Strategic data sales with partial segment profiling*

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 consider an oligopoly market *à la* Salop in which only one segment of consumers is profiled. In particular, the segment includes a share of the consumers in the market around one of the firms. We study the incentives of a data broker to sell data about such a segment to three competing 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 considering to mandate data sharing can shift the surplus from the data broker to downstream firms.

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Keywords: data markets, personalised pricing, price discrimination, oligopoly, selling mechanisms.

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†Department of Economics, University of Bologna, Piazza Scaravilli 2, 40126 Bologna, Italy. Email: flavio.delbono@unibo.it.

‡European Commission JRC, Sevilla, Spain and Department of Economics and University of Manchester, United Kingdom. Email: carlo.reggiani@manchester.ac.uk

§Quantitative Social and Management Sciences Research Group, Budapest University of Technology and Economics, Hungary. Email: sandrini.luca@gtk.bme.hu.

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 amounts of data. Many businesses are demanding access to harvest the data and exploit their potential. Data intermediaries as data brokers and marketing agencies have contributed to the production, collection and sharing of data, and are experiencing 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). Notwithstanding these positive aspects, data transfers can also pose risks for consumers. Besides the well known individual privacy concerns (Acquisti *et al.*, 2016), data exchanges can also affect market competition. Whereas in the past personalised pricing in competitive markets has been mostly thought as favourable for consumers by both the academic (Thisse and Vives, 1988) and policy (OECD, 2018) literature, recently circumstances have been identified where this is not necessarily the case and competition may be softened even if firms can engage in personalised pricing (Rhodes and Zhou, 2022).

We contribute to this discussion on the competitive effects of data and personalised pricing by considering the following scenario. There are competing firms that can potentially access information about *one segment* of the market. Indeed, not all consumers have been profiled, but only a segment which mainly covers those with a relative preference for one of the competing firms. In this situation, that we refer to as "partial segment profiling", we focus on two main issues. First, the *market interaction* when different firms have access to data about one segment of consumers. More in details, how does partial segment profiling affect market competition? Are firms pricing more or less aggressively than in presence of information about either all segments or none? Second, the *incentives of a data broker* to sell such information to one or more of the market competitors. In particular, 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 carry on our analysis through in a simple model with three firms that engage in price competition and one data broker. 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 preferences of consumers, the data can be used to personalise prices and, hence, price discriminate (Thisse and Vives, 1988). Clarity of exposition motivates the choice of presenting the three firms setting with a fixed arc of consumers profiled as the main model. However, in section 6 we consider arcs of different length. Moreover, as we show in section 7, all the benchmark results appear to be robust in presence of more than three firms on the market.

There are a number of insights provided by our analysis. First, we confirm a number of results from the literature on personalised pricing duopoly and price discrimination. For example, if there is no consumer information or if information is given to all firms, price competition leads to the most efficient outcome. In the first case aggregate profits are maximised, in the second consumer surplus is. Beyond these benchmarks, however, who accesses consumer data under partial segment profiling makes a difference. This is because the access to the list makes a company more aggressive in pricing, and this is particularly true for the firm whose segment is profiled. As a result, social welfare and consumer surplus are relatively high when the firms whose segments are not profiled that access the list, whereas aggregate profits are enhanced if one of those firms can access consumer information exclusively. Welfare is instead minimised if it is the firm whose segment is profiled that has such exclusive access. Overall, the distribution of surplus is affected by the pricing regime resulting from the access to consumer information.

Second, the selling mechanism influences the outcome of the game. In particular, we analyse the strategic incentives of the data broker if she sells information either via an auction with and without reserve price or via a take-it-or-leave-it offer (TIOLI). Consistently with the literature, we show that auctioning the information maximises the data broker's ability to extract surplus from the bidders. Moreover, we compare two auction designs, one in which the data broker commits to sell information to a specific number of firms, and one in which this commitment is not considered. Although the latter design maximises surplus extraction, results are qualitatively similar.

Third, in case the data broker chooses to auction the data, 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 one of the firm for which the data seem tailored.

Instead, if the data broker uses a TIOLI offer as the selling mechanism, 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 consumer information by the firm for which the data would seem tailored is not an equilibrium outcome.

Finally, when considering arcs of different length, we show that our main findings apply for a sufficiently high share of profiled consumers. We also notice that if the length of the profiled arc is chosen by the data broker, in the absence of data gathering costs, it would be optimal to profile half of the consumers in the arc between a firm and its two neighbours. This information would be sold to all the firms.

Partial segment profiling is a stylised and somewhat extreme modelling feature. However, data do *not always uniformly cover all consumers in the market* and our results can shed light on these situations. For example, a relevant policy issue is whether the access to data from upstream firms can advantage some competing firms that have access to it. 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.

In this example, a vehicle transmits data to the manufacturer which, in turn, may have exclusive deals with authorised repair garages. This, then, is a case of partial segment profiling, as the data would cover owners of the manufacturer's cars. These consumer represent part of the potential clientele of the repair garages, and they are likely to have a relative preference for those linked to the manufacturers through exclusivity or other agreements. Our work, then, helps understand how accessing such information can impact competition between repair garages. Moreover, we study whether the manufacturer has an incentive to transmit such data to the authorised repairs or their rivals.

Beyond digital cars, similar uses of data are commonplace in various sectors. For example, the legal and liberal professions in recent years have experienced an unprecedented adoption of data intensive artificial intelligence (AI) for various application. At the same time, the regulation of fee settings in these sectors is a disputed matter at the EU and member states level, as trade-offs exist between liberalisation and regulation (Ferraro, 2018; Verboven and Yontcheva, 2022): yet, personalised fee setting is still the standard in many countries. Similarly, smart devices in the household produce a large amount of data that can be transferred to utility companies. In these examples, due to the recent progresses in AI systems, it is likely that segments of consumers are profiled and only some firms can access this information to personalise prices (Carroni *et al.*, 2019; Acemoglu, 2021).[1]

Clearly, there are alternative ways to specify the limited profiling data that are as easily justified as ours. For example, Conitzer *et al.* (2012) and Montes *et al.* (2019), inter alios, consider active consumers that can costly avoid profiling, whereas Casadesus-Masanell and Hervas-Drane (2015), Hidir and Vellodi (2021), Xu and Dukes (2022) and Ali *et al.* (2023) allow consumers to control the amount of information to be revealed. The partial nature of the data coverage that we consider 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. Our results, then, apply when the partially profiled segment has preferences for a specific firm.

[1] As another example, in healthcare some insurance companies or retail pharmacies may benefit from data shared by digital platforms gathering information through wearables and other devices (Apple Watch, FitBit).

Related literature. Recent years have witnessed a growing interest in the economic impact of data in markets and, in particular, data sharing and trading (see Pino, 2022 for a recent in-depth review). There is a wide literature on privacy and its market implications (Acquisti and Varian, 2005; Liu and Serfes, 2006; Choe *et al.*, 2017; Choi *et al.*, 2019; Ichihashi, 2020; Clavorà Braulin, 2023; Anderson *et al.*, 2023, inter alios). As discussed above, a number of these papers have considered incomplete profiling as a direct result of consumers' actions. In our model, instead, the data broker can only achieve partial segment profiling due to the costs or limitations they directly face as, for example, a stronger local or market-specific privacy rules and regulations or data access only through a product, as with digital cars.

Other articles have considered the impact of personalised pricing when firms have asymmetric access to consumer information. Gu *et al.* (2019) study the effect of exclusive information that enables personalised offers on the incentives to act as price leader in the market. Belleflamme *et al.* (2020) focus on asymmetric precision on 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 prices 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.

This paper also contributes to the literature on data brokers incentives. Bergemann *et al.* (2021), Ichihashi (2021), Gu *et al.* (2022), and Abrardi *et al.* (2023) analyse upstream competition (or lack of) between data brokers which can then be sold downstream. 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. Abrardi *et al.* (2022) consider endogenous entry and show that a data broker reduces downstream competition and only sells to a subset of firms. Bounie *et al.* (2021) study a spatial duopoly and characterise the optimal partition of a consumer database. Through partitioning, the data broker offers non-overlapping information to both firms, leaving a uniform price segment in the middle. The former segment allow firms to enhance their profits, whereas the latter is characterised by fiercer competition. Given this trade-off, the data broker eventually sells only one partition to one firm exclusively. In our case, the presence of the third firm implies that the uniform price segment is not necessarily extremely competitive. This feature makes it profitable to sell the partial information to more than one firm.

Finally, Kim *et al.* (2019) and Martens *et al.* (2021) also study data sharing in a Salop model with three firms: the former in the context of data-driven mergers, whereas the latter focuses on platforms. Martens *et al.* (2021) assume that only the platform knows the locations of the firms and, as a result, may bias consumer recommendations. Instead, in Kim *et al.* (2019), like in our paper, the relevant information is the location of consumers. In their article, all consumers in the market are profiled and in a pre-merger equilibrium the data are sold exclusively. Instead, 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.

The rest of the paper is structured as follows. Section 2 presents the benchmark 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 extends our stylised benchmark model by allowing for different sizes of the profiled arc of consumers. Section 7 evaluates numerically the impact of a higher number of firms. Section 8 discusses the results and their managerial and policy implications. Unless otherwise stated, the proofs are in Appendix A.

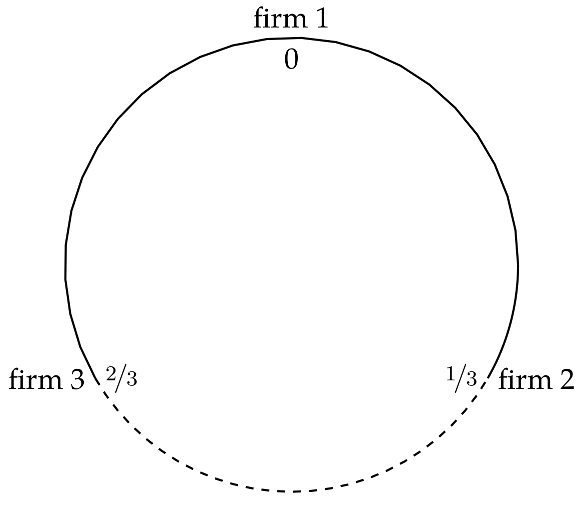
2 The framework

The market. Consider a market with one data broker (she) 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. We assume that v is sufficiently high for the market to be fully covered and $v > t$ is sufficient (but not necessary) for that to be the case. For simplicity, there are no variable or fixed costs.

