Excessive intermediation in two-sided markets

based on

(1) *Equilibrium in two-sided markets for payments: consumer awareness and the welfare cost of the interchange fee* (Kim P. Huynh, Gradon Nicholls and Alex Shcherbakov), and

(2) *Interchange fee, market structure and excessive intermediation in the payment markets* (Hanna Halaburda, Soo Jin Kim and Alex Shcherbakov)

presented by
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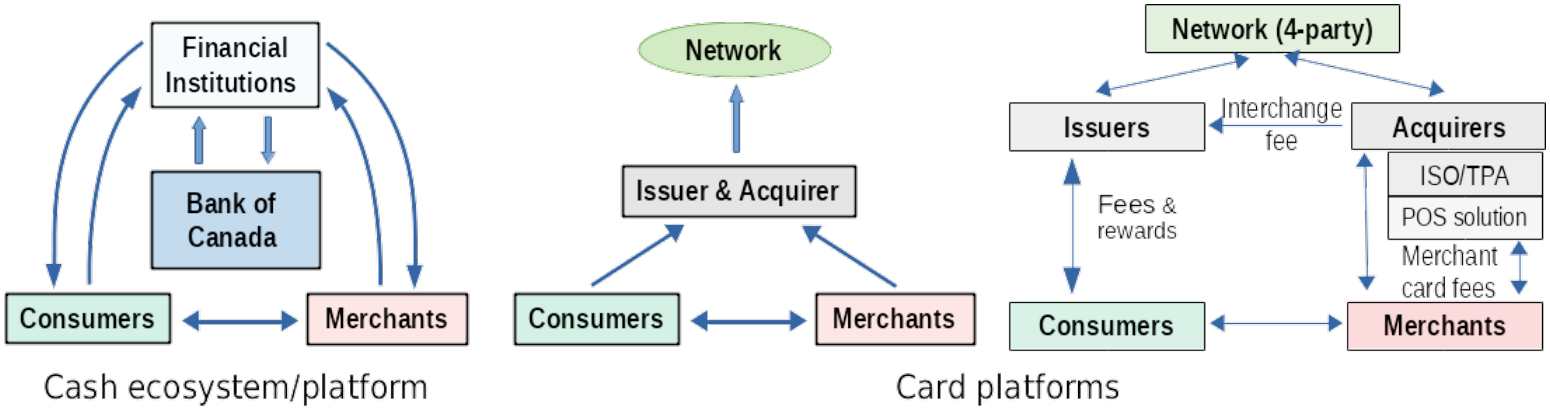
Introduction: What do we do?

- Study two-sided market for payment instruments.
- Develop an equilibrium structural model of a payment ecosystem



consumers & merchants make adoption, acceptance and usage decisions.

- Important features
  - focus on the POS transactions;
  - consumers awareness about merchant decisions;
  - consumers & merchants can multi-home;
  - structural interpretation of network effects;
  - profit-maximizing issuers & acquirers in the upstream market.

Introduction: Why do we care?

- Two important observations about the payment industry
  - declining use of cash at the POS,
  - emergence of private and central bank digital currencies.

  raise lots of interesting questions about
  - potential transition to a cashless economy,
  - distributional effects of payment instruments and financial inclusion,
  - new technologies, platform intermediation and social welfare.
- Our objectives are
  1) identify key determinants of consumer & merchant decisions;
  2) relate the interchange fee, market equilibrium and social welfare;
  3) deliver insights into the role of competition between the networks;
  4) assess the importance of the double-marginalization problem.

Introduction: Preview of the results

- Network effects can be heterogeneous and non-monotone
  - $\Uparrow$ consumer adoption leads to $\Uparrow$ or $\Downarrow$ merchant acceptance.
- Interchange fee & social welfare
  - in 2014, socially optimal interchange fee was lower than observed.
- Competition in the upstream market
  - has asymmetric effects for outcomes on opposite sides;
  - to maximize welfare need fewer issuers & more acquirers.
- Double-marginalization problem exists
  - joint profit maximization $\Longrightarrow$
    - $\Uparrow$ 9% in consumer rewards;
    - $\Downarrow$ in merchant fees;
    - $\Uparrow$ 4.5% in total welfare;
    - overall, merchants & issuers lose, consumers & acquirers win.

Introduction: Related literature

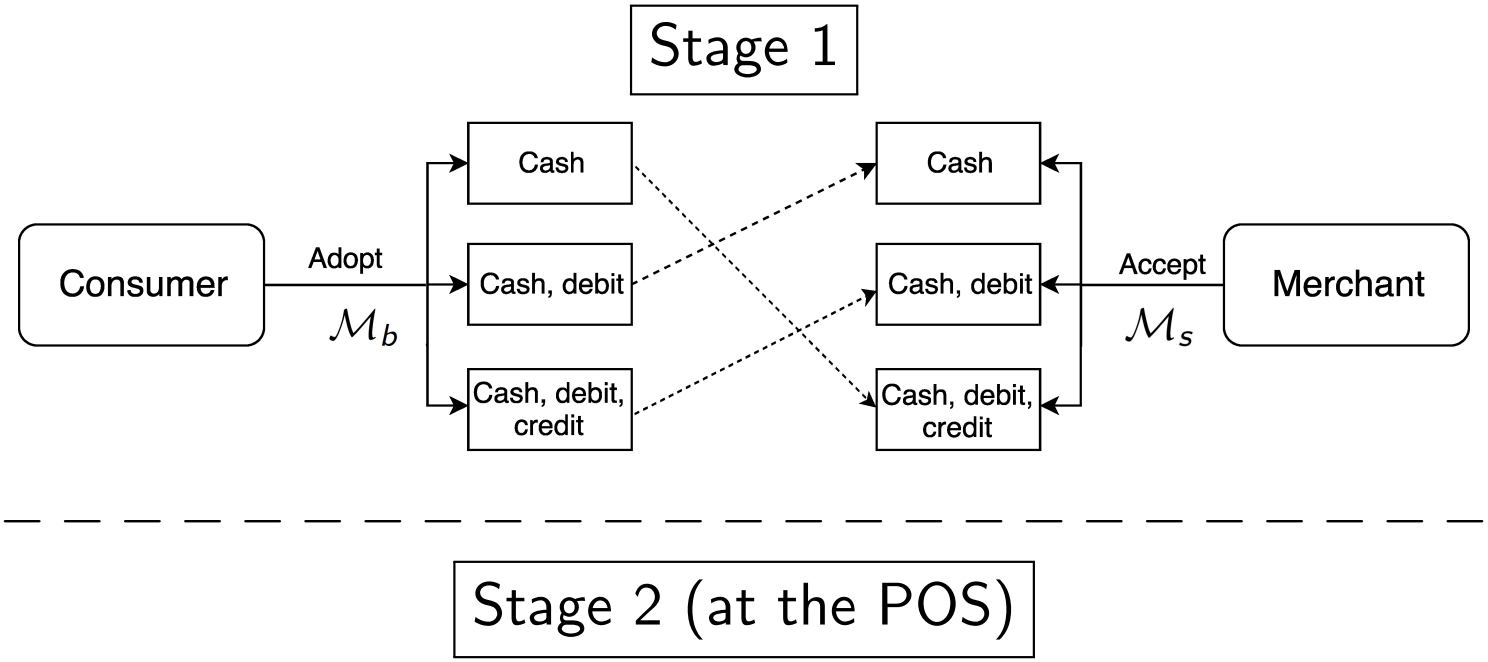
- Theory work on multi-sided markets and platforms
  - Rochet and Tirole (2002; 2003; 2011), Schmalensee (2002), Rochet (2003), Wright (2003; 2004), Belleflamme and Peitz (2019), Anderson and Peitz (2020), Jain and Townsend (2020),
  - Bedre-Defolie and Calvano (2013), Edelman and Wright (2015)
- Empirical models of payment choice
  - Gowrisankaran and Stavins (2004), Rysman (2007; 2009), Loke (2007), Schuh and Stavins (2010), Jonker (2011), Carbó-Valverde et al. (2016), Bounie et al. (2016), Li et al. (2019),
  - Koulayev et al. (2016)

