of the Baseline Model

We first analyze the incentives of Firm 2 to purchase information from Firm 1 in the absence of a regulator. 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 an M&A under imperfect information.

4.1 Competition

Suppose that Firm 1 shares $s > 0$, and let us ignore for the moment the possibility of an M&A. If Firm 2 invests $C(s)$ and learns v, it can provide its customers a value vs while Firm 1 can provide a value u. Assuming Bertrand competition[17] the equilibrium profits if the two firms per consumer are

$$\begin{aligned} &\pi_1(v,s) = 0,\ \pi_2(v,s) = vs - u \text{ if } vs - u \geq 0 \\ &\pi_1(v,s) = u - vs,\ \pi_2(v,s) = 0 \text{ if } vs - u \leq 0. \end{aligned} \tag{1}$$

If Firm 2 does not invest, its profit per consumer is equal to 0, the profit of Firm 1 is equal to u, and synergies are not learned. Firm 2 can benefit from the share of data by firm 1 only if its Bertrand profit $vs - u$ is positive, hence only if $v = \overline{v}$ and if s is greater than $\frac{u}{\overline{v}}$. We will refer to the ratio $\frac{u}{\overline{v}}$ as the Arrow (lower) bound on data sharing and denote it

$$A := \frac{u}{\overline{v}}. \tag{Arrow bound}$$

4.2 M&A

After the M&A, the merged entity has access to the full stock of data $s = 1$ that it can exploit at cost $C(1) = 0$. Therefore, the expected product value of an M&A if there is investment is denoted $\mathbb{E}[v]$:

$$\mathbb{E}[v] = \alpha\underline{v} + (1-\alpha)\overline{v}.$$

[17] Alternative types of competition can be considered, such as for instance Cournot competition, which would induce an elastic consumer demand. This would not change our qualitative results that rely on the fact that sharing information intensifies competition between firms.

An M&A is ex-ante efficient for firms if $\mathbb{E}[v] \geq u$ and it is clear that without information, Firm 2 will acquire Firm 1 only when the M&A is ex-ante efficient. We will show that information sharing can allow firms to merge even in cases where M&As are ex-ante inefficient.

We first analyze equilibrium profits with information sharing, taking into account transfer payments that Firm 2 makes to induce Firm 1 to share information. Two regimes arise: when the degree of information sharing is greater or lower than the ratio A – the minimum competitive gap between Firm 1 and Firm 2 when they compete head-to-head. Whether the maximum profit of Firm 2 under information sharing is achieved at a level greater or lower than this ratio will depend on whether the cost of exploration $C(s)$ is smaller or greater than a cutoff value that we characterize. We will then be able to show when information sharing is optimal.

4.3 Profits with Information Sharing

Suppose Firm 1 shares s with Firm 2, and that 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 v. In this case, the two firms anticipate payoffs $\pi_i(v, s)$ as given by (1) if there is no M&A. Firm 2 can make a TIOLI offer to buy Firm 1's asset at a price $p(v, s)$ that will make Firm 1 indifferent between merging and not merging:

$$p(v, s) := \pi_1(v, s). \tag{2}$$

When $s \leq A$, Firm 1 makes positive profits when the companies compete, regardless of the value of v. By assumption H2, firms benefit from merging when synergies are high since the total surplus from merging ($\overline{v}$) is greater than the total surplus under competition ($u - \overline{v}s$). However, by assumption H3, firms do not benefit from merging when synergies are low since $\underline{v} < u - \underline{v}s$. In both cases, Firm 1 incurs a competitive loss from sharing information, and Firm 2 has to pay $T(s) = \mathbb{E}[v]s$ to acquire information s and to compensate for this loss.

However, when $A \leq s$ and firms compete, Firm 1 makes positive profits if $v = \underline{v}$, and makes zero profits if $v = \overline{v}$. Therefore, to compensate for this loss, Firm 2 must pay Firm 1 an amount $T(s) = u - \alpha(u - \underline{v}s)$ to acquire information. As in the previous case, H2 and H3 imply that Firm

2 wants to merge only when $v = \overline{v}$, and because Firm 1 makes zero profits under competition, Firm 2 can acquire Firm 1 at a zero price.

Lemma 1 summarizes this discussion (all proofs absent from the text are in the Appendix).

Lemma 1. *The price of information, and the price Firm 2 pays to acquire Firm 1 when synergies are high are:*

- *When* $s \leq A$: $T(s) = \mathbb{E}[v]s$ *and* $p(\overline{v}, s) = \overline{v}(A - s)$.
- *When* $s \geq A$: $T(s) = u - \alpha(u - \underline{v}s)$ *and* $p(\overline{v}, s) = 0$.

The price $p(v, s)$ Firm 2 pays to Firm 1 for an M&A after learning the value of v decreases with s. As Firm 1 expects lower revenues when sharing more information, Firm 2 must compensate for this expected loss to incentivize information sharing. The marginal increase in $T(s)$ is lower when the amount of data is larger than the Arrow bound than when it is smaller than that bound. Indeed, when s is lower than A, increasing s reduces the profit of Firm 1 both when synergies are high and when synergies are low. On the contrary, the profit of Firm 1 when $v = \overline{v}$ is equal to 0 for all values of s greater than A, and increasing the value of s in this interval only reduces the profit of Firm 1 if synergies are low.

Now, Firm 2 is willing to acquire information only if it can recoup the exploitation cost. The expected profit of Firm 2 purchasing information s from Firm 1 is:

$$\pi_2^N(s) = (1 - \alpha)(\overline{v} - u) - \alpha\underline{v}s - C(s). \tag{3}$$

An increase in information sharing has two opposite effects on the profits of Firm 2. On the one hand, more information is costly to acquire from Firm 1, which lowers the profits of Firm 2. On the other hand, more information decreases the data exploration cost $C(s)$. We characterize in the next section the optimal amount of information shared, which balances these two opposite effects of information acquisition on the profits of Firm 2.

4.4 Information Sharing

We analyze when it is profitable for Firm 2 to purchase information from Firm 1, and we characterize information sharing in equilibrium. The alternative for Firm 2 is not to purchase data: if $\mathbb{E}[v] \geq u$ Firm 2 makes a TIOLI offer to buy Firm 1 at price u and Firm 2 makes expected profit $\mathbb{E}[v] - u$; if $\mathbb{E}[v] < u$ Firm 2 does not propose an M&A.

We show that acquiring the optimal amount of information dominates no information acquisition for Firm 2. By concavity of $\pi_2^N(s)$, the equilibrium amount of information shared s^* satisfies $\alpha\underline{v} = -C'(s^*)$:[18]

$$s^* = C'^{-1}(-\alpha\underline{v}). \tag{4}$$

Example 1. *To illustrate our results we will use throughout the examples the specification*

$$C(s) = c\frac{(1-s)^2}{s}, \tag{5}$$

where $c > 0$. Then, $C'(s) = c\left(-\frac{1}{s^2}+1\right)$ and $s^* = \sqrt{\frac{c}{c+\alpha\underline{v}}}$. $\alpha\underline{v}s$ corresponds to the expected loss of Firm 1 when sharing s and synergies are low, which must be compensated by a lump sum payment by Firm 2 when purchasing information from Firm 1. Consequently, when $\alpha\underline{v}$ increases, the relative benefit from sharing information to reduce the data exploration cost decreases as it becomes more profitable for Firm 2 to identify low synergies, and Firm 2 purchases less information.

We now compare profits with and without information sharing and, in Proposition 1, we provide conditions for Firm 2 to purchase information before the M&A.

Proposition 1.

(i) If $\mathbb{E}[v] \geq u$ information sharing is always optimal.

(ii) If $\mathbb{E}[v] < u$ Firm 2 acquires information if and only if $C(s^*) \leq (1-\alpha)(\overline{v} - u) - \alpha\underline{v}s^*$.

Proposition 1 indicates that information sharing allows companies to make more efficient merger decision, and to avoid inefficient M&A. In particular, we show in Proposition 1 (ii) that firms may engage into an M&A process that would not take place without information sharing.

When $\mathbb{E}[v] \geq u$, M&As are ex-ante efficient, but information allows companies to learn the value of synergies and to avoid the M&A when synergies are low. This is a first-order effect

[18]Note that the Inada condition $C'(1) = 0$ ensures that s^* is less than one.

and because of our Inada conditions on $C(s)$, the effect of a marginal sharing of information is second-order, and sharing is always optimal when M&As are ex-ante efficient.

