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Strategic data sales to competing firms

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Foreword

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Executive summary

This article focuses on the role of consumers' level information, and how it can affect market competition. The question is of particular relevance given the unprecedented availability of consumer data that are produced, gathered and shared in great amounts every second. These data have value to competing firms because, between other uses, they facilitate more precisely targeted individual pricing.

In particular, we consider the situation of a data broker that has collected and stored information about one segment of consumers. There are firms competing for consumers in the downstream market and the segment covered by the data only includes a share of the consumers in the market around one of the firms. In this setting, we study the incentives of the data broker to sell the data to the competing firms and how data affect the way firms compete.

Our main findings are as follows:

- The availability of data does change the strategic incentives of firms. On the one hand, the information allows to personalise price and extract more surplus from the consumers. On the other hand, the availability of the data induces an aggressive competitive response from other competitors that do not want to lose market share.
- Overall, the aggregate profits decrease when the information is available and downstream firms would prefer not to have it. Yet, all firms benefit individually if they get to access the data. As a result, firms face a typical prisoner's dilemma strategic situation.
- The data broker can sell the data to the firms in various ways: for example, using an auction or through a take-it-or-leave-it offer. Unlike most of the literature on data brokers, no matter the way of selling data, we find that exclusively sale is never part of the equilibrium.
- Moreover, despite the data are particularly tailored to the potential clientele of one of the competing firms, we show that the data broker has incentives to sell the list to its competitors. The intuition is that the strong competitive response from the rivals erodes the benefit of having a tailored list exclusively. Such a response is less severe when rival firms hold the information, and the data broker can extract from them more profits.
- Importantly, the market outcome induced by the data broker is not socially optimal. A regulator that aims to maximise consumers and social welfare should consider mandating data sharing.

Strategic data sales to competing firms*

Flavio Delbono[†] Carlo Reggiani[‡] Luca Sandrini[§]

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Abstract

The unprecedented access of firms to consumer level data facilitates more precisely targeted individual pricing. We study the incentives of a data broker to sell data about a segment of the market to three competing firms. The segment only includes a share of the consumers in the market around one of the firms. Data are never sold exclusively. Despite the data are particularly tailored to the potential clientele of one of the firms, we show that the data broker has incentives to sell the list to its competitors. Such market outcome is not socially optimal, and a regulator that aims to maximise consumers and social welfare should consider mandating data sharing.

JEL Classification: D43; K21; L11; L13; L41; L86; M21; M31.
Keywords: data markets, personalised pricing, price discrimination, oligopoly, selling mechanisms.

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1 Introduction

Data gathering, sharing and usage is widespread in today's digital economy. The use of mobile phones and other connected devices has resulted into the continuous generation of massive amount of data. Many businesses are demanding access to harvest the data and exploit their potential. Data intermediaries as data brokers and marketing agencies have experienced sustained success. For instance, estimates suggest that the data brokerage sector is expected to grow at an annual rate of 11.5 percent until 2026 (Transparency Market Research, 2017).

The contribution of data to the economy goes beyond the size of the sector: for example, the total impact of the data market on the EU's economy in 2017 was estimated to be 335.6 billion euros, corresponding to 2.4 per cent of total GDP (Frontier Technology Quarterly, 2019). More generally, data are mostly non-rival and, as such, their use and re-use can generate positive externalities and boost growth (Jones and Tonetti, 2020). As a result, data sharing is strongly incentivised by policy makers and, in certain circumstances, it may even be mandated. The European Commission, for example, announced the EU Data Strategy (European Commission, 2020) to boost data sharing among firms. This is achieved through both the proposed Data Governance Act and the and the complementary Data Act. The Digital Market Act regulating large platforms also includes mandatory data sharing as a crucial tool.

Beyond the positives, data sharing also poses risks. There are well known individual privacy concerns, but data transfers can also negatively affect market competition. The recent report by the UK Financial Conduct Authority (2019) highlights how the use of data for price discrimination is an established practice in the insurance market. Moreover, they show how insurance companies charge different prices to consumers in the same risk class, depending on other individual characteristics, such as the likelihood to switch the service provider.

An important issue is whether the access to data from upstream firms can advantage some competing firms that have access to it. For example, Martens and Mueller-Langer (2020) point out how sharing real-time digital car data between manufacturers and a network of official dealers can lead to price discrimination and potential foreclosure of independent downstream competitors.

Data do not always uniformly cover all consumers in the market. In the previous example, access to real-time vehicles' data may not be provided to all dealers and garages. In the health sector, some retail pharmacies or insurance companies may benefit from data shared by digital platforms gathering health information through wearables and other devices (Apple Watch, FitBit). In these examples and in other sectors (e.g., finance and banking, hospitality), due to the recent progresses in AI systems, it is likely that a segment of consumers is profiled and only some firms can access this information to personalise prices (Acemoglu, 2021).

This article studies the competitive issues related to data selling or sharing by focusing on a data broker that possesses information about *one segment* of the market. This information can be thought of as being the result of a marketing study on a particular segment of the market or, alternatively, as data gathered on the previous or potential clientele of one of the firms competing in the downstream market. In this context, we ask how is the data broker selling this information, and to whom. Are the data sold exclusively or to more than one of the market competitors? Which of the downstream firms ends up buying the data, and what are the implications for the market outcome?

We tackle the previous questions in a simple model with one data broker and three firms that compete in prices. The firms and consumers are located in a circular city (Salop, 1979). The data broker has information on the location of consumers in the arc of the city around one of the firms. As location captures the preference of the consumers, the data can be used to personalise prices and, hence, price discriminate.

There are a number of insights provided by our analysis. First, the selling mechanism influences the outcome of the game. Second, consider the case in which the data broker chooses to auction the data. Then, the firm whose arc of consumers is included in the data broker's dataset does not purchase it. Instead, the data broker has an incentive to sell it to the two competing firms. Even if the data appear tailored for the firm whose consumers have been profiled, such firm does not have the highest willingness to pay for the dataset.

The intuition for this finding lies in the *strategic reaction* of competing firms to the use of data. The possession of data for consumers close to the firm and the ability to personalise the price offers, make rival firms particularly aggressive in pricing. This limits the benefit of obtaining the data for the firm. The strategic price reaction of competing firms is less pronounced when the data are handed to the two competing firms neighbouring the one whose market arc has been profiled by the data broker. This implies that the willingness to bid of the two rivals is higher than the tailored firm's one.

