Softening Competition through Unilateral Sharing of Customer Data

Chongwoo Choe (Monash)

Jiajia Cong (Fudan)

Chengsi Wang (Monash)

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Data is the new oil

Value of consumer data

1. Value of data for firms
   - Data-enabled learning can lead to new and improved products, and improvement of management practice.
   - More effective surplus extraction by price discrimination
   - Monetization through data-based services
   - Direct sales of data to third parties

2. The flip side
   - Privacy concerns: Privacy laws (GDPR, CCPA, etc) aim at addressing this.
   - Potential adverse effects on competition

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Consumer data and competition

1. Data can harm competition in data-driven businesses.

   - Network effects and economies of scale and scope in data can lead to market tipping.

   - Data can be an entry barrier.

2. How about mandated data sharing?

   - Can dampen incentives for data collection, hence upfront competition

   - Can create room for collusion

   - Can aggravate privacy concerns

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3. Data can also intensify competition when competition is based on price discrimination using finer levels of consumer data.

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Firms' incentives to share consumer data

1. Firms are generally averse to sharing consumer data if it can be used for price discrimination.

2. Can a data-rich firm voluntarily share its consumer data with a data-poor competitor?

- Yes, if it can charge for the data: data sharing can increase industry profit, which the sharing firm can extract through the payment.
- What if the sharing firm cannot charge for the data?

3. We show that *unilateral data sharing*, even without payment, can benefit both firms given the optimally chosen amount of shared data.

Example: Amazon

Figure: Coupon targeting in Amazon.

Example: Alibaba and JD.com

Chinese online platforms, Alibaba and JD.com, introduced A100 and Zu Chongzhi programs, which provide individual level data to their third-party sellers to improve their marketing strategies.

- For example, Bestore Co Ltd, a Chinese snack food chain, links customer data from its facial recognition technology with the data shared by Alibaba, improving its targeting strategies.
- At the same time, Alibaba and JD.com have invested heavily in their offline stores to compete with these firms.

Research questions

1. Main research questions
   - Can unilateral sharing of consumer data benefit both firms when the data can be used for personalized pricing?
   - If yes, how to do it optimally?
   - Welfare implications of unilateral data sharing

2. Extensions
   - No search discrimination (making price discrimination less effective)
   - Data sharing for third-degree price discrimination
   - The implication for data as an entry barrier
   - Fee for sales of data

Preview of results

1. There exists mutually beneficial data sharing.

2. It is optimal for the data-rich firm to share data on consumers who are more loyal to the data-poor competitor, but not share the data on the competitor's most loyal consumers.

3. The above data sharing softens competition for consumers whose data is not shared, i.e., data sharing is an example of a fat-cat strategy.

4. Data sharing has two effects: surplus-extraction effect and quality-of-matching effect.

- Surplus-extraction effect is always negative, hence consumers are worse off and firms are better off.
- Quality-of-matching effect can be positive, which may increase total welfare despite the lower consumer surplus.

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Literature review

1. Consumer data sharing between rivals
   - Bilateral (mutual) data sharing: Chen et al. (2001), Shy and Stenbacka (2013), Jentzsch et al. (2013), Choe et al. (2022)
   - Unilateral data sharing with transfer or data brokers: Chen et al. (2001), Liu and Serfes (2006)
   - Data brokers: Montes et al. (2019), Bounie et al. (2021)

2. Competition based on personalized pricing
   - Static model: Thisse and Vives (1988), Rhodes and Zhou (2022)
   - Dynamic model: Zhang (2011), Fudenberg and Villas-Boas (2012), Choe et al. (2018)

The model

1. Hotelling framework

   - A unit-length Hotelling line with firm 1 at $x = 0$ and firm 2 at $x = 1$, cost of production normalized to zero
   - A unit mass of consumers distributed on the Hotelling line with CDF $F(x)$ and PDF $f(x)$ satisfying the monotone hazard rate condition
   - A consumer's utility from buying from firm i is $v - p_i - d_i$ where p_i is the price paid, d_i is the distance traveled, and $v \geq 2$.

2. Consumer data

   - Firm 1 is a data-rich: it is fully informed, i.e., knows each consumer's exact location.
   - Firm 2 is a data-poor: it has no information on any consumer's location.
   - Note: Our results hold if firm 1 has data on $[0, a]$ only where a is larger than a certain threshold and firm 2 has data on $[b, 1]$ where b is smaller than the threshold.