By contrast, when $\mathbb{E}[v] < u$, M&As will not happen without information that synergies are high. Information sharing is profitable if $\pi_2(s^*) = (1-\alpha)(\overline{v} - u) - \alpha\underline{v}s^* - C(s^*) \geq 0$. The profitability of partial information sharing thus depends on the level of the data exploration cost. If the data exploration cost is high, Firm 2 does not exploit the data and, as M&As are ex-ante inefficient, the companies do not merge. On the contrary, if $C(s)$ decreases quickly, partial information sharing is more profitable than not merging, and information sharing allows M&As with high synergies to take place even when the M&A is ex-ante inefficient.

Example 2. *We use the cost specification given in* (5)*. If* $\overline{v} = 64, \underline{v} = 16$*,* $\alpha = \frac{1}{2}$*; then* $\mathbb{E}[v] = 40$*. In this case, case (i) condition in Proposition 1 applies when* $u < 40$*. If* $u > 40$*, for illustration* $u = 42$*, to verify whether the condition in case (ii) is satisfied, note that we can make the change of variable* $c = \alpha\underline{v}\frac{s^2}{1-s^2}$*, with the interpretation that* c *is the value of the cost parameter for which* s *is the equilibrium amount of information shared. Then the condition holds when* $s \leq \frac{11}{5}$*, which trivially holds because* $s \leq 1$*.*

We can now characterize how a change in the potential outcome of the M&A affects the expected payoff of Firm 2 when there is information sharing. According to the envelop theorem, it is immediate that:[19]

Corollary 1. *When mergers are ex-ante efficient, the expected payoff of Firm 2 increases when the value of low synergies decreases.*

This result contrasts with the literature, which finds a lower expected profitability of a merger when potential losses are important (Capron and Shen, 2007). The incentive of companies to engage in an M&A decreases when there is a risk that they will incur a loss in case of low synergies. Accordingly, the literature analyzes how companies may avoid a merger depending on the risk of ex post merger failure (Reuer, Shenkar and Ragozzino, 2004), or how they can mitigate the risk of low synergies (Balakrishnan and Koza, 1993). The same is true in our case *when firms do not share information* because the expected return from an M&A decreases when

[19]Indeed, by the envelop theorem: $\frac{\partial \pi_2^N}{\partial \underline{v}} = -\alpha\underline{v}$.

$\underline{v}$ decreases. We obtain an opposite result when information sharing is possible because as $\underline{v}$ decreases, there are two forces that make M&As more attractive. The first is a competitive effect, as a lower $\underline{v}$ softens competition, for any information sharing s, in case of low synergies (the price $u - \underline{v}s$ is larger when $\underline{v}$ is lower). This, therefore, increases the expected profits of Firm 2 that needs to provide a lower compensation to Firm 1 to induce information sharing. The second is an outside option effect, as the incentives to share information increase because the value of not sharing information decreases.

5 Information Sharing in the Shadow of a Regulator

5.1 Effect of a Regulator on Information Sharing

We introduce a regulator who is in charge of allowing or preventing the M&A. The overall objective of competition policy may be to protect consumers, but in reality, regulatory oversight may not perfectly achieve this objective. 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. The weight that the regulator places on consumer surplus – their "bias' – may be explicit or induced by political lobbying, mis-interpretation of the M&A documentation or ambiguity in other variables used by the regulator to evaluate the M&A.

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 increases both under M&A *and* under competition. There is indeed a benefit for consumers if the regulator prevents the M&A, as after having shared information, firms compete and lower their prices. Therefore, when evaluating an M&A proposal, the regulator will compare the *relative industry gain* weighted by $1 - \rho$ to the *relative gain of consumer surplus* weighted by ρ.

The total profit of the industry is equal to u if there is no information sharing and no M&A, to $\max\{u - vs, vs - u\}$ if Firm 2 has information s and the companies compete, and to v if the companies merge.

Consumer surplus is equal to 0 if a firm is a monopolist and there is full surplus extraction.

This case takes place when there is no information sharing and no M&A, and Firm 1 is a monopolist, or when Firm 2 acquires Firm 1. On the contrary, if information has been shared and firms compete, consumer surplus is equal to $\min\{u, vs\}$.

M&A decision without information sharing. In the absence of information sharing, the regulator and the firms have a common interest: an M&A is authorized as long as firms request it. Indeed, because Firm 2 cannot compete with Firm 1, consumer surplus is 0 whether or not there is an M&A and the variation of the regulator's surplus is equal to $(1-\rho)(\mathbb{E}[v]-u)$, and with probability one the 'ρ-regulator' authorizes the M&A if $\mathbb{E}[v]-u$ is non-negative. Because for $v = \underline{v}$ an M&A should not arise, the lack of information makes some M&As ex-post inefficient.

M&A decision with information sharing. At the time the regulator has to evaluate an 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 v. Firms request M&A approval if synergies are high, and the regulator can infer the value of v from their M&A request.[20] Contrary to the previous case, the objectives of the regulator and the firms are no longer aligned.

If $v = \underline{v}$ Firm 2 does not propose to merge and exerts a competitive pressure on Firm 1. Both the firms and the regulator prefer head-to-head competition to an M&A. However, if $v = \overline{v}$, under competition firms lower their prices providing consumers with a surplus equal to $\min\{u, \overline{v}s\}$, which is lost to consumers if the regulator allows the M&A. Conversely, the industry gain if the M&A is allowed is $\overline{v}\,(1-\max\{A-s, s-A\})$. Therefore, the regulatory welfare gain from the M&A is:

$$(1-\rho)\,\overline{v}\,(1-\max\{A-s, s-A\}) - \min\{u, \overline{v}s\}\rho.$$

and the regulator will authorize the M&A only if ρ is small enough.

Lemma 2. *There exists a decreasing function $\rho^*(s)$ such that the regulator authorizes the M&A*

[20] Alternatively, Cosnita-Langlais and Tropeano (2012) analyze signaling by firms willing to convince the regulator that synergies are high and to accept the merger.

if, and only if, $\rho \leq \rho^*(s)$*. Hence, the probability of an M&A is* $F(\rho^*(s))$*, with:*

$$\rho^*(s) = \begin{cases} \frac{1+s-A}{1+2s-A} & \text{if } s \leq A, \\ \frac{1-s+A}{1-s+2A} & \text{if } s \geq A. \end{cases} \tag{6}$$

The probability $F(\rho^*(s))$ that an M&A is allowed decreases with s, companies compete more fiercely when more information is shared, which benefits consumers. The opportunity cost of an M&A is thus larger for higher values of s and an M&A is beneficial only if ρ is large enough.

Consequently, with the presence of the regulator, the expected payoff of Firm 2 when purchasing information s from Firm 1 is:

$$\begin{aligned} \pi_2^R(s) =& (1-\alpha)\,\overline{v}\;[F(\rho^*(s)) + (1-F(\rho^*(s)))\max\{s-A, A-s\}] \\ & - \alpha\underline{v}s - (1-\alpha)u - C(s). \end{aligned} \tag{7}$$

Does the Presence of the Regulator Drive Information Sharing Up or Down ? We analyze how the presence of the regulator and the possibility that it prevents the M&A affect the incentives of Firm 2 to purchase information from Firm 1. While it is immediate that Firm 2's payoff decreases in the presence of a regulator, it does not follow that the marginal incentives for information sharing decrease.

Indeed, there are two opposite effects of the regulator on the incentives of companies to share information. On the one hand, the possibility that the regulator prevents an M&A increases with the amount of information shared, which reduces the incentives of firms to share information. On the other hand, Firm 2 has an interest in acquiring more information in case the M&A does not go through: with more information, Firm 2 will achieve higher profits in the competitive case.

We show that the second effect can dominate the first one only if s is greater than the Arrow bound. This result allows us to characterize the environments for which the presence of a regulator leads to an increase in the amount of information shared. In short, this happens only when the no-regulator amount of information shared is greater than A.

Using (3) and (7), we can write for $s \in [0,1]$:

$$\begin{aligned} \pi_2^R(s) &= \pi_2^N(s) - (1-\alpha)K(s) \\ \text{where } K(s) &:= (1-F(\rho^*(s)))\,\overline{v}\,\left(1-\max\{s-A, A-s\}\right) \end{aligned} \tag{8}$$

and the additional marginal incentives for information sharing are positive if $K(s)$ has negative variation. We show that this can happen only if s is greater than the Arrow bound A and if the following condition holds:

$$\forall s \geq A,\ \frac{f(\rho^*(s))}{1-F(\rho^*(s))} < \frac{(1-s+2A)^2}{A(1-s+A)}. \tag{Hazard}$$

Lemma 3. *Suppose that (Hazard) holds. Then $K(s)$ is quasi-concave with a maximum at $s = A$.*

Proof. If $s < A$, $K(s) = (1-F(\rho^*(s)))\overline{v}(1+s-A)$. By Lemma 2, $1-F(\rho^*(s))$ is an increasing function of s, and therefore $K(s)$ is an increasing function on $s \leq A$. It follows, that local incentives to invest decrease with a regulator, or $\frac{d\pi_s^R(s)}{ds} < \frac{d\pi_s^N(s)}{ds}$.