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



Consumer information and data selling. The data broker possesses information only on some of the consumers in the market but not all. For example, the data broker may have 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 particular, to begin with, 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 arc 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 5, we show that an auction is a more profitable strategy 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).

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, consumer information in data broker's possession is sold to firms. At Stage 2, firms engage in price competition.[2] As we look for the Subgame Perfect Nash Equilibrium, the game is solved by backward induction.

3 Price competition

There are several possible subgames 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).

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:

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

[2] In cases when one firm holds information about consumers on a specific arc, a well known problem is the existence of a pure strategy Bertrand-Nash equilibrium (see Rhodes and Zhou, 2022, p.25). In order to ensure equilibrium existence, we assume that personalised price schedules are set only after uniform prices are set.

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 consumers 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, as otherwise they would make a loss and decrease their profit. Hence, the closest firm can attract the consumers, by charging a non-negative price that exactly matches the offer of the second closest firm (Thisse and Vives, 1988; Taylor and Wagman, 2014). 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 for firm 1.

Following a similar reasoning, the firms' price schedules on the arc $x \in [2/3, 1]$ and $x \in [0, 1/3]$ are as follows:

$$p_1(x) = \begin{cases} t\left(1/3 - 2x\right), & \text{if } 0 \leq x < 1/6 \\ t\left(2x - 5/3\right), & \text{if } 5/6 \leq x < 1 \\ 0, & \text{otherwise} \end{cases}; \tag{2}$$

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

$$p_3(x) = \begin{cases} t\left(5/3 - 2x\right), & \text{if } 2/3 \leq x < 5/6 \\ 0, & \text{otherwise} \end{cases}. \tag{4}$$

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

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

The firms' profits are, respectively,

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

Proposition 2 illustrates the asymmetric profit impact of the possession of 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. The average price paid by profiled consumers is lower than the benchmark, and firm 1 suffers twice from this intensified competition.

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:

$$p_1(x) = \begin{cases} \max\left\{p_2 + t\left(1/3 - 2x\right), 0\right\}, & \text{if } 0 \leq x < 1/3 \\ \max\left\{p_3 + t\left(2x - 5/3\right), 0\right\}, & \text{if } 2/3 \leq x < 1 \end{cases}. \tag{5}$$

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, which we verify is the case in equilibrium. 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. *If firm 1 has exclusive access to consumer information, the equilibrium consists of the price schedules* (5), *with prices and marginal consumers given by:*

$$p_2 = p_3 = \frac{2}{9}t, \;\; \tilde{x}_{12} = \frac{5}{18}, \;\; \tilde{x}_{13} = \frac{13}{18}.$$

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 higher than in the two benchmark cases. Firm 2 and firm 3, instead, make less profits than in the cases of Section 3.1. Compared to the benchmark where all firms have the data, one can notice that the uniform price of firms 2 and 3 acts as a reference for personalised offers by firm 1, which pushes the average price up.

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 that firm 2 has access to the consumers' information without loss of generality. In this case, firm 2 sets a price schedule for the profiled consumers ($x \in [0, 1/3]$) and a price p_2 for non-profiled consumers on the anonymous segment.[3] Firm 1 and firm 3 set uniform prices p_1 and p_3. Given these prices, firm 2 personalised price schedule is:

$$p_2(x) = \max\left\{p_1 + t\left(2x - 1/3\right), 0\right\}. \quad (6)$$

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, i.e., $\tilde{x}_{21} \in [0, 1/3]$. 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. *If firm 2 has exclusive access to consumer information, the equilibrium consists of*

[3]Note that in principle firm 2 could also reach consumers in the arc $x \in [2/3, 1]$, but this never happens in equilibrium.

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 marginal consumer is located at $\tilde{x}_{21} = {}^{7}\!/_{156}$. *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. In summary, we note that the competitive effect of a rival holding information about the profiled segment affects firm 1. The shock then propagates to firm 3 and, finally, bites back firm 2 through its own uniform price.

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's 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 $\tilde{x}_{31} \in [{}^2\!/_3, 1]$ holds, the equilibrium 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. *If firm 1 and firm 2 have access to consumer information, the equilibrium consists of the price schedules* (7)-(8) *and the prices*

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

The marginal consumer is located at $\tilde{x}_{31} = {}^{30}/_{42}$. *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. As in the case in which only firm 2 has access to the data, the competitive effect of personalised prices hits firm 3 more directly, and then propagates to firm 2. However, in this case the portion of the list that is actually used is larger, which decreases the profitability of firms 3 and 2 even further.

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 $x \in [0, {}^1/_3]$). 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, which we verify is the case in equilibrium. 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. *If firm 2 and firm 3 have access to consumer information, the equilibrium 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 marginal consumers are $\tilde{x}_{21} = {}^{1}\!/_{12}$ and $\tilde{x}_{31} = {}^{11}\!/_{12}$. 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

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

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.

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.

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

$$\pi_1^1 > \pi_1^{NI} > \pi_1^{12} = \pi_1^{13} > \pi_1^2 = \pi_1^3 > \pi_1^{AI} > \pi_1^{23},$$

$$\pi_2^2 > \pi_2^{23} > \pi_2^{NI} > \pi_2^3 > \pi_2^{AI} > \pi_2^{12} > \pi_2^{13} > \pi_2^1,$$

$$\pi_3^3 > \pi_3^{23} > \pi_3^{NI} > \pi_3^2 > \pi_3^{AI} > \pi_3^{13} > \pi_3^{12} > \pi_3^1.$$

Proof: Follows from Table 1.

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.

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 result is in line with Parker *et al.* (2020), who call for a regulatory intervention that facilitates data sharing mechanisms to benefit consumers. In our setting, 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:*

$$\Pi^{NI} > \Pi^2 = \Pi^3 > \Pi^{23} > \Pi^1 > \Pi^{12} = \Pi^{13} > \Pi^{AI}.$$

As for consumer surplus:

$$CS^{AI} > CS^{12} = CS^{13} > CS^{23} = CS^1 > CS^2 = CS^3 > CS^{NI},$$

and total surplus:

$$TS^{NI} = TS^{AI} > TS^{23} > TS^{12} = TS^{13} > TS^2 = TS^3 > TS^1.$$

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 upon Jehiel and Moldovanu (2000), we assume that the data broker sells the list to one or more firms via a system of auctions with *reserve price*. In other words, the data broker set the minimum bid the firms must match in order to win the auction. We assume firms can form *coalitions* to jointly purchase and use the list. For example, if the data broker announces two contracts, firms 1 and 2 may agree on a joint bid to submit to the data broker reflecting what they are willing to pay in order to both exploit the data. In the next paragraphs we will analyse how the findings are affected if the data broker uses other selling mechanisms.

We design the auction as follows. First, the data broker chooses how many contracts to sell. If the data broker commit to sell $k \in [1, 3]$ contracts, then data will be purchased by a coalition of exactly k members - or no one if the reserve price is too high. Given the number of contracts available, the data broker sets the reserve price for the auction - i.e., the minimum bid that the coalition of bidders must pay in order to win the auction. Finally firms place their bids. We define each firm's willingness to pay as the difference in the firms' payoffs if they obtain the list and the counterfactual case in which a rival company purchases the data in their place. The only constraint from the data broker perspective is that it cannot violate the commitment on the number of contracts available.

Using the payoffs in Table 1, the auctions lead to the following data broker profits:

$$\pi^1_{DB} = \pi^1_1 - \pi^2_1 = 0.095t, \qquad \pi^2_{DB} = \pi^3_{DB} = \pi^2_2 - \pi^1_2 = 0.086t,$$
$$\pi^{12}_{DB} = \pi^{13}_{DB} = (\pi^{12}_1 - \pi^{23}_1) + (\pi^{12}_2 - \pi^{12}_3) = 0.093t, \quad \pi^{23}_{DB} = \pi^{32}_{DB} = 2(\pi^{23}_2 - \pi^{12}_3) = 0.122t,$$
$$\pi^{AI}_{DB} = (\pi^{AI}_1 - \pi^{23}_1) + 2(\pi^{AI}_2 - \pi^{12}_3) = 0.080t$$

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

$$\pi^{23}_{DB} > \pi^1_{DB} > \pi^{12}_{DB} = \pi^{13}_{DB} > \pi^2_{DB} = \pi^3_{DB} > \pi^{AI}_{DB}.$$

Proof: Follows from the above derivations.

Proposition 9 introduces our main result, as it identifies the strategic reaction of competing firms to the use of data tailored on the firm 1's clientele. 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 firms' benefit of obtaining the data. 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 jointly higher than the one of the firm for which the data seem tailored.

Discussion of the main result. There are three main economic forces driving the main result in Proposition 9. First, intuitively, firms 2 and 3 can effectively use the list to price discriminate consumers in one segment of their total markets. Their cumulative incentives to use the data opposes firm 1's willingness to exclusively exploit all the list. Second, both firms 2 and 3 react from firm 1's usage of the list by lowering their price and reducing both their extensive and intensive margins in the profiled segments of the market. Hence, to avoid this losses, they have positive incentives to purchase the data leaving the main rival uninformed. Again, this opposes firm 1's incentives to buy the list to limits price competition in the profiled segment. Finally, and importantly, the effects of enhanced price competition propagate in the anonymous segment of the market, limiting the intensive margin of firms 2 and 3. Thus, they are both willing to pay for the list to prevent this additional negative effect on their payoffs. This third economic driver is unique to firms 2 and 3. In fact, firm 1 has no interests in what happens in the anonymous segment.

The sum of these three economic forces drive the results in Proposition 9. Notice that the number of firms in the winning coalition plays a role only in the first of the three drivers described above. In particular, because the data broker wants to maximize the value of the list, it wants to sell it to a coalition that can use it entirely. This has more to do with which firms are in the coalition, rather than how many. In fact, the data broker has higher incentives to sell the list to firm 1 in exclusive than to the coalition 1 and 2 (or 3).

