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

Antoine Dubus[†] Patrick Legros[‡]

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Abstract

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

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

These questions are relevant in a world where firms are uncertain of the extent of synergies at the time of a M&A. In such an environment, more precise information about the level of synergies that will follow a M&A is valuable not only for the companies involved but also for a regulator willing to maximize social welfare.

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

[Arrow \(1962a,b\)](#) famously pointed out the benefits and the difficulty of inducing such collaborations among competitors, especially if what is sold can be replicated at no cost.¹ But even if there is a cost to replication, providing assets to competitors enhances their ability to compete, and sharing its assets can be costly for a firm.² Sharing information changes the firms’ competitive positions if the M&A does not go through, and also changes the desire of a regulator – who is aware of this information or can infer it from the decisions of firms to merge – to allow the M&A. Our contribution is to show that the competitive disadvantage is balanced by more efficient M&A choices 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 seemed motivated by the potential synergies from aggregating and matching data sets. For instance, Facebook acquired WhatsApp to merge phone numbers with the profiles of Facebook

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

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

users, 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 about Google and Fitbit. Before acquiring Fitbit, Google did not have a competing product nor accumulated such data on users. Therefore, Fitbit had a significant competitive advantage over Google for wearable devices and was at least a market leader 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. 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 product or algorithm and compete with Fitbit using this data to provide consumers with better-personalized recommendations and overall a better product quality. Hence, selling some of its information weakens the competitive position of Fitbit if both firms compete.

We characterize the optimal level of information sharing and show that, while sharing will reduce the extent of inefficient M&As, firms do not always find it profitable to share information. If, after exploration, synergies are learned to be low, an acquisition is not beneficial, and Google and Fitbit would compete, 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 firms' profits. Furthermore, 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 the information is shared, to the benefit of consumers. However, for this reason, the regulator will be tempted not to encourage M&As even if synergies are high. Assuming that the weight placed by a regulator on consumer surplus is uncertain 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, a M&A is more likely to be refused when the information sharing increases. This weakens the incentives for 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 the 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, potentially harming 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 is more interested in acquiring information, as it can leverage it on multiple 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. First, we review the literature on M&As in Section 1. Second, we describe the model in Section 2, and we characterize the equilibrium in Section 3. Third, Section 4 analyzes the impacts of a regulator on information sharing and welfare. Finally, we extend the model in several directions in Section 5 and conclude in Section 6.

1 Literature

Information sharing and competition policy. Competition policy for the digital era has been the object of growing attention in the past few years. While [Scott Morton](#), [Bouvier](#),

Ezrachi, Jullien, Katz, Kimmelman, Melamed and Morgenstern (2019) and Shapiro (2019) call for a tightening of merger policy to fight abuses of dominant position, Cabral (2021) suggests caution so as not to discourage innovation. The role of data is central to this debate, as the success of digital companies is primarily built upon the collection, use, sharing, and sale of vast amounts of consumer data (Varian, 1989; Bergemann and Bonatti, 2015). However, data are a competitive asset (Hagi 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 ensuring 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) argues that companies attempt to prevent competitors from accessing their data to maintain a substantial competitive advantage over a market. The ability to secure exclusive access to high-quality, relevant data is viewed by many as a cause for the domination of digital markets by companies such as Facebook and Google.

An 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 essential information synergies, the merger of two firms' data sets can be an important motivation for M&As (Stucke and Grunes, 2016). The European Commission investigated this possibility in the acquisition of WhatsApp by Facebook (Argentesi, Buccirosi, Calvano, Duso, Marrazzo and Nava, 2019).⁵ More recently, the European Commission gave its green light for Google to acquire Fitbit under the condition that data from both companies

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

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

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

would not be merged,⁶ as the resulting information synergies would increase the market power of Google, reducing consumer welfare in turn. Microsoft has also recently tried to acquire the large consumer base and the related consumer data of Discord, a fast-growing social media.⁷

Synergies. The literature has extensively studied the sources of synergies resulting from M&As.⁸ [Chatterjee \(1986\)](#) distinguishes three types of synergies: financial, operational, and collusive, and indicates that collusive synergies are associated with the highest value from a M&A, while operational synergies are associated with the lowest value. Nevertheless, [Mukherjee, Kiyimaz and Baker \(2004\)](#) report that operational synergies are provided by firms as the main reason to merge. In contrast, [Gupta and Gerchak \(2002\)](#) quantify operational synergies and highlight the importance of the acquirer’s product characteristics and the target for synergies to arise. [Larson 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 the extent of interaction and coordination during the organizational integration process. [Madura and Ngo \(2008\)](#) reveal that the valuation of synergies by companies and markets is based on synergies measured in recent takeovers in the same industry.

Our focus in this paper will be on uncertain synergies and how the merging parties can anticipate their extent by sharing data. [Leccese, Sweeting, Tao and Yao \(2022\)](#) also start from the observation that synergies (taking the form of reduced costs of production) may not be known before a merger and focus on the informational rents that firms will obtain since the regulator is uninformed. In our case, synergies refer to the increased value provided to consumers, and because this value is learned by consumers when the product is sold on the market, firms do not get informational rents.

This literature does not consider information synergies, probably because data have only recently become essential for many business models. As [Parker, Petropoulos and Van Alstyne \(2021\)](#) emphasize, information synergies naturally arise depending on the complementarity of data sources, and they have become essential elements of M&As between digital companies. A

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

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

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

firm has incentives to learn the potential for complementarity before engaging in data-driven M&As, and we will show how companies can use information sharing to assess information synergies.