Finally, assume the selling mechanism is a take-it-or-leave-it (TIOLI) offer. Then the profit maximising choice of the data broker is to sell the consumer information to all the firms in the market. This result confirms that the exclusive purchase of the data by the tailored firm is not an equilibrium outcome.

Recent years have witnessed a growing interest in the economic impact of data in markets and, in particular, data sharing and trading. A number of studies have concentrated on issues such as privacy and its market implications (Conitzer et al., 2012; Casadesus-Masanell and Hervas-Drane, 2015; Choi et al., 2019; Ichihashi, 2020), the impact of data-driven mergers (Chen et al., 2020; De Cornière and Taylor, 2020; Prat and Valletti, 2021), and data ownership (Dosis and Sand-Zantman, 2019). Bergemann et al. (2021), Gu et al. (2021), and Ichihashi (2021) analyse upstream competition (or lack of) between data brokers which can then be sold downstream.

Some articles, like ours, have modelled the asymmetric access of firms to consumer information. Gu et al. (2019) consider the effect of exclusive information that enables personalised on the incentives to act as price leader in the market. Belleflamme et al. (2020) study the impact of asymmetric precision in the information held for the profitabilty of price discrimination. They find that as long as the two firms are not identically able to profile consumers, they can both charge price above the marginal cost. Our work also models personalised pricing but the asymmetric access to the information is endogenous, as it is sold by the data broker. Further, the information only covers a segment of consumers that have an innate preference for a specific firm.

In terms of the data brokers incentives, the closest contributions are Montes et al. (2019), Bounie et al. (2021), and Kim et al. (2019). Montes et al. (2019) model privacy concerned consumers and finds that a data broker always has an incentive to sell data exclusively to a competing duopoly firm. Bounie et al. (2021) also study a duopoly and characterises the optimal partition of consumer database. Through partitioning the data broker always sells non-overlapping information to both firms. Finally, Kim et al. (2019) study data-driven mergers in a Salop model with three firms. The information covers all consumers in the market and in a pre-merger equilibrium the data are sold exclusively. Our contribution complements and adds to the previous literature in a number of ways. First, like Kim et al. (2019), we consider downstream competition with more than two firms; however, innovatively, we focus on situation in which the information held by the data broker only covers a particular segment of the market. The main implication is that exclusive selling of the non-divisible information is never the optimal strategy for a data broker.

The rest of the paper is structured as follows. Section 2 briefly presents the model. Section 3 focuses on price competition. Section 4 presents the equilibrium prices, profits and welfare. Section 5 studies the data broker's sale of the dataset. Section 6 discusses the results and their implications. Unless otherwise stated, the proofs are in the Appendix.

2 The framework

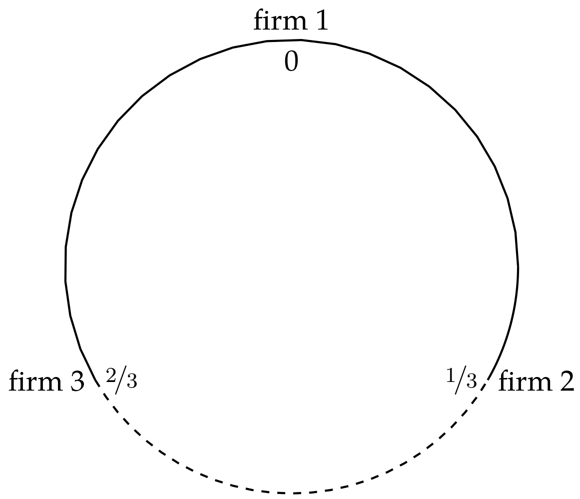
The market. One data broker and three competing retailers $i = 1, 2, 3$. Consumers are uniformly distributed on the unit circle (Salop, 1979) and their location is denoted as x. Firms are located equidistantly at $y_1 = 0$, $y_2 = 1/3$, and $y_3 = 2/3$. Consumers can demand at most one unit of the good. The utility of a consumer x for the good of firm i is:

$$U(x, y_i) = v - t|x - y_i| - p_i, \tag{1}$$

where v is the good's valuation, t is the unit transport cost, and p_i is the price. For simplicity, there are no variable or fixed costs.

Consumer information and data selling. The data broker can collect information only on some of the consumers in the market but not all. For example, the data broker may collect data on consumers located in the segment between firm $i - 1$ and firm $i + 1$. Without loss of generality, we assume that the data broker has information about consumer located between firm 3 and firm 2. In other words, the data broker has information on consumers *on the arc around firm 1*, i.e., $x \in [2/3, 1]$ and $x \in [0, 1/3]$, respectively. For sake of clarity, we will refer to this arch as to the *profiled segment* of the market. Instead, we will refer to the non-profiled arc between firm 2 and firm 3 - i.e., $x \in [1/3, 2/3]$ - as to the *anonymous segment* (Figure 1). The valuable information in this model is the location of consumers x. The data broker sells the data by auction. In section 4, we show that auction is a more profitable stratetgy for the data broker than making a *take-it-or-leave-it-offer* to a subset of the firms in the market (Montes et al., 2019; Bounie et al., 2021).[1]

Figure 1: The Salop model with three firms. The dashed line represents the anonymous segment and the full line the profiled one.



Timing. At Stage 0 the data broker costlessly gathers information about consumers on one of the segments of the market; in our case, the segment between firm 2 and firm 3, i.e., the segments $x \in [2/3, 1]$ and $x \in [0, 1/3]$. At Stage 1, the firms bid for the consumer information in data broker's possession. At Stage 2, firms engage in price competition. The game is solved by backward induction.

3 Price competition

There are several possible sub-games to be considered at Stage 2. We start from two benchmark cases (Section 3.1): (i) no firm has access to consumer information, (ii) all firms have access to consumer information. We then consider the case in which one firm has exclusive access to the list (Section 3.2): this firm can be firm 1, whose market segment has been profiled, or one between firm 2 and firm 3. Finally, we consider the case in which two firms get the consumer information: in one case, the two firms include firm 1, in the other, firm 2 and firm 3 have access to the information (Section 3.3).

[1] Results under different pricing schemes are different, as they embed different incentives. However, the main result of the analysis, namely the non-exclusive selling of data to the firm around which the dataset has been built, holds under both scenarios. Moreover, it is possible to prove that when the data broker sells the data via a sequential bargaining approach, results are qualitatively the same as in the scenario with auction.