If $s > A$, $K(s) = (1-F(\rho^*(s)))\overline{v}(1-s+A)$, and we have the two opposite forces discussed earlier: as s increases, the probability that the M&A is rejected $(1-F(\rho^*(s)))$ increases but the loss when the M&A is refused $(\overline{v}(1-s+A))$ decreases. Simple algebra shows that on $s > A$,

$$K'(s) = (1-F(\rho^*(s)))\overline{v}\left[-1 - \frac{d\rho^*(s)}{ds}\frac{f(\rho^*(s))}{1-F(\rho^*(s))}(1-s+A)\right].$$

Because when $s > A$, $\frac{d\rho^*(s)}{ds} = \frac{-A}{(1-s+2A)^2}$, $K'(s)$ is negative whenever the hazard rate condition (Hazard) is satisfied. □

Remark 1. *Condition (Hazard) is satisfied for many distributions. A first case is when ρ is uniformly distributed for then (Hazard) holds for any value of s because the hazard rate is*

$$\frac{f(\rho^*(s))}{1-F(\rho^*(s))} = \frac{1-s+2A}{A}$$

which is clearly smaller than $\frac{(1-s+2A)^2}{A(1-s+A)}$.

For general distributions with monotonically increasing hazard rate $H(\rho) := \frac{f(\rho)}{1-F(\rho)}$ the left hand side of the inequality in (Hazard) is a decreasing function of s (indeed $\rho^*(s)$ is a decreas-

ing function of s and the hazard rate $\frac{f(\rho)}{1-F(\rho)}$ is increasing in ρ) while the right hand side is a decreasing function of s, a sufficient condition is that the right hand side evaluated at $s = A$ is lower than the left hand side evaluated at $s = 1$. Because $\rho^*(A) = \frac{\overline{v}}{\overline{v}+u}$, the condition reduces to $H\left(\frac{\overline{v}}{\overline{v}+u}\right) < 4$. For instance, if $\overline{v} = 2u$, the condition is $H(2/3) < 4$.

The quasi-concavity of $K(s)$ allows us to infer that if s^* is greater than A, the function $\pi_2^R(s)$ attains a maximum over the region $s \geq A$ for $s^R \geq s^*$. However, because $K'(s)$ is positive in the other region $s < A$ we cannot exclude the possibility of another local maximum in that region. To simplify, and to illustrate the possibility of regulation-enhancing information sharing, we will make an assumption sufficient to ensure that all global maxima are in the region $s \geq A$.

A sufficient condition is that under no regulation, companies use $s^* > A$; note that the Inada condition $C'(1) = 0$ ensures that s^* is less than 1 and that for all $s \leq A$, the ex-ante surplus from information sharing is lower than the surplus $\max\{\mathbb{E}[v] - u, 0\}$ when there is no information sharing. These conditions reduce to having a probability of low synergies that is small enough.

Assumption H4. (Restricted Environment) (a) $\mathbb{E}[v] > u$, (b) $s^* > A$, (c) $\pi_2^N(A) < \mathbb{E}[v] - u$.

A necessary and sufficient condition for (b) is that $\alpha < \frac{-C'(A)}{\underline{v}}$ which ensures that $\pi_2^N(s)$ has positive variation on $s \leq A$, hence that $s^* > A$; because $C'(1) = 0$, $s^* < 1$. When (a) holds, a sufficient condition for (c) to be satisfied is $\alpha < \frac{C(A)}{u}$. For the specification of cost (5), (b) is the binding constraint and we need:[21] $\alpha < c\frac{(\overline{v}-u)^2}{u^2\overline{v}}$. There is clearly c large enough, or α low enough, for this condition to hold. Under H4, firms facing a regulator will obtain $\mathbb{E}[v] - u$ if they do not acquire information (remember that in this case the regulator has the same objective as the firms). Therefore, they will not engage in information sharing unless s is greater than A, (because without a regulator they would not do so when s is lower than A.)

Proposition 2. *(i) It is possible that s^R is greater than s^* only if $s^R > A$.*

(ii) Full information sharing ($s = 1$) is profitable for the firms when

$$\alpha < \frac{1 - (2 - F(1/2))A}{1 + \frac{\underline{v}}{\overline{\overline{v}}} - (2 - F(1/2))A}.$$

[21] Indeed, $-\frac{C'(A)}{\underline{v}} = c\frac{\overline{v}^2-u^2}{u^2\underline{v}} > c\frac{(\overline{v}-u)^2}{u^2\overline{v}} = \frac{C(A)}{u}$ reduces to $\frac{\overline{v}^2-u^2}{\underline{v}} > \frac{(\overline{v}-u)^2}{\overline{v}}$, which is clearly satisfied.

(iii) Suppose that condition (Hazard) and assumption H4 hold and that full information sharing is profitable. Then companies exchange more information under regulatory oversight, $s^R > s^*$.

As the first part (i) of the proposition establishes, independently of the conditions used in the other parts of the proposition, there is more information with than without a regulator only if the level of information sharing is greater than A. The necessity part (i) in the proposition follows a revealed preference argument. The next claim (ii) is simple algebra solving $\pi_2^R(1) > \mathbb{E}[v] - u$. Observe that the condition is more likely to be satisfied the smaller the ratio $\frac{\underline{v}}{\overline{v}}$, that is the farther apart are the low and high synergy values. Part (iii) follows Lemma 3 since the marginal variation of $\pi_2^R(s)$ is greater than $\pi_2^N(s)$: this implies that the local maximum on $s \geq A$ is greater than s^* and revealed preferences together with (ii) imply that firms prefer sharing information over not sharing data and engaging into M&A proceedings without information on synergies.

The proposition highlights the two relevant cases to consider to understand the impact of the regulator on pre-M&A information sharing. When $s^R < A$, more information shared decreases the exploration cost but increases the probability that the M&A is prevented, in which case Firm 2 makes 0 profits. Both effects discourage Firm 2 and *less* information is shared when a regulator is present than when it is not.

When $s^R > A$ there is an additional positive effect of information sharing on the profits of Firm 2: if the M&A is prevented, the larger the value of s, the higher the profits of Firm 2 under competition $\overline{v}s - u$. When condition (Hazard) holds, this second effect dominates the first effect when $s > A$, and Firm 2 purchases *more* information than in a situation without a regulator.

5.2 The Impact of the Regulator on Consumer Surplus

We now analyze the impact of the regulator on consumer surplus. Companies 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. However, the regulator can also prevent the M&A when synergies are high to force companies to compete and maintain a high level of consumer surplus.

The first effect depends on the optimal amount of information shared by Firm 1. If Firm

2 purchases $s^R < A$ data, it purchases less information than without the regulator: $s^R < s^*$. Consumer surplus is equal to $\alpha\ \underline{v}\ s^R + (1 - F(\rho^*(s^R)))\ \overline{v}\ s^R$ which can be greater or smaller than the surplus without the regulator $\alpha\ \underline{v}\ s^*$, depending on the amount of information shared and on the probability that the M&A is prevented.

Under the conditions of Proposition 2, if Firm 2 purchases $s^R > A$, it purchases more data when there is a regulator than when there is not. Expected consumer surplus is equal to $\alpha\ \underline{v}\ s^R + (1 - F(\rho^*(s^R)))u$, which is always greater than expected surplus without the regulator, $\alpha\ \underline{v}\ s^*$. Therefore, a simple consequence of Proposition 2 (iii) is that if information sharing increases with regulation, consumers are better off because there is a lower probability that M&As are approved, and consumers face reduced prices when firms compete.

Corollary 2. *Suppose that condition (Hazard) and assumption H4 hold, and that full information sharing is profitable. Then, the presence of the regulator increases expected consumer surplus.*

If we are outside the scope of the conditions of Proposition 2 (iii), it is possible that s^R is inferior to s^*, and in this case the presence of a regulator may have ambiguous effects on consumer surplus.

Moreover, because there is a chance that the regulator prevents the M&A and forces the companies to compete when synergies are high, it can be more profitable for Firm 2 to acquire Firm 1 with probability 1 under imperfect information. We illustrate this last case in the example below.