By contrast, the literature on information theory has long acknowledged the importance of information synergies. A recent trend 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 measures 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 merged data sets require an ‘exploration’ cost.

Selling innovation and information. This article is closely related to the literature on the sale of technology. [d’Aspremont, Bhattacharya and Gérard-Varet \(2000\)](#) focus on a problem in which a seller can disclose verifiable knowledge that is used for contracting. [Anton and Yao \(2002\)](#) analyze how inventors can reveal part of their innovations to prospective buyers to signal their quality. Our focus differs since the initial owner can sell its product to consumers. The case $u = 0$ in our model would be equivalent to the assumption that the inventor needs another firm to develop its product. By assuming that the investor can sell its product ($u > 0$), we introduce the idea that the receiver can use shared information to compete with the sender, resulting in the well-known Arrow information paradox.

These questions have recently been revisited by a growing literature on the sale of information ([Bergemann and Bonatti, 2015](#); [Kastl, Pagnozzi and Piccolo, 2018](#); [Bounie, Dubus and Waelbroeck, 2021b](#)). In particular, [Hörner and Skrzypacz \(2016\)](#) analyze sequential information disclosure by a privately informed agent. As in previous articles and the present paper, the shared information can be expropriated by the receiver. We contribute to this literature by considering the possibility for the information receiver to use the information to compete with the sender, and by showing how this competitive effect impacts equilibrium information sharing.

Killer acquisitions. The competitive effect of information sharing implies that a M&A will be motivated – at least in part – by a reduction of competition. 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.

In this article, we consider a different situation, 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 a 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 the 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 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 \(2021 a\)](#) analyze mergers between data intermediaries and their competitive impact on product markets. [Chen, Choe, Cong and](#)

⁹A 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](#)).

¹⁰Alternatively, [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 data 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.

Matsushima (2022) 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 the extent of their complementarities, particularly regarding information synergies. They can discover this synergistic value and make better decisions by sharing information before the M&A takes place.

2 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 data stock. Combining data from Firms 1 and 2 will enhance customer value to $v \in \{\underline{v}, \bar{v}\}$. The value of v is unknown to firms, but each company knows that $v = \underline{v}$ with probability α , and $v = \bar{v}$ 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: $u \leq \bar{v}$.

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

The literature on the pricing of information goods (Shapiro and Varian, 1998) points out that consumers can quickly discover their product valuation before acquiring it through sampling, free downloading, freemium, ratings, and reviews, and provides support to Assumption H1. This assumption allows us to focus on information-sharing strategies and avoid information asymmetries in the product market.

Assumptions H2 and H3 allow for negative and positive synergies. However, 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. 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 service to share user data with Facebook, its parent company.¹² This change of the value of a product after a 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 operate it as a separate entity and make profits u . We consider in Section 5.4 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 a M&A only with type \bar{v} .¹³

Data sharing. Firm 1 can share a portion of its data $s \in [0, 1]$ with Firm 2. 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 be high or low with probabilities $1 - \alpha$ and α .

The data shared can be used by Firm 2 to better compete with Firm 1 in its market, and Firm 1 may be reluctant to share information for free. Therefore, firm 2 can purchase the data at an agreed-upon price $T(s)$. Firm 2 will set the value of this ex-ante compensation for data to cover the ex-post competitive loss for Firm 1 resulting from partial expropriation. In equilibrium, Firm 2 will choose how much data it purchases from Firm 1 by selecting the value of $T(s)$.

Exploration cost. If Firm 1 does not share data, the companies may merge but will do so 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

¹²“WhatsApp delays privacy update over user ‘confusion’ and backlash about Facebook data sharing,” link on CNBC, last accessed June 2, 2021.

¹³We 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 a M&A under imperfect information.

denote this cost by $C(s)$. The exploration cost includes the development of new algorithms or code and the matching of data sets.

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 database.) 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, upon receiving s Firm 2 will either exert an 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.¹⁴ (We show in 5.2 that our results are robust to the case where Firm 2 receives this information privately.)

This shape of the exploration cost $C(s)$ also corresponds to diminishing returns in data, a property highlighted by recent empirical literature in various contexts, such as industrial data for firm performance (Bajari, Chernozhukov, Hortaçsu and Suzuki, 2019), Internet query data for search results by web browsers (Schäfer and Sapi, 2020), data used for algorithmic recommendation by online advertisers (Claussen, Peukert and Sen, 2021), and medical data for drug prescription (Huang, Ribers and Ullrich, 2021). (See also Arnold, Marcus, Petropoulos and Schneider (2018) for a review of empirical evidence.)

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 also increase. Our results hold for any convex and increasing cost function. In the basic model, 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

¹⁴We 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 the exploration cost is positive when all information is shared: $C(1) > 0$. This would not change our main insights, as the essential 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.

the connected wearable market, and we show in Section 5.3 that our results are robust if there are positive entry costs.

If v is known, Firm 2 can make a Take-It-Or-Leave-It (TIOLI) offer to Firm 1 for a M&A, or can use the shared information to compete with Firm 1. If there is a 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 from maximizing a welfare function that is the weighted 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

When the firms ask for approval of the M&A, they do not 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 regulator's decision balances these two effects depending on the weight ρ they put on consumer surplus. 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 type of the regulator is drawn from the distribution $F(\rho)$ and the regulator makes a decision.¹⁷

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

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

¹⁷Beyond approval for a 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 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 chooses to pay $T(s)$ to obtain a portion s of the data of Firm 1. In the latter case Firm, 2 chooses to invest $C(s)$ and learns v or not to invest and remains uncertain about the value of v .