3.1 Benchmark cases

3.1.1 No firm has access to consumer information

If no firm has access to consumer information, each firm simultaneously sets their prices to maximise profits. In other words, there is price competition *à la* Salop with three firms. For given prices, each firm's demand depends on the consumers indifferent between buying from the firm or one of its two neighbours, i.e.:

$$U(x, y_i) = U(x, y_{i-1}) \text{ and } U(x, y_i) = U(x, y_{i+1}),$$

where the utility functions are defined as in equation (1). As a result, the profit function of, for example, firm 1 is:

$$\pi_1 = p_1 \left[\left(\frac{t}{3} + \frac{p_2 - p_1}{2t} \right) + \left(\frac{t}{3} + \frac{p_3 - p_1}{2t} \right) \right].$$

Standard profit maximization leads to the following result (proof omitted):

Proposition 1. (***Salop, 1979***) *The unique equilibrium in a pricing subgame in which no firm has access to consumer information is characterised by the following prices and profits:*

$$p_i = \frac{t}{3}, \;\; \pi_i = \frac{t}{9}, \;\; i = 1, 2, 3.$$

3.1.2 All firms have access to consumer information

If all firms have access to the information on consumers on the profiled segment of the market, firms will use the information to condition price offers to the consumers location, and price discriminate. In other words, firms can send personalised offers to consumers at each location x on the arc.

This implies that firms are competing fiercely at each location x: as the distance of each firm is the only source of differentiation, Bertrand competition with heterogeneous costs (due to the distance) takes place at each location. Firms charge a non-negative price at each location, as otherwise they would make a loss and decrease their profit. Hence, the closest firm attracts the consumers, and it can charge a non-negative price that exactly matches the offer of the second closest firm (Thisse and Vives, 1988; Taylor and Wagman, 2014; Montes et al., 2019). For example, considering the sub-arc between firm 1 and firm 2, firm 1 can attract all consumers located between $x = 0$ and $x = 1/6$. On that sub-arc, firm 2 cannot offer any price lower than $p_2(x) = 0$. The price schedule for firm 1 can be found by solving for $p_1(x)$ the following:

$$U(x, y_1) = v - tx - p_1(x) = v - t(1/3 - x) = U(x, y_2),$$

leading to: $p_1(x) = {}^t/_3 - 2tx$. On the sub-arc between $x = {}^1/_6$ and $x = {}^1/_3$, a similar argument establishes that $p_1(x) = 0$ as the non-negativity constraint binds.

Following a similar reasoning, the firms' price schedules on the arc $x \in [{}^2/_3, 1]$ and $x \in [{}^1/_3, {}^2/_3]$ are as follows:

$$p_1(x) = \begin{cases} t\left({}^1/_3 - 2x\right), & \text{if } 0 \leq x < {}^1/_6 \\ t\left(2x - {}^5/_6\right), & \text{if } {}^5/_6 \leq x < 1 \\ 0, & \text{otherwise} \end{cases}; \tag{2}$$

$$p_2(x) = \begin{cases} t\left(2x - {}^1/_3\right), & \text{if } \frac{1}{6} \leq x < \frac{1}{3} \\ 0, & \text{otherwise} \end{cases}; \tag{3}$$

$$p_3(x) = \begin{cases} t\left({}^5/_6 - 2x\right), & \text{if } {}^2/_3 \leq x < {}^5/_6 \\ 0, & \text{otherwise} \end{cases}. \tag{4}$$

Despite the access to the data is symmetric, the price schedules (2)-(3)-(4) are clearly different and firms face an asymmetric situation. In particular, firm 1 price discriminates consumers both on its left and its right, whereas firms 2 and 3 can apply personalised schedules only on one side. This feature will play a notable role in the following analysis. The remaining consumers on the anonymous segment, i.e., between firm 2 and firm 3, are offered a uniform price. The indifferent consumer is identified by solving $U(x, y_2) = U(x, y_3)$. Solving the profit-maximisation problem leads to:

Proposition 2. *The equilibrium if all firms have access to consumer information consists of the price schedules* (2)-(3)-(4) *and the prices:*

$$p_2 = p_3 = \frac{t}{3}.$$

The firms' profits are, respectively,

$$\pi_1 = \frac{t}{18}, \quad \pi_2 = \pi_3 = \frac{t}{12}.$$

Proposition 2 illustrates the asymmetric profit impact of the possession of the consumer information. Indeed, all firms compete more fiercely for the profiled segment and, as a result, they make less profit than in the no information benchmark (Proposition 1). However, firm 1 is more damaged than firms 2 and 3, as its potential customers are profiled on both sides. The rivals' customers are only profiled on one of their two market segments. The uniform prices paid by the non profiled consumers on the anonymous segment are relatively high: in fact, they are the same as in the no information benchmark.

3.2 Exclusive access to consumer information

3.2.1 Firm 1 has access to consumer information

If firm 1 has exclusive access to the list, it will use it to personalise offers to the consumers on the profiled segment. Firm 2 and firm 3, instead, can only set uniform prices, p_2 and p_3, for all consumers. Given those prices, firm 1 price schedule is:

$$p_1(x) = \begin{cases} \max\left\{p_2 + t\left({}^1\!/\!{}_3 - 2x\right), 0\right\}, & \text{if } 0 \le x < {}^1\!/\!{}_3 \\ \max\left\{p_3 + t\left(2x - {}^5\!/\!{}_6\right), 0\right\}, & \text{if } {}^2\!/\!{}_3 \le x < 1 \end{cases}. \tag{5}$$

Denote the consumers for which the price schedule of firm 1 is zero, i.e., $p_1(\tilde{x}_{12}) = p_1(\tilde{x}_{13}) = 0$, as $\tilde{x}_{12} = {}^1\!/\!{}_6 + {}^{p_2}\!/\!{}_{2t}$ and $\tilde{x}_{13} = {}^5\!/\!{}_6 - {}^{p_3}\!/\!{}_{2t}$. Assume these consumers lie on the profiled segment. Then, the following proposition summarises our main findings in the pricing subgame if firm 1 has exclusive access to information about consumers on its own arc.

Proposition 3. *The equilibrium if firm 1 has exclusive access to consumer information consists of the price schedules* (5) *and the prices:*

$$p_2 = p_3 = \frac{2}{9}t.$$

The firms' profits are, respectively,

$$\pi_1 = \frac{25}{162}t, \;\; \pi_2 = \pi_3 = \frac{4}{81}t.$$

As a result of firm 1 having exclusive access to the consumer information, firm 2 and firm 3 become more aggressive in pricing. The equilibrium prices, in fact, reflect the trade-off between the usual uniform price competition on the anonymous segment and the need to match firm 1's personalised prices on the profiled segment. Firm 1 makes more profit than the competitors thanks to the exclusive information. Its profits are even higher than in the two benchmark cases. Firm 2 and firm 3, instead, make less profits than in the cases of Section 3.1.