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Data sharing and pricing

1. Data sharing
   - Firm 1 can costlessly share a set $S \subseteq [0,1]$ of consumer data with firm 2.
   - Data sharing does not involve any monetary transfer.

2. Pricing
   - Firm 1 charges personalized prices $p_1(x)$ for any $x \in [0,1]$.
   - Firm 2 charges personalized prices $p_2(x)$ for any $x \in S$, and uniform price p_2 for all $x \notin S$.

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Timing and equilibrium concept

1. Firm 1 makes a data sharing decision by choosing S.
2. Firm 2 decides whether or not to accept the shared data.
3. Firm 2 chooses p_2.
4. Firm 1 chooses $p_1(x)$ for all $x \in [0, 1]$, and firm 2 chooses $p_2(x)$ for all x in S if it accepted data sharing in stage 2.

We solve for subgame perfect Nash equilibria.

Benchmark without data sharing

- Firm 2 sets uniform price p_2 for all consumers.
- Marginal consumer z is given by $z + p_1(z) = 1 - z + p_2$. But firm 1 can lower $p_1(z)$ down to 0, so $z = (1 + p_2)/2$.
- Firm 2 maximizes $\pi_2 = p_2(1 - F(z))$

$$p_2^N := \frac{2}{h(z^N)}, \quad z^N := \frac{1}{2} + \frac{1}{h(z^N)} > 1/2.$$

where $h(z^N) = f(z^N)/(1 - F(z^N))$ is the hazard rate at z^N.

- $[z^N, 1]$ is firm 2's **customer base** that firm 2 can serve even without any data.
- Firm 1 serves $[0, z^N]$ by choosing $p_1^N(x) = \max\{p_2^N + (1 - 2x), 0\}$ that makes all consumers on $[0, z^N]$ indifferent.

Uniform example and the key intuition

- Suppose F is a uniform distribution, $F(x) = x$.
- Then $h(x) = 1/(1-x)$.
- Thus, $z^N = 3/4$, $p_2^N = 1/2$, and $p_1(x) = p_2^N + (1 - 2x) = 3/2 - 2x$ for all $x \leq 3/4$ and $p_1(x) = 0$ for all $x > 3/4$.
- $\pi_1^N = \int_0^{3/4} p_1(x)dx = 9/16$, $\pi_2 = (1/2)(1 - 3/4) = 1/8$.
- Can firm 1 choose data sharing that makes both firms better off?
- Observation 1: Data sharing can benefit firm 2 by allowing it to use personalized prices for consumers with shared data.
- Observation 2: Firm 1's potential cost of data sharing is lost market share.
- Observation 3: Firm 1 can benefit if data sharing induces firm 2 to increase its uniform price. Recall $p_1(x) = \max\{p_2 + (1 - 2x), 0\}$.
- So how?

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Interval sharing

> **Lemma**
>
> *Firm 1 weakly prefers sharing data on a single interval $[a, b]$ to sharing data on disjoint intervals.*

Sketch of proof: Firm 1 prefers sharing data on $[a, b]$ to sharing data on $[a, b] \cup [a', b']$. In the latter, data sharing on one of the two intervals becomes redundant or profit-reducing for firm 1. Likewise, firm 1 prefers sharing data on n intervals to sharing data on $n + 1$ intervals. By induction, data sharing on a single interval is preferred to any other data sharing.

Interval sharing
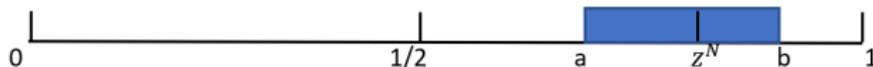
In addition, it must be that $b > z^N$ and $a \geq 1/2$

- Choosing $b \leq z^N$ intensifies competition on $[a, b]$ without raising p_2 above p_2^N.
- Sharing data on $[a, b]$ with $a < 1/2$ is dominated by sharing data on $[1/2, b]$.