Model: Outline

- Consumers:
  - want to complete a set of exogenously given transactions;
  - can always use cash;
  - can use debit or credit card only if merchants accept them;
  - can be unaware about merchant acceptance choice;
  - choose what to adopt and what to use at the POS.
- Merchants:
  - price-takers and maximize profit by choosing what to accept;
  - we do not model supply of real products (assume constant margin);
  - choose what to accept at the POS.
- Equilibrium:
  - two-stage repeated game played every period:
    (1) adoption & acceptance stage, followed by
    (2) usage stage and payoff realization.
  - depends on the consumer awareness about merchant choice;
  - Subgame Perfect Nash Equilibrium (SPNE) as the solution concept.

Model: Outline

- Two-stage game representation:
  1) consumes and merchants choose what to adopt/accept,
  2) for each transaction a consumer and a merchant are matched: uninformed are randomly matched, informed use directed search,
  3) consumers choose what to use at the POS.



- *Informed* consumers: choose from their adoption set $\mathcal{M}_b$;
- *Uninformed* consumers: choose from an overlap $\mathcal{M}_b \cap \mathcal{M}_s$.

Model: Consumer side

- Every consumer b is endowed with a set of transactions, $\mathcal{J}_b$.
- A transaction is characterized by (p_{bj}, I_{bj}, T_{bj}):
  - p_{bj} is transaction value,
  - I_{bj} is transaction-specific information status (informed or uninformed),
  - T_{bj} is transaction type (e.g., gas, groceries, parking, durable products).
- Consumer per-transaction utility at the POS

$$U_{bjm} = X_{bm}\beta + \alpha\, C_{bm}(p_{bj}) + \xi_m(D_b, T_{bj}) + \epsilon_{bjm},$$

where

  - $m \in \{ca, dc, cc\}$ denotes payment instrument;
  - X_{bm} perceptions of ease-of-use, security, costs;
  - $C_{bm}(p_{bj})$ transaction cost as a function of transaction value;
  - $\xi_m(D_b, T_{bj})$ match value between consumer, transaction type and a payment instrument such that $\xi_{ca,b,j} \equiv 0\ \forall b, j$;
  - ϵ_{bjm} iid innovations at the POS;
  - $(\alpha, \beta, \xi_{mbj})$ are parameters to estimate.

Model: Consumer side

- Expected maximum utility in the second stage,

$$EU_b(\mathcal{M}_b) = \sum_{j \in \mathcal{J}_b} \mathbb{E}_\epsilon \left[I_{bj} \max_{m \in \mathcal{M}_b} U_{bjm} + (1 - I_{bj}) \sum_{\mathcal{M}_s \in \mathcal{M}} \bar{P}_{\mathcal{M}_s} \max_{m \in \mathcal{M}_b \cap \mathcal{M}_s} U_{bjm} \right],$$

  where
  - $\mathcal{M}_b \in \{\{ca\}, \{ca, dc\}, \{ca, dc, cc\}\}$ is adoption combination;
  - $\bar{P}_{\mathcal{M}_s}$ is a vector of probabilities of merchant acceptance choices;

- Adoption probability

$$P_{b,\mathcal{M}_b} = \Pr\left(\mathcal{M}_b = \arg\max_{\mathcal{M}'_b \in \mathcal{M}} \left\{ EU_b(\mathcal{M}'_b) - F_{b,\mathcal{M}'_b} \right\} \right),$$

  where
  - $F_{b,\mathcal{M}_b}$ is combination-specific adoption cost to estimate, which
  - is a function of observable characteristics (perceptions, demographics).

Model: Merchant side

- Incur method-specific usage cost at the POS

$$C_{sm}(p_{bj}) = c_{0sm} + c_{1sm} p_{bj},$$

where

  - p_{bj} is transaction value, and
  - (c_{0sm}, c_{1sm}) are parameters known from previous studies.

- Every merchant earns constant per-transaction profit margin

$$\gamma_{sbj} \equiv \frac{p_{bj} - mc_{sbj}}{p_{bj}},$$

where

  - mc_{sbj} is marginal cost of product j offered to buyer b by merchant s,
  - we assume $\gamma_{sbj} = \gamma$ for all s, b, j.

- Acceptance probability

$$P_{s,\mathcal{M}_s} = \Pr\left(\mathcal{M}_s = \arg\max_{\mathcal{M}'_s \in \mathcal{M}} \left\{ \mathrm{E}\Pi_s(\mathcal{M}'_s) - F_{s,\mathcal{M}'_s} \right\}\right).$$

where $F_{s,\mathcal{M}_s}$ is a function of merchant size.

Model: Summary

- Consumers
  - make adoption decisions in anticipation of the usage stage,
  - since adoption is costly have to consider
    (1) expected merchant acceptance decisions, and
    (2) own awareness about exact merchant choices.
- Merchants
  - can attract informed consumers by accepting more methods;
  - wider acceptance combinations do not minimize operating costs;
  - due to the fixed acceptance costs have to consider
    (1) expected consumer adoption, and
    (2) consumer awareness about own acceptance choice.
- In equilibrium
  - each side solves a corresponding single-agent maximization problem;
  - consumer expectations are consistent with realized merchant choice;
  - merchant expectations are consistent with realized consumer choice.