Other selling mechanisms. An alternative way to model the auction with reserve price, in the spirit of Bounie *et al.* (2020), is that the data broker commits to a maximum number of contracts (not the exact number of contracts). By doing so, the data broker is able to extract even more surplus from the downstream firms. To understand it, consider firm 1's problem. The best thing she can do is to buy the list exclusively. The data broker maximizes surplus extraction by committing to sell two contracts at most and threatening firm 1 to offer the list to the coalition composed by firms 2 and 3. Similarly, the data broker can offer the two contracts to the coalition of firms 2 and 3, threatening them to offer the list only to firm 1. The main result does not change as $\pi_{DB}^{23} = 2(\pi_2^{23} - \pi_2^1) = 0.134t > 0.128t = \pi_1^1 - \pi_1^{23} = \pi_{DB}^1$.

Assuming that the data broker can set a reserve price for the bids ensures that the auction extracts the highest surplus from the downstream firms. However, the assumption is not crucial for our results to hold. In fact, if we consider a more standard second price auction, the incentives of the data broker remains unaltered. The only difference is that the coalition composed by firms 2 and 3 will pay a lower price for the information, namely the willingness to pay of the coalition with the second-highest reservation value -i.e., the coalition composed by firm 1 only.

Finally, a different mechanism that the data broker could use to sell data is through a TIOLI offer (Sugden *et al.*, 2019). In this case we define the willingness to pay of the firms 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:

$$\pi_{DB}^1 = \pi_1^1 - \pi_1^{NI} = 0.043t, \qquad \pi_{DB}^2 = \pi_2^2 - \pi_2^{NI} = 0.024t,$$
$$\pi_{DB}^{12} = (\pi_1^{12} - \pi_1^2) + (\pi_2^{12} - \pi_2^1) = 0.070t, \qquad \pi_{DB}^{23} = 2(\pi_2^{23} - \pi_3^2) = 0.046t$$
$$\pi_{DB}^{AI} = (\pi_1^{AI} - \pi_1^{23}) + 2(\pi_3^{AI} - \pi_3^{12}) = 0.080t$$

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

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

Proof: Follows from the above derivations.

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).

Differently from the case in which the data broker organises auctions, with a TIOLI offer she is not able to extract all the willingness to pay from the firms. In fact, firms do not internalise the danger that a rival gets the information in their place, which in turns does not trigger any strategic reaction.

The optimal selling mechanism A natural question that may emerge following the analysis presented above is which selling mechanism the data broker prefers in order to maximise profits. Unsurprisingly, the data broker earns larger profits from auctioning the data rather than selling the list using a TIOLI offer. This follows naturally from the fact that auctioning the list allows the data broker to efficiently extract the downstream competing firms willingness to pay.

Furthermore, focusing on the auction mechanisms presented above, the larger profits are obtained by not committing to a certain number of contracts. In fact, doing so the data broker can exert additional pressure on the competing firms by threatening them to sell the list to the firm or coalition of firms that maximise competition intensity in the downstream market.

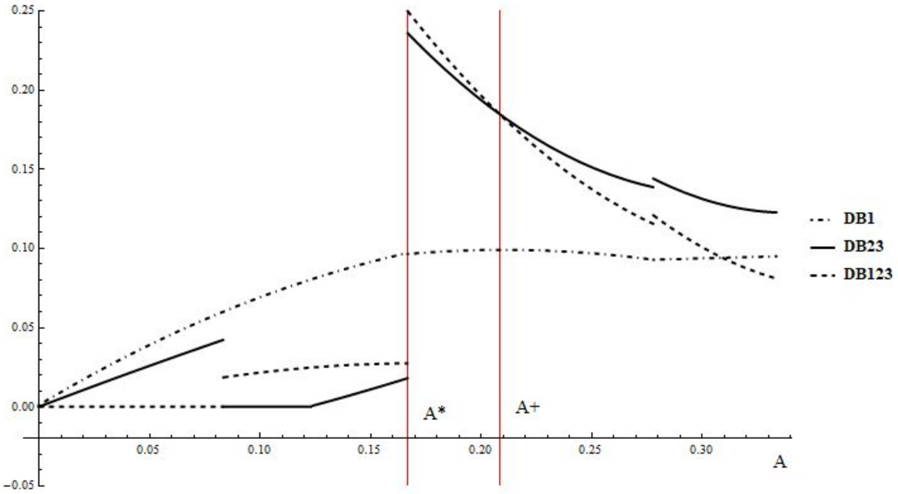
6 The coverage of the list

A simplifying assumption of the benchmark model is that all consumers located in the arc between firm 3 and firm 2 and centered around firm 1 are profiled. Here, we relax this assumption and extend the model to consider a symmetric arc, of length A on each side of firm 1. In the light of the many subcases and the lengthy and often repetitive derivations, the details of the setup and the formal analysis can be found in Web Appendix B. Figure 2 provides a graphical summary of the main findings by plotting how the willingness to pay of the firms or groups of firms changes with the width of the arc of profiled consumers.

Intuitively, the analysis suggests that, as long as the arc of profiled consumers is sufficiently large to allow firms 2 and 3 to directly benefit from it, the data broker never sells the list exclusively to one firm. Indeed, we identify two main thresholds of the length of the profiled arc that play an important role for the robustness our main findings: these are $A^* = 1/6$, and $A^+ = 5/24$.

The first threshold (A^*) separates the case where the data broker sells the list *exclusively to firm 1* ($A < A^*$) and the ones where more than one firm obtains the list in equilibrium. In fact, above the threshold ($A > A^*$), *all firms* obtain the list in equilibrium. This holds true only up to the second threshold ($A = A^+$): if the profiled arc is wider, a data broker sells the information only to the two rivals of the firm around which the data have been gathered (i.e., firms 2 and 3).

Figure 2: Willingness to pay for and length of the list



In other words, the main finding is that as long as $A \geq 1/6$, selling the information to the firm whose arc is profiled is never part of the data broker profit maximizing strategy as in our benchmark model. Indeed, the list is sold to either all the firms in the market ($A \in [1/6, 5/24]$), or to both firm 2 and firm 3 ($A \in [5/24, 1/3]$). The latter finding confirms that the results in 9 holds as long as the profiled arc is sufficiently wide. Finally, it is only when the arc of profiled consumers is relatively small, $A < 1/6$, that the data broker finds selling the information exclusively to firm 1 more convenient.

Interestingly, we identify a global maximum in the data broker's revenues that coincides with an arc's length larger than but close to $A = 1/6$. This result suggests that, if the data broker has information about all the consumers on the potential market of firm 1, her incentive is to sell only a half of it to all the competing firms. Consequently, the data broker is willing to throw away a share of the list and sell the "damaged" version to all the firms in the market. Intuitively, this result implies that if collecting data is costly, the data broker would never gather information about all the potential customers of one firm, but only a fraction of them.

7 A higher number of firms

A market with three firms is undoubtedly a special case, and we would like to gain insights on cases in which more firms, potentially n (≥ 3) of them are active in the market. Regrettably, a full generalization to n firms proves to be complex. This is due to asymmetric shock on the prices of different firms, which are then asymmetrically transmitted to all other firms.[4] In Web Appendix C, we setup the problem of all the firms and identify the first-order conditions in all subgames of the firm pricing stage.

[4]We note that the problem has similarities with the case of asymmetric costs shock in the Salop model, addressed by Syverson (2004) and solved under fixed locations and complete information by Alderighi and Piga (2012). Yet, there are further types of asymmetry that makes it even more complicated.

Table 2: The number of firms, prices and profits.

No info	p_1	p_2	p_n	π_1	π_2	π_n	π_{DB}^{Auct}
$n = 3$	0.333t	0.333t	0.333t	0.111t	0.111t	0.111t	0
$n = 4$	0.250t	0.250t	0.250t	0.063t	0.063t	0.063t	0
$n = 5$	0.200t	0.200t	0.200t	0.040t	0.040t	0.040t	0
$n = 10$	0.100t	0.100t	0.100t	0.010t	0.010t	0.010t	0
1, 2 and n	p_1	p_2	p_n	π_1	π_2	π_n	π_{DB}^{Auct}
$n = 3$	-	0.333t	0.333t	0.056t	0.083t	0.083t	0.080t
$n = 4$	-	0.250t	0.250t	0.031t	0.469t	0.469t	0.043t
$n = 5$	-	0.200t	0.200t	0.020t	0.030t	0.030t	0.027t
$n = 10$	-	0.100t	0.100t	0.005t	0.008t	0.008t	0.0068t
Excl 1	p_1	p_2	p_n	π_1	π_2	π_n	π_{DB}^{Auct}
$n = 3$	-	0.222t	0.222t	0.154t	0.049t	0.049t	0.095t
$n = 4$	-	0.179t	0.179t	0.092t	0.032t	0.032t	0.058t
$n = 5$	-	0.145t	0.145t	0.060t	0.021t	0.021t	0.038t
$n = 10$	-	0.073t	0.073t	0.015t	0.005t	0.005t	0.0096t
Excl 2 (n)	p_1	p_2	p_n	π_1	π_2	π_n	π_{DB}^{Auct}
$n = 3$	0.244t	0.321t	0.308t	0.059t	0.135t	0.095t	0.086t
$n = 4$	0.183t	0.247t	0.232t	0.033t	0.077t	0.054t	0.046t
$n = 5$	0.146t	0.199t	0.186t	0.021t	0.050t	0.034t	0.029t
$n = 10$	0.073t	0.100t	0.093t	0.005t	0.013t	0.009t	0.0071t
Both 1 & 2 (n)	p_1	p_2	p_n	π_1	π_2	π_n	π_{DB}^{Auct}
$n = 3$	-	0.286t	0.238t	0.109t	0.069t	0.057t	0.093t
$n = 4$	-	0.240t	0.183t	0.062t	0.045t	0.034t	0.058t
$n = 5$	-	0.197t	0.146t	0.040t	0.030t	0.021t	0.038t
$n = 10$	-	0.099t	0.073t	0.010t	0.007t	0.005t	0.0096t
Both 2 & n	p_1	p_2	p_n	π_1	π_2	π_n	π_{DB}^{Auct}
$n = 3$	0.167t	0.333t	0.333t	0.028t	0.118t	0.118t	0.122t
$n = 4$	0.125t	0.250t	0.250t	0.016t	0.066t	0.066t	0.066t
$n = 5$	0.100t	0.200t	0.200t	0.010t	0.043t	0.043t	0.042t
$n = 10$	0.050t	0.100t	0.100t	0.003t	0.011t	0.011t	0.0105t

The model, however, can be fully solved numerically for any number of firms.[5] We can then provide results and confirm the validity of our previous insights for a given number of competing firms: $n = 4$, $n = 5$, and $n = 10$. The monotonicity of these numerical results suggests that similar findings would obtain for other market sizes.