Firm 2's choice of uniform price

1. Data sharing on $[a, b]$ allows firm 2 to delink its pricing decisions.

2. Firm 2 chooses personalized prices $p_2(x) = 2x - 1$ on $[a, b]$.

3. For the rest of the market, firm 2 chooses a uniform price.

4. It can either set high $p_2 = 2b - 1$ to serve $[b, 1]$, and earn profit $\pi_{21} = p_2(1 - F(b))$.
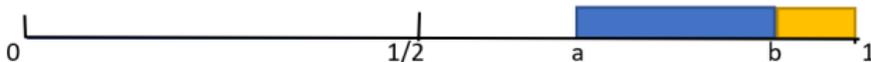
5. Or, it can set low $p'_2 = 2z' - 1$ to serve $[z', a] \cup [b, 1]$ for some $z' < a$, and earn profit $\pi_{22} = p'_2(1 - F(b) + F(a) - F(z'))$.
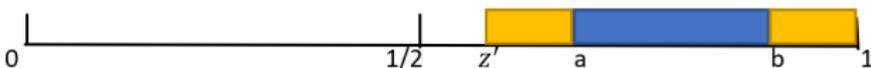
Firm 2's choice of uniform price

Lemma

For data sharing on $[a, b]$ to be profitable for firm 1, it should necessarily induce firm 2 to choose its uniform price $p_2 = 2b - 1$ to serve $[b, 1]$ only.

Sketch of proof:

- Given $a \geq 1/2$, firm 1 loses entire $[a, b]$ to firm 2.
- The only way to profit from sharing data is to be able to set higher $p_1(x)$ to consumers on $[0, a]$.
- This can only happen if $p_2 > p_2^N$, which is true for $p_2 = 2b - 1$.
- For p_2', the monotone hazard rate condition implies $z' < z^N$, which in turn implies $p_2' < p_2^N$.

Mutually beneficial data sharing

Mutually beneficial data sharing satisfies the following conditions.

- (IC) firm 2 chooses high $p_2 = 2b - 1$: $\pi_{21}(b) \geq \pi_{22}(a, b)$
- (IR) firm 2 is better off by accepting the data:
  $\pi_2(a, b) = \int_a^b (2x - 1)dF(x) + \pi_{21}(b) \geq \pi_2^N$

Proposition

For any distribution F that satisfies the monotone hazard rate condition, there exists $b' \in (z^N, 1)$ such that sharing data on $[z^N, b']$ makes both firms better off compared to the benchmark without data sharing.

Mutually beneficial data sharing: intuition

- Sharing data on $[z^N, b']$ does not cost firm 1 any market share because it is a subset of firm 2's customer base.
- Firm 1 keeps data on consumers who have high loyalty to firm 2, i.e., $[b, 1]$. This softens competition as firm 2 chooses a high uniform price for them.
- This allows firm 1 to raise its own personalized prices.
- Firm 1 benefits from data sharing through higher personalized prices but at no cost of reduced market share.
- Firm 2 also benefits from such data sharing because it serves the same set of consumers but at higher prices.

Optimal data sharing

1. The previous data-sharing strategy $[z^N, b']$, although mutually beneficial, may or may not be firm 1's optimal data-sharing strategy.

2. Firm 1's optimal data sharing problem solves

$$\max_{(a,b)} \pi_1(a,b) = \int_0^a (p_2 + (1-2x))dF(x)$$

$$\text{s.t. (IC) and (IR)}$$

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Optimal data sharing with $x \sim U[0, 1]$

Proposition

If $x \sim U[0, 1]$, then $[a^*, b^*] \approx [0.71, 0.97]$.

- Firm 1 serves consumers on $[0, a^*]$ with personalized price $p_1^*(x) = 2b^* - 2x$ and earns profit $\pi_1^* \approx 0.87 > 9/16 = \pi_1^N$.
- Firm 2 serves consumers on $[a^*, b^*]$ with personalized price $p_2^*(x) = 2x - 1$, consumers on $[b^*, 1]$ with uniform price $p_2^* = 2b^* - 1$, and earns profit $\pi_2^* \approx 0.21 > 1/8 = \pi_2^N$.

1. Recall $z^N = 3/4$ and $p_2^N = 1/2$. Note that $a^* < z^N$!

2. The key is how to satisfy firm 2's (IC).

3. If F is left-skewed around $z^N > 1/2$, i.e., a fat right tail, then choosing $a > z^N$ and large b can satisfy (IC).

4. If F is right-skewed around z^N (including the symmetric case since $z^N > 1/2$), then choosing $a < z^N$ and small b can satisfy (IC).

Optimal data sharing: numerical results for $x \sim Beta(\alpha, \beta)$

PDF	(α, β)	z^N	$[a^*, b^*]$	CS^*-CS^N	TS^*-TS^N
unimodal	$(2, 4)$	0.61	$[0.50, 0.98]$	–	+
U-shaped	$(0.9, 0.9)$	0.76	$[0.72, 0.97]$	–	+
decreasing	$(0.9, 2)$	0.67	$[0.50, 0.99]$	–	+
increasing	$(5, 1)$	0.81	$[0.83, 0.96]$	–	–
uniform	$(1, 1)$	0.75	$[0.71, 0.97]$	–	+

All satisfy $\pi_1^* > \pi_1^N$ and $\pi_2^* > \pi_2^N$. Except for the case with increasing density, we have $a^* < z^N$.