Stage 2: Firm 2 makes a TIOLI offer to Firm 1 for a 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.

3 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 a M&A under imperfect information.

3.1 Competition

Suppose that Firm 1 shares $s > 0$, and, for now, let us ignore the possibility of a M&A. If Firm 2 invests $C(s)$ and learns v ; it can provide its customers a value vs while Firm 1 can give a value u . Assuming Bertrand competition¹⁸ the equilibrium profits if the two firms per consumer are

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

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

¹⁸Alternative types of competition can be considered, such as 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.

Bertrand profit $vs - u$ is positive, hence only if $v = \bar{v}$ and if s is greater than $\frac{u}{\bar{v}}$. We will refer to the ratio $\frac{u}{\bar{v}}$ as the Arrow (lower) bound on data sharing and denote it.

(Arrow bound)
$$A := \frac{u}{\bar{v}}.$$

3.2 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 a M&A, if there is investment, is denoted $\mathbb{E}[v]$:

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

a 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 the cutoff value we characterize. We will then be able to show when information sharing is optimal.

3.3 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:

$$(2) \quad p(v, s) := \pi_1(v, s).$$

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 (\bar{v}) is greater than the total surplus under competition ($u - \bar{v}s$). 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 $v = \bar{v}$. 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 $v = \bar{v}$, 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 $p(\bar{v}, s) = \bar{v}(A - s)$.
- When $s \geq A$: $T(s) = u - \alpha(u - \underline{v}s)$ and $p(\bar{v}, s) = 0$.

The price $p(v, s)$ Firm 2 pays to Firm 1 for a M&A after learning the value of v decreases with s . Firm 1 expects lower revenues when sharing more information, so Firm 2 must compensate for this expected loss. Therefore, 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 $v = \bar{v}$ 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:

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

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 earnings of Firm 2. On the other hand, more information decreases the data exploration cost $C(s)$. We characterize in the next section the amount of information shared that maximizes the expected profits of Firm 2, which balances these two opposite effects of data sharing.

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.

3.4 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 a M&A.

We show that acquiring the profit-maximizing 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 $\alpha \underline{v} = -C'(s^*)$:¹⁹

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

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

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

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

¹⁹Note that the Inada condition $C'(1) = 0$ ensures that s^* is less than one.

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 $C(s^*) \leq (1 - \alpha)(\bar{v} - u) - \alpha \underline{v} s^*$.

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

When $\mathbb{E}[v] \geq u$, M&As are ex-ante efficient, but the 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 and because of our Inada conditions on $C(s)$, the effect of a marginal sharing of information is second-order. 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 $\pi_2(s^*) = (1 - \alpha)(\bar{v} - u) - \alpha \underline{v} s^* - C(s^*) \geq 0$. 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 $\bar{v} = 64, \underline{v} = 16, \alpha = \frac{1}{2}$; 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:²⁰

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 lower expected merger profitability when potential losses increase (Capron and Shen, 2007). Companies' incentive to engage in a M&A decreases when there is a risk of 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 a M&A decreases when \underline{v} decreases. We obtain the opposite result when information sharing is possible. Indeed, as \underline{v} decreases, competition is softened for any information sharing s in case of low synergies (the price $u - \underline{v}s$ is larger when \underline{v} is lower). This increases the expected profits of Firm 2 and decreases the compensation to Firm 1 needed to induce information sharing.

4 Information Sharing in the Shadow of a Regulator

4.1 Effect of a Regulator on Information Sharing

We introduce a regulator 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. However, the weight that the regulator places on consumer surplus –

²⁰Indeed, by the envelop theorem: $\frac{\partial \pi_2^N}{\partial \underline{v}} = -\alpha \underline{v}$.

their ‘bias’ – may be explicit or induced by political lobbying, misinterpretation of the M&A documentation, or ambiguity in other variables used by the regulator to evaluate the M&A.

The assumption that firms do not know the preference parameter ρ of the regulator they will be facing allows us to offer novel insights into how regulation affects information sharing. In particular, we will show in Section 4 that firms can share more information when there is a risk that the regulator blocks the merger.

While synergies can arise during the M&A process, they can also be realized under competition when Firm 2 exploits the data provided by Firm 1. Positive synergies create a two-edged sword for the regulator because welfare increases both under M&A *and* under competition. Consumers benefit if the regulator prevents the M&A, as firms compete and lower their prices after sharing information. Therefore, when evaluating a M&A proposal, the regulator will compare the *relative industry gain* weighted by $1 - \rho$ to the *relative 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 complete surplus extraction. This case occurs when there is no information sharing, and no M&A, Firm 1 is a monopolist, or when Firm 2 acquires Firm 1. On the contrary, if the information has been shared and firms compete, consumer surplus is equal to $\min\{u, vs\}$.