Example 3. *Consider $\underline{v} = 2$, $u = 4$, $\overline{v} = 64$, $\alpha = \frac{1}{2}$, $C(s) = \frac{(1-s)^2}{s}$, and F is the uniform distribution. Hence $A = 1/16$. In equilibrium information sharing without regulation is $s^* = \frac{1}{3}$, and the expected consumer surplus is equal to $2,666$. With regulatory oversight, if Firm 2 acquires s and synergies are high, the merger is approved with probability $\rho(s) = \frac{1+2s}{1+4s}$ and declined with probability $1-\rho(s)$. Therefore, replacing the numerical values in (7), the expected payoff of Firm 2 acquiring information is equal to $16(1 + \frac{1}{1+4s}) + \frac{s(64s-32)}{1+4s} - 8s - 16 - C(s)$. Solving for the optimal sharing we find $s^R \approx 0,593$ and the expected profit of Firm 2 is equal to $0,7$. It is thus more profitable for Firm 2 to acquire Firm 1 under imperfect information than to acquire information. Firm 2 makes a profit of 8, but consumer surplus is equal to 0.*

5.3 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 the decision to allow information sharing in an industry is made by a regulatory authority 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 a positive or negative advice for an 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 a greater or lesser intense lobbying, or can have different ideological opinions that will affect their final decision. The decision to allow or prevent information sharing is not case-specific but holds for all industries, and we assume that it is made by the regulatory authority.[22]

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 0 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 3. *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 are allowed to.*

A regulatory authority that is strongly oriented toward consumer surplus sees information sharing practices with a keen eye, as they lead to more competition and a higher consumer surplus if the M&A is prevented. However, a strong bias towards consumer surplus can discourage companies from sharing information.

Consider the special case where $\rho_0 = \mathbb{E}[\rho] = 1$, and firms know that if they share information, the M&A will be denied and they will compete with probability 1. Firm 2 can either acquire information $s = 1$,[23] leading to a consumer surplus equal to $(1-\alpha)u + \alpha\underline{v}$, or firms can merge under imperfect information in which case the expected payoff of Firm 2 is equal to $(1-\alpha)(\overline{v}-u)+$

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

[23]With $s \geq A$, Firm 2 makes expected profits equal to $(1-\alpha)(\overline{v}s - 2u) - \alpha\underline{v}s - C(s)$: when $(1-\alpha)\overline{v} < \alpha\underline{v}$ Firm 2 does not acquire information; when $(1-\alpha)\overline{v} \geq \alpha\underline{v}$, Firm 2 acquires $s = 1$.

$\alpha(\underline{v} - u)$, and consumer surplus is equal to 0. Thus when an M&A under imperfect information is more profitable than acquiring information (i.e., when $(1 - \alpha)\overline{v} < \alpha\underline{v}$ or $2\alpha\underline{v} \geq (2\alpha - 1)u$) the presence of the regulator discourages companies from sharing data and reduces the expected consumer surplus. This result is in the spirit of second-best analysis and suggests that a limited bias of regulatory agents toward industry profits can encourage firms to share data, resulting in possible surplus enhancement for consumers.

5.4 Cross-Market Data Externalities

Firm 2 may use the information shared by Firm 1 in other data-driven markets.[24] For instance, an important concern for data protection agencies and competition authorities during the acquisition of Fitbit by Google was the risk that Google may use health related data to discriminate consumers in healthcare and health insurance markets (Bourreau, Caffarra, Chen, Choe, Crawford, Duso, Genakos, Heidhues, Peitz and Rønde, 2020).

In this section we explicitly model such a connected market, for example the health insurance market, in which Firm 2 sells to consumers a product with quality $v_h(s)$ increasing with s. We assume that Firm 2 is a monopolist in this market, and earns profits equal to $v_h(s)$ while consumer surplus is equal to 0.[25]

Let us denote by $l(s)$ an additional privacy loss when s information is shared by Firm 1 and used by Firm 2 in the connected market, which increases with the amount of information shared by Firm 1. We assume that $l(s)$ is not internalized by the market and does not reduce the profit of Firm 2. While we already consider consumers' privacy concerns in Firm 1's product market, which reduces the utility that consumers derive from purchasing a product once information has been shared, we allow for an additional privacy loss that depends on the scope of use of information by Firm 2, in line with our Google/Fitbit illustration.

Profits. The profits of Firm 2 when acquiring Firm 1 are higher when considering the connected market: on top of its expected payoff in Firm 1's market, Firm 2 makes additional profits equal to $v_h(s)$ when s information is shared, and equal to $v_h(1)$ if it acquires Firm 1. This additional

[24] Prufer and Schottmüller (2017) analyze dynamic competition when markets are connected by data.

[25] We can assume that $v_h(s)$ is a concave and bounded utility function. Without loss of generality we normalize $v_h(0)$ to 0.

profit increases the willingness of Firm 2 to acquire information from Firm 1. In particular, if the increase in profits is high enough in this connected market, Firm 2 may acquire Firm 1 even when synergies are low.

Consumer surplus. Firm 2 is a monopolist in the connected market and extracts full consumer surplus, which does not depend on product quality $v_h(s)$. However, as consumers' privacy loss is not internalized by the market, consumer surplus in the connected market depends on $l(s)$. Overall, consumer surplus increases with the intensity of competition in Firm 1's market, and decreases when information is shared in the connected market due to the privacy loss. Consequently, without regulatory oversight, the expected consumer surplus in Firm 1's market at the time information is shared is equal to $\alpha\underline{v}s$, while the expected loss of surplus due to privacy concerns in the connected market is $(1-\alpha)l(1)+\alpha l(s)$. The expected variation of surplus when companies share information is equal to $\alpha\underline{v}s-(1-\alpha)l(1)-\alpha l(s)$, whose sign depends on $l(.)$.

The decision of the regulator to allow or prevent the M&A depends on the definition of the relevant markets when assessing the impact of an M&A. Limiting the analysis to the market in which Firm 1 operates leads the regulator to the same decision process as in our baseline framework. However, Firm 2 acquires more information when it can use it to leverage on its profits in the connected market. Therefore, two opposite effects of the connected market on consumer surplus emerge, and both depend on the privacy loss. In the limit case without privacy cost ($l(s)=0$), the expected consumer surplus increases as Firm 2 acquires more information. When consumers incur a high privacy cost, their surplus is lower when Firm 2 uses information in the connected market.

Information sharing. When the regulator considers a broad definition of relevant markets, it also accounts for the impact of an M&A on consumer surplus in the connected market. The presence of regulatory oversight will have the same opposite effects on information sharing as in the main analysis. On the one hand, the regulator is more willing to prevent the M&A when more information is shared, as the privacy cost increases – and consumer surplus decreases – if firms merge and share all of their information. On the other hand, Firm 2 also has an interest in acquiring more information to reach high profits in the connected market in case the M&A is prevented, as $v_h(s)$ increases with s.

5.5 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 that are not related to data to take place - such as efficiency gains or the complementarity of the companies' patent portfolios - while preventing potential negative impacts of data-driven effects. The latters usually relate to privacy issues, but also to increased market power resulting from the merger of data sources.

We consider such data silos in this section, and we analyze whether they increase or decrease the willingness of companies to share their data. Because of our focus on information synergies and information sharing, our analysis necessarily offers an incomplete picture of the overall impacts of data silos on market power, innovation and overall efficiency gains. Nevertheless, we can address their impact on consumer surplus through changes in data sharing and in the incentives of firms to proceed with an M&A.

We introduce a probability γ under which the data sources of firms cannot be merged in case the M&A goes through, and they cannot benefit from the resulting synergies. Consequently, an M&A with data silos is motivated only by a reduction of competition. It should be clear that, absent social benefits that we do not directly model, a regulator always prefers either to allow the M&A and have the industry benefit from data synergies, or to prevent the M&A and preserve competition between firms. Therefore, for simplicity, we take γ as exogenous.

Let us focus on values for which the regulator would allow the M&A to go through despite the loss of competition. With probability $1-\gamma$ firms merge and make a profit equal to $\overline{v}$; with probability γ, firms merge but data remain separated, and the only synergies that take place are those resulting from data sharing, yielding industry profits equal to $\max\{u, \overline{v}s\}$. Therefore, Firm 2 still has an interest in acquiring Firm 1 in the case of high synergies.[26]

[26]When $A > s$, the expected payoff from the M&A is $\gamma u + (1-\gamma)\overline{v}$ which is greater than the price of the acquisition $u - \overline{v}s$. When $A < s$, the price of acquisition is 0 and merger is also always profitable.

Data silos may increase the incentives of Firm 2 to acquire information, as when $s^* \geq A$, industry profits with data silos are equal to $\overline{v}s$ which increases with s. However, because expected industry profits are reduced as data silos may be implemented, the regulator will prevent the merger with a higher probability to protect consumer surplus. This second effect lowers the incentives of firms to share data, to reduce the competitive effect of data sharing and the resulting increase of consumer surplus. Either effect may dominate the other, depending on the weights the regulator places on surplus and industry profits, and data silos may increase or decrease the sharing of data.