3.2.2 Firm 2 or firm 3 have access to consumer information

Consider the case of either firm 2 or firm 3 having exclusive access to information about consumers on the arc around the rival (firm 1), i.e., the profiled segment. Assume, without loss of generality, that firm 2 has access to the information. In this case, firm 2 sets a price schedule for the profiled consumers ($x \in [{}^2\!/\!{}_3, 1]$ and $x \in [{}^1\!/\!{}_3, {}^2\!/\!{}_3]$) and a price p_2 for non-profiled consumers on the anonymous segment. Firm 1 and firm 3 set uniform prices

p_1 and p_3. Given these prices, firm 2 personalised price schedule is:

$$p_2(x) = \max\left\{p_1 + t\left(2x - {}^1\!/_3\right), 0\right\}. \tag{6}$$

Denote the consumers for which the price schedule of firm 2 is zero, i.e., $p_2(\tilde{x}_{21}) = 0$, as $\tilde{x}_{21} = {}^1\!/_6 - {}^{p_1}\!/_{2t}$, and assume that these consumers lie on the profiled segment. The equilibrium in the pricing subgame if firm 2 has exclusive information on consumers on firm 1's arc can be characterised as follows.

Proposition 4. *The equilibrium if firm 2 has exclusive access to consumer information consists of the price schedule* (6) *and the prices*

$$p_1 = \frac{19}{78}t, \;\; p_2 = \frac{25}{78}t, \;\; p_3 = \frac{4}{13}t.$$

The firms' profits are, respectively,

$$\pi_1 = \frac{361}{6084}t, \;\; \pi_2 = \frac{3275}{24336}t, \;\; \pi_3 = \frac{16}{169}t.$$

Firm 1 suffers the competition of firm 2's personalised prices on its own arc and, as a result, decreases its price, which is the lowest. This affects firm 3, who posts a higher price but lower than firm 2 in response. The pricing rankings reflect those of profits: firm 2 benefits the most from exclusive information about firm 1's arc of consumers. Firm 1, in turn, is the most damaged by firm 2 having information about its own market segment.

3.3 Two firms access consumer information

The final subgames to consider are when a subset of more than one firm but not all have access to the information on firm 1 arc of consumers. The subset can include firm 1 or not, and we will analyse these two cases in turn in what follows.

3.3.1 Firm 1 and 2 have access to consumer information

If firm 1 and firm 2 have access to the information, they can offer personalised prices to consumers on the profiled segment ($x \in [{}^2\!/_3, 1]$ and $x \in [0, {}^1\!/_3]$). There will be intense competition between firm 1 and firm 2 for the profiled consumers lying on the sub-arc between them. In particular, neither firm can offer a price lower than its cost or it would make losses, i.e., $p_i(x) \geq 0, \;\forall x[0, {}^1\!/_3], i = 1, 2$. This allows identifying the price schedule and the indifferent consumer on that arc. Moreover, firm 2 and firm 3 also offer posted prices p_2 and p_3. Given the price of firm 3 and the previous observations, the price schedules of firm 1 and firm 2 are, respectively:

$$p_1(x) = \begin{cases} \max\left\{t\left(1/3 - 2x\right), 0\right\} & \text{if } x \in [0, 1/3] \\ \max\left\{p_3 + t\left(2x - 5/3\right), 0\right\} & \text{if } x \in [2/3, 1] \end{cases}, \tag{7}$$

$$p_2(x) = \max\left\{t\left(2x - 1/3\right), 0\right\}. \tag{8}$$

The consumers for which the price schedule of firm 1 and firm 2 are zero are located $\tilde{x}_{12} = 1/6$. Denote also the consumers for which the price schedule of firm 1 is zero, i.e., $p_1(\tilde{x}_{31}) = 0$, as $\tilde{x}_{31} = 5/6 - p_3/2t$. As a result, the equilibrium in the pricing subgame if firm 1 and firm 2 have information on the consumers on firm 1's arc can then be characterised as follows.

Proposition 5. *The equilibrium if firm 1 and firm 2 have access to consumer information consists of the price schedules* (7)-(8) *and the prices*

$$p_2 = \frac{2}{7}t, \;\; p_3 = \frac{5}{21}t.$$

The firms' profits are, respectively,

$$\pi_1 = \frac{193}{1764}t, \;\; \pi_2 = \frac{121}{1764}t, \;\; \pi_3 = \frac{25}{441}t.$$

In case the firm whose arc is profiled and a rival have the information, the third firm with no information is the most damaged. Firm 3, in fact, faces fierce competition from the personalised offers of firm 1 and, as a result, its price is lower than the one of firm 2. Firm 3 also gets the lowest profit, whereas firm 1 benefits from personalised pricing and has the highest profit.

3.3.2 Firm 2 and firm 3 have access to consumer information

If firm 2 and firm 3 have access to the information, they can offer personalised prices to consumers on the profiled segment ($x \in [2/3, 1]$ and $x \in [1/3, 2/3]$). All three firms will also offer posted prices p_i. Given these prices, the schedules for firm 2 and firm 3 are, respectively:

$$p_2(x) = \max\left\{p_1 + t\left(2x - 1/3\right), 0\right\}, \tag{9}$$

$$p_3(x) = \max\left\{p_1 + t\left(5/3 - 2x\right), 0\right\}. \tag{10}$$

Denote the consumers for which the price schedule of firm 2 and firm 3 are zero, i.e., $p_2(\tilde{x}_{21}) = p_2(\tilde{x}_{31}) = 0$, as $\tilde{x}_{21} = 1/6 - p_1/2t$ and $\tilde{x}_{31} = 5/6 + p_1/2t$, respectively. Assume that these consumers lie on the profiled arc. Then, the equilibrium in the pricing subgame if firm

2 and firm 3 have information on the consumers on firm 1's arc can then be characterised as follows.

Proposition 6. *The equilibrium if firm 2 and firm 3 have access to consumer information consists of the price schedules* (9) - (10) *and the prices*

$$p_1 = \frac{t}{6}, \;\; p_2 = \frac{t}{3}, \;\; p_3 = \frac{t}{3}.$$

The firms' profits are, respectively,

$$\pi_1 = \frac{t}{36}, \;\; \pi_2 = \frac{17}{144}t, \;\; \pi_3 = \frac{17}{144}t.$$

The equilibrium prices for non profiled consumers are the same as in the benchmark: the competition between firm 2 and firm 3 for the anonymous segment is not affected by the information. The profiled segment, in fact, is served by both firms through personalised offers. Firm 1 suffers the consequences of this information allocation, as it has to decrease its price to compete with personalised pricing on its own market arc. The lower price of firm 1 is also reflected in much lower profit than the two informed competitors.