M&A decision without information sharing. Without information sharing, the regulator and the firms have a common interest: a 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 a 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 when $v = \underline{v}$ a 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 a M&A, Firm 1 has already shared s with Firm 2. Hence the exploration cost $C(s)$ is sunk, and

both firms know the value of v . Firms request M&A approval if synergies are high, and the regulator can infer the value of v from their M&A request.²¹ 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 competitive pressure on Firm 1. Both the firms and the regulator prefer head-to-head competition to a M&A. However, if $v = \bar{v}$, under competition, firms lower their prices providing consumers with a surplus equal to $\min\{u, \bar{v}s\}$, which is lost to consumers if the regulator allows the M&A. Conversely, the industry gain if the M&A is allowed is $\bar{v} (1 - \max\{A - s, s - A\})$. Therefore, the regulatory welfare gain from the M&A is:

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

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

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

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

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

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

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

²¹Alternatively, [Cosnita-Langlais and Tropeano \(2012\)](#) analyze signaling by firms willing to convince the regulator that synergies are high and to accept the merger.

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, there is a larger possibility that the regulator prevents a M&A as the amount of information shared increases, which reduces the incentives for firms to share information. On the other hand, Firm 2 is interested 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 in 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 $s \in [0, 1]$:

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

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

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

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

Proof. If $s < A$, $K(s) = (1 - F(\rho^*(s)))\bar{v}(1 + s - A)$. 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 $s > A$, $K(s) = (1 - F(\rho^*(s)))\bar{v}(1 - s + A)$, 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 ($\bar{v}(1-s+A)$) decreases. Simple algebra shows that on $s > A$,

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

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

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 decreasing 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 $\rho^*(A) = \frac{\bar{v}}{\bar{v}+u}$, the condition reduces to $H\left(\frac{\bar{v}}{\bar{v}+u}\right) < 4$. For instance, if $\bar{v} = 2u$, 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 the 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 $\alpha < \frac{-C'(A)}{v}$ 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:²² $\alpha < c \frac{(\bar{v}-u)^2}{u^2\bar{v}}$. Clearly there exist 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 .

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*

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

(iii) *Suppose 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 sharing 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 $\frac{v}{\bar{v}}$, 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 information sharing before the M&A. 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.

²²Indeed, because $\frac{\bar{v}^2 - u^2}{v} > \frac{(\bar{v} - u)^2}{\bar{v}}$, we have $-\frac{C'(A)}{v} = c \frac{\bar{v}^2 - u^2}{u^2 v} > c \frac{(\bar{v} - u)^2}{u^2 \bar{v}} = \frac{C(A)}{u}$.

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 $\bar{v}s - u$. 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.

4.2 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 $\alpha \underline{v} s^R + (1 - F(\rho^*(s^R))) \bar{v} s^R$ 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 the 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 the expected consumer surplus.*

If we are outside the scope of the conditions of Proposition 2 (iii), s^R may be 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 one under imperfect information. We illustrate this last case in the example below.

Example 3. Consider $\underline{v} = 2$, $u = 4$, $\bar{v} = 64$, $\alpha = \frac{1}{2}$, $C(s) = \frac{(1-s)^2}{s}$, 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 equals 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 equals 0.

4.3 Regulating Pre-M&A Information Sharing

Another tool for the regulator is to allow or prevent Firm 2 from purchasing information from Firm 1. To simplify, let us assume that a regulatory authority allows information sharing in an industry with a bias equal to ρ_0 . We distinguish between the authority, such as the DG Competition in Europe, and its regulatory agents, for instance, the various teams in charge of M&A review. Regulatory agents will offer a bit of positive or negative advice for a M&A, and they have potentially different views on the importance of industry profits compared to consumer surplus. For example, each agent can be subject to greater or lesser intense lobbying or have different ideological opinions 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 the regulatory authority makes it.²³

This regulatory authority compares welfare with and without information sharing and chooses whether to allow companies to share. As the regulator has ρ_0 close to 1 and is mainly concerned with consumer surplus, not allowing information sharing yields a 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

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

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 toward 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 $s = 1$,²⁴ 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 $(1 - \alpha)(\bar{v} - u) + \alpha(\underline{v} - u)$, and consumer surplus is equal to 0. Thus when a M&A under imperfect information is more profitable than acquiring information (i.e., when $(1 - \alpha)\bar{v} < \alpha\underline{v}$ 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. It suggests that a limited bias of regulatory agents toward industry profits can encourage firms to share data, resulting in possible surplus enhancement for consumers.

4.4 Cross-Market Data Externalities

Firm 2 may use the information shared by Firm 1 in other data-driven markets.²⁵ 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 against 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

²⁴With $s \geq A$, Firm 2 makes expected profits equal to $(1 - \alpha)(\bar{v}s - 2u) - \alpha\underline{v}s - C(s)$: when $(1 - \alpha)\bar{v} < \alpha\underline{v}$ Firm 2 does not acquire information; when $(1 - \alpha)\bar{v} \geq \alpha\underline{v}$, Firm 2 acquires $s = 1$.

²⁵Prufer and Schottmüller (2017) analyze dynamic competition when markets are connected by data.

surplus is equal to 0.²⁶

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 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 the entire consumer surplus, which does not depend on product quality $v_h(s)$. However, as the market does not internalize consumers' privacy loss, 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 privacy loss. Consequently, without regulatory oversight, the expected consumer surplus in Firm 1's market when information is shared equals $\alpha v s$. In contrast, the expected loss of surplus due to privacy concerns in the connected market is $(1 - \alpha)l(1) + \alpha l(s)$. The predicted variation of surplus when companies share information is equal to $\alpha v s - (1 - \alpha)l(1) - \alpha l(s)$, whose sign depends on $l(\cdot)$.