Model: Estimation method

- We construct joint likelihood function

$$\mathcal{L}(\theta_1^b, \theta_2^b, \theta_1^s) = \prod_{b=1}^{N_b} \prod_{\mathcal{M}_b \in \mathcal{M}} P_{b,\mathcal{M}_b}^{*\ A_{b,\mathcal{M}_b}}$$
$$\times \prod_{b=1}^{N_b} \prod_{j \in \mathcal{J}_b} \prod_{m \in \{ca,dc,cc\}} P_{bjm}^{*\ a_{bjm}}$$
$$\times \prod_{s=1}^{N_s} \prod_{\mathcal{M}_s \in \mathcal{M}} P_{s,\mathcal{M}_s}^{*\ A_{s,\mathcal{M}_s}},$$

where the first line matches consumer adoption decisions, the second line is for the equilibrium usage decisions, and the last line is for merchant acceptance choice.

Caveats: It is worth noting

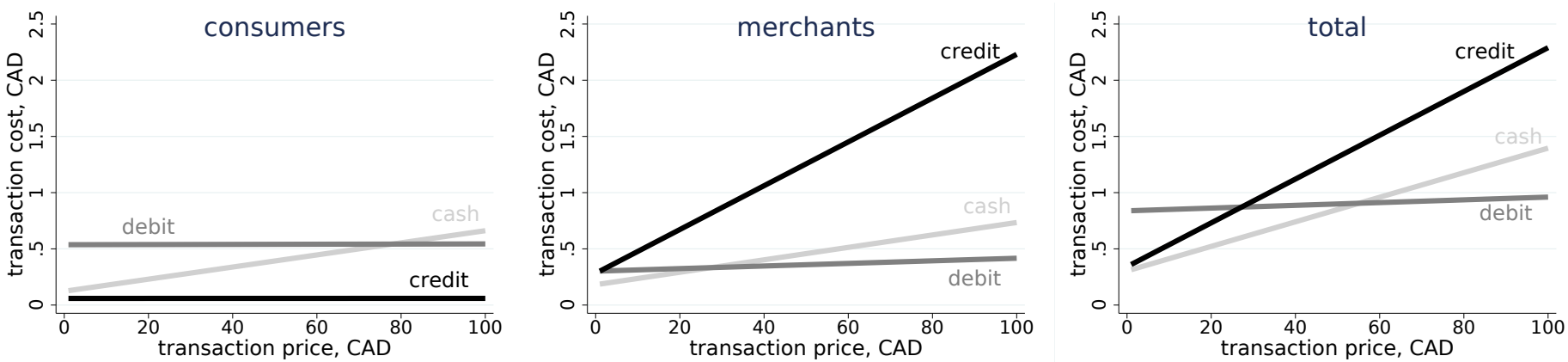
- We do not model large merchants and strategic interactions:
  - no data for identification of these;
  - we care about small and medium firms for financial inclusion reasons;
  - cost: ignoring network effects from the choices by large acquirers.
- The role of consumer awareness:
  - accounts for repeated purchases made by consumers over time:
    - returning customers is an empirical fact, very few "tourists".
  - incentivize merchants to accept wider set of instruments
    - no reason to accept costlier instruments otherwise!
  - reduces networks effect from acceptance choice of local stores:
    - consumer can patronize a store accepting their preferred instruments.
- Heterogeneity of merchants:
  - our merchants differ by (1) size, (2) vector of usage costs, and (3) acceptance choice;
  - we assume every merchant sells all the products recorded in the DSI.
  - Why? No data to support further heterogeneity in the model.

Data: Sources

- CONSUMERS: 2013 MOP Survey
  1) Survey Questionnaire, and
  2) Diary Survey Instrument (3-day purchases).
     - Cost functions for each payment instrument from Kosse et al. (2017).

- MERCHANTS: 2015 RSCPM.
  - Cost functions for each payment instrument from Kosse et al. (2017)

Figure: Linear usage cost functions



Data: Summary Statistics

Table: Summary statistics for the POS transaction types and prices

Transaction type	Frequency of use			Prices		
	Cash	Debit	Credit	Mean	Median	SD
Groceries/drugs	0.39	0.26	0.34	34.34	20.00	41.43
Gasoline	0.20	0.29	0.51	45.32	41.00	24.23
Personal attire	0.25	0.29	0.46	53.59	34.00	51.95
Health care	0.35	0.27	0.38	50.75	32.50	55.46
Hobby/sporting goods	0.41	0.19	0.40	37.70	20.00	47.55
Professional/personal services	0.45	0.16	0.39	55.88	32.00	57.71
Travel/parking	0.61	0.10	0.29	23.46	10.00	37.55
Entertainment/meals	0.59	0.18	0.23	17.43	9.00	26.21
Durable goods	0.30	0.26	0.45	49.27	30.00	57.78
Other	0.55	0.20	0.24	31.77	15.00	45.31
Average	0.44	0.23	0.33	32.95	18.50	41.66

Notes: The number of observations is 12,029. Our sample includes transactions completed at the POS only and, hence, may represent the lower tail of the distribution of consumer expenditures.

Data: Summary Statistics

Table: Consumer awareness, probability of repeated visits, 2017

	Age, years		Income, '000		Gender		University		Price, CAD	
Transaction type	≤ 25	> 25	< 65	≥ 65	male	female	No	Yes	< 100	≥ 100
Groceries/drugs	0.96	0.98	0.97	0.98	0.98	0.97	0.98	0.97	0.98	0.97
Gasoline	0.96	0.96	0.98	0.94	0.95	0.97	0.96	0.96	0.96	0.90
Personal attire	0.91	0.92	0.94	0.90	0.91	0.92	0.92	0.92	0.91	0.94
Health care	0.79	0.92	0.92	0.89	0.87	0.94	0.92	0.89	0.92	0.85
Hobby/sporting goods	0.90	0.91	0.88	0.93	0.86	0.93	0.91	0.90	0.91	0.82
Professional service	0.79	0.84	0.81	0.85	0.84	0.83	0.87	0.81	0.82	0.86
Travel/parking	0.92	0.88	0.90	0.87	0.84	0.94	0.86	0.90	0.89	0.88
Entertainment/meals	0.90	0.92	0.94	0.90	0.93	0.91	0.94	0.90	0.92	0.76
Durable goods	0.96	0.94	0.94	0.95	0.95	0.94	0.95	0.94	0.97	0.87
Other	0.87	0.93	0.94	0.91	0.93	0.92	0.94	0.91	0.93	0.89

Notes: The numbers represent frequencies of consumers' reported return visits to stores by transaction type, age, income, gender, education level and transaction price. These data will be used to impute the probabilities of being aware about combinations of merchant payment acceptances in 2013.