Some notes about the pricing subgames are in order. First, it is important to establish that *no firm other than 1, 2 and n* has an incentive to buy the list. As all the other firms are located far from the consumers that the data broker has profiled, they cannot extract profits through personalised pricing and, as such, their willingness to pay for the list is zero in all pricing subgames.

Second, all segments apart from those with profiled consumers are characterised by first order conditions typical of competition *à la* Salop. In particular, in subgames where the list affects *symmetrically* the firms on both sides of firm 1, but not their posted prices (i.e., when firms 2 and n have the list or all three firms have it), all competitors except firm 1 pick Salop prices in equilibrium.

Further, in case firm 1 holds the list exclusively, the price impact of it propagates

[5] In the case of asymmetric subgames, the procedure can be quite tedious as n grows large.

symmetrically through both firm 2 and firm n, and then through to the other competitors. The more challenging cases, instead, are the ones where the list affects *asymmetrically* firms that do not own it: this is the case for subgames where firm 2 has the list exclusively or when both firms 1 and firm 2 acquire it.

What are then the implications for the data broker? As in our benchmark model with three firms, we find that the DB has no incentives to sell the data exclusively. Moreover, our numerical results confirm that, in equilibrium, information is sold symmetrically to the two firms located at the extremes of the list, jointly. In other words, Propositions 9 and 10 hold regardless of the number of competitors in the market. Indeed, all variables change smoothly and monotonically with the number of firms: Table 2 provides a summary of the firms prices and profits and the data brokers profit in case of sale through an auction.[6]

Finally, on the basis of Table 2, we can note that the market structure induced by the data broker is such that firms 2 and n have the list. This implies that all $n-3$ firms located away from the arc of profiled consumers are *unaffected* by the price competition in the profiled segment of the market. As noticed above, these firms play the usual Salop strategy, i.e. their price is t/n. Indeed, the firm suffering from the enhanced price competition induced by the list is firm 1, which ends up charging its customers $t/2n$.

8 Discussion

Not always detailed information is available about all consumers in the market, and often the potential clientele of one firm is better profiled than others. This paper has studied the strategic incentives of a data broker to sell this type of partial segment profiling information to competing firms. Indeed, we considered a database of consumers 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 three firms in the market would benefit 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. In particular, we find that if the access to the information creates an asymmetry between the competitors, the defensive response of firms without the list can be particularly aggressive, with a negative impact on profitability.

At the aggregate level, firms would be better off when no information is shared, as this is the scenario in which price competition is as soft as possible. Conversely, when all three 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 orderings are the mirror image of the above results. When all firms have access to data, the intensity of competition in the profiled segment makes consumers

[6]The results for a TIOLI selling mechanism are equally robust.

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 considering to mandate data-sharing or not faces a choice between which side of the market to back. This is a typical feature of spatial models à la Salop (1979) - Thisse and Vives (1988), as the one we employ.

The most important findings, however, regard the sale of data. 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 (Montes *et al.*, 2019; Kim *et al.*, 2019, inter alios), an implication of our findings is that the data broker *never* has an incentive to sell the data exclusively.

Morever, the data broker's incentives are not aligned with social welfare. In fact, 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.

Our framework is clearly stylised and it aims to address situations where there is a sharp disparity in the incomplete profiling of consumers: one segment of potential consumers of a firm is accurately profiled, whereas other segments are scantly or not profiled at all. The contribution, then, is to show that in presence of this type of information structures and more than two firms, the usual incentives to sell data exclusively do not apply. This is due to the softened competition between the firms whose consumers are not profiled and the less aggressive consequent price response of the rival profiled firm.

Notwithstanding the recalled limitations, our findings can provide relevant managerial and policy implications. Consider, for example, a data broker that is in possession of data on the potential clientele of a firm. A somewhat counter-intuitive implication of our findings is that, unless the portion of consumers profiled is rather limited, the data broker should not approach such a firm first. Instead, the maximum willingness to pay could be extracted by auctioning off the data. In that case, as long as the data cover a sufficient part of the arc around the firm, the closest rivals would acquire the list.

A firm whose potential clientele is profiled faces a profitability threat, and needs to adopt defensive strategies. For example, if the data are not already available, one option could be to make it harder for a data broker to profile the consumers. One of these strategies could entail making privacy salient on their website, to enhance their consumers attention in releasing data. Another, more costly, option could be to vertically integrate with the data broker, in order to internalise the impacts of data selling. Finally, a regulation mandating data sharing would be in the interest of such a firm.

From a policy perspective, we note that the data broker is not spontaneously willing to sell the information to all the firms in the market. Thus, the welfare maximising 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 the second policy option changes firms incentives substantially, and the stakeholders should be aware of it. Whereas selling data to all three firms can be an optimal strategy under certain circumstances, if the data broker *must* sell consumer information to all the firms, her *bargaining power* collapses to the minimum.

Such a regulatory intervention would be welcomed downstream but is likely to face hostile reactions by data holders. Thus, a policy-maker that aims to support this policy might 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.

We already noted some of the limitations of our circular city spatial framework à la Salop (1979) - Thisse and Vives (1988). These types of models are characterised by localised competition: despite all firms are potentially competing with each other, in equilibrium consumers tends to focus on the firms located most closely to them. Moreover, the demand is inelastic and all consumers buy, if consumers have sufficiently high valuations for the good. An interesting direction for further research would be to assess how our results would change under non-localised competition and elastic demand (Perloff and Salop, 1985; Chen and Riordan, 2007).

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A Appendix

A.1 Proof of Proposition 2

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

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

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:

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

Standard calculations lead to the profit-maximising anonymous prices

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

We note that there is no positive price that allows firm 1 to attract unprofiled consumers away from firms 2 and 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:

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

Firm 2 (or firm 3) have no unilateral incentive to increase discretely the price to $p_2^{dev} = t/3$, as this would give profits $\pi_2^{dev}(t/3, 2t/9) = t/27 < 4t/81$. *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:

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

Firm 1 has no unilateral incentive to increase discretely the price to $p_1^{dev} = t/3$, as this would give profits $\pi_1^{dev}(t/3, 4t/13) = 2t/39 < 361t/6084$. *Q.E.D.*

A.4 Proof of Proposition 5

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

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

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

$$\pi_3 = p_3 \left[\left(\frac{1}{6} + \frac{p_2 - p_3}{2t} \right) + (\tilde{x}_{31} - {}^2\!/_3) \right].$$

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:

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

Firm 2 and firm 3 have no unilateral incentive to increase discretely the price to $p^{dev} = t/3$, as this would give profits $\pi_2^{dev}(t/3, 5t/21) = 5t/126 < 121t/1764$ and $\pi_3^{dev}(t/3, 2t/7) = t/21 < 25t/441$, respectively. *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:

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

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

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

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

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

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.

B Web Appendix (not for publication): Variable coverage of the list

Let us turn back to the case with three firms and assume that the data broker collected a list of consumers around firm 1's location. In the main model in section 2, we assumed the list includes all the potential consumers of firm 1. In other words, segments $x \in [2/3, 1]$ and $x \in [0, 1/3]$ are profiled. Here we consider a more general case in which the data broker has information on consumers located in the segments $x \in [(1-A), 1]$ and $x \in [0, A]$, where $A \leq 1/3$. Consequently, we analyse the case in which the list is shorter than the full market segments where firm 1 potentially competes.

In order to provide the full characterization of the equilibria, we need to distinguish between four main scenarios: i) The list is relatively long, i.e, $A \in [5/18, 1/3]$; ii) the list is short, i.e, $A \in [1/6, 5/18)$; iii) the list is very short, i.e., $A \in [1/12, 1/6]$; finally iv) the list is tiny, i.e., $A \in [0, 1/12]$.

For the sake of brevity, we present here only the relevant cases where firm 1 buys the list in exclusive, firms 2 and 3 buy the list jointly, and all firms buy the list. It can be proven that the remaining subgames never emerge as equilibria.

B.1 Long list

We solve the model as in the main scenario, but taking into consideration that now, if the firms 2 and (or) 3 get the list, they cannot use it to price discriminate the consumers that are outside the list coverage, i.e., those located in $x \in (A, 1/3]$. As we are interested in Subgame Perfect Nash Equilibrium, we solve the model by backward induction, analysing all the subgames in which one or more firms obtain the list of consumers.

Firm 1 obtains the list in exclusive

In this case, there are no differences from the main case analysed in the paper. If firm 1 gets the exclusive right to use the list, then it will set a price schedule that applies to all individuals on the list according to their position. The indifferent consumers for which the personalised price by firm 1 and the market prices by firm 2 and 3, respectively, yield the same utility, are located at $x_{12} = 5/18$ and $x_{31} = 13/18$. As firm 1 would not have been able to use the list to set a personalised price to consumers located too close to the rivals' location, any consumers who is farther than $A = 5/18$ from firm 1 is not considered. Thus, the result is as described in the proof of proposition 3 in Appendix A.

Firm 2 and 3 obtain the list

Consider the case of firm 2 and firm 3 having access to information about consumers on the profiled segment. In this case, firm 2 and 3 set a price schedule for the profiled consumers

($x \in [0, A]$ and $x \in [(1-A), 1]$). Additionally, they also set uniform prices p_2 and p_3 for non-profiled consumers on the anonymous segment ($x \in (A, 2/3]$) and $x \in (2/3, (1-A))$, whereas firm 1 sets a uniform price p_1. Given these prices, firms 2 and 3 personalised price schedules are:

$$p_{21}(x) = \max\left\{p_1 + t\left(2x - 1/3\right), 0\right\}, \qquad p_{31}(x) = \max\left\{p_1 + t\left(5/3 - 2x\right), 0\right\}.$$

where the subscripts $\{i, j\}$ indicate the price of i competing against j.