4 Prices, profits, and welfare

We start with a recap of the results of the pricing stage. Table 1 reports the equilibrium posted prices, firms' and industry profits in all the pricing subgames. Each subgame's label is used as superscript in the ensuing comparisons and analysis. The table highlights one interesting feature of the presence of personalised pricing on posted prices: no matter what subgame is reached, posted prices are never higher than in the no information benchmark ($t/3$). This underlines the pro-competitive effect of personalised prices, which induces rivals to be more competitive and best respond with lower posted prices.

Table 1: Summary of the prices and profits in each subgame of the pricing stage.

	No info (NI)	All info (AI)	Excl 1 (1)	Excl 2 (2)	Both 1 & 2 (12)	Both 2 & 3 (23)
p_1	0.333 t	-	-	0.244 t	-	0.167 t
p_2	0.333 t	0.333 t	0.222 t	0.321 t	0.286 t	0.333 t
p_3	0.333 t	0.333 t	0.222 t	0.308 t	0.238 t	0.333 t
π_1	0.111 t	0.056 t	0.154 t	0.059 t	0.109 t	0.028 t
π_2	0.111 t	0.083 t	0.049 t	0.135 t	0.069 t	0.118 t
π_3	0.111 t	0.083 t	0.049 t	0.095 t	0.057 t	0.118 t
Π	0.333 t	0.222 t	0.253 t	0.289 t	0.235 t	0.264 t
CS	v - 0.417 t	v - 0.306 t	v - 0.361 t	v - 0.388 t	v - 0.333 t	v - 0.361 t
TS	v - 0.084 t	v - 0.084 t	v - 0.108 t	v - 0.099 t	v - 0.098 t	v - 0.097 t

Proposition 7 provides a comparison of the firm's profits in each of the possible pricing subgames. It is important to recall that if one of the firms whose consumers are not all profiled gets the information exclusively, this is firm 2 and not firm 3.

The proposition makes clear that firm 1, whose segment of nearby consumers is profiled, benefits from exclusive use of the list, despite the consequent increase of competition intensity. Interestingly, its second best would be that no information is shared or sold. This outcome would be better than sharing the data with firm 2, as it drives all firms to set the highest possible price, whereas sharing the list would entail a competitive pressure that is detrimental to profits. In detail, by sharing data with firm 2 rather than have them alone, firm 1 would not be able to fully exploit the potential of the list when competing against firm 2. Ultimately, this negative effect more than compensate the relatively softer competitive pressure exerted by firm 3.

Similarly, firm 2, greatly benefits from having exclusively access to consumers' information. Intuitively, exclusive access to data means that firm 2 can price discriminate one segment of the market. Firm 1's best reply is to lower her price and be more aggressive against both firm 2's prices schedule and firm 3's price. However, price competition does not propagate as if firm 1 had the data, since firm 3 faces competition on just one sub-segment of her market.

Finally, it is interesting to notice that the profit of firm 2 when all firms buy the data is higher than its profit when it buys it jointly with firm 1, i.e., $\pi_2^{AI} > \pi_2^{12}$. At same time, the profit of firm 3 is higher when firms 1 and 2 have both access to the list than when firm 1 has it exclusively, i.e., $\pi_3^{12} > \pi_3^{1}$. When all firms have access to the information, there is no impact of the list on pricing in the non-profiled segment. Then, this leads to standard Salop competition between firm 2 and firm 3. When, instead, only firm 1 and 2 have access to the list, firm 3 needs to price more aggressively to match the personalised offers of firm 1. This more intense price competition also affects firm 2 and negatively impacts its profit. At the same time, competition is even fiercer when firm 1 has exclusive access to the list. In that case both firms 2 and 3 have to react aggressively to the personalised offers of firm 1 on its arc.

Proposition 7. *The equilibrium profit of each firm in the pricing subgames compare as follows:*

$$\pi_1^1 > \pi_1^{NI} > \pi_1^{12} > \pi_1^2 > \pi_1^{AI} > \pi_1^{23},$$

$$\pi_2^2 > \pi_2^{23} > \pi_2^{NI} > \pi_2^{AI} > \pi_2^{12} > \pi_2^1,$$

$$\pi_3^{23} > \pi_3^{NI} > \pi_3^2 > \pi_3^{AI} > \pi_3^{12} > \pi_3^1.$$

Proof: Follows from Table 1.

4.1 Welfare analysis

The previous analysis has important implications. From the industry perspective, no information maximises the joint profits whereas the most competitive subgame is when all firms have access to the list of profiled consumers. When the firm whose arc is profiled has access to the information, either exclusively or jointly, the industry profits decrease compared to the case when the rivals do. Exclusive information (for example, to firm 2 or firm 1) leads to higher industry profits than if the same firms share the information with one of the rivals.

As expected, the consumer surplus displays an almost perfectly inverse order. The best scenario is when all firms have access to the list, whereas no information is the less desirable subgame. This can be explained as a consequence of the intense price competition when all firms have access to the information. Interestingly, from a consumer's perspective we note that the exclusive availability of the information to firm 1 is equivalent to the case in which both firm 2 and 3 access it. Indeed, the different allocation of the information does not affect the intensity competition in each sub-segment of the market.

Finally, the total surplus is maximised in the two benchmark cases of no information and when all firms have access to it. The only difference is that in the former case the allocation is biased towards the firms, whereas in the latter towards consumers. Moreover, the subgame in which the information is held by the firm whose arc of consumers has been profiled (firm 1) is the least desirable from a welfare perspective. As there are no demand expansion effects and prices are transfers, all the total surplus results are driven by the overall transport costs and the symmetry of the location of the indifferent consumers.

Proposition 8. *The industry profits in the pricing subgames compare as follows:*

$$\Pi^{NI} > \Pi^2 > \Pi^{23} > \Pi^1 > \Pi^{12} > \Pi^{AI}.$$

As for consumer surplus:

$$CS^{AI} > CS^{12} > CS^{23} = CS^1 > CS^2 > CS^{NI},$$

and total surplus:

$$TS^{NI} = TS^{AI} > TS^{23} > TS^{12} > TS^2 > TS^1.$$

5 Data sales

We finally focus on the data broker decision. There are several mechanisms that the data broker can employ to sell the data. In particular, building on Jehiel and Moldovanu (2000) we consider an auction in which the firms can bid to ensure access to the data. In the next subsection we will analyse how the findings are affected if the data broker uses other selling mechanisms.