To illustrate this possibility, consider first $s^* > A, \rho = 0$, and the regulator focuses only on industry profits. The M&A is always allowed when synergies are high, and data silos increase information sharing following the first effect. On the contrary, when $s^* < A, \rho > 0$, the only effect that takes place is the second, negative one on data sharing, and the companies share less data when there is a chance that data must be kept separated after the merger.

Finally, data silos also impact the willingness of firms to merge. Without data sharing, the expected payoff of a merger with the probability of data silos is $(1-\alpha)(\gamma u+(1-\gamma)\overline{v})+\alpha\underline{v} < \mathbb{E}[v]$, while with data sharing, the expected payoff of Firm 2 is $\pi_2 = (1-\alpha)(1-\gamma)(\overline{v}-u) - \alpha\underline{v}s - C(s)$ which is smaller than expected profits without silos.

6 Extensions

In this section, we consider several extensions of the baseline model. In Section 6.1 we show that our results are robust to private learning of synergies by Firm 2, and in Section 6.2 we consider positive costs of entry. We analyze the possibility of divestment after an M&A in Section 6.3, and in Section 6.4 we analyze bilateral information sharing between firms, and we characterize market conditions under which firms prefer to purchase or to exchange information. Finally, we analyze Nash bargaining on the final value of the M&A in Section 6.5.

The baseline model is considered without regulation for simplicity purposes, which also corresponds to the case where the regulator is fully oriented toward the industry ($\rho = 0$).

6.1 Asymmetric Learning of Synergies

In the main 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 the possibility of learning synergies privately in this section, and we show that it has no impact on information sharing and M&A decision. The intuition is that to have Firm 1 accepting the M&A, Firm 2 will 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 price of information. Therefore, the expected payoff of Firm 2 when acquiring information from Firm 1 will be equal to the expected payoff with public learning of synergies. Companies approach the regulator only when synergies are high, and there is no information asymmetry at this point.

Consider the situation where after having acquired s and invested $C(s)$, Firm 2 learns v privately. As usual, there are three candidates for pure strategy signaling equilibrium by Firm 2: pooling and not offering an M&A, pooling and offering an M&A and separating by offering an M&A only when synergies are high, which is equivalent to an excluding equilibrium. Pooling equilibria are not sustainable as Firm 2 does not have interest to acquire Firm 1 when synergies are low (because by assumption $2\underline{v} < u$, hence $\underline{v} \leq u - \underline{v}s$). 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 an M&A when synergies are high. In this case, Firm 2 obtains $\max\{0, \overline{v}s - u\}$, and therefore there is incentive compatibility only if $\overline{v} - p(s) \geq \max\{0, \overline{v}s - u\}$. Simple algebra shows that there exists a positive $p(s)$ such that the condition holds for all values of s.

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 $p(s)$ is greater than the competitive payoff $\max\{0, u - \overline{v}s\}$. Hence, Firm 2 has interest to offer $p(s)$ when synergies are low as long as

$$\underline{v} \geq p(s).$$

It follows that a separating strategy is incentive compatible when $p(s) \geq \underline{v}$, and Firm 1's continuation payoff is equal to $u - \underline{v}s$ when synergies are low and to $\max\{\underline{v}, u - \overline{v}s\}$ when synergies are high. Hence, Firm 1 will agree (in a TIOLI system) to share information if the ex-ante payment is $T(s) = u - (1-\alpha)\max\{\underline{v}, u - \overline{v}s\} - \alpha(u - \underline{v}s)$, and Firm 2's expected payoff is

$$\pi_2(s) := (1-\alpha)(\overline{v} - u) - \alpha\underline{v}s - C(s),$$

and therefore the equilibrium level of information is s^*, as in the baseline model with symmetric information.

6.2 Positive Entry Costs Under Competition

We have assumed that after having obtained information s, Firm 2 can compete with Firm 1 at no cost and provide a utility vs to consumers. We now extend our framework to account for a positive entry cost: Firm 2 incurs a cost f to compete with Firm 1, or can choose to remain out of the market.[27] There are many situations where such an entry cost is required, such as for instance markets for hardware like Fitbit's products.

The entry cost lowers the competitive pressure that Firm 2 exerts on Firm 1. When Firm 1 shares a small amount of information with Firm 2 ($vs \leq f$), it is never profitable for Firm 2 to enter the market and there is no competitive loss for Firm 1. In this case Firm 1 can provide information to Firm 2 without requiring a money transfer. When more information is shared and entering the market becomes profitable for Firm 2, the entry cost will relax the competitive pressure when synergies are low, reducing in turn the price of information. When synergies are high, a positive entry cost does not change the equilibrium as Firm 2 acquires Firm 1 regardless of f.

Hence the expected payoff of Firm 2 purchasing $s \leq \frac{f}{\underline{v}}$ is:

$$\pi_2(s) = (1-\alpha)(\overline{v} - u) - C(s). \tag{9}$$

[27] We assume that Firm 2 simultaneously decides whether to enter and chooses the price of it's product. Assuming sequential entry decision and price competition would lead to an equilibrium identical to perfect information at the beginning of the game.

This expected payoff is clearly maximized for $s = \min\{\frac{f}{\underline{v}}, 1\}$. Note that when $\underline{v} \leq f$ Firm 2 acquires $s = 1$ and makes profits equal to an M&A under perfect information.

If $\underline{v} \geq f$, Firm 2 can also acquire information $s \geq \frac{f}{\underline{v}}$ from Firm 1 to reduce the data exploration cost. The amount of information shared in this case is equal to information sharing without entry cost s^*, as defined in (4). Firm 2 then compares its expected payoffs with s^* and $s = \frac{f}{\underline{v}}$ to decide how much information to acquire.

6.3 Possibility of Divestment After the M&A

Firms may engage in an M&A without sharing information and then separate the merged entity if synergies are low. Assume that Firm 1 can still achieve profits u by operating its company separately.[28] If synergies are low, the former owners of Firm 1 can make a TIOLI offer to Firm 2 and buy their company back for a value equal to $\underline{v}$. As a result, Firm 2 can acquire Firm 1 at price $p = (1-\alpha)u + \alpha\underline{v}$, and make an expected payoff at the time information is shared equal to $\pi_2 = (1-\alpha)(\overline{v} - u)$. As Firm 2 makes no loss when synergies are low, profits are those with perfect information at the beginning of the game.

However, we have assumed until now that M&As are costless to realize, which is clearly a far cry from reality. For the same reason, divestitures also entail costs. Assuming for simplicity that the cost of an M&A is $\phi > 0$ and that the cost of a 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 $\underline{v} < u - \hat{\phi}$. Hence, the expected industry profit is $(1-\alpha)\overline{v} + \alpha u - \phi - \alpha\hat{\phi}$ – assuming that this expression is greater than u. By contrast, if there is merger after sharing of s, the expected industry profit is $(1-\alpha)\overline{v} + \alpha(u - \underline{v}s) - C(s) - (1-\alpha)\phi$ because there is a merger only if synergies are high, in which case there is no further divestiture. When synergies are low the industry incurs the standard competitive loss $-\underline{v}s$. Comparing industry profits in both scenarios, sharing of information emerges whenever

$$C(s^*) + \underline{v}s^* < \alpha(\phi + \hat{\phi}).$$

[28]In the main analysis we have assumed that the M&A by Firm 2 induces reputation concerns for consumers, which will remain even if the company is sold back to Firm 1.

Where s^* maximizes the expected payoff of Firm 2 when acquiring information: $(1-\alpha)(\overline{v}-u)-\alpha\underline{v}s-C(s)-(1-\alpha)\phi$, and in equilibrium, $s^*=-C'^{-1}(\alpha\underline{v})$ as in the baseline mode. However, the value from a merger is now lower than without merging and divesting costs, because M&As are costly.

6.4 Bilateral Information Sharing

In our analysis, Firm 2 can purchase information from Firm 1. In practice, companies can also engage in bilateral sharing of information, which we analyze in this section.[29] 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 an M&A. If Firm 2 invests $C(s_1)$, both firms learn the synergy and Firm 2 can provide its customers with a value $v\ s_1$. Firm 1 also learns v and it can provide its customers with a value $u+\beta\ v\ s_2$ where $\beta \geq 0$. Assuming Bertrand competition, it follows that the equilibrium price p paid by the consumers and the profits per consumer are

- If $v(s_1-\beta s_2) \geq u$,

$$p(v,s_1,s_2)=v(s_1-\beta s_2)-u; \quad \pi_1(v,s_1,s_2)=0; \quad \pi_2(v,s_1,s_2)=v(s_1-\beta s_2)-u$$

- If $v(s_1-\beta s_2) \leq u$,

$$p(v,s_1,s_2)=u-v(s_1-\beta s_2); \quad \pi_1(v,s_1,s_2)=u-v(s_1-\beta s_2); \quad \pi_2(v,s_1,s_2)=0.$$

We assume that there is no competitive loss for Firm 2 when sharing information with Firm 1. This assumption simplifies the analysis and is natural for instance in our illustrative example. There is no risk for Google that Fitbit will enter the markets of web browsers or video streaming services, even if Google shares some of its information.