Denote the consumers for which the price schedules of firms 1 and 2 are zero, i.e., $p_{21}(\tilde{x}_{12}) = p_{31}(\tilde{x}_{31}) = 0$, as $\tilde{x}_{12} = \frac{t-3p_1}{6t}$ and $\tilde{x}_{31} = \frac{3p_1+5t}{6t}$ respectively, and assume that these consumers lie on the profiled segment. The equilibrium in the pricing subgame can be characterised as follows:

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

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

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

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

$$p_1 = \frac{t}{6},\ p_2 = p_3 = (1-2A)t.$$

Using these prices and the price schedules above, it is possible to derive the profits of the firms:

$$\pi_1 = \frac{t}{36},\ \pi_2 = \pi_3 = \frac{1}{144}\left[24A(18A - 13) + 73\right]t.$$

All firms obtain the list

Consider the case of all firms having access to information about consumers on the profiled segment. In this case, firms 1, 2, and 3 set a price schedule for the profiled consumers ($x \in [0, A]$ and $x \in [(1-A), 1]$). Additionally, firms 2 and 3 also set uniform prices p_2 and p_3 for non-profiled consumers on the anonymous segment ($x \in (A, 2/3]$) and $x \in (2/3, (1-A))$. Given these prices, firms 2 and 3 personalised price schedules are:

$$p_{12}(x) = \max\left\{t\left(1/3 - 2x\right), 0\right\}, \qquad p_{13}(x) = \max\left\{t\left(2x - 5/3\right), 0\right\},$$

$$p_{21}(x) = \max\left\{t\left(2x - 1/3\right), 0\right\}, \qquad p_{31}(x) = \max\left\{t\left(5/3 - 2x\right), 0\right\}.$$

where the subscripts $\{i, j\}$ indicate the price of i competing against j.

Denote the consumers for which the price schedules of firms 1, 2, and 3 are zero, i.e., $p_{12}(\tilde{x}_{12}) = p_{21}(\tilde{x}_{31}) = 0$, as $\tilde{x}_{12} = \frac{1}{6}$ and $p_{13}(\tilde{x}_{31}) = p_{31}(\tilde{x}_{31}) = 0$, as $\tilde{x}_{31} = \frac{5}{6}$. Assume that these consumers lie on the profiled segment. The equilibrium in the pricing subgame can be characterised as follows:

$$\pi_1 = \int_0^{\tilde{x}_{12}} \left[t\left(1/3 - 2x\right)\right] dx + \int_{\tilde{x}_{31}}^{1} \left[t\left(2x - 5/3\right)\right] dx,$$

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

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

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

$$p_2 = p_3 = (1-2A)t.$$

Using these prices and the price schedules above, it is possible to derive the profits of the firms:

$$\pi_1 = \frac{t}{18}, \ \pi_2 = \pi_3 = \frac{1}{36}[12A(9A-7) + 19]t.$$

Data Sales

Using the same method to derive the payoff from selling data to firms via auction as illustrated in Section 5, we can compute the data broker's incentives to sell the list.

$$\pi^1_{DB} = \frac{25t}{162} - \frac{1}{676}(7-2A)^2 t, \qquad \pi^{23}_{DB} = \frac{\left(6864A^2 - 4648A + 931\right)t}{1176},$$

$$\pi^{AI}_{DB} = \left(\frac{286A^2}{49} - \frac{30A}{7} + \frac{31}{36}\right)t.$$

B.2 Short list

Let us now turn to the case in which $A \in [1/6, 5/18]$.

Firm 1 obtains the list in exclusive

Because the list is shorter than $5/18$, firm 1 sets both the price schedules $p_{12}(x)$ and $p_{13}(x)$ for the consumers on the list, and an uniform price p_1 for the consumers on the non-profiled segment. Instead, firms 2 and 3 set the uniform prices p_2 and p_3, respectively.

Given these prices, firm 1 personalised price schedules are:

$$p_{12}(x) = \max\left\{p_2 + t\left(1/3 - 2x\right), 0\right\}, \qquad p_{13}(x) = \max\left\{p_3 + t\left(2x - 5/3\right), 0\right\}.$$

It is easy to see that the consumers who derive zero utility from the price schedules are not on the profiled list, i.e. $A < x^*_{12}$ and $(1-A) > x^*_{31}$.

Thus, the indifferent consumers' locations are

$$\tilde{x}_{12} = \frac{3(p_2 - p_1) + t}{6t}, \; \tilde{x}_{23} = \frac{p_3 - p_2 + t}{2t}, \; \tilde{x}_{31} = \frac{3(p_1 - p_3) + 5t}{6t}$$

The equilibrium in the pricing subgame if firm 1 has exclusive information on consumers on firm 1's arc can be characterised as follows:

$$\pi_1 = \int_0^A \left[t\left(1/3 - 2x\right)\right] dx + \int_{1-A}^1 \left[t\left(2x - 5/3\right)\right] dx + p_1\left[\tilde{x}_{12} - A + (1-A) - \tilde{x}_{31}\right],$$

$$\pi_2 = p_2\left(\frac{p_3 - p_2 + t}{2t} - \frac{3(p_2 - p_1) + t}{6t}\right),$$

$$\pi_3 = p_3\left(\frac{3(p_1 - p_3) + 5t}{6t} - \frac{p_3 - p_2 + t}{2t}\right).$$

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

$$p_1 = \left(\frac{1}{3} - \frac{6A}{5}\right)t, \; p_2 = p_3 = \frac{1}{15}(5 - 6A)t$$

and to the profits of the firms:

$$\pi_1 = \frac{1}{225}\left(25 + 120A - 306A^2\right)t, \; \pi_2 = \pi_3 = \frac{1}{225}(5 - 6A)^2 t.$$

Firm 2 and 3 obtain the list

Consider the case of firm 2 and firm 3 having access to information about consumers on the profiled segment. In this case, firm 2 and 3 set a price schedule for the profiled consumers ($x \in [0, A]$ and $x \in [(1-A), 1]$). Additionally, they also set uniform prices p_2 and p_3 for non-profiled consumers on the anonymous segment ($x \in (A, 2/3]$) and $x \in (2/3, (1-A))$), whereas firm 1 sets a uniform price p_1. Given these prices, firms 2 and 3 personalised price schedules are:

$$p_{21}(x) = \max\left\{p_1 + t\left(2x - 1/3\right), 0\right\}, \qquad p_{31}(x) = \max\left\{p_1 + t\left(5/3 - 2x\right), 0\right\}.$$

where the subscripts $\{i, j\}$ indicate the price of i competing against j.

Denote the consumers for which the price schedules of firms 1 and 2 are zero, i.e., $p_{21}(\tilde{x}_{12}) = p_{31}(\tilde{x}_{31}) = 0$, as $\tilde{x}_{12} = \frac{t - 3p_1}{6t}$ and $\tilde{x}_{31} = \frac{3p_1 + 5t}{6t}$ respectively, and assume that these consumers lie on the profiled segment. The equilibrium in the pricing subgame can be characterised as follows:

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

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

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

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

$$p_1 = \frac{t}{6},\ p_2 = p_3 = (1-2A)t.$$

Using these prices and the price schedules above, it is possible to derive the profits of the firms:

$$\pi_1 = \frac{t}{36},\ \pi_2 = \pi_3 = \frac{1}{144}[24A(18A-13)+73]t.$$

All firms obtain the list

Consider the case of all firms having access to information about consumers on the profiled segment. In this case, firms 1, 2, and 3 set a price schedule for the profiled consumers ($x \in [0, A]$ and $x \in [(1-A), 1]$). Additionally, firms 2 and 3 also set uniform prices p_2 and p_3 for non-profiled consumers on the anonymous segment ($x \in (A, 2/3]$) and $x \in (2/3, (1-A))$. Given these prices, firms 2 and 3 personalised price schedules are:

$$p_{12}(x) = \max\left\{t\left(1/3 - 2x\right), 0\right\}, \qquad p_{13}(x) = \max\left\{t\left(2x - 5/3\right), 0\right\},$$

$$p_{21}(x) = \max\left\{t\left(2x - 1/3\right), 0\right\}, \qquad p_{31}(x) = \max\left\{t\left(5/3 - 2x\right), 0\right\}.$$

where the subscripts $\{i, j\}$ indicate the price of i competing against j.

Denote the consumers for which the price schedules of firms 1, 2, and 3 are zero, i.e., $p_{12}(\tilde{x}_{12}) = p_{21}(\tilde{x}_{31}) = 0$, as $\tilde{x}_{12} = \frac{1}{6}$ and $p_{13}(\tilde{x}_{31}) = p_{31}(\tilde{x}_{31}) = 0$, as $\tilde{x}_{12} = \frac{5}{6}$. Assume that these consumers lie on the profiled segment. The equilibrium in the pricing subgame can be characterised as follows:

$$\pi_1 = \int_0^{\tilde{x}_{12}} \left[t\left(1/3 - 2x\right)\right] dx + \int_{\tilde{x}_{31}}^{1} \left[t\left(2x - 5/3\right)\right] dx,$$

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

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

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

$$p_2 = p_3 = (1-2A)t.$$

Using these prices and the price schedules above, it is possible to derive the profits of the firms:

$$\pi_1 = \frac{t}{18}, \ \pi_2 = \pi_3 = \frac{1}{36}[12A(9A-7)+19]t.$$

Data Sales

Using the same method to derive the payoff from selling data to firms via auction as illustrated in Section 5, we can compute the data broker's incentives to sell the list.

$$\pi_{DB}^{1} = \frac{\left(-207756A^2 + 87420A + 5875\right)t}{152100}, \qquad \pi_{DB}^{23} = \frac{1}{648}\left(3312A^2 - 2040A + 401\right)t,$$
$$\pi_{DB}^{AI} = \frac{1}{324}\left(1656A^2 - 1128A + 223\right)t$$

B.3 Very short list

Let us now turn to the case in which $A \in [1/12, 1/6]$.