The data broker chooses how many "contracts" to sell, and let the firms bid for the data. We define the willingness to pay as the difference in the profits if one (or more) firm buys the list and the counterfactual case in which it does not but one (or more) of their rivals does. This leads to the following data broker profits:

$$\begin{aligned}
\pi^1_{DB} &= \pi^1_1 - \pi^2_1 = 0.095t,\\
\pi^2_{DB} &= \pi^2_2 - \pi^1_2 = 0.086t,\\
\pi^{12}_{DB} &= (\pi^{12}_1 - \pi^{23}_1) + (\pi^{12}_2 - \pi^{12}_3) = 0.093t,\\
\pi^{23}_{DB} &= 2(\pi^{23}_2 - \pi^{12}_3) = 0.122t,\\
\pi^{AI}_{DB} &= (\pi^{AI}_1 - \pi^{23}_1) + 2(\pi^{AI}_2 - \pi^{12}_3) = 0.080t
\end{aligned}$$

Proposition 9. *Assume the selling mechanism is an auction offer. Then, the profits of the data broker in the pricing subgames compare as follows:*

$$\pi^{23}_{DB} > \pi^1_{DB} > \pi^{12}_{DB} > \pi^2_{DB} > \pi^{AI}_{DB}.$$

Proof: Follows from the above derivations.

5.1 Other selling mechanisms

Another mechanism that the data broker could use to sell data is through a TIOLI offer. That way, the data broker can extract all the willingness to pay of the firms for the list. In particular, we define the willingness to pay as the difference in the profits if they buy the list and the counterfactual case in which they do not. This leads to the following data broker profits:

$$\pi^1_{DB} = \pi^1_1 - \pi^{NI}_1 = 0.043t, \qquad \pi^2_{DB} = \pi^2_2 - \pi^{NI}_2 = 0.024t,$$
$$\pi^{12}_{DB} = (\pi^{12}_1 - \pi^2_1) + (\pi^{12}_2 - \pi^1_2) = 0.070t, \qquad \pi^{23}_{DB} = 2(\pi^{23}_2 - \pi^2_3) = 0.046t$$
$$\pi^{AI}_{DB} = (\pi^{AI}_1 - \pi^{23}_1) + 2(\pi^{AI}_3 - \pi^{12}_3) = 0.080t$$

Proposition 10. *Assume the selling mechanism is a TIOLI offer. Then, the profits of the data broker in the pricing subgames compare as follows:*

$$\pi^{AI}_{DB} > \pi^{12}_{DB} > \pi^{23}_{DB} > \pi^1_{DB} > \pi^2_{DB}.$$

Proof: Follows from the above derivations.

Finally, we consider the possibility that the data are sold through sequential bargaining (Rubinstein, 1982; Sobel and Takahashi, 1983). Under this mechanism, the data broker makes an offer for the whole list to each firm sequentially. The game stops when one firm acquires information and we assume there is no discount factor. At each stage, the data intermediary proposes the list to one firm or to a group of firms and nothing to the others. In this case, we define the willingness to pay as the difference in the profits if they buy the list and the counterfactual case in which they do not but one (or more) of their rivals does. The results of the analysis are qualitatively identical to the case of an auction (see Proposition 9).

Propositions 9, 10 and, more generally, our findings on data selling provide interesting insights. A data broker that has profiled one arc of consumers around a firm never sells the consumers information *exclusively* to the firm whose market segment has been profiled.

If the data broker adopts an auction or a sequential bargaining selling method, the optimal choice is to sell consumers information not to firm 1, but to the two rivals together, firms 2 and 3. The only scenario in which firm 1 obtains the list is when the data broker chooses a TIOLI offer and sells the data to all firms in the market. This is also the only scenario in which private incentives are aligned with the social optimum (see Section 4.1).

6 Discussion

This article has studied the strategic incentives of a data broker to sell consumer information to competing firms. In particular, we considered a list of consumer data that covers only the potential customers of one of the competing firms. The data can be used to implement personalised pricing. In this setting, we find that each of the firms in the market benefits from the exclusive use of the data. Interestingly, however, the second-best outcome for the firm whose segment of potential consumers is profiled would be that no information is shared nor sold.

The impact of data on downstream Salop competition allows us to disentangle two sub-categories of results. First, the data broker sells the list *symmetrically* - namely, either i) to the firm located at the centre of the list alone, ii) to both the firms located at the extremes of the profiled segment or iii) to all firms. Second, the data broker sells the list *asymmetrically* - namely, either i) to only one of the firms located at the extremes of the profiled segment or ii) to the firm in the centre jointly with one of its rivals.

In the former case, the list-owners set a personalised price for the profiled consumers, but they do not deviate from the Salop price in the anonymous segment. In the latter case, to best respond to rivals' aggressive pricing, firms in possession of the list set a price schedule in the profiled segment and lower the anonymous price elsewhere.

At the aggregate level, firms are better off when no information is shared, as this is the scenario in which price competition is as soft as possible. Conversely, when all firms have access to consumer data, price competition in the profiled segment is very fierce. As all firms can set a competitive personalised price for the consumers in the profiled segment, surplus extraction is minimal.

Consumer surplus ordering shows the mirror image of the above results. When all firms have access to data, the intensity of competition in the profiled segment makes consumers better off on average. Although non-profiled consumers face the usual Salop price, the gains for those on the profiled sub-arc is so high that they outweigh any other scenarios.

Interestingly, total surplus represents a synthesis of the opposite results for industry profits and consumers surplus. From a welfare perspective, there is no difference between all firms having access to data or no firm, as they both represent the first best. However, the two cases are not equivalent, as the former favours consumers, whereas the latter would be preferred by firms. In other words, a policy-maker faces a choice between which side of the market to back.

The most important finding, however, is that the data broker's incentives are not aligned with those of the policy-maker. In fact, the data broker's strategy depends on the selling mechanism adopted. In case data are auctioned, it sells the consumer list to both the firms located at the extremes of the profiled segment. Instead, in case of a TIOLI offer, the list is sold to all firms in the market. Contrary to previous findings in the literature (e.g., Montes et al., 2019; Kim et al., 2019), an implications of our findings is that the data broker *never* has an incentive to sell the data exclusively.

Morever, as an auction provides the data broker with higher profits than a TIOLI offer, we shall identify this scenario as the expected equilibrium of the game. Thus, in such equilibrium, the second best is realised and the firm whose potential consumers are profiled needs to price aggressively in order to best respond to the personalised price of the two neighbouring rivals. On the other hand, consumers on the anonymous sub-arc are not affected by the list and, as a result, they do not suffer from possible brand mismatches.