Table: Distribution of merchant by revenue

	Revenue, thousands of CAD							Total
	50	175	375	625	875	3,000	7,500	
Number	149	114	124	72	58	182	34	733
Percent	20.33	15.55	16.92	9.82	7.91	24.83	4.64	100
Cumulative	20.33	35.88	52.8	62.62	70.53	95.36	100	

Notes: The data description can be found in Kosse et al. (2017)

Data: Summary Statistics

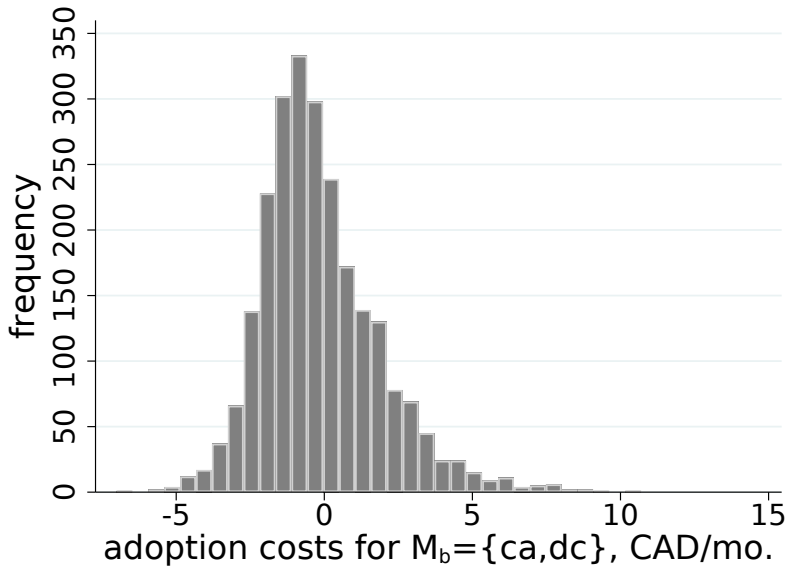
Table: Summary statistics for perception variables

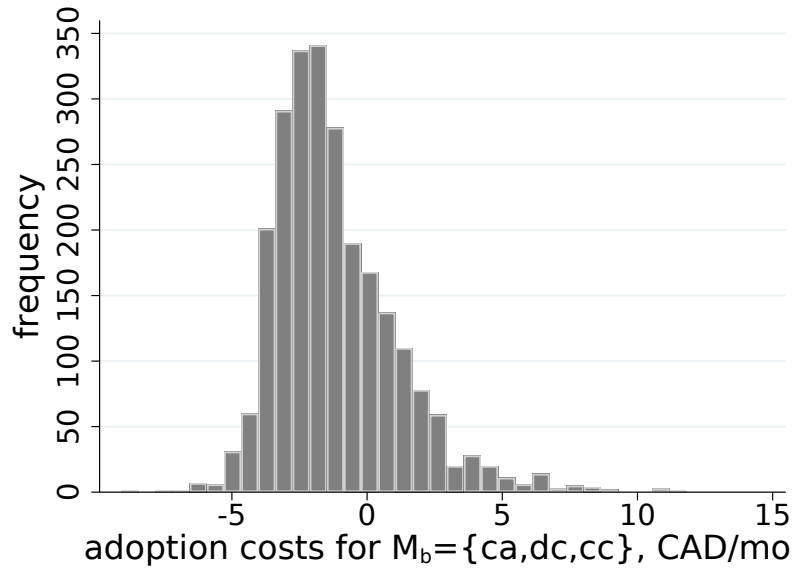
Characteristic	Method	Mean	Median	Min	Max	SD
Ease of use	cash	4.70	5.00	1.00	5.00	0.64
	debit	4.48	5.00	1.00	5.00	0.72
	credit	4.48	5.00	1.00	5.00	0.73
Affordability	cash	4.58	5.00	1.00	5.00	0.78
	debit	3.74	4.00	1.00	5.00	1.10
	credit	2.97	3.00	1.00	5.00	1.34
Security	cash	4.25	5.00	1.00	5.00	1.01
	debit	3.76	4.00	1.00	5.00	0.91
	credit	3.64	4.00	1.00	5.00	0.95
Acceptance	cash	3.92	4.00	1.00	4.00	0.36
	debit	3.66	4.00	1.00	4.00	0.64
	credit	3.59	4.00	1.00	4.00	0.61

Notes: In estimation, we normalize all perception variables using the formula: $X_m = \hat{X}_m / \left(\hat{X}_{ca} + \hat{X}_{dc} + \hat{X}_{cc}\right)$, *where* $\hat{X}_m$ *denotes the consumer rating on a 4- or 5-point Likert scale, with the larger values denoting higher characteristics.*

Estimation Results: Adoption Costs & Benefits

Figure: Expected adoption costs/benefits for $\mathcal{M}_b = \{ca, dc\}$ and $\mathcal{M}_b = \{ca, dc, cc\}$





Adoption costs/benefits	Mean	Median	Min	Max	SD
Cash and debit	-0.15	-0.43	-7.01	10.70	2.01
All payment methods	-1.18	-1.61	-9.09	11.82	2.29

Notes: The left-hand panel is a histogram of adoption costs for the cash and debit combination, while the right-hand panel is a histogram of adoption costs for the combination including all means of payments. All numbers are in Canadian dollars per month.

Estimation Results: Estimates of Match Values

- Match values: consumer $\times$ transaction type $\times$ payment instruments
  - unobserved factors (e.g., fees/rewards, nonpecuniary costs), which are
  - not explained by the observed covariates, e.g.,
  - Costco members (high income&consumption) have 3% cashback on gas.

- Estimated as FEs (cash values normalized to zero) ⏩ Estimates:
  - all else equal, consumers Debit $\succ$ Cash $\succ$ Credit;
  - older consumers don't like electronic payment instruments;
  - preference for credit transactions increases with income and education;
  - strong positive correlation in the "quality" of debit & credit cards;
  - ⏩ Projection

Estimation Results: Merchant-side Parameters

- We estimate gross profit margin at 5.2 percent of price.
- After banking fees are paid it reduces to 3.4 percent.
- Net of acceptance costs the margin drops to 1.6 percent.