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 a 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 its profits

²⁶We can assume that $v_h(s)$ is a concave and bounded utility function. Without loss of generality we normalize $v_h(0)$ to 0.

in the connected market. Therefore, two opposite effects of the connected market on consumer surplus emerge, and both depend on privacy loss. In the limit case without privacy cost ($l(s) = 0$), the expected consumer surplus increases as Firm 2 acquires more information. Conversely, 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 a M&A on consumer surplus in the connected market. The presence of regulatory oversight will have the opposite effects on information sharing as in the primary 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 data. On the other hand, Firm 2 is interested in acquiring more information to reach high profits in the connected market if the M&A is prevented, as $v_h(s)$ increases with s .

4.5 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 latter usually relate to privacy issues and 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 sharing, our analysis necessarily offers an incomplete picture of the impacts of data silos on market power, innovation, and overall efficiency gains. Nevertheless, we can address their effects on consumer surplus through changes in data sharing and in firms' incentives to proceed with a 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, a M&A with data silos is motivated only by reduced competition. It should be clear that absent social benefits that we do not directly model, a regulator prefers 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 \bar{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 $\max\{u, \bar{v}s\}$. Therefore, Firm 2 is still interested in acquiring Firm 1 in the case of high synergies.²⁷

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 $\bar{v}s$ 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 of protecting consumer surplus. This second effect lowers firms' incentives to share data, reducing the competitive effect of data sharing and the resulting increase in consumer surplus. Either outcome may dominate the other, depending on the weights the regulator places on surplus and industry profits, and data silos may increase or decrease data sharing.

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 $(1 - \alpha)(\gamma u + (1 - \gamma)\bar{v}) + \alpha v < \mathbb{E}[v]$, while with data sharing, the expected payoff of Firm 2 is $\pi_2 = (1 - \alpha)(1 - \gamma)(\bar{v} - u) - \alpha v s - C(s)$ which is smaller than expected profits without silos.

²⁷When $A > s$, the expected payoff from the M&A is $\gamma u + (1 - \gamma)\bar{v}$ which is greater than the price of the acquisition $u - \bar{v}s$. When $A < s$, the acquisition price is 0 and a merger is also always profitable.

5 Extensions

In this section, we consider several extensions of the baseline model.²⁸ As in the basic model, we ignore the regulation, and we show that these alternative scenarios may reduce the competitive impact of information sharing and increase the amount of information shared by Firm 1. While we do not explicitly introduce a regulator in these extensions, it should be clear that the qualitative effects identified in Section 4 will be similar.

In Section 5.1 we consider the implications of having several competitors in the product market. In Section 5.2 we show that our results are robust to private learning of synergies by Firm 2 and that the equilibrium amount of information shared is obtained when synergies are publicly learned. We consider positive entry costs in Section 5.3. We analyze the possibility of divestment after a M&A in Section 5.4, and in Section 5.5 we analyze bilateral information sharing between the firms. We characterize market conditions under which firms prefer to purchase or exchange information. We analyze Nash bargaining on the final value of the M&A in Section 5.6, and finally, we consider data that depreciate with time in Section 5.7.

5.1 Other Competitors

As in most literature, we have assumed that only two firms exist. If other firms produce close substitute products, the equilibrium prices will be lower than what we obtain in the basic model (whether or not our two firms merge). For instance, if the next best competitor can provide a value w to consumers, our analysis goes through by replacing the price u that Firm 1 can obtain by $\hat{u} := \max(u - w, 0)$, and the maximum price that Firm 2 can get is $\max(0, \min(vs - u, vs - w))$. When $w > u$, our framework resembles models in which an investor cannot develop a product (e.g., Anton and Yao (2002)), and there is no competitive effect of information sharing. Still, when $u > w$, our competitive impact of information sharing arises.

5.2 Asymmetric Learning of Synergies

In the primary analysis, we have assumed that Firm 1 and the regulator learn the value of synergies when Firm 2 explores the data. However, Firm 2 can also explore the data privately and

²⁸This also corresponds to the case where the regulator is entirely oriented toward the industry ($\rho = 0$).

then report the value of the synergies. We analyze the possibility of learning synergies privately in this section, showing that it has no impact on information sharing and M&A decisions. 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 cost of information. Therefore, the expected yield of Firm 2 when acquiring data from Firm 1 will equal the expected payoff with public learning of synergies. Companies approach the regulator only when synergies are high, and there is no information asymmetry.

Consider the situation where after having acquired s and invested $C(s)$, Firm 2 learns v privately. As usual, there are three candidates for pure strategy signaling equilibrium by Firm 2: pooling and not offering a M&A, pooling and offering a M&A, and separating by offering a M&A only when synergies are high, which is equivalent to an excluding equilibrium. However, pooling equilibria are not sustainable as Firm 2 is not interested in acquiring Firm 1 when synergies are low (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 a M&A when synergies are high. In this case, Firm 2 obtains $\max\{0, \bar{v}s - u\}$, and therefore there is incentive compatibility only if $\bar{v} - p(s) \geq \max\{0, \bar{v}s - u\}$. Simple algebra shows 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 $\max\{0, u - \bar{v}s\}$. 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 an 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 $\max\{\underline{v}, u - \bar{v}s\}$ when synergies are high. Hence, Firm 1 will agree (in a TIOLI system) to share information if the

ex-ante payment is $T(s) = u - (1 - \alpha) \max\{\underline{v}, u - \bar{v}s\} - \alpha(u - \underline{v}s)$, and Firm 2's expected payoff is

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

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

5.3 Positive Entry Costs Under Competition

We have assumed that after obtaining 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 $\psi(s)$ to compete with Firm 1, or can remain out of the market.²⁹ There are many situations where such an entry cost is required, such as markets for hardware like Fitbit's products.