These findings carry important policy implications. The data broker is not spontaneously willing to sell the information to all the firms in the market. Thus, the welfare maximisng policy-maker should consider either a ban on data collection and sale (if the goal is to favour aggregate profits over consumer surplus) or a mandatory data sharing regulation, which would not only achieve the maximum exploitation of data but also induce pro-competitive market outcomes.

We shall note, however, that second policy option changes firms incentives substantially, and the policy-maker should be aware of it. If the data broker *must* sell consumer data to all the firms, her *bargaining power* collapses to the minimum. Thus, a policy-maker that aims to support this policy should design a tax on data usage to competing firms to redistribute the revenues with the data broker, particularly if the latter has to recover from the costs of collecting data and needs to be incentivised to do so.

Finally, some conclusive considerations are in order. First, if they could coordinate, firms would be better off by not purchasing the data or, eventually, by not using it. However, as they all have a profitable deviation, the problem collapses to a prisoner dilemma game. The data broker, who owns the data, coordinate the game such that only two firms have access to consumer data. This observation opens the question of whether consumer information can be used as a coordination device for downstream firms to sustain collusive behaviour and anti-competitive practices.

Second, this article extends the analysis of data sales to the case in which the market is not a duopoly. In more detail, we focus on the particular case of three competing firms.

Although we do not explicitly address an oligopoly setting with n competing firms, we can conjecture that the equilibrium outcome of the game would not change when more firms are added to the model. The two firms at the extremes of the profiled segments are those with the highest aggregate willingness to pay, as they are the ones suffering the most from competing with an informed rival at the centre of the profiled segment. All other firms in the anonymous segment would play a relatively passive role.

Third, our setting could help shed light on situations in which the data broker is integrated with one of the competing firms. A natural situation is, for example, the one in which the final good transmits data to the data broker that can eventually feed it back to downstream firms. In the car sector, this is the real-time vehicles data transmission envisaged in Martens and Mueller-Langer (2020). We can conjecture that such integrated data broker would not have an incentive to share the data about their clients' segment with the downstream unit, as that would lead to a fiercer overall price competition.

Fourth, we analyse a game in which a data broker collects info about all of a firm's potential customers. How would the equilibrium change if the segment was longer or shorter is a direction left open to further research.

A Appendix

A.1 Proof of Proposition 2

As a result of the pricing results (2)-(3)-(4), the profits on the profiled segment of the market are:

$$\begin{aligned}\pi_1^d &= \int_0^{1/6} p_1(x)dx + \int_{5/6}^{1} p_1(x)dx = \frac{t}{18} \\ \pi_2^d &= \int_{1/6}^{1/3} p_2(x)dx = \frac{t}{36} \\ \pi_3^d &= \int_{2/3}^{5/6} p_3(x)dx = \frac{t}{36}\end{aligned} \quad .$$

The remaining consumers on the anonymous segment, i.e., between firm 2 and firm 3, are offered a uniform price. The indifferent consumer is identified by solving $U(x, y_2) = U(x, y_3)$. The firms' profit functions are:

$$\begin{aligned}\pi_2 &= p_2 \left(\frac{1}{6} + \frac{p_3 - p_2}{2t} \right) + \frac{t}{36}, \\ \pi_3 &= p_3 \left(\frac{1}{6} + \frac{p_2 - p_3}{2t} \right) + \frac{t}{36}.\end{aligned}$$

Standard calculations lead to the profit-maximising anonymous prices

$$p_2 = p_3 = \frac{t}{3}.$$

Using the price schedules (2)-(3)-(4), and the prices p_2 and p_3, the profits of the firms can be written as

$$\pi_1 = \frac{t}{18}, \;\; \pi_2 = \pi_3 = \frac{t}{12}.$$

Q.E.D.

A.2 Proof of Proposition 3

From the price schedule (5), the profit function of the firms are:

$$\pi_1 = \int_0^{\tilde{x}_{12}} \left[p_2 + t\left({}^{1}\!/_{3} - 2x \right) \right] dx + \int_{\tilde{x}_{13}}^{1} \left[p_3 + t\left(2x - {}^{5}\!/_{6} \right) \right] dx.$$

$$\pi_2 = p_2 \left[\left(\frac{1}{6} + \frac{p_3 - p_2}{2t} \right) + \left(\frac{1}{3} - \tilde{x}_{12} \right) \right].$$

$$\pi_3 = p_3 \left[\left(\frac{1}{6} + \frac{p_2 - p_3}{2t} \right) + \left(\tilde{x}_{13} - \frac{2}{3} \right) \right].$$

Standard calculations lead to the profit-maximising prices for the anonymous segment

$$p_2 = p_3 = \frac{2}{9}t.$$

Using these prices and the price schedule (5), it is possible to derive the profits of the firms:

$$\pi_1 = \frac{25}{162}t, \;\; \pi_2 = \pi_3 = \frac{4}{81}t.$$

Q.E.D.

A.3 Proof of Proposition 4

From the price schedule (6), the profit function of the firms can be written as:

$$\pi_1 = p_1 \left[\tilde{x}_{21} + \left(\frac{1}{6} + \frac{p_3 - p_1}{2t} \right) \right].$$

$$\pi_2 = p_2 \left(\frac{1}{6} + \frac{p_3 - p_2}{2t} \right) + \int_{\tilde{x}_{21}}^{1/3} \left[p_1 + t\left(2x - 1/3\right) \right] dx.$$

$$\pi_3 = p_3 \left[\left(\frac{1}{6} + \frac{p_2 - p_3}{2t} \right) + \left(\frac{1}{6} + \frac{p_1 - p_3}{2t} \right) \right].$$

Standard calculations lead to the profit-maximising prices for the anonymous segment

$$p_1 = \frac{19}{78}t, \;\; p_2 = \frac{25}{78}t, \;\; p_3 = \frac{4}{13}t.$$

Using these prices and the price schedule (5), it is possible to derive the profits of the firms:

$$\pi_1 = \frac{361}{6084}t, \;\; \pi_2 = \frac{3275}{24336}t, \;\; \pi_3 = \frac{16}{169}t.$$

Q.E.D.