Firm 1 obtains the list in exclusive

Because the list is shorter than $5/18$, firm 1 sets both the price schedules $p_{12}(x)$ and $p_{13}(x)$ for the consumers on the list, and an uniform price p_1 for the consumers on the non-profiled segment. Instead, firms 2 and 3 set the uniform prices p_2 and p_3, respectively. This subgame solves equivalently as in the case where $A \in [1/6, 5/18)$ presented above.

Firm 2 and 3 obtain the list

Consider the case of firm 2 and firm 3 having access to information about consumers on the profiled segment. In this case, firm 2 and 3 set a price schedule for the profiled consumers ($x \in [0, A]$ and $x \in [(1-A), 1]$). Additionally, they also set uniform prices p_2 and p_3 for non-profiled consumers on the anonymous segment ($x \in (A, 2/3]$) and $x \in (2/3, (1-A))$), whereas firm 1 sets a uniform price p_1. Notice that, as $A < 1/6$, the segment of consumers between firms 1 and 2 may be fragmented. Given the prices mentioned above, firms 1 and 2 personalised price schedules are:

$$p_{21}(x) = \max\left\{p_1 + t\left(2x - 1/3\right), 0\right\}, \qquad p_{31}(x) = \max\left\{p_1 + t\left(5/3 - 2x\right), 0\right\}.$$

where the subscripts $\{i, j\}$ indicate the price of i competing against j.

Denote the consumers for which the price schedules of firms 2 and 3 is zero, i.e., $p_2(\tilde{x}_{12}) = 0$ and $p_3(\tilde{x}_{31}) = 0$, as $x_{12}^* = 1/6 - p_1/2t$ and $x_{31}^* = 5/6 + p_1/2t$, and assume that these consumers lie on the profiled segment. In this case, the locations of the indifferent consumers are:

$$\tilde{x}_{12} = \frac{3(p_2 - p_1) + t}{6t}, \ \tilde{x}_{23} = \frac{p_3 - p_2 + t}{2t}, \ \tilde{x}_{31} = \frac{3(p_1 - p_3) + 5t}{6t},$$

$$x_{12}^* = {}^1\!/_6 - {}^{p_1}\!/_{2t}, \;\; x_{31}^* = {}^5\!/_6 + {}^{p_1}\!/_{2t}$$

Notice that we identified two locations between firms 1 and 2 (and 3). This is possible as firm 1 best-replies aggressively to firm 2(3)'s price schedule and set an uniform price p_1 that is sufficiently low to attract some of the consumers outside the list.

The equilibrium in the pricing subgame can be characterised as follows:

$$\pi_1 = p_1 \left[x_{12}^* + (\tilde{x}_{12} - A) + (1 - x_{31}^*) + ((1-A)\tilde{x}_{31}) \right],$$

$$\pi_2 = p_2 \left(\tilde{x}_{23} - \tilde{x}_{12} \right) + \int_{x_{12}^*}^{A} \left[p_1 + t \left(2x - {}^1\!/_3 \right) \right] dx,$$

$$\pi_3 = p_3 \left(\tilde{x}_{31} - \tilde{x}_{23} \right) + \int_{1-A}^{x_{31}^*} \left[p_1 + t \left({}^5\!/_3 - 2x \right) \right] dx$$

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

$$p_1 = \frac{2(4-9A)}{33} t, \;\; p_2 = p_3 = \frac{2(5-3A)}{33} t.$$

Using these prices and the price schedules above, it is possible to derive the profits of the firms:

$$\pi_1 = \frac{8(4-9A)^2 t}{1089}, \;\; \pi_2 = \pi_3 = \frac{[48A(51A-16)+409]t}{4356}.$$

All firms obtain the list

Consider the case of all firms having access to information about consumers on the profiled segment. In this case, firms 1, 2, and 3 set a price schedule for the profiled consumers ($x \in [0, A]$ and $x \in [(1-A), 1]$). Additionally, firms 2 and 3 also set uniform prices p_2 and p_3 for non-profiled consumers on the anonymous segment ($x \in (A, {}^2\!/_3]$) and $x \in ({}^2\!/_3, (1-A))$. Given these prices, firms 2 and 3 personalised price schedules are:

$$p_{12}(x) = \max \left\{ t \left({}^1\!/_3 - 2x \right), 0 \right\}, \qquad p_{13}(x) = \max \left\{ t \left(2x - {}^5\!/_3 \right), 0 \right\},$$

$$p_{21}(x) = \max \left\{ t \left(2x - {}^1\!/_3 \right), 0 \right\}, \qquad p_{31}(x) = \max \left\{ t \left({}^5\!/_3 - 2x \right), 0 \right\}.$$

where the subscripts $\{i, j\}$ indicate the price of i competing against j.

Denote the consumers for which the price schedules of firms 1, 2, and 3 are zero, i.e., $p_{12}(x_{12}^*) = p_{21}(x_{31}^*) = 0$, as $x_{12}^* = \frac{1}{6}$ and $p_{13}(x_{31}^*) = p_{31}(x_{31}^*) = 0$, as $x_{12}^* = \frac{5}{6}$. Clearly, these consumers do not lie on the profiled segment. In this case, the locations of the indifferent consumers are:

$$\tilde{x}_{12} = \frac{3(p_2 - p_1) + t}{6t}, \;\; \tilde{x}_{23} = \frac{p_3 - p_2 + t}{2t}, \;\; \tilde{x}_{31} = \frac{3(p_1 - p_3) + 5t}{6t}.$$

The equilibrium in the pricing subgame can be characterised as follows:

$$\pi_1 = p_1\left((\tilde{x}_{12} - A) + ((1-A) - \tilde{x}_{31})\right) + \int_0^A \left[t\left(1/3 - 2x\right)\right]dx + \int_{1-A}^1 \left[t\left(2x - 5/3\right)\right]dx,$$

$$\pi_2 = p_2\left(\tilde{x}_{23} - \tilde{x}_{12}\right), \qquad \pi_3 = p_3\left(\tilde{x}_{31} - \tilde{x}_{23}\right).$$

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

$$p_1 = \frac{(5-18A)}{5}t,\ p_2 = p_3 = \frac{(5-6A)}{15}t$$

Using these prices and the price schedules above, it is possible to derive the profits of the firms:

$$\pi_1 = \frac{1}{225}[25 - 6A(21A+5)]t,\ \pi_2 = \pi_3 = \frac{1}{225}(5-6A)^2 t.$$

Data Sales

Using the same method to derive the payoff from selling data to firms via auction as illustrated in Section 5, we can compute the data broker's incentives to sell the list.

$$\pi_{DB}^1 = \frac{\left(-180972A^2 + 96540A + 125\right)t}{115200}, \qquad \pi_{DB}^{23} = \frac{\left(14592A^2 + 3280A - 625\right)t}{18150},$$
$$\pi_{DB}^{AI} = -\frac{\left(31446A^2 - 10770A + 175\right)t}{27225}.$$

B.4 Tiny list

Let us now turn to the case in which $A < 1/12$.

Firm 1 obtains the list in exclusive

As the list is shorter than $5/18$, firm 1 sets both the price schedules $p_{12}(x)$ and $p_{13}(x)$ for the consumers on the list, and an uniform price p_1 for the consumers on the non-profiled segment. Instead, firms 2 and 3 set the uniform prices p_2 and p_3, respectively. This subgame solves equivalently as in the case where $A \in [1/6, 5/18)$ presented above.

Firm 2 and 3 obtain the list

Consider the case of firm 2 and firm 3 having access to information about consumers on the profiled segment. In this case, firm 2 and 3 set a price schedule for the profiled consumers ($x \in [0, A]$ and $x \in [(1-A), 1]$). Additionally, they also set uniform prices p_2 and p_3 for non-profiled consumers on the anonymous segment ($x \in (A, 2/3]$) and $x \in (2/3, (1-A))$), whereas firm 1 sets a uniform price p_1. Notice that, as $A < 1/6$, the segment of consumers between firms 1 and 2 may be fragmented. Given the prices abovementioned, firms 1 and 2 personalised price schedules are:

$$p_{21}(x) = \max\left\{p_1 + t\left(2x - 1/3\right), 0\right\}, \qquad p_{31}(x) = \max\left\{p_1 + t\left(5/3 - 2x\right), 0\right\}.$$

where the subscripts $\{i, j\}$ indicate the price of i competing against j.

Denote the consumers for which the price schedules of firms 2 and 3 is zero, i.e., $p_2(\tilde{x}_{12}) = 0$ and $p_3(\tilde{x}_{31}) = 0$, as $x^*_{12} = 1/6 - p_1/2t$ and $x^*_{31} = 5/6 + p_1/2t$, and assume that these consumers lie on the profiled segment. In this case, the locations of the indifferent consumers are:

$$\tilde{x}_{12} = \frac{3(p_2 - p_1) + t}{6t}, \; \tilde{x}_{23} = \frac{p_3 - p_2 + t}{2t}, \; \tilde{x}_{31} = \frac{3(p_1 - p_3) + 5t}{6t},$$

$$x^*_{12} = 1/6 - p_1/2t, \; x^*_{31} = 5/6 + p_1/2t$$

Notice that there are virtually two identified locations between firms 1 and 2 (and 3). This is possible as firm 1 best-replies aggressively to firm 2(3)'s price schedule and set an uniform price p_1 that is sufficiently low to attract some of the consumers outside the list. However, when $A < 1/12$, the indifferent consumers x^*_{12} and x^*_{31} lie outside the profiled segment. Thus, the game collapses to a standard Salop-game with no information.

All firms obtain the list

Consider the case of all firms having access to information about consumers on the profiled segment. In this case, firms 1, 2, and 3 set a price schedule for the profiled consumers ($x \in [0, A]$ and $x \in [(1-A), 1]$). Additionally, firms 2 and 3 also set uniform prices p_2 and p_3 for non-profiled consumers on the anonymous segment ($x \in (A, 2/3]$) and $x \in (2/3, (1-A))$). This subgame solves equivalently as in the case where $A \in [1/12, 1/6)$ presented above.

