Privacy as a Public Good: A Case for Electronic Cash

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1 Views expressed do not necessarily reflect official positions of the Bank of Canada.
Privacy in payments is a feature inherent to cash but its survival is threatened.

- Decreasing cash share at the point of sale
  - Declined to 33 per cent of volume in Canada, 31 percent in US
- Increasing share in online payments

- Data collection and data sharing between commercial payments providers and other companies (Google/Mastercard)
- R&D of commercial payment providers in predicting behaviour for marketing purposes based on payments data in combination with other data sources
- Corporations with data-intensive business models outside the realm of payments seek to expand into payments (Facebook)
Mastercard (2011): “Systems and methods for analyzing and segregating payment card account profiles into clusters and targeting offers to cardholders. (...) Customers who have no transaction history with a merchant may be selected for offers based on similarities with respect to other customers of the merchant.”

Mastercard (2018): “Disclosed herein are systems and methods of individual level learning that include receiving purchase event data from a merchant device that indicates that a purchase event occurred by a user on a user device, and transmitting the purchase event data to an analytics server. The methods may also include processing the purchase event data. (...) When the purchase hazard probability is above a threshold, the system may push a message to the user device.”
1. What could be adverse economic consequences of losing privacy in payments?

2. Might individuals make sub-optimal choices when it comes to preserving privacy in payments?

3. Is there a role for government and/or central bank action?
General point
Your information and choices reveal something about you, and also others

► Individuals may not be properly incentivized to protect their private information
► Do not bear the full social cost of failing to protect privacy
► Privacy lost through actions of others regardless of what you do
► Leads to sub-optimal choices and role for government action
Related literature

**Money is Privacy** (Kahn, McAndrews and Roberds, 2005)
- Allows consumers to purchase goods without revealing their identities
- Protects them from theft

**Privacy Paradox** (Norberg et al., 2007; Athey et al., 2017)
- Observed dichotomy between attitudes toward privacy and behavior
- Potential explanations in the literature:
  - Information disclosure based on optimal trade-off
  - Unawareness of cost of information disclosure by consumers
- Explanation in this paper
  - A public good aspect of privacy in payments
Modeling Approaches

One-period model
- 3 types of agents
- Money in the utility function

Dynamic model
- Overlapping generations model, agents live 3 periods
- Full monetary equilibrium

Both models deliver the same result regarding the public good aspect of privacy in payments.

Dynamic model endogenizes/rationalizes assumptions of the static model.
Three cohorts, each consisting of \( n \) agents indexed by \( i \):

- **Young merchants (\( y \))**
  - Endowed with two units of a consumable good
  - Wish to sell goods for money
  - \( U_y(m_{iy}) = \frac{m_{iy}}{2} \)

- **Middle-aged (\( a = m \)) and old (\( a = o \)) consumers**
  - Endowed with money, interested in consuming 1 unit of the good
  - Two **types**: Fraction \( z \) of consumers are willing to pay a high price (\( r_H \)) and the others are willing to pay a low price (\( r_L \)), depending on their unobservable type \( s \in \{H, L\} \)
  - \( U_a(c_{ia}, m_{ia}, e_{ia}; s) = c_{ia}r_s + m_{ia} + e_{ia}(\beta - \delta) \)

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*Privacy as a Public Good*
Model: Observable characteristic

Consumers have an observable characteristic $h_{ia} \in \{X, Y\}$

- For example, address information, online profile, etc

- Simple relationship with consumer type:
  - Perfectly correlated with type of middle-aged consumers
  - Imperfectly correlated with type of old consumers: fraction $\varepsilon$ of old consumers have the “wrong” observable characteristic

- Merchants do not know the sign of the relationship
Model: Timeline

Start

Meet middle-aged

· Merchant meets a random middle-aged consumer
· Makes a take-it-or-leave-it offer
· If accepted, the merchant sells a unit of the good to the middle-aged consumer

Meet old

· Merchant meets a random old consumer
· Makes a take-it-or-leave-it offer
· If accepted, the merchant sells a unit of the good to the old consumer

End

· Middle-aged and old consumers randomly adopt observable characteristic $h_{ia}$ based on their type $s_{ia}$
Outcome without price discrimination

- Merchants quote a low price $r_L$ to all consumers
- All consumers accept the offers made by the merchants
- Consumers protect their privacy in payments if the net personal benefit is positive