[29] For instance, Scaria, Berghmans, Pont, Arnaut and Leconte (2018) describe practices of information sharing between companies in Europe. Bilateral information sharing is also reminiscent of practices 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 $p(v, s_1, s_2)$ that will make Firm 1 indifferent between merging and not merging, that is

$$p(v, s_1, s_2) := \pi_1(v, s_1, s_2). \tag{10}$$

Profits with bilateral information sharing. When firms share information, they anticipate their profits if there is competition and if there is an M&A, and they share information accordingly. Lemma 4 characterizes the expected payoff of Firm 2 when exchanging information with Firm 1.

Lemma 4. *Bilateral information sharing occurs in equilibrium if, and only if,* $s_1 - \beta s_2 \leq 0$. *The expected payoff of Firm 2 sharing* s_2 *and investing* $C(s_1)$ *is:*

$$\pi_2(s_1, s_2) = (1 - \alpha)(\overline{v} - u + \overline{v}(s_1 - \beta s_2)) - C(s_1).$$

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: $\beta s_2 \geq s_1$. 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.

Information sharing. It is clear that $\pi_2(s_1, s_2)$ is maximized for the highest value of s_1 under the condition that $s_1 \leq \beta s_2$. If $\beta \leq 1$, the equilibrium amounts of information shared by Firm 1 and Firm 2 are $s_1 = \beta$, $s_2 = 1$ and the expected payoff of Firm 2 when sharing information is: $\pi_2(s_1, s_2) = (1 - \alpha)(\overline{v} - u) - C(\beta)$. However, if $\beta \geq 1$, in equilibrium Firm 1 shares $s_1 = 1$ and Firm 2 shares $s_2 = \frac{1}{\beta}$, and the expected payoff of Firm 2 when sharing information is: $\pi_2(s_1, s_2) = (1 - \alpha)(\overline{v} - u)$.

Bilateral information sharing versus information purchasing. We compare profits in equilibrium under bilateral information sharing and information purchasing. As we have shown in Lemma 4, the expected profit of Firm 2 purchasing the optimal amount of information s^* from Firm 1 when there is no regulator is: $\pi_2(s^*) = (1-\alpha)(\overline{v}-u) - \alpha\underline{v}s^* - C(s^*)$.

It is clear that bilateral sharing is always more profitable than information purchasing if $\beta \geq 1$. Sharing information with Firm 1 is a costless way for Firm 2 to learn the value of the synergies. If synergies are low, firms do not merge and Firm 2 makes 0 profits. If synergies are high, Firm 2 can acquire Firm 1 at price u.

If $\beta \leq 1$, bilateral information sharing is more profitable than information purchasing if the information shared by Firm 2 increases the profits of Firm 1 above a threshold: $\beta \geq \beta_0 = C^{-1}(\alpha\underline{v}s^* + C(s^*))$.

This leads us to the following proposition:

Proposition 4.

- *Bilateral information sharing yields higher profits than information purchasing if the information shared by Firm 2 is profitable enough for Firm 1, i.e., if* $\beta \geq \beta_0 = C^{-1}(\alpha\underline{v}s^* + C(s^*))$.
- *If* $\beta \geq 1$, $s_1 = 1$, $C(s_1) = 0$ *and bilateral information sharing yields the same profits for Firm 2 as under perfect information about* v *at the beginning of the game.*

The value β_0 corresponds to the threshold below which the profitability for Firm 1 of the information shared by Firm 2 is too low to induce profitable information sharing. Firm 1 shares a small portion of its information in exchange of s_2, resulting in a high data exploration cost for Firm 2. Information purchasing is more profitable in this case because in exchange of a money transfer, Firm 2 can acquire more information from Firm 1, thus reducing the data exploration cost.

6.5 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 an 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 take place if Firm 1 has a positive stake in the future M&A.

In this extension we assume that the spoils of an M&A are shared following the cooperative Nash bargaining solution. Therefore, if $\pi_i^c(s)$ is the threat point when the expected synergy is v, and firms shared s, firm $i \neq j$ has a Nash payoff of $\frac{1}{2}(v - \pi_j^c(s) + \pi_i^c(s))$.

Without information sharing, firms merge if and only if the M&A is ex ante efficient. If in this case firms $1, 2$ have respective threat points $u, 0$ and the Nash payoffs under no information sharing are respectively

$$(\pi_1^N, \pi_2^N) := \left(\frac{1}{2} \left(\mathbb{E}[v] + u \right), \frac{1}{2} \left(\mathbb{E}[v] - u \right) \right).$$

With information sharing s, and exploration cost $C(s)$, if synergies are low, there is no M&A, hence firms compete and Firm 1 makes profit $u - \underline{v}s$ while Firm 2 makes not profit. If synergies are high, an M&A is efficient, while firms have threat points $\pi_1^c(s) = \max\{0, u - \overline{v}s\}$ and $\pi_2^c(s) = \max\{0, \overline{v}s - u\}$. Simple algebra shows that, independently of whether s is greater or lower than A, the Nash profits when the surplus from M&A is $\overline{v}$ are

$$\pi_1^*(s) = \frac{1}{2}(\overline{v}(1 - s) + u); \; \pi_2^*(s) = \frac{1}{2}(\overline{v}(1 + s) - u).$$

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

$$\begin{aligned} \pi_1^I(s) &= \alpha(u - \underline{v}s) + (1 - \alpha) \left\{ \frac{1}{2}(\overline{v}(1 - s) + u) \right\} \\ \pi_2^I(s) &= (1 - \alpha) \left\{ \frac{1}{2}(\overline{v}(1 + s) - u) \right\} - C(s). \end{aligned}$$

It follows that there is scope for information sharing if, and only if,

$$\pi_1^I(s) \geq \pi_1^N \text{ and } \pi_2^I(s) \geq \pi_2^N.$$

Example 4. *We use the cost function of our example 3, and these conditions reduce to*

$$\frac{\alpha(u - \underline{v})}{(1 - \alpha)\overline{v} + 2\alpha\underline{v}} \geq s \; \textit{and} \; \frac{1 - \alpha}{2} \, \overline{v} \, s - \frac{(1 - s)^2}{s} \geq \frac{\alpha}{2}(\underline{v} - u).$$

Replacing the variables by their numerical values we obtain the conditions $\frac{1}{6} \geq s \geq 0,127$. *The* *amount of information shared must be high enough to lower the data exploration cost and have Firm 2 explore the data ($s \geq 0,127$), but not too high so that the expected benefits of the M&A for Firm 1 are not outweighed by the competitive loss ($\frac{1}{6} \geq s$).*

7 Conclusion

Our model of information sharing allows us to reach four conclusions regarding the regulation of M&As. First, firms can profitably engage in information sharing to reduce uncertainty about information synergies. Several failed M&As may have been avoided if the companies involved had better realized their potential for synergies. For instance, e-Bay expected a higher complementarity with the services of Skype than what eventually occurred after Skype's acquisition.[30] However information sharing may be opposed to merger policy guidelines that forbid sharing sensitive information before an M&A,[31] as well as gun jumping practices.[32]

Secondly, by reducing the risk of M&As, information sharing can have an impact on the willingness of firms to merge, and thus on market concentration, innovation and consumer surplus. This effect is especially strong as, when information sharing is possible, the most profitable M&As are those leading to the greatest losses in case of low synergies, reversing standard analysis on the incentives of firms to merge and on the choices of their target. Preliminary studies suggest that firms are increasingly sharing data (Scaria et al., 2018) and it is thus essential to better document to what extent information sharing is a common practice between firms and how it impacts M&As decisions.

Thirdly, we have shown that data exploration costs are key to understand the information sharing decisions of firms. With low data exploration costs, firms need to share less data to learn the value of synergies, and it is more probable that information sharing flies below the radar of regulators such as competition authorities. It is therefore essential for policy makers to assess the cost of exploiting data, as recent advances in cloud computing have allowed costs of data

[30] e-bay/Skype, last accessed, September 29, 2021.

[31] Avoiding antitrust pitfalls during pre-M&A negotiation and due diligence FTC, last accessed May 05, 2021.