We allow the entry cost to vary with s , following the idea that the entry cost may be related to the amount of data available to Firm 2. For instance, the literature has analyzed how data can constitute a barrier to entry (Mahnke et al., 2015), and in this case, obtaining more data allows Firm 2 to lower this barrier. Our model can capture this effect by considering ψ strictly decreasing with s , and we will use this specification in the remaining section.³⁰ Let $s_{\underline{v}}$ be the minimum value of s for which $\psi(s) \leq \underline{v}s$ and $s_{\bar{v}}$ be the minimum value of s for which $\psi(s) \leq \bar{v}s$. For simplicity, we assume that \underline{s} is positive. Clearly, since $\psi(s)$ is a decreasing function, $s_{\bar{v}} < s_{\underline{v}}$.

The entry cost lowers the competitive pressure that Firm 2 exerts on Firm 1. When Firm 1 shares an amount of information smaller than $s_{\bar{v}}$, it is not 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 Firm 1 shares an amount between the two bounds ($s_{\bar{v}} < s < s_{\underline{v}}$), entering the market becomes profitable for Firm 2 only when synergies are high. The cost of entry relaxes the competitive pressure when synergies are low, eventually reducing data transfer price with respect to no entry costs. However, when synergies are high, a positive entry cost does not change the

²⁹We assume that Firm 2 simultaneously decides whether to enter and chooses its product's price. Taking sequential entry decisions and price competition would lead to an equilibrium identical to perfect information at the beginning of the game.

³⁰Our qualitative results also hold for a fixed cost that is independent of s .

equilibrium outcome as Firm 2 acquires Firm 1 regardless of the entry cost.

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

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

This expected payoff is maximized for s as high as possible, that is, for $s = s_{\underline{v}}$.

Finally, if the amount shared is greater than $s_{\underline{v}}$, even when synergies are low, sharing data increases the competitive pressure on Firm 1 as Firm 2 enters the market in case the merger does not occur. This increased competitive pressure increases the price of information but does not impact the expected profits of Firm 2. Indeed, when synergies are low, Firm 2 does not incur $\psi(s)$ since there is no entry. On the other hand, if synergies are high, Firm 2 acquires Firm 1 and does not pay the entry cost either. Hence, the expected payoff of Firm 2 in the case $s > s_{\underline{v}}$ is:

$$\pi_2(s) = (1 - \alpha)(\bar{v} - u) - \alpha \underline{v} s - C(s).$$

The amount of information shared is equal to the amount of information shared without entry cost, that is s^* , as defined in (4). Firm 2 then compares its expected payoffs with s^* and $s = s_{\underline{v}}$ to decide how much information to acquire.

5.4 Possibility of Divestment After the M&A

Firms may engage in a 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.³¹ If synergies are low, the former owners of Firm 1 can make a TIOLI offer to Firm 2 and repurchase their company for a value equal to \underline{v} . As a result, Firm 2 can acquire Firm 1 at a price $p = (1 - \alpha)u + \alpha \underline{v}$, and make an expected payoff at the time information is shared equal to $\pi_2 = (1 - \alpha)(\bar{v} - u)$. 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

³¹In 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.

the cost of a M&A is $\phi > 0$ and that the cost of divestiture is $\hat{\phi} > 0$. The lack of information about synergies at the time of a merger implies that the cost ϕ is paid at the time of the merger, and there will be divestiture if synergies are low and $\underline{v} < u - \hat{\phi}$. Hence, the expected industry profit is $(1 - \alpha)\bar{v} + \alpha u - \phi - \alpha\hat{\phi}$ – assuming that this expression is greater than u . By contrast, if there is a merger after sharing of s , the expected industry profit is $(1 - \alpha)\bar{v} + \alpha(u - \underline{v}s) - C(s) - (1 - \alpha)\phi$ 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

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

Where s^* maximizes the expected payoff of Firm 2 when acquiring information: $(1 - \alpha)(\bar{v} - u) - \alpha\underline{v}s - C(s) - (1 - \alpha)\phi$, 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.

5.5 Bilateral Information Sharing

In our analysis, Firm 2 can purchase information from Firm 1. In practice, companies can also engage in the bilateral sharing of information, which we analyze in this section.³² We will show that bilateral information sharing can be more profitable for Firm 2 than information purchasing if the information shared by Firm 2 enhances the quality of the product of Firm 1.

Competition. Firm 1 shares information $s_1 \geq 0$ and Firm 2 shares $s_2 \geq 0$, and we ignore for the moment the possibility of a M&A. 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 for a cost $C(s_1)$, it can provide its customers with a value $u + \beta v + s_2$ where $\beta \geq 0$. Upon paying $C(s_1)$ and assuming Bertrand competition, it follows that the equilibrium price p paid by the consumers and the profits per consumer are

³²For instance, [Scaria, Berghmans, Pont, Arnaut and Leconte \(2018\)](#) describe practices of information sharing between companies in Europe. Bilateral information sharing is also reminiscent of cross-licensing of innovation ([Fershtman and Kamien, 1992](#)).

- 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.