Optimal data sharing: numerical results for $x \sim Beta(\alpha, \beta)$
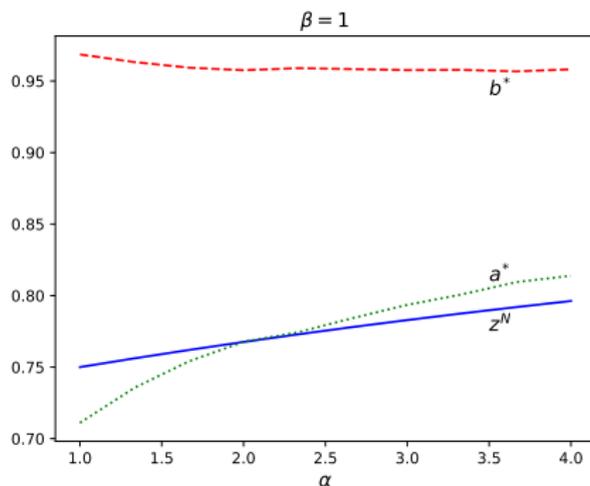
1. For all $\alpha = \beta$, i.e., F is symmetric around $1/2$, we have $a^* < z^N$.

2. F becomes more left-skewed as α increases, holding β fixed. Thus, a^* monotonically increases in α, holding β fixed.

Consumer surplus

Proposition

For any distribution F that satisfies the monotone hazard rate condition, data sharing on $[a^*, b^*]$ decreases consumer surplus unambiguously.

1. Consumers who do not switch firms are all worse off because they pay higher prices after data sharing (negative surplus extraction effect).

2. For consumers who switch firms,
   - If $z^N < a^*$, all consumers on $[z^N, a^*]$ are worse off (negative quality-of-matching effect).
   - If $a^* < z^N$, all consumers on $[a^*, z^N]$ are better off (positive quality-of-matching effect). But the gain is offset by the loss on non-switching consumers, hence total consumer surplus is lower.

Total surplus

1. Because the market is fully covered (due to $v \geq 2$), total surplus can be proxied by the average distance travelled by a consumer, which is minimized when the marginal consumer is at $1/2$.

2. Since $z^N > 1/2$, total surplus increases if and only if $a^* < z^N$.

- In the example with beta distributions, total surplus increases in all cases except for the case with increasing density.

No search discrimination

1. No **search discrimination**: firm 2 cannot prevent a consumer who is offered its personalized price from choosing its uniform price.

2. Without search discrimination, (IC) is automatically satisfied.
- Consumer $x \in [a, b]$ chooses $\min\{p_2(x), p_2\}$.
- Firm 2 never wants to serve consumers on $[z', a]$ with $p_2 = 2z' - 1$ because, then, all consumers on $[a, b]$ will choose p_2.
- Firm 2 sets $p_2(x) = 2x - 1$ to serve all $x \in [a, b]$ and $p_2 = 2b - 1$ to serve all $x \in [b, 1]$.

3. Because firm 1 benefits from high p_2, it sets b as high as possible while choosing a to make (IR) binding.

No search discrimination

Proposition

Suppose firm 2 cannot engage in search discrimination.

- *Firm 1's optimal data sharing is given by $[\hat{a}, 1]$ where $\hat{a}$ solves $\int_{\hat{a}}^{1}(2x - 1)dF(x) = \pi_2^N$, and $\hat{a} > \max\{z^N, a^*\}$.*

- *Firm 1 serves consumers on $[0, \hat{a}]$ with personalized prices $\hat{p}_1(x) = \hat{p}_2 + (1 - 2x) \geq 2 - 2x$ and earns profit strictly higher than the case with search discrimination, where $\hat{p}_2 \geq 1$ is firm 2's (off-the-path) uniform price.*

- *Firm 2 serves consumers on $[\hat{a}, 1]$ with personalized prices $\hat{p}_2(x) = 2x - 1$, and earns the same profit as in the benchmark without data sharing.*

- *Both consumer surplus and total surplus are lower compared to the case without data sharing, as well as the case with data sharing and search discrimination.*

Third-degree price discrimination

1. Firm 2 may not have capabilities such as data analytics necessary to process the shared data for personalized pricing.