Data Sales

Using the same method to derive the payoff from selling data to firms via auction as illustrated in Section 5, we can compute the data broker's incentives to sell the list. For the sake of simplicity, we focus on $A > 1/26$. We treat any negative willingness to pay as zero in the comparison.

$$\pi^1_{DB} = \frac{\left(125 + 96540A - 180972A^2\right)t}{115200}, \qquad \pi^{23}_{DB} = \frac{8A(3A-5)t}{75},$$

$$\pi^{AI}_{DB} = -\frac{2A(21A+5)t}{75}.$$

C Web Appendix (not for publication): A generic number of firms

In this Appendix we set up the game for a generic number of firms n. We analyse the firms' pricing choices for a given allocation of the list covering the arc around firm 1 and spanning between firms n and 2. As per Table 2, there are six pricing subgames to consider: no firm has access to the list (No info), all relevant firms have the list (1,2 and n), exclusive access of firm 1 (Excl 1) or one of its neighbours firm 2 or firm n (Excl 2(n)) and, finally, when the list is acquired by firm 1 and firm 2 (or firm n, labelled Both 1 & 2) or by firm 2 and firm n (Both 2 & n). We consider each of these subgames in turn. Whereas finding a general solution for any number of firms n is beyond the scope, we identify the asymmetries in pricing that make such a problem challenging in a number of subgames.

C.1 No information

If no firm has access to the list, each firm simultaneously sets posted prices to maximise profits and price competition *à la* Salop takes place. The indifferent consumers between buying from any firm i and its left or its right neighbour (i.e., firms $i-1$ or $i+1$) are:

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

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

$$\pi_i = p_i \left[\left(\frac{t}{n} + \frac{p_{i+1} - p_i}{2t} \right) + \left(\frac{t}{n} + \frac{p_{i-1} - p_i}{2t} \right) \right]. \tag{C.1}$$

The first order conditions are obtained by taking the first derivative of (C.1) with respect to p_i and setting it equal to zero. In this subgame, symmetry allows to easily find the equilibrium. Indeed, the unique pricing equilibrium if no firm has a list is:

$$p_i = \frac{t}{n}, \;\; \pi_i = \frac{t}{n^2}, \;\; i = 1, \ldots, n.$$

Note that this benchmark is equivalent to the case in which the list is held by any firm that is not on or around the profiled arc (i.e., firms 1, 2 and n). This is because the distance from the firm and the profiled consumers would be too high to try offer personalised prices.

C.2 Firms 1, 2 and n have the list

Suppose all the relevant firms on and around the profiled arc have access to the list. In this case, firm 1 posts a price schedule using the list, whereas firm 2 and firm n post both a personalised schedule and a posted price. All other firms set posted prices. Between the firms that set posted prices, standard price competition *à la* Salop takes place.

Consider first the list segments. The price schedules are identified as follows:

$$U(x, y_1) = v - tx - p_1(x) = v - t(1/n - x) - p_2(x) = U(x, y_2) \tag{C.2}$$

$$U(x, y_n) = v - t(x - {}^{n-1}/n) - p_n(x) = v - t(1 - x) - p_1(x) = U(x, y_1) \tag{C.3}$$

Firm 1 personalised price schedule on the $x \in [0, 1/n]$ is obtained by solving (C.2) for $p_1(x)$ and setting $p_2(x) = 0$. Similarly, the price schedule on the $x \in [{}^{n-1}/n, 1]$ is obtained by solving (C.3) for $p_1(x)$ and setting $p_n(x) = 0$.

Following the above procedure in this case, we obtain this schedule for firm 1:

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

and the schedules for firms 2 and n can be derived similarly. The indifferent consumers between firms 1 and 2 are located at $\tilde{x}_{12} = 1/2n$, and between 1 and n are at $\tilde{x}_{n1} = {}^{2n-1}/2n$. They are exactly halfway between firm 1 and its rivals on both sides.

Consider firms k and k-1 ($k = 3, \ldots, n$) not using the list on a segment. The indifferent consumers between such firms is identified by setting:

$$U(x, y_k) = v - t({}^{k-1}/n - x) - p_k = v - t(x - {}^{k-2}/n) - p_{k-1} = U(x, y_{k-1})$$

so that:

$$x_{kk-1} = \left[\frac{2k-3}{2n} + \left(\frac{p_k - p_{k-1}}{2t}\right)\right] \tag{C.4}$$

As a result, the profit functions for firms 1, 2, n and k ($k \neq 1, 2, n$) are, respectively:

$$\begin{aligned}
\pi_1 &= \int_{\tilde{x}_{n1}}^{1} \left[t\left(2x - {}^{2n-1}/n\right)\right] dx + \int_{0}^{\tilde{x}_{12}} \left[t\left(1/n - 2x\right)\right] dx \\
\pi_2 &= \int_{\tilde{x}_{12}}^{1/n} \left[t\left(2x - 1/n\right)\right] dx + p_2\left(\frac{1}{2n} + \frac{p_3 - p_2}{2t}\right) \\
\pi_n &= p_n\left(\frac{1}{2n} - \frac{(p_n - p_{n-1})}{2t}\right) + \int_{{}^{n-1}/n}^{\tilde{x}_{n1}} \left[t\left({}^{2n-1}/n - 2x\right)\right] dx \\
\pi_k &= p_k\left(x_{k+1k} - x_{k-1k}\right) = p_k\left[\frac{1}{n} + \frac{p_{k+1} - 2p_k + p_{k-1}}{2t}\right].
\end{aligned}$$

The first order conditions for profit maximisation are exactly the same as in the Salop model for firms k, $k \neq 1, 2, n$, and the equivalent but for only one segment for the extreme firms 2 and n:

$$i = 2: \ \frac{1}{2n} + \frac{p_3 - 2p_2}{2t} = 0 \qquad\qquad i = n: \ \frac{1}{2n} + \frac{p_{n-1} - 2p_n}{2t} = 0$$
$$i = k: \ \frac{1}{n} + \frac{p_{k+1} - 4p_k + p_{k-1}}{2t} = 0.$$

Symmetry allows solving this subgame analytically, and fully characterise the equilibrium. In particular:

$$p_2 = p_k = p_n = \frac{t}{n} \ \text{ and } \ \pi_1 = \frac{t}{2n^2}, \ \pi_2 = \pi_n = \frac{3t}{4n^2}, \ \pi_k = \frac{t}{n^2}.$$

C.3 Exclusive list to firm 1

Consider now if firm 1 has acquired the list exclusively. In this scenario, only firm 1 chooses a price schedule using the list, whereas all the remaining firms post a uniform price. The price schedule of firm 1 for the list segment are identified using (C.2) and (C.3), but noting that p_2 and p_n are posted prices, and not price schedules this time. Following the outlined procedure, the schedule of firm 1 is:

$$p_1(x) = \begin{cases} p_2 + t\left({}^1\!/_n - 2x\right), & \text{if } 0 \le x < \tilde{x}_{12} \\ p_n + t\left(2x - {}^{2n-1}\!/_n\right), & \text{if } \tilde{x}_{n1} \le x < 1 \\ 0, & \text{otherwise} \end{cases}.$$

The indifferent consumers between firms 1 and 2 are located at $\tilde{x}_{12}(p_2) = {}^{p_2}\!/_{2t} + {}^1\!/_{2n}$, and between 1 and n are at $\tilde{x}_{n1}(p_n) = {}^{p_n}\!/_{2t} + {}^{2n-1}\!/_{2n}$. Their location depends on the posted prices of the rival firms on both sides. This crucially affects the pricing incentives.

Consider firms k and k-1 ($k = 3, \ldots, n$). The indifferent consumers between such firms and the neighbouring firms are still identified by (C.4) above. As a result, the profit functions for firms 1, 2, n and k ($k \neq 1, 2, n$) are, respectively:

$$\pi_1 = \int_{\tilde{x}_{n1}}^{1} \left[p_n + t\left(2x - {}^{2n-1}\!/_n\right)\right] dx + \int_0^{\tilde{x}_{12}} \left[p_2 + t\left({}^1\!/_n - 2x\right)\right] dx$$
$$\pi_2 = p_2 \left[\left(\frac{1}{2n} + \frac{p_3 - p_2}{2t}\right) + \left({}^1\!/_n - \tilde{x}_{12}(p_2)\right)\right]$$
$$\pi_n = p_n \left[\left(\frac{1}{2n} - \frac{(p_n - p_{n-1})}{2t}\right) + \left(\tilde{x}_{n1}(p_n) - {}^{n-1}\!/_n\right)\right]$$
$$\pi_k = p_k\left(x_{k+1k} - x_{k-1k}\right) = p_k\left[\frac{1}{n} + \frac{p_{k+1} - 2p_k + p_{k-1}}{2t}\right].$$

The first order conditions for profit maximisation are:

$$i=2: \ \frac{1}{2n}+\frac{p_3-2p_2}{2t}-p_2=0 \qquad\qquad i=n: \ \frac{1}{2n}+\frac{p_{n-1}-2p_n}{2t}-p_n=0$$
$$i=k: \ \frac{1}{n}+\frac{p_{k+1}-4p_k+p_{k-1}}{2t}=0.$$

Note that for firms k, $k \neq 1, 2, n$, these are exactly the same as in the Salop model, but there is an important difference for firms 2 and n. In fact, these firms face the competition of firm 1 through individualised prices. This introduces a new term, the third on the left hand side, and affects their best response functions. Indeed, one may notice that the slope of the first order condition of firms 2 and n $(-{}^{1+t}/_{t})$ is steeper than those of other firms k $(-{}^{1}/_{t})$. Intuitively, this implies that firms 2 and n price more aggressively in equilibrium.

This competitive response to firm 1 affects the equilibrium prices of firms 2 and n symmetrically, but these firms also affect all other firms as a result. A complete solution of this problem is beyond the scope of this paper.