- Total welfare (ignoring aggregate money holding) equals

$$W^* = \begin{cases} 2zn & \text{Consumers with high valuations} \\ r_H + 2(1 - z)n r_L + 2en(\beta - \delta), & \text{Consumers with low valuations} \end{cases}$$

where $e = 1$ when $\beta \geq \delta$ and $e = 0$ otherwise.
Outcome with price discrimination

- we assume $zr_H < r_L$
- to be willing to price discriminate, merchants need to learn something about the relationship between consumer characteristics (observable) and consumer types (unobservable).
- when $\beta \geq \delta$ this requires experimentation with high reserve prices
- when $\beta < \delta$ can use information obtained from consumers paying without protecting their privacy
Price Discrimination when $\beta \geq \delta$

Consumers protect their privacy in payments

- Meet middle-aged: Quote the high price $r_H$ to all consumers.
  - Type $H$ consumers accept the offer
  - Type $L$ consumers reject the offer
- Meet old: Quote high price to consumers with characteristic associated with type $H$ and low price to all others.
  - Type $H$ consumers accept the offer
  - Only correctly classified type $L$ consumers accept the offer
- Not all “win-win” situations lead to transactions.
  - Welfare will be lower than $W^*$
    \[ W^{UD} = W^* - n(1 + \varepsilon)(1 - z)r_L \]

- Price discrimination is optimal for merchants whenever the profiling technique is sufficiently precise: $\varepsilon < \theta^U(z, r_H, r_L)$. 
Price Discrimination when $\beta < \delta$

Consumers do not protect their privacy in payments

- Meet middle-aged: Quote the low price $r_L$ to all consumers.
  - All consumers accept the offer
- Meet old: Quote high price to consumers with characteristic associated with type $H$ and low price to all others.
  - Type $H$ consumers accept the offer
  - Only correctly classified type $L$ consumers accept the offer

- Not all “win-win” situations lead to transactions.
  - Welfare will be lower than $W^*$
    $$W^{WD} = W^* - n\varepsilon(1 - z)r_L.$$  
- Price discrimination is optimal for merchants whenever the profiling technique is sufficiently precise: $\varepsilon < \theta^W(z, r_H, r_L).$
Profiling Accuracy and Price Discrimination

Perfect profiling

0

$\theta^u$

Price discrimination

Price discrimination without, but not with privacy in payments

$\theta^w$

1/2

Uninformative profiling

No price discrimination
Dynamic Model

Every period, there are $n$ new agents who live three periods

- Agent $i$ starting in generation $t$
  - can produce up to three perishable consumable goods when young
  - meets random middle-aged agent and two random old agents
  - wishes to consume when middle-aged (meeting A) and when old (meetings B and C)
  - has utility function

$$u(c^A_{it}, c^B_{it}, c^C_{it}, Q_{it}, e_{it}) = c^A_{it} + c^B_{it} b + c^C_{it} c - Q_{it} f + e_{it} (\beta - \delta),$$

Consumption

Production

where $\frac{1}{3} < c < 1 < b$ and the production cost $f < 1/3$
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where $\frac{1}{3} < c < 1 < b$ and the production cost $f < 1/3$

- Agents can carry up to 3 units of an indivisible durable asset
Dynamic Model

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u(c^A_{it}, c^B_{it}, c^C_{it}, Q_{it}, e_{it}) = c^A_{it} + c^B_{it} b + c^C_{it} c - Q_{it} f + e_{it}(\beta - \delta),\]

where \( \frac{1}{3} < c < 1 < b \) and the production cost \( f < 1/3 \)

- Agents can carry up to 3 units of an indivisible durable asset
- In total \( 4n \) units of this asset ("money"), no record-keeping
Dynamic: Timeline when Young

- Young agent \( i \) is born
- Middle-aged and old agents randomly adopt observable characteristics \( h_{i,t-1}^t \) and \( h_{i,t-2}^t \) based on their respective statuses \( s_{i,t-1} \) and \( s_{i,t-2} \) and the time-specific relationships between \( h_{i,\tau}^t \) and \( s_{i,\tau} \), \( \tau \in \{t-1, t-2\} \), for period \( t \)

\[ h_{i,t}^t \]

Meeting A

- Young agent \( i \) randomly meets a middle-aged agent
- Makes a take-it-or-leave-it offer
- If offer is accepted, the young agent produces a unit of the good for the old agent

Meeting B

- Young agent \( i \) randomly meets an early old agent
- Makes a take-it-or-leave-it offer
- If offer is accepted, the young agent produces a unit of the good for the old agent

Meeting C

- Young agent \( i \) randomly meets a late old agent
- Makes a take-it-or-leave-it offer
- If offer is accepted, the young agent produces a unit of the good for the old agent

\[ t+1 \]