2. It instead exercises third-degree price discrimination (3DPD): a uniform price p_{2l} for $[a, b]$, and another uniform price p_{2h} for the rest.

3. Compared to the case where data is used for personalized pricing, if (IR) holds under $[a^*, b^*]$,

- firm 1's optimal data sharing does not change;
- firm 1's profit under optimal data sharing does not change but firm 2's profit decreases (3DPD is a less effective tool for firm 2 to extract surplus);
- total surplus does not change but consumer surplus increases.

Data as an entry barrier

1. Customer data is often an important input in digital markets and, therefore, can act as a barrier to entry. Assume uniform F.

   - Firm 1 is an incumbent and firm 2 needs to incur E to enter.
   - If firm 1 does not have data, each firm makes a post-entry profit $1/2$.
   - If firm 1 has data but does not share, firm 2 makes a post-entry profit $1/8$.
   - Then, does data works as an entry barrier when $E \in [1/8, 1/2]$?

2. The above argument ignores the possibility of post-entry data sharing.

   - Firm 2's post-entry profit is $1/8$ without data sharing and 0.21 with optimal data sharing.
   - Firm 1 can then deter entry by committing not to share data when $E \in [1/8, 0.21]$, although such a commitment is not credible.
   - The possibility of data sharing mitigates the role of data as an entry barrier.

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Data as an entry barrier

Proposition

Suppose firm 1 makes a data sharing decision before firm 2 makes an entry decision, and firm 2's entry cost is E.

- *If $E < 1/8$, then firm 1 shares data on $[0.71, 0.97]$ and firm 2 enters.*
- *If $E \in (1/8, 0.21]$, then firm 1 commits not to share customer data, which deters firm 2's entry; if instead firm 2 makes an entry decision first, then firm 2 enters and firm 1 shares data on $[0.71, 0.97]$.*
- *If $E > 0.21$, then firm 2 does not enter the market regardless of firm 1's data sharing decision.*

Fee for sales

1. Many hybrid platforms (Amazon, Alibaba, etc) sell first-party goods in direct competition with third-party sellers on their platforms.

2. Suppose firm 1 charges firm 2 a fixed per-unit sales fee k (proportional fee is harder to analyze).

3. Firm 1 can serve consumer x for profit $p_1(x)$ or concede consumer x to firm 2 and earn k instead.

4. For consumers more loyal to firm 2, firm 1 prefers earning k instead of choosing zero personalized price.

5. The sales fee softens competition.

   - Firm 2 shifts k entirely onto its customers by raising its prices.
   - Firm 1 can raise its personalized prices by k.
   - Firm 1 collects k from each consumer, either through higher personalized prices or through k collected from firm 2.

Fee for sales

Proposition

Suppose firm 1 charges firm 2 a per-unit fee for sales $k \geq 0$.

- *In the equilibrium with or without data sharing, each firm's market share and firm 2's profit are the same as those without the sales fee, but all prices and firm 1's profit increase by k.*

- *Firm 1's optimal data sharing is the same with or without the sales fee.*

Additional discussions

1. Data sharing with side payment
   - Suppose firm 1 can charge Φ to firm 2 for data sharing.
   - Firm 1 can choose $[a, b]$ to maximize industry profit, and set Φ to make firm 2's (IR) binding.
   - Firm 1 shares more data and earns a larger profit.

2. When firm 1 cannot price discriminate
   - Firm 1's benefit from data sharing hinges on firm 2's ability to price discriminate and increase its uniform price.
   - It does not depend on firm 1's ability to price discriminate. Our results continue to hold in this case.

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3. Partially covered markets
   - Suppose $v < z^N$ so that $[v, z^N]$ is not served without data sharing.
   - The segment $[v, z^N]$ separates the two firms, making each firm a local monopoly, and prices are no longer strategic complements.
   - There does not exist mutually beneficial data sharing, although data sharing can benefit firm 2 and increase total surplus.

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Conclusion

1. A data-rich firm can soften competition by strategically choosing the amount of data to share with its data-poor competitor.

2. Share data on consumers who are more loyal to the competitor, but withhold the data on the competitor's most loyal consumers. (Release the hostage except the most important one).

3. Such data sharing, while reducing consumer surplus, can increase total surplus if the quality-of-matching effect is significant. So, there is no prima facie case against such data sharing.

4. Future research:
   - More general use of data including that for product improvement
   - General platform fee as an additional revenue source
   - Platforms' data collection from third-party sellers
   - Consumers' privacy choice and opt-in decisions