C.4 Exclusive list to firm 2

Suppose now firm 2 has acquired the list exclusively.[7] Hence, only firm 2 chooses a price schedule using the list, for the consumers located between its location and firm 1. It also chooses a posted price, like all the remaining firms. The price schedule of firm 2 is identified using (C.2), but noting that p_1 is a posted price and not a price schedule in this case. The schedule of firm 2 is, then:

$$p_2(x) = \begin{cases} p_1 + t\left(2x - {}^{1}/_{n}\right), & \text{if } \tilde{x}_{12} \leq x < {}^{1}/_{n} \\ 0, & \text{otherwise} \end{cases}.$$

The indifferent consumers between firms 1 and 2 are located at $\tilde{x}_{12}(p_2) = {}^{1}/_{2n} - {}^{p_1}/_{2t}$. Note that its location depends on the posted price of firm 1. This crucially affects the pricing incentives of firm 1 and, as a consequence of the chain of the best responses, all other firms in the market including firm 2.

Consider firms k and k-1 ($k = 1, 3, \ldots, n$). The indifferent consumers between such firms and the neighbouring firms are still identified by (C.4) above. As a result, the profit functions for firms 1, 2, and k ($k \neq 1, 2$)[8] are, respectively:

[7] If it is firm n, instead of firm 2, to get exclusive access to the list, the derivations are unchanged apart from the suscripts.

[8] If $k = n$, clearly $k + 1 = 1$.

$$\pi_1 = p_1 \left[\left(\frac{1}{2n} + \frac{p_n - p_1}{2t} \right) + \tilde{x}_{12}(p_1) \right]$$

$$\pi_2 = p_2 \left(\frac{1}{2n} + \frac{p_3 - p_2}{2t} \right) + \int_{\tilde{x}_{12}}^{1/n} \left[p_1 + t\left(2x - 1/n\right) \right] dx$$

$$\pi_k = p_k \left(x_{k+1k} - x_{k-1k} \right) = p_k \left[\frac{1}{n} + \frac{p_{k+1} - 2p_k + p_{k-1}}{2t} \right].$$

The first order conditions for profit maximisation are:

$$i = 1: \ \frac{1}{2n} + \frac{p_n - 2p_1}{2t} - p_1 = 0 \qquad i = 2: \ \frac{1}{2n} + \frac{p_3 - 2p_2}{2t} = 0$$

$$i = k: \ \frac{1}{n} + \frac{p_{k+1} - 4p_k + p_{k-1}}{2t} = 0.$$

Note that these are exactly the same as in the Salop model for firms k, $k \neq 1, 2$, but there are important differences for firms 1 and 2. In particular, firm 2 only faces standard price competition on one side from firm 3. Hence, its first order condition is more similar to the classical Hotelling model than Salop's one.

Firm 1 has a similar first order condition to firm 2, but also faces the competition through individualised prices exactly from that firm. This competitive effect is captured by the third term on the left hand side. The competitive response to firm 2 affects the equilibrium prices of firm 1 and all other firms, whose best responses are concatenated. A complete solution of this problem is challenging and beyond the scope of this paper.

C.5 List available to both firm 1 and firm 2

Suppose that both firm 1 and firm 2 have acquired the list.[9] Hence, both firms choose a price schedule for the consumers located on the profiled arc. Firm 2 also chooses a posted price, like all the remaining firms, $k = 3, \ldots, n$. The price schedule of firm 1 is identified using (C.2), which also identifies the one of firm 2, and (C.3). Note however that $p_1(x)$ and $p_2(x)$ are price schedules, but p_n is a posted price in this case. The schedule of firm 1 is, then:

$$p_1(x) = \begin{cases} t\left(1/n - 2x\right), & \text{if } 0 \leq x < 1/2n \\ p_n + t\left(2x - {}^{2n-1}/n\right), & \text{if } \tilde{x}_{n1} \leq x < 1 \\ 0, & \text{otherwise} \end{cases};$$

and of firm 2 is:

$$p_2(x) = \begin{cases} t\left(2x - 1/n\right), & \text{if } 1/2n \leq x < 1/n \\ 0, & \text{otherwise} \end{cases}.$$

[9] If it is firm n, instead of firm 2, to get access to the list together with firm 1, the derivations are unchanged apart from the subscripts.

The indifferent consumers between firms 1 and 2 are located at $\tilde{x}_{12} = {}^{1}/_{2n}$, and between firms 1 and n at $\tilde{x}_{n1}(p_n) = {}^{2n-1}/_{2n} - {}^{p_n}/_{2t}$. Note that the location of $\tilde{x}_{n1}$ depends on the posted price of firm n. This crucially affects the pricing incentives of firm n and, as a consequence of the chain of the best responses, all other firms in the market.

Consider firms k and k-1 ($k = 3, \ldots, n$). The indifferent consumers between such firms and the neighbouring firms are still identified by (C.4) above. As a result, the profit functions for firms 1, 2, n and k ($k \neq 1, 2, n$) are, respectively:

$$\pi_1 = \int_{\tilde{x}_{n1}}^{1} \left[t\left(2x - {}^{2n-1}/_{n}\right)\right] dx + \int_{0}^{\tilde{x}_{12}} \left[t\left({}^{1}/_{n} - 2x\right)\right] dx$$
$$\pi_2 = \int_{\tilde{x}_{12}}^{1/n} \left[t\left(2x - {}^{1}/_{n}\right)\right] dx + p_2\left(\frac{1}{2n} + \frac{p_3 - p_2}{2t}\right)$$
$$\pi_n = p_n\left[\left(\frac{1}{2n} - \frac{(p_n - p_{n-1})}{2t}\right) + \left(\tilde{x}_{n1}(p_n) - {}^{n-1}/_{n}\right)\right]$$
$$\pi_k = p_k\left(x_{k+1k} - x_{k-1k}\right) = p_k\left[\frac{1}{n} + \frac{p_{k+1} - 2p_k + p_{k-1}}{2t}\right].$$

The first order conditions for profit maximisation are:

$$i = 2: \ \frac{1}{n} + \frac{p_3 - 2p_2}{2t} = 0 \qquad\qquad i = n: \ \frac{1}{n} + \frac{p_{n-1} - 2p_n}{2t} - p_n = 0$$
$$i = k: \ \frac{1}{n} + \frac{p_{k+1} - 4p_k + p_{k-1}}{2t} = 0.$$

Note that these are exactly the same as in the Salop model for firms k, $k \neq 1, 2, n$, but there are important differences for firms 2 and n. In particular, firm 2 only faces standard price competition from firm 3's side, so its first order condition is similar to the classical Hotelling model.

Firm n, instead, has a similar first order condition to firm 2, but also faces the competition through individualised prices from firm 1. This effect is captured by the third term on the left hand side. The competitive response to firm 1 affects the equilibrium prices of firm n and all other firms. A complete solution of this problem is challenging and beyond the scope of this paper.

C.6 List available to both firm 2 and firm n

Suppose that both firm 2 and firm n have acquired the list. Both firms choose a price schedule for the consumers located on the profiled arc. They also chooses a posted price, like all the remaining firms, $k = 1, 3, \ldots, n$. Note that firm 1 potential market segment can be offered personalised offers by its rivals in this scenario. As a result, firm 1 faces a strong pressure to price aggressively.

The price schedule of firms 2 and n are identified using (C.2) and (C.3). Note however that $p_2(x)$ and $p_n(x)$ are price schedules, whereas p_1 is a posted price. The schedule of firm 2 is, then:

$$p_2(x) = \begin{cases} p_1 + t\left(2x - {}^1\!/_n\right), & \text{if } \tilde{x}_{12} \leq x < {}^1\!/_n \\ 0, & \text{otherwise} \end{cases};$$

and the one of firm n is:

$$p_n(x) = \begin{cases} p_1 + t\left({}^{2n-1}\!/_n - 2x\right), & \text{if } {}^{n-1}\!/_n \leq x < \tilde{x}_{n1} \\ 0, & \text{otherwise} \end{cases}.$$

The indifferent consumers between firms 1 and 2 are located at $\tilde{x}_{12}(p_1) = {}^1\!/_{2n} - {}^{p_1}\!/_{2t}$, and between firms 1 and n at $\tilde{x}_{n1}(p_n) = {}^{2n-1}\!/_{2n} + {}^{p_1}\!/_{2t}$. Note that the location of the indifferent consumers depends on the prices of firm 2 and n.

Consider firms k and k-1 ($k = 3, \ldots, n$). The indifferent consumers between such firms and the neighbouring firms are still identified by (C.4) above. As a result, the profit functions for firms 1, 2, n and k ($k \neq 1, 2, n$) are, respectively:

$$\begin{aligned}
\pi_1 &= p_1\left[1 - \tilde{x}_{n1}(p_1) + \tilde{x}_{12}(p_1)\right] = p_1\left({}^1\!/_n - {}^{p_1}\!/_t\right) \\
\pi_2 &= \int_{\tilde{x}_{12}}^{1/n} \left[t\left(2x - {}^1\!/_n\right)\right] dx + p_2\left(\frac{1}{2n} + \frac{p_3 - p_2}{2t}\right) \\
\pi_n &= \int_{\tilde{x}_{12}}^{1/n} \left[t\left(2x - {}^1\!/_n\right)\right] dx + p_n\left(\frac{1}{2n} + \frac{p_{n-1} - p_n}{2t}\right) \\
\pi_k &= p_k\left(x_{k+1k} - x_{k-1k}\right) = p_k\left[\frac{1}{n} + \frac{p_{k+1} - 2p_k + p_{k-1}}{2t}\right].
\end{aligned}$$

The first order conditions for profit maximisation are:

$$i = 1: \ \frac{1}{n} - \frac{2p_1}{t} = 0 \qquad\qquad i = 2: \ \frac{1}{2n} + \frac{p_3 - 2p_2}{2t} = 0$$

$$i = n: \ \frac{1}{2n} + \frac{p_{n-1} - 2p_n}{2t} = 0 \qquad\qquad i = k: \ \frac{1}{n} + \frac{p_{k+1} - 4p_k + p_{k-1}}{2t} = 0.$$

Symmetry allows to solve this subgame analytically and fully characterise the equilibrium. In particular, we find that:

$$p_1 = \frac{t}{2n} \ p_2 = p_k = p_n = \frac{t}{n} \quad \text{and} \quad \pi_1 = \frac{t}{4n^2}, \ \pi_2 = \pi_n = \frac{17t}{16n^2}, \ \pi_k = \frac{t}{n^2}.$$