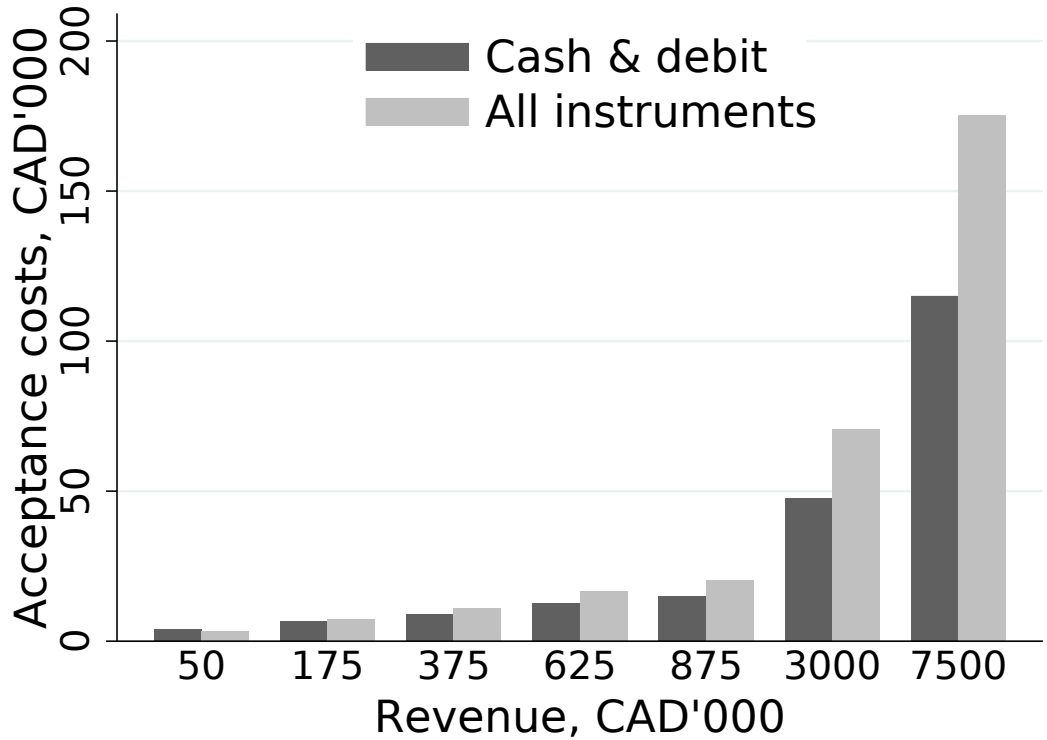
Table: Merchant profit measures (thousands of Canadian dollars)

Revenue, R_s	Gross as given by $\gamma \times R_s$	Net of banking fees		Net of acceptance cost	
		profit	margin, %	profit	margin, %
50	2.58	1.67	3.34	1.00	2.01
175	9.02	5.89	3.37	3.10	1.77
375	19.32	12.84	3.42	5.23	1.40
625	32.20	21.00	3.36	8.96	1.43
875	45.08	29.75	3.40	11.92	1.36
3000	154.55	100.54	3.35	41.77	1.39
7500	386.37	248.80	3.32	105.09	1.40
Average	68.22	44.35	3.37	18.64	1.58

Estimation Results: Merchant-side Parameters

- Merchants accept more instruments to attract informed consumers.
- Difference in acceptance costs increases with firm size.
- Rental cost of terminals is very small relative to total costs.

Figure: Merchant acceptance costs by revenue



Estimation Results: Network Effects

- How to measure various network effects, and
  - can we avoid making ad hoc assumptions on cross-method substitution?
- Adoption, acceptance and usage and cost shocks:
  - how does usage respond to cost shocks on each side? Let
    - $P^*_{b,j,cc}$: equilibrium usage probability for CC,
    - $\Pr(\mathcal{M}_s)$: merchant acceptance probability for CC,
    - $\Pr(\mathcal{M}_b)$: consumer adoption probability for CC,

$$E^{usage}_{C_{b,cc}} = \mathbb{E}_{b,j}\left[\frac{\partial P^*_{b,j,cc}}{\partial C_{b,j,cc}}\frac{C_{b,j,cc}}{P^*_{b,j,cc}}\right]$$

elasticity of usage probabilities w.r.t. consumer usage cost.

  - Cross-elasticities of adoption and acceptance w.r.t. costs of other side

$$E^{\text{merch. acceptance}}_{\text{cons. costs}} = \mathbb{E}_s\left[\frac{\partial \Pr(\mathcal{M}_s = \{ca, dc, cc\})}{\partial \text{ consumer costs}}\frac{\text{costs}}{\Pr(\cdot)}\right]$$

merchant acceptance w.r.t. consumer adoption costs;

$$E^{\text{cons. adoption}}_{\text{merch. costs}} = \mathbb{E}_b\left[\frac{\partial \Pr(\mathcal{M}_b = \{ca, dc, cc\})}{\partial \text{merchant costs}}\frac{\text{costs}}{\Pr(\cdot)}\right]$$

consumer adoption w.r.t. merchant acceptance costs.

Estimation Results: Network Effects

- Equilibrium usage probabilities w.r.t. usage costs
  - inelastic: $E^{usage}_{C_b,cc} = -0.33$ (cons.) vs $E^{usage}_{C_s,cc} = -0.07$ (merch.), and
  - respond more to shocks to the consumer usage cost.
- Cross-elasticities of adoption and acceptance:

	w.r.t. merchant acceptance costs	w.r.t. consumer adoption costs
merchant acceptance	-3.708	**0.036**
consumer adoption	-0.013	-0.178

  - lower consumer adoption of CC $\Longrightarrow$ higher merchant acceptance!
- Heterogeneity in merchant response:
  - stats for $E^{\text{merch. acceptance}}_{cons.costs}$: $min = -0.62, max = 0.46, sd = 0.11$;
  - share of merchants with positive elasticity is 0.54.

Estimation Results: Network Effects

- Main drivers of $\Uparrow$ acceptance response to $\Downarrow$ adoption are:
  1) relative merchant costs of instruments (CC is most expensive),
  2) inelastic consumer demand for transactions,
  3) larger bundles include all instruments from smaller ones.
- When cash or debit is used instead of CC
  - positive surplus is generated for merchants due to (1).
- Extra surplus is distributed across acceptance bundles such that
  - substitution to cash doesn't change relative values of bundles, since cash belongs to every bundle, but
  - substitution to debit $\Uparrow$ value of $\{ca, dc\}$ and $\{ca, dc, cc\}$ relative to $\{ca\}$
    $\Rightarrow$ $\Pr(\mathcal{M}_s = \{ca, dc\}$ and $\Pr(\mathcal{M}_s = \{ca, dc, cc\})$ increase,
    $\Rightarrow$ $\Pr(\mathcal{M}_s = \{ca\})$ decrease.
- Intuition: if consumers substitute more expensive CC by debit, merchant incentives to adopt bundles containing debit increase.