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

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

Profits with bilateral information sharing. When firms share information, they anticipate their profits if there is competition and a M&A, and they share information accordingly. Firm 1 accepts the exchange if its expected payoff, accounting for the data exploration cost, is greater than u . Hence, we need $\pi_1(s_1, s_2) = u - \mathbb{E}[v](s_1 - \beta s_2) - C(s_2) \geq u$, which requires that $\beta s_2 - \frac{C(s_2)}{\mathbb{E}[v]} > s_1$. 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, $\beta s_2 - \frac{C(s_2)}{\mathbb{E}[v]} > s_1$. The expected payoff of Firm 2 sharing s_2 and investing $C(s_1)$ is:*

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

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 , accounting for the data exploration costs incurred by Firm 1: $\beta s_2 - \frac{C(s_2)}{\mathbb{E}[v]} > s_1$. 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 $\pi_2(s_1, s_2) = (1 - \alpha)(\bar{v} - u) - C(\beta)$. However, if $\beta \geq 1$, in equilibrium Firm 1 shares $s_1 = 1$ and Firm 2 shares s_2 such that $s_2 = \frac{1}{\beta} \left(1 + \frac{C(s_2)}{\mathbb{E}[v]}\right)$,³³ and the expected payoff of Firm 2 when sharing information is: $\pi_2(s_1, s_2) = (1 - \alpha)(\bar{v} - u)$.

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: $\pi_2(s^*) = (1 - \alpha)(\bar{v} - u) - \alpha v s^* - C(s^*)$.

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: $\beta \geq \beta_0 = C^{-1}(\alpha v s^* + C(s^*))$.

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 $\beta \geq \beta_0 = C^{-1}(\alpha v s^* +$*

³³Note that the shape of the cost function ensures the existence and unicity of the solution to this equality.

$C(s^*)$.

- 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.

5.6 Nash Bargaining

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

In this extension, we assume that the spoils of a M&A are shared following the cooperative Nash bargaining solution. 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

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

With information sharing s , and exploration costs $C(s)$, 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 no profit. If synergies are high, a M&A is efficient, while firms have threat points $\pi_1^c(s) = \max\{0, u - \bar{v}s\}$ and $\pi_2^c(s) = \max\{0, \bar{v}s - u\}$. Simple algebra shows that independently of whether s is greater or

lower than A , the Nash profits when the surplus from M&A is \bar{v} are

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

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

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

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

$$\frac{\alpha(u - \underline{v})}{(1 - \alpha)\bar{v} + 2\alpha\underline{v}} \geq s \text{ and } \frac{1 - \alpha}{2} \bar{v} s - \frac{(1 - s)^2}{s} \geq \frac{\alpha}{2}(\underline{v} - u).$$

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 ($\frac{1}{6} \geq s$).

5.7 Depreciation of Data

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

There are many ways to model data depreciation,³⁴ but a full analysis is beyond the scope of

³⁴See Valavi, Hestness, Ardalani and Iansiti (2020) for recent work on data depreciation articulating a tradeoff between accumulating stocks or flows of data to maximize the accuracy of machine learning models.

this paper. Here, we model the durability of data by assuming that data that is shared is useful only during a finite time frame. Precisely, consider an infinite number of competition stages t , and assume that the data shared by Firm 1 gives perfect information about the value of synergies for T periods, and lose all informational value at $T+1$. Firm 1 makes the following profits where $0 < \delta < 1$ is the discount factor:

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

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

$$\begin{aligned} \text{If } s \leq A, \pi_1(s) &= \sum_{t=0}^T \delta^t ((1-\alpha)(u - \bar{v}s) + \alpha(u - \underline{v}s)) + \sum_{t=T+1}^{+\infty} \delta^t u + T(s) \\ &= \frac{u}{1-\delta} - \mathbb{E}[v]s \frac{1-\delta^{T+1}}{1-\delta} + T(s). \\ \text{If } s \geq A, \pi_1(s) &= \sum_{t=0}^T \delta^t \alpha(u - \underline{v}s) + \sum_{t=T+1}^{+\infty} \delta^t u + T(s) \\ &= \alpha(u - \underline{v}s) \frac{1-\delta^{T+1}}{1-\delta} + \sum_{t=T+1}^{+\infty} \delta^t u + T(s). \end{aligned}$$

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

$$\begin{aligned} \text{If } s \leq A, \text{ then } T(s) &= \frac{1-\delta^{T+1}}{1-\delta} \mathbb{E}[v]s. \\ \text{If } s \geq A, \text{ then } T(s) &= \frac{1-\delta^{T+1}}{1-\delta} (u - \alpha(u - \underline{v}s)). \end{aligned}$$

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

$$\begin{aligned}\pi_2(s) &= \frac{1 - \delta^{T+1}}{1 - \delta} ((1 - \alpha)(\bar{v} - u) - \alpha \underline{v}s) + \sum_{t=T+1}^{+\infty} \delta^t (\mathbb{E}[v] - u) - C(s) \\ &= \frac{1 - \delta^{T+1}}{1 - \delta} ((1 - \alpha)(\bar{v} - u) - \alpha \underline{v}s) + \frac{\delta^{T+1}}{1 - \delta} (\mathbb{E}[v] - u) - C(s).\end{aligned}$$

When $\mathbb{E}[v] > u$ an increase in T , the duration of data, reduces the equilibrium amount of information shared and increases the expected profit of Firm 2.