[32] Recent examples of gun jumping include Altice/OTL in which the FCA found that Altice and SFR engaged in an extensive exchange of commercially sensitive information (including individualized trade data and future forecasts) and Altice PT Portugal, in which Altice received detailed commercially sensitive information about PT Portugal outside the framework of any confidentiality agreement.

storage and data exploration to fall in the last decade (Lambrecht and Tucker, 2015).[33]

Fourthly, our results emphasize the need for a broad definition of relevant markets when assessing the impacts of an M&A. As data-driven M&As may imply important data externalities in connected markets, there is a risk that an M&A lowers consumer privacy, even when information synergies are high. A cost/benefit analysis must therefore account for these connected markets when assessing the impacts of M&A for consumers.

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A Appendix A: proofs

Proof of Lemma 1

We characterize the price of information as well as the profits of Firm 1 and Firm 2 after sharing information s. There are several cases to consider depending on the value of s and the value of the synergy v.

Low synergies. With probability α, synergies are low ($v = \underline{v} < u$). Firm 1 makes profits $\pi_1(\underline{v}, s) = u - \underline{v}s$ and Firm 2 make profits equal to $\pi_2(\underline{v}, s) = 0$.

High synergies. With probability $1 - \alpha$, synergies are high ($v = \overline{v} > u$) and there are two cases to consider, depending on whether s is smaller or greater than $A = \frac{u}{\overline{v}}$.

- If $s \leq A$, Firm 1 makes profits $\pi_1(\overline{v}, s) = u - \overline{v}s$ and firms 2 makes profits $\pi_2(\overline{v}, s) = 0$. Firm 2 proposes to merge and acquires Firm 1 at price $p(\overline{v}, s) = u - \overline{v}s$, and the expected payoff of Firm 2 is equal to

$$\pi_1(s) = \alpha(u - \underline{v}s) + (1 - \alpha)(u - \overline{v}s) + T(s).$$

  The price Firm 2 must pay for the information of Firm 1 is equal to $T(s) = \mathbb{E}[v]s$

- If $s \geq A$, Firm 1 makes profits $\pi_1(\overline{v}, s) = 0$, and Firm 1 makes profits $\pi_2(\overline{v}, s) = \overline{v}s - u$. Firm 2 acquires Firm 1 at price $p(\overline{v}, s) = 0$, and its expected payoff is equal to:

$$\pi_1(s) = \alpha(u - \underline{v}s) + T(s).$$

  The price Firm 2 pays for the information of Firm 1 is equal to $T(s) = u - \alpha(u - \underline{v}s)$

Proof of Proposition 1

We characterize cases for which it is profitable for Firm 2 to purchase information.

Consider first the case when $\mathbb{E}[v] \leq u$. Without information sharing Firm 2 does not acquire Firm 1 and makes 0 profits. The expected profit of Firm 2 with information sharing is:

$$\pi_2(s^*) = (1-\alpha)(\overline{v} - u) - \alpha\underline{v}s^* - C(s^*)$$

Information sharing occurs when profits are positive: $(1-\alpha)(\overline{v} - u) - \alpha\underline{v}s^* - C(s^*) \geq 0$.

If $(1-\alpha)(\overline{v} - u) - \alpha\underline{v}s^* \leq C(s^*)$, profits are always negative and information sharing does not occur.

If $(1-\alpha)(\overline{v} - u) - \alpha\underline{v}s^* \geq C(s^*)$, profits are positive and information sharing occurs.

By continuity for a given s^* there exists a threshold $\overline{c}$ such that profits are positive when $C(s^*)$ is below $\overline{c}$ and negative above. We focus on this last case in the proposition.

Consider now the case when $\mathbb{E}[v] \geq u$. The optimal amount of information satisfies the same condition as above. Partial information sharing is optimal under the condition that:

$$\begin{aligned} &\pi_2(s^*) - \pi_2 \geq 0 \\ \Longrightarrow\ &(1-\alpha)(\overline{v} - u) - \alpha\underline{v}s - C(s^*) \geq \alpha\underline{v} + (1-\alpha)\overline{v} - u \\ \Longrightarrow\ &\alpha u \geq \alpha\underline{v}(1+s^*) + C(s^*) \end{aligned} \tag{11}$$

As we have assumed that $u \geq 2\underline{v}$, this condition is satisfied for $s = 1$, and thus it is always satisfied at s^*, and information sharing is always optimal when $\mathbb{E}[v] \geq u$.

Proof of Lemma 2

We characterize the probability that an M&A is accepted.

If $s \leq A$, the regulator authorizes the M&A if

$$\rho \leq \rho^*(s) := \frac{\overline{v}(1+s) - u}{\overline{v}(1+2s) - u} = \frac{1+s-A}{1+2s-A} \tag{12}$$

Clearly, $\frac{\partial\rho^*(s)}{\partial s} := -\frac{\overline{v}(\overline{v}-u)}{(\overline{v}(1+2s)-u)^2}$ is negative.

If $s \geq A$, the M&A is authorized for

$$\rho \geq \rho^*(s) := \frac{\overline{v}(1-s) + u}{\overline{v}(1-s) + 2u} = \frac{1-s+A}{1-s+2A} \tag{13}$$

and $\frac{\partial\rho^*(s)}{\partial s} := -\frac{\overline{v}u}{(\overline{v}(1-s)+2u)^2}$ is negative.

We now provide the expected payoff of Firm 2 when purchasing s information from Firm 1.

- When $v = \underline{v}$ (w.p. α) Firm 2 makes 0 profits;
- When $v = \overline{v}$ (w.p. $1-\alpha$) Firm 2 makes an offer to Firm 1;
  - If $s \leq A$
    - With probability $F(\rho^*(s))$ the M&A is authorized and expected profits are equal to

$$(1-\alpha)(\overline{v}(1+s) - u)$$

    * With probability $1 - F(\rho^*(s))$ the M&A is prevented, firms compete and the expected profits of Firm 2 are equal to 0.

  – If $s \geq A$
    * With probability $F(\rho^*(s))$ the M&A is authorized and expected profits are

$$(1 - \alpha)\overline{v}$$

    * With probability $1 - F(\rho^*(s))$ the M&A is prevented and the expected profit is equal to

$$(1 - \alpha)(\overline{v}s - u)$$

Overall the expected profit of Firm 2 from purchasing s information is:
If $s \leq A$:

$$\pi_2^R(s) = F(\rho^*(s))(1 - \alpha)(\overline{v}(1 + s) - u) - T(s) - C(s) \tag{14}$$

The expected payoff of Firm 1 when providing Firm 2 with information is:

$$w_1(s) = T(s) + \alpha(u - \underline{v}s) + (1 - \alpha)(u - \overline{v}s)$$

and the price paid by Firm 2 for information is:

$$T(s) = \mathbb{E}[v]s$$

and

$$\pi_2^R(s) = (1 - \alpha)F(\rho^*(s))(\overline{v}(1 + s) - u) - \mathbb{E}[v]s - C(s) \tag{15}$$

If $s \geq A$:

$$\pi_2^R(s) = (1 - \alpha)[F(\rho^*(s))\overline{v} + (1 - F(\rho^*(s)))(\overline{v}s - u)] - T(s) - C(s) \tag{16}$$

The expected payoff of Firm 1 when providing Firm 2 with information is:

$$w_1(s) = T(s) + \alpha(u - \underline{v}s)$$

and the price paid by Firm 2 for information is:

$$T(s) = u - \alpha(u - \underline{v}s)$$

Thus the expected payoff of Firm 2 is:

$$\pi_2^R(s) = (1 - \alpha)[F(\rho^*(s))\overline{v} + (1 - F(\rho^*(s)))(\overline{v}s - u) - u] - \alpha\underline{v}s - C(s) \tag{17}$$

Proof of Proposition 2

(i) By revealed preference, if s^R is the solution with a regulator and s^* the solution without a regulator:

$$\pi_2^R(s^R) \geq \pi_2^R(s^*) \text{ and } \pi_2^N(s^*) \geq \pi_2^N(s^R),$$

hence, using (8)[34]

$$(1-\alpha)(1-F(\rho^*(s^R)))\left\{\overline{v}-\max\{\overline{v}s^R-u,u-\overline{v}s^R\}\right\}$$
$$\leq \pi_2^N(s^*)-\pi_2^R(s^R)\leq$$
$$(1-\alpha)(1-F(\rho^*(s^*)))\left\{\overline{v}-\max\{\overline{v}s^*-u,u-\overline{v}s^*\}\right\}.$$

Because $\rho^*(s)$ is decreasing of s, if $s^R > s^*$ we have $(1-F(\rho^*(s^R))) > (1-F(\rho^*(s^*)))$ and therefore the previous inequalities hold only if $\max\{\overline{v}s^R-u, u-\overline{v}s^R\}$ is greater than $\max\{\overline{v}s^*-u, u-\overline{v}s^*\}$. Because the function $\max\{\overline{v}s-u, u-\overline{v}s\}$ is convex with a minimum value of 0 at $s = A$, and because we have assumed that $s^R > s^*$, it must be the case that $s^R > A$, a necessary condition for information sharing to increase in the presence of a regulator.