Counterfactual 1. Interchange fee & welfare

- Interchange fee (IF) is a transfer from acquirer to issuer:
  - $\Uparrow$ merchant costs of using CC;
  - $\Downarrow$ consumer costs or $\Uparrow$ consumer rewards.
- Price coherence and price-taking behavior in product market
  - cannot surcharge, and
  - cannot pass increase in costs to product prices.
- We assume
  1) Full pass through on the acquiring side;
  2) Profit maximizing monopoly issuer

$$\max_{B \in \mathbb{R}} \sum_{s} \sum_{b} \sum_{j} (\mathrm{IF} - B - MC^{i}) \times p_{bj} \times P^{*}_{sbj,cc},$$

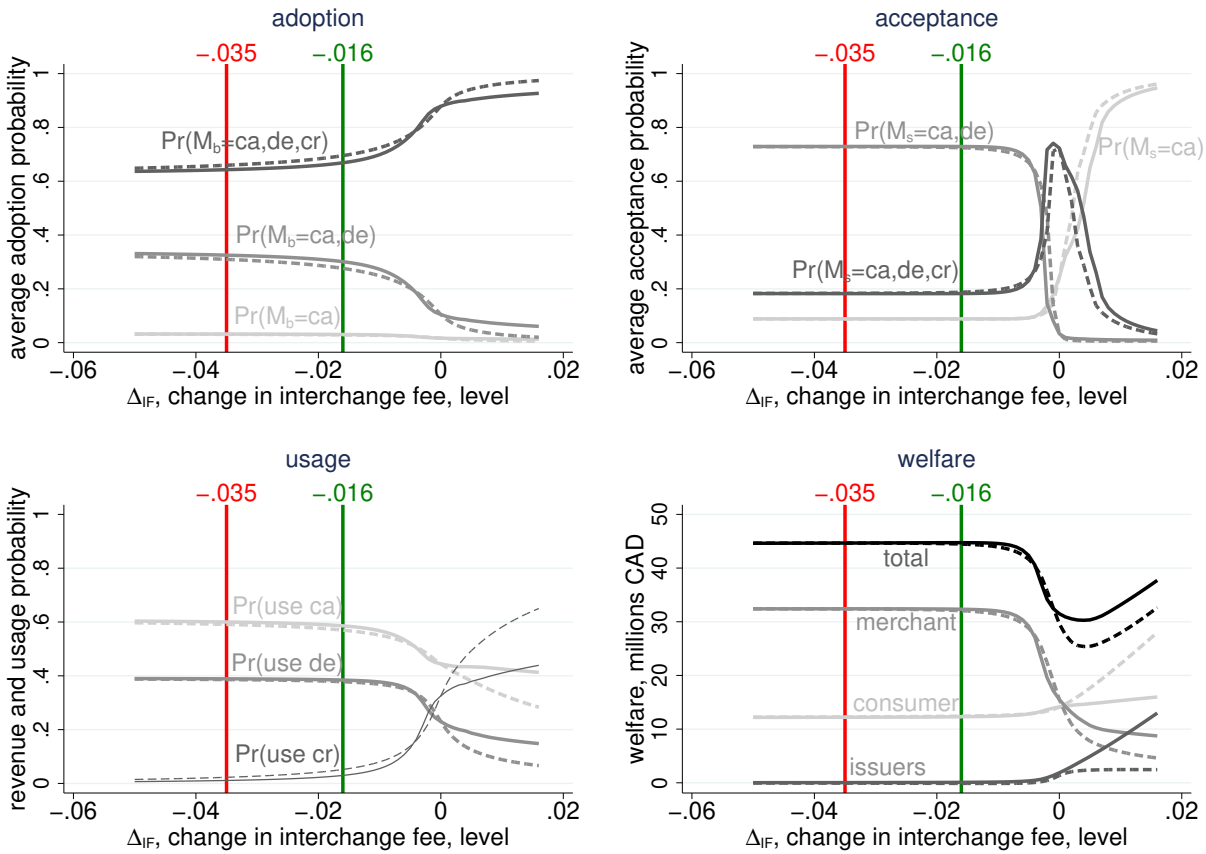
  where MC^{i} is issuer marginal cost, p_{bj} is transaction price, and $P^{*}_{sbj,cc}$ is the equilibrium probability of using CC;
  3) Exogenous change in the interchange fee, Δ_{IF}.

▸▸ Define surpluses & welfare

Counterfactual 1. Interchange fee & welfare

- When a monopoly issuer responds to a change in IF
  - by full pass-through, total welfare is maximized at **red line** ($\Delta^*_{\text{IF}} = -0.035$);
  - by optimal pass-through, it is at max at **green line**, i.e., $\Delta^*_{\text{IF}} = -0.016$;
  - CC was too costly for society in 2014 (it was overused relative to optimum).