A.4 Proof of Proposition 5

From the price schedules (7)-(8), the profit function of the firms are:

$$\pi_1 = \int_0^{1/6} \left[t\left(1/3 - 2x\right) \right] dx + \int_{\tilde{x}_{31}}^{1} \left[p_3 + t\left(5/3 - 2x\right) \right] dx.$$

$$\pi_2 = p_2 \left(\frac{1}{6} + \frac{p_3 - p_2}{2t} \right) + \int_{1/6}^{1/3} \left[t\left(2x - 1/3\right) \right] dx.$$

$$\pi_3 = p_3 \left[\left(\frac{1}{6} + \frac{p_2 - p_3}{2t} \right) + \left(\tilde{x}_{31} - 2/3 \right) \right].$$

Standard calculations lead to the profit-maximising prices for the anonymous segment

$$p_2 = \frac{2}{7}t, \; p_3 = \frac{5}{21}t.$$

Using these prices and the price schedules (7)-(8), it is possible to derive the profits of the firms:

$$\pi_1 = \frac{193}{1764}t, \; \pi_2 = \frac{121}{1764}t, \; \pi_3 = \frac{25}{441}t.$$

Q.E.D.

A.5 Proof of Proposition 6

From the price schedules (9)-(10), the profit function of the firms are: The profit function of the firms are:

$$\pi_1 = p_1 \left[\tilde{x}_{21} + (1 - \tilde{x}_{31})\right].$$

$$\pi_2 = p_2 \left(\frac{1}{6} + \frac{p_3 - p_2}{2t}\right) + \int_{\tilde{x}_{21}}^{1/3} \left[p_1 + t\left(2x - 1/3\right)\right] dx.$$

$$\pi_3 = p_3 \left(\frac{1}{6} + \frac{p_2 - p_3}{2t}\right) + \int_{\tilde{x}_{31}}^{1/3} \left[p_1 + t\left(5/3 - 2x\right)\right] dx.$$

Standard calculations lead to the profit-maximising prices for the anonymous segment

$$p_1 = \frac{t}{6}, \; p_2 = p_3 = \frac{t}{3}t.$$

Using these prices and the price schedules (7)-(8), it is possible to derive the profits of the firms:

$$\pi_1 = \frac{t}{36}, \; \pi_2 = \pi_3 = \frac{17}{144}t.$$

Q.E.D.

References

Acemoglu, D. (2021). Harms of AI. NBER Working Paper No. w29247.

Belleflamme, P., Lam, W. M. W., and Vergote, W. (2020). Competitive imperfect price discrimination and market power. *Marketing Science*, 39(5):996–1015.

Bergemann, D., Bonatti, A., and Gan, T. (2021). The economics of social data. *Cowles Foundation Discussion Paper No. 2203R*.

Bounie, D., Dubus, A., and Waelbroek, P. (2021). Selling strategic information in competitive markets. *RAND Journal of Economics*, 52(2):283–313.

Casadesus-Masanell, R. and Hervas-Drane, A. (2015). Competing with privacy. *Management Science*, 61(1):229–246.

Chen, Z., Choe, C., Cong, J., Matsushima, N., et al. (2020). Data-driven mergers and personalization. *Institute of Social and Economic Research Discussion Papers*, 1108:1–14.

Choi, J. P., Jeon, D.-S., and Kim, B.-C. (2019). Privacy and personal data collection with information externalities. *Journal of Public Economics*, 173:113–124.

Conitzer, V., Taylor, C. R., and Wagman, L. (2012). Hide and seek: Costly consumer privacy in a market with repeat purchases. *Marketing Science*, 31(2):277–292.

De Cornière, A. and Taylor, G. (2020). Data and competition: a general framework with applications to mergers, market structure, and privacy policy. *CEPR Discussion Paper No. DP14446*.

Dosis, A. and Sand-Zantman, W. (2019). The ownership of data. *Mimeo*.

European Commission (2020). A European strategy for data. https://ec.europa.eu/digital-single-market/en/news/summary-report-public-consultation-european-strategy-data. [Last accessed November 29, 2021].

Financial Conduct Authority (2019). General insurance pricing practices. https://www.fca.org.uk/publication/market-studies/ms18-1-2-interim-report.pdf. [Last accessed November 29, 2021].

Frontier Technology Quarterly (2019). Data economy: Radical transformation or dystopia? https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/FTQ_1_Jan_2019.pdf. [Last accessed November 29, 2021].

Gu, Y., Madio, L., and Reggiani, C. (2019). Exclusive data, price manipulation and market leadership. *CESifo Working Paper No. 7853*.

Gu, Y., Madio, L., and Reggiani, C. (2021). Data brokers co-opetition. *Oxford Economic Papers*. Forthcoming.

Ichihashi, S. (2020). Online Privacy and Information Disclosure by Consumers. *American Economic Review*, 110(2):569–595.

Ichihashi, S. (2021). Competing data intermediaries. *RAND Journal of Economics*. Forthcoming.

Jehiel, P. and Moldovanu, B. (2000). Auctions with downstream interaction among buyers. *RAND Journal of Economics*, pages 768–791.

Jones, C. I. and Tonetti, C. (2020). Nonrivalry and the economics of data. *American Economic Review*, 110(9):2819–58.

Kim, J.-H., Wagman, L., and Wickelgren, A. L. (2019). The impact of access to consumer data on the competitive effects of horizontal mergers and exclusive dealing. *Journal of Economics & Management Strategy*, 28(3):373–391.

Martens, B. and Mueller-Langer, F. (2020). Access to digital car data and competition in aftermarket maintenance services. *Journal of Competition Law & Economics*, 16(1):116–141.

Montes, R., Sand-Zantman, W., and Valletti, T. (2019). The Value of Personal Information in Online Markets with Endogenous Privacy. *Management Science*, 65(3):1342–1362.

Prat, A. and Valletti, T. (2021). Attention oligopoly. *American Economic Journal: Microeconomics, Forthcoming*.

Rubinstein, A. (1982). Perfect equilibrium in a bargaining model. *Econometrica*, 50(1):97–109.

Salop, S. C. (1979). Monopolistic competition with outside goods. *Bell Journal of Economics*, 10(1):141–156.

Sobel, J. and Takahashi, I. (1983). A multistage model of bargaining. *The Review of Economic Studies*, 50(3):411–426.

Taylor, C. and Wagman, L. (2014). Consumer privacy in oligopolistic markets: Winners, losers, and welfare. *International Journal of Industrial Organization*, 34:80–84.

Thisse, J.-F. and Vives, X. (1988). On the strategic choice of spatial price policy. *American Economic Review*, 78(1):122–137.

Transparency Market Research (2017). Data broker market report. `https://www.transparencymarketresearch.com/data-brokers-market.html`. [Last accessed November 29, 2021].

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