6 Conclusion

We have analyzed an environment in which information sharing facilitates the discovery of synergies but may also weaken the competitive position of the owner of the data. We have shown that this second effect can make information sharing pro-competitive since consumers will face lower prices if the recipient of the data decides to enter the market rather than merge or acquire the other firm. Because learning the level of synergies reduces the risk of engaging in inefficient M&As, information sharing can have an impact on the willingness of firms to merge, and thus on market concentration, innovation, and social surplus. The identification of these causal links is a topic for further research.

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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 ($v = \bar{v} > u$) and there are two cases to consider, depending on whether s is smaller or greater than $A = \frac{u}{\bar{v}}$.

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

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

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 $\pi_1(\bar{v}, s) = 0$, and Firm 1 makes profits $\pi_2(\bar{v}, s) = \bar{v}s - u$. Firm 2 acquires Firm 1 at price $p(\bar{v}, s) = 0$, 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:

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

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

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

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

By continuity for a given s^* there exists a threshold \bar{c} such that profits are positive when $C(s^*)$ is below \bar{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:

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

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 a M&A is accepted.

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

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

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

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

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

and $\frac{\partial \rho^*(s)}{\partial s} := -\frac{\bar{v}u}{(\bar{v}(1-s)+2u)^2}$ 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 $v = \bar{v}$ (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
$$(1 - \alpha)(\bar{v}(1+s) - u)$$
 - * 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
$$(1 - \alpha)\bar{v}$$
 - * With probability $1 - F(\rho^*(s))$ the M&A is prevented and the expected profit is equal to
$$(1 - \alpha)(\bar{v}s - u)$$

Overall the expected profit of Firm 2 from purchasing s information is:

If $s \leq A$:

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

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

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

and the price paid by Firm 2 for information is:

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

and

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

If $s \geq A$:

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

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:

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

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)³⁵

$$\begin{aligned} & (1 - \alpha)(1 - F(\rho^*(s^R))) \{ \bar{v} - \max\{\bar{v}s^R - u, u - \bar{v}s^R\} \} \\ & \leq \pi_2^N(s^*) - \pi_2^R(s^R) \leq \\ & (1 - \alpha)(1 - F(\rho^*(s^*))) \{ \bar{v} - \max\{\bar{v}s^* - u, u - \bar{v}s^*\} \}. \end{aligned}$$

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 $\max\{\bar{v}s^R - u, u - \bar{v}s^R\}$ is greater than $\max\{\bar{v}s^* - u, u - \bar{v}s^*\}$. Because the function $\max\{\bar{v}s - u, u - \bar{v}s\}$ 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.

³⁵It should be clear that $\pi_2^N(s^*) - \pi_2^R(s^R)$ is positive as the regulator constraints the firms.

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 $1 - \alpha$, $v = \bar{v} > u$:
 - If $\bar{v}\delta \leq u$:
 - * $\pi_1(\bar{v}, \delta) = u - \bar{v}\delta$;
 - * $\pi_2(\bar{v}, \delta) = 0$;
 - If $\bar{v}\delta \geq u$:
 - * $\pi_1(\bar{v}, \delta) = 0$;
 - * $\pi_2(\bar{v}, \delta) = \bar{v}\delta - u$;

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

- If $\delta \leq A$:

$$\pi_1(\delta) = \alpha(u - \underline{v}\delta) + (1 - \alpha)(u - \bar{v}\delta)$$

and necessarily Firm 2 needs $\delta \leq 0$ so that Firm 1 accepts to share information.

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

$$\pi_1(\delta) = (1 - \alpha)(u - \bar{v}\delta)$$

and $\delta < 0$, which is impossible as $\delta \geq A$.

- 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:

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

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 $\alpha v = 8$:

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

Consumer surplus without the regulator can be written:

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

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:

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

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

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

Hence,

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

and the overall expression is positive by H3, when $\rho_0 \rightarrow \infty$.

Consider now the case $\mathbb{E}[v] > u$ and $s^R < A$. Similar computations yield

$$W^R - W^N = \alpha \left((1 - \rho_0)(u - \underline{v}(1 + s^R) + \rho_0 \underline{v} s^R) \right. \\ \left. + (1 - \alpha)(1 - F(\rho^*(s^R))) (\rho_0 \bar{v} s^R - (1 - \rho_0)(\bar{v}(1 + s^R) - u)) - (1 - \rho_0)C(s^R) \right)$$

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

(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 $s^R > A$,

$$W^R := \alpha \{ u - \underline{v} s^R + \rho_0(2\underline{v} s^R - u) \} \\ + (1 - \alpha) \{ F(\rho^*(s^R))(1 - \rho_0)\bar{v} + (1 - F(\rho^*(s^R))) (\rho_0 u + (1 - \rho_0)(\bar{v} s^R - u)) \} - (1 - \rho_0)C(s^R)$$

and therefore,

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

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

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

$$W^R := \alpha \{ u - \underline{v} s^R + \rho_0(2\underline{v} s^R - u) \} - (1 - \rho_0)C(s^R) \\ + (1 - \alpha) \{ F(\rho^*(s^R))(1 - \rho_0)\bar{v} + (1 - F(\rho^*(s^R))) (\rho_0 \bar{v} s^R + (1 - \rho_0)(u - \bar{v} s^R)) \} \\ W^R - W^N = \alpha(2\rho_0 - 1)\underline{v} s^R - (1 - \rho_0)C(s^R) \\ + (1 - \alpha) \left(F(\rho^*(s^R))(\bar{v} - u)(1 - \rho_0) + (1 - F(\rho^*(s^R))) ((2\rho_0 - 1)\bar{v} s^R) \right)$$

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