Figure: Equilibrium response to changes in merchants' per-value cost of credit

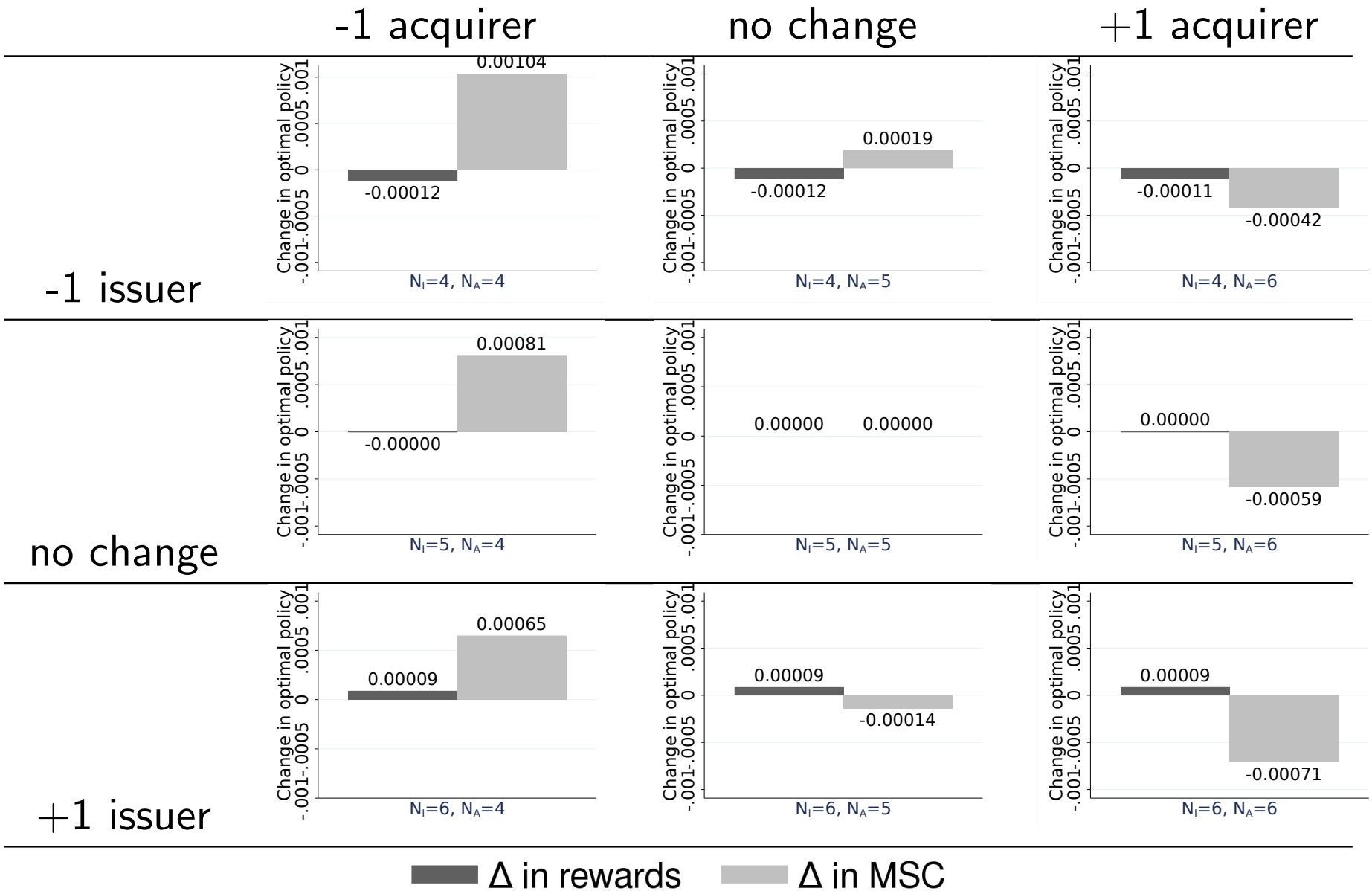


Counterfactual 2. Competition in the upstream market

- How are the equilibrium fees changing with the number of firms?
  - Can more issuers and acquirers resemble competition between networks?
  - Assume adding a network $\equiv \Uparrow$ number of issuers and acquirers by one.
- Quantity competition for consumers and merchants $\Longrightarrow$
  - Issuer's markup $\equiv \mathrm{IF} - B - MC^i$ (control variable B)
    - non-discriminating monopolist retains 19% of IF;
    - discriminating across consumers retains 48% of IF.
  - Acquirer's markup $\equiv f - \mathrm{IF} - MC^a$ (control variable f)
    - non-discriminating monopolist earns 1.08% of transaction value;
    - discriminating across merchants 3.27% of transaction value.
- Assume current market structure is $N_I = N_A = 5$, symmetric players
  - uniform price on the consumer side, $B_{s,b,j} = B \ \forall s, b, j$;
  - individual merchant prices in each market s, $f_{s,b,j} = f_s \ \forall b, j$.
- Using estimates of ⏩ issuer and ⏩ acquirer markups
  - simulate optimal responses to changes in the number of players.

Counterfactual 2. Competition in the upstream market

Change in rewards and merchant fees



Counterfactual 2. Competition in the upstream market

Change in welfare

	-1 acquirer	no change	+1 acquirer
-1 issuer	CS=99.56 PS=100.20 **IS=112.70** **AS=109.41** NS=97.98 TS=100.66	CS=99.60 PS=101.69 IS=112.52 AS=100.61 NS=98.10 TS=100.81	CS=99.63 **PS=102.76** IS=112.32 AS=93.74 NS=98.21 **TS=100.87**
no change	CS=99.97 PS=98.47 IS=99.96 AS=108.54 NS=99.90 TS=99.82	CS=100.00 PS=100.00 IS=100.00 AS=100.00 NS=100.00 TS=100.00	CS=100.02 PS=101.12 IS=100.03 AS=93.32 NS=100.07 TS=100.10
+1 issuer	CS=100.27 PS=97.37 IS=89.59 AS=107.68 NS=101.29 TS=99.26	CS=100.29 PS=98.91 IS=89.95 AS=99.35 NS=101.34 TS=99.46	**CS=100.32** PS=100.02 IS=89.97 AS=92.82 **NS=101.41** TS=99.56

- Consumer surplus is maximized with increased competition on both sides.
- Downstream market surplus is maximized with less issuers & more acquirers.
- Upstream market surplus is maximized with less competition on both sides.
- Total welfare is maximized with less issuers & more acquirers.

Counterfactual 3. Double-marginalization problem:

- Independent profit maximization by issuers and acquirers
  - positive margins: $\widehat{\mathrm{IF} - B - MC^i} = 0.004$, $\widehat{\mathbb{E}[f_s - \mathrm{IF}_s - MC_s^a]} = 0.033$,
  - do not choose the level of IF optimally,
  - ignore externalities imposed on the other size

  $\rightarrow$ potential for *"double-marginalization"* problem.

- Horizontal integration of an issuer and an acquirer
  - internalizes the effects of price choice on both sides;
  - if there are other issuers and acquirers the internalization is not full:
  - joint profit of issuers and acquirers in all markets is

$$\Pi^J = \sum_s \sum_b \sum_j (\mathrm{IF} - B - MC^i) p_{bj} P^i_{sbj,cc} + \sum_s \sum_b \sum_j (f_s - \mathrm{IF} - MC^a_s) p_{bj} P^a_{sbj,cc}$$

  - $P^i_{bj,cc} > P^a_{bj,cc} \implies$ consumers may use CC outside of the merchants served by the merged acquirer;
  - in our model, $P^i_{bj,cc} - P^a_{bj,cc}$ is the probability that an informed consumer uses credit card to transact with a large merchant (not in the model).