- Consumable goods and old agents perish
- Young agent \( i \) (potentially) receives inheritance from an old agent
- Young agent \( i \) attains lifetime status \( s_i = \{H, L\} \) based on whether or not she accumulated three units of money
- Young agent \( i \) turns middle-aged
Dynamic: Timeline when Young

- Young agent $i$ is born
- Middle-aged and old agents randomly adopt observable characteristics $h_{i,t-1}^t$ and $h_{i,t-2}^t$ based on their respective statuses $s_{i,t-1}$ and $s_{i,t-2}$ and the time-specific relationships between $h_{i,t}^t$ and $s_{i,t}$, $\tau \in \{t-1, t-2\}$, for period $t$

$t$

Meeting A
- Young agent $i$ randomly meets a middle-aged agent
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- Young agent $i$ randomly meets a late old agent
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Dynamic: Timeline when Young

- Young agent \( it \) is born
- Middle-aged and old agents randomly adopt observable characteristics \( h_{i,t-1}^t \) and \( h_{i,t-2}^t \) based on their respective statuses \( s_{i,t-1} \) and \( s_{i,t-2} \) and the time-specific relationships between \( h_{i,t}^t \) and \( s_{i,t} \), \( \tau \in \{t-1, t-2\} \), for period \( t \)

\[ t \]

\begin{align*}
\text{Meeting A} & \quad \text{Meeting B} & \quad \text{Meeting C} & \quad t + 1 \\
\cdot \text{Young agent } it \text{ randomly meets a middle-aged agent} & \cdot \text{Young agent } it \text{ randomly meets an early old agent} & \cdot \text{Young agent } it \text{ randomly meets a late old agent} & \cdot \text{Consumable goods and old agents perish} \\
\cdot \text{Makes a take-it-or-leave-it offer} & \cdot \text{Makes a take-it-or-leave-it offer} & \cdot \text{Makes a take-it-or-leave-it offer} & \cdot \text{Young agent } it \text{ (potentially) receives inheritance from an old agent} \\
\cdot \text{If offer is accepted, the young agent produces a unit of the good for the old agent} & \cdot \text{If offer is accepted, the young agent produces a unit of the good for the old agent} & \cdot \text{If offer is accepted, the young agent produces a unit of the good for the old agent} & \cdot \text{Young agent } it \text{ attains lifetime status } s_t = \{H, L\} \text{ based on whether or not she accumulated three units of money} \\
\cdot \text{Young agent } it \text{ turns middle-aged} & \quad & \quad & \quad \end{align*}

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Dynamic Model: Best Feasible Monetary Equilibrium

Socially optimal allocation

- Young agent always charge a price of one
- They earn 2 or 3 units of money, each with probability 1/2
- $\mathbb{E}u^* = 1 + b - 2f + \frac{1}{2}(c - f) + $ potential privacy benefit

This is a monetary equilibrium if

P1 profiling errors $\epsilon \geq \theta^U$ for $\beta > \delta$ (individuals protect privacy)
P2 profiling errors $\epsilon \geq \theta^W$ for $\beta < \delta$ (individuals do not protect privacy)
P3 where $\theta^U < \theta^W$ as in the one-period model

Otherwise, young agents optimally price discriminate.
Privacy in Payments and Big Data: Past, Present & Future

\[ \beta - \delta \]

- Socially optimal monetary equilibrium feasible
- Socially optimal monetary equilibrium not feasible

Past\end{itemize}

- Future?

Present\end{itemize}

Future?
Privacy in Payments and Big Data: Past, Present & Future

\[ \beta - \delta \]

- **Past**
  - Socially optimal monetary equilibrium 
  - Feasible

- **Present**
  - Socially optimal monetary equilibrium 
  - Feasible

- **Future?**
  - Socially optimal monetary equilibrium 
  - Not feasible

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Concluding remarks

Options for promoting privacy in payments

- Encourage/subsidize cash use
  - Does not address increasing share of online payments
- Promotion of electronic cash substitutes
  - CBDC (designed as electronic cash)
  - Privacy preserving cbDC (eg Digicash)
  - Cryptocurrencies (eg Bitcoin)
- Regulation to promote privacy in payments
  - Makes current payment methods more “cash-like”
  - Social optimum not necessarily achieved with consent-based approach (externality)

Advantages of CBDC

- “…(i) financial inclusion, (ii) security and consumer protection; and to provide what the private sector cannot: (iii) privacy in payments.”
  (Christine Lagarde, 2018)
Thank you!