Proof of Lemma 4

We write the profits of both firms and the price of the M&A when exchanging information s_1 and s_2. Let $\delta = s_1 - \beta s_2$

- With probability α, $v = \underline{v} < u$:
  - If $\underline{v}\delta \leq u$:
    - $\pi_1(\underline{v},\delta) = u - \underline{v}\delta$;
    - $\pi_2(\underline{v},\delta) = 0$;
  - If $\underline{v}\delta \geq u$:
    - $\pi_1(\underline{v},\delta) = 0$;
    - $\pi_2(\underline{v},\delta) = \underline{v}\delta - u$;
- With probability $1-\alpha$, $v = \overline{v} > u$:
  - If $\overline{v}\delta \leq u$:
    - $\pi_1(\overline{v},\delta) = u - \overline{v}\delta$;
    - $\pi_2(\overline{v},\delta) = 0$;
  - If $\overline{v}\delta \geq u$:
    - $\pi_1(\overline{v},\delta) = 0$;
    - $\pi_2(\overline{v},\delta) = \overline{v}\delta - u$;

In this case, the expected payoff of Firm 1 from sharing δ information is:

- If $\delta \leq A$:
  $$\pi_1(\delta) = \alpha(u-\underline{v}\delta) + (1-\alpha)(u-\overline{v}\delta)$$
  and necessarily Firm 2 needs $\delta \leq 0$ so that Firm 1 accepts to share information.
- If $A \leq \delta \leq u/\underline{v}$:
  $$\pi_1(\delta) = (1-\alpha)(u-\overline{v}\delta)$$
  and $\delta < 0$, which is impossible as $\delta \geq A$.

[34] It should be clear that $pi_2^N(s^*) - \pi_2^R(s^R$ is positive as the regulator constraints the firms.

- If $u/\underline{v} \leq \delta$:

$$\pi_1(\delta) = 0$$

and $\delta < 0$, which is impossible as $\delta \geq u/\underline{v}$.

Thus in equilibrium, bilateral information sharing can occur if $\delta \leq 0$.

The expected payoff of Firm 2 of sharing s_2 and investing $C(s_1)$ following sharing of data and learning v is:

$$\pi_2(s_1, s_2) = (1-\alpha)(\overline{v} - u + \overline{v}(s_1 - \beta s_2)) - C(s_1).$$

with $s_2 \geq s_1$.

Proof of Example 3

We detail the computation of equilibrium values with and without the regulator in our illustrative example, and we show that consumer surplus is higher when there is no regulator.

Information sharing without the regulator is given in Example 1, and we are in the case with $c = 1$ and $\alpha\underline{v} = 8$:

$$s^* = \frac{1}{3}.$$

Consumer surplus without the regulator can be written:

$$CS^N(s^*) = \alpha\underline{v}s = \frac{1}{2}\frac{1}{3}16 = \frac{8}{3} \tag{18}$$

With regulation and uniform distribution, $s^R < A$ and we compute the expected payoff of Firm 2. Replacing the numerical values we obtain $\rho^*(s) = \frac{1+2s}{1+4s}$.

The expected payoff of Firm 2 in this case is:

$$\begin{aligned} \pi_2^R(s) &= (1-\alpha)\left\{F(\rho^*(s))\overline{v} + (1 - F(\rho^*(s)))(u - \overline{v}s)\right\} - \alpha\underline{v}s - (1-\alpha)u - C(s) \\ &= 32\frac{1+3s-2s^2}{1+4s} - 8s - 16 - \frac{(1-s)^2}{s} \end{aligned} \tag{19}$$

A numerical resolution gives $s^R = 0{,}181$, and $\pi_2^R(0{,}181) = 6{,}27$. The expected payoff of Firm 2 without information sharing is $\mathbb{E}[v] - u = 8$, and Firm 2 does not acquire information in equilibrium.

Consumer surplus is equal to 0, and $CS^N(1/3) \geq CS^R$, and the presence of the regulator decreases consumer surplus.

Proof of Proposition 3

(i) **Consider the case** $\mathbb{E}[v] > u$ and $s^R > A$. Without information sharing, firms merge and expected regulatory welfare is

$$W^N := (1-\rho_0)\mathbb{E}[v]$$

By contrast with information sharing, M&As happen only if synergies are high and if $\rho \geq \rho^*(s^R)$, and

$$
\begin{aligned}
W^R :=& \alpha \left\{u - \underline{v}s^R + \rho_0(2\underline{v}s^R - u)\right\} \\
&+ (1-\alpha)\left\{F(\rho^*(s^R))(1-\rho_0)\overline{v} + (1 - F(\rho(s^R))\left(\rho_0 u + (1-\rho_0)(\overline{v}s^R - u)\right)\right\} \\
&- (1-\rho_0)C(s^R)
\end{aligned}
$$

Hence,

$$
\begin{aligned}
W^R - W^N =& \alpha\left((1-\rho_0)(u - \underline{v}(1+s^R)) + \rho_0\underline{v}s^R\right) \\
&+ (1-\alpha)(1 - F(\rho^*(s^R)))\left(\rho_0 u - (1-\rho_0)(\overline{v}(1-s^R) + u)\right) - (1-\rho_0)C(s^R)
\end{aligned}
$$

and the overall expression is positive by H3, when $\rho_0 \to \infty$.
Consider now the case $\mathbb{E}[v] > u$ and $s^R < A$. Similar computations yield

$$
\begin{aligned}
W^R - W^N =& \alpha\left((1-\rho_0)(u - \underline{v}(1+s^R) + \rho_0\underline{v}s^R\right) \\
&+ (1-\alpha)(1 - F(\rho^*(s^R)))\left(\rho_0\overline{v}s^R - (1-\rho_0)(\overline{v}(1+s^R) - u)\right) - (1-\rho_0)C(s^R)
\end{aligned}
$$

again, this expression is positive when $\rho_0 \to \infty$.

(ii) When $\mathbb{E}[v] < u$, firms do not merge in the absence of information sharing and Firm 1 is a monopolist. Expected regulatory welfare is

$$
W^N = (1-\rho_0)u.
$$

If $s^R > A$,

$$
\begin{aligned}
W^R :=& \alpha\left\{u - \underline{v}s^R + \rho_0(2\underline{v}s^R - u)\right\} \\
&+ (1-\alpha)\left\{F(\rho^*(s^R))(1-\rho_0)\overline{v} + (1 - F(\rho^*(s^R))\left(\rho_0 u + (1-\rho_0)(\overline{v}s^R - u)\right)\right\} - (1-\rho_0)C(s^R)
\end{aligned}
$$

and therefore,

$$
\begin{aligned}
W^R - W^N =& (1-\alpha)\left(F(\rho^*(s^R))(\overline{v} - u)(1-\rho_0) + (1 - F(\rho^*(s^R)))\left(\rho_0(3u - \overline{v}s^R) + \overline{v}s^R - 2u\right)\right) \\
&+ \alpha(2\rho_0 - 1)\underline{v}s^R - (1-\rho_0)C(s^R)
\end{aligned}
$$

When $\rho_0 \to 1$, $\rho_0(3u - \overline{v}s^R) + \overline{v}s^R - 2u$ and the overall expression are positive.

If $s^R < A$, using the expression for W^R, we have

$$
\begin{aligned}
W^R :=& \alpha\left\{u - \underline{v}s^R + \rho_0(2\underline{v}s^R - u)\right\} - (1-\rho_0)C(s^R) \\
&+ (1-\alpha)\left\{F(\rho^*(s^R))(1-\rho_0)\overline{v} + (1 - F(\rho^*(s^R)))\left(\rho_0\overline{v}s^R + (1-\rho_0)(u - \overline{v}s^R)\right)\right\}
\end{aligned}
$$

$$
\begin{aligned}
W^R - W^N =& \alpha(2\rho_0 - 1)\underline{v}s^R - (1-\rho_0)C(s^R) \\
&+ (1-\alpha)\left(F(\rho^*(s^R))(\overline{v} - u)(1-\rho_0) + (1 - F(\rho^*(s^R))\left((2\rho_0 - 1)\overline{v}s^R\right)\right)
\end{aligned}
$$

Again the expression is positive when $\rho_0 \to 1$.