Counterfactual 3. Double-marginalization problem

- Remove IF and allow issuer and acquirer to max joint profit by
  - setting same benefit for all consumers and all transactions, and
  - setting individual merchant fee in each market s.
- Optimal policies are expressed as change in the level of
  - consumer benefits, $\Delta_B^* \equiv B^*_{\text{no double-margin}} - B^*_{\text{observed}}$,
  - merchant service fees, $\Delta_{f,s}^* \equiv f^*_{s,\text{no double-margin}} - f^*_{s,observed}$.
- Optimal policies without double-marginalization
  1) consumer rewards $\Uparrow$: $\Delta_B^* = 0.0027$ (e.g., 9% increase in a cash-back program assuming initial reward of three percent);
  2) merchant costs $\Downarrow$:

	mean	median	min	max	sd
Change in MSC, $\Delta_{f,s}^*$	-0.0046	-0.0037	-0.0155	-0.0008	0.0030
$\Delta_{f,s}^* / \left(f_s - \widehat{\text{IF}_s - MC_s^a}\right)$	-0.25	-0.21	-0.65	-0.01	0.17

Note: joint issuer and acquirer profit is maximized by choosing a single consumer reward level B for all transactions of all consumers and individual merchant MSC f_s.

Counterfactual 3. Double-marginalization problem

- Eliminating it helps consumers & acquirers, hurts merchants & issuers.
- Total welfare of the system $\Uparrow$ 4.56%.
- Joint issuer & acquirer total profit $\Uparrow$ from \$12,663,853 to \$14,307,232 which is about 13% increase:
  - total issuer profit $\Downarrow$ from \$1,867,193 to \$651,973 (i.e., -65%)
  - total acquirer profit $\Uparrow$ from \$10,796,660 to \$13,655,259 (i.e., +26%)
- Network surplus:
  - defined as 0.02 times the expected number of transactions;
  - $\Uparrow$ by 36% from \$228,286 to \$310,477
- Summary statistics on surplus change by markets, %

	mean	median	min	max	sd
Consumer	13.21	13.21	13.21	13.21	0.00
Merchant	-10.34	-11.53	-24.41	10.47	7.33
Issuer	-65.08	-65.08	-65.08	-65.08	0.00
Acquirer	13.81	37.20	-100.00	56.78	45.84

Discussion: downstream market

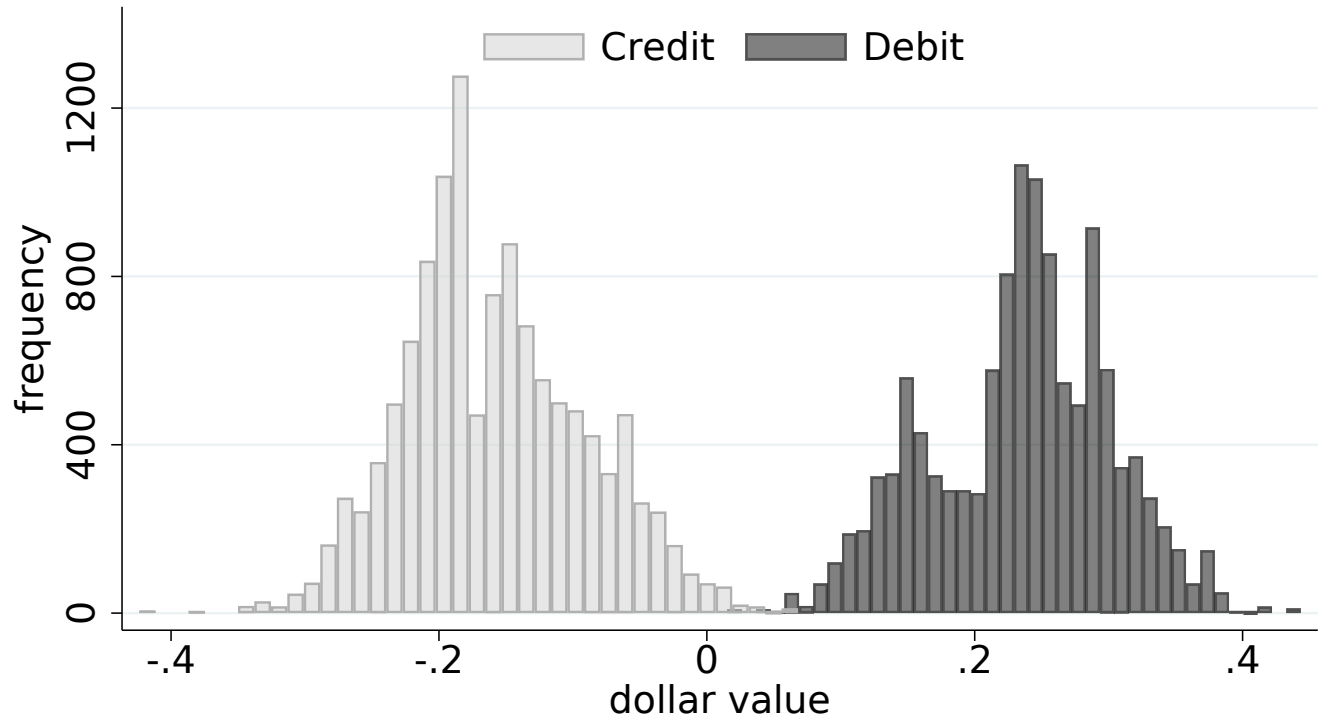
- Consumers are heterogeneous w.r.t cost and benefits of adoption
  - the costs and benefits rarely exceed \$5/month;
  - adoption benefits increase with the adoption set.
- At the POS, consumers
  - all else equal prefer to use debit over cash and cash over credit;
  - of older age don't like electronic payment instruments;
  - strong positive correlation in quality of debit and credit cards.
- ... merchants
  - earn a slim profit margin;
  - play prisoners'-dilemma-type technology adoption game;
  - pay acceptance costs well beyond the rental cost of terminals.
- Consumer awareness is important for market equilibrium:
  - explains why merchants accept wider set of instruments;
  - helps in technology diffusion.
- Network effects are heterogeneous and can be non-monotone.
- Also interesting: hard to drive cash out from the market.

Discussion: upstream market

- We confirm theory prediction of excessive intermediation
  - socially optimal fee should be lower by at least 1.6%.
- Competition in the upstream market has asymmetric effects:
  - between issuers makes excessive intermediation worse;
  - between acquirers has positive effects on MSCs.
- Double-marginalization problem costs 4.5% of total welfare.

APPENDIX: Estimates of Match Values

Figure: Match values between consumers, transactions, and payment methods



Fixed effect	Mean	Median	Min	Max	SD
Debit	0.24	0.24	0.02	0.44	0.07
Credit	-0.16	-0.16	-0.42	0.07	0.07

Notes: Match values are estimates as fixed effects. All numbers are in Canadian dollars.

APPENDIX: Estimates of Match Values

Table: Explaining consumer-transaction-method match values

Variable	Debit fixed effect		Credit fixed effect	
	coef.	(s.e.)	coef.	(s.e.)
Constant	3.861	(0.078)	-4.218	(0.078)
Age	-0.011	(0.000)	-0.001	(0.000)
Ln(income)	-0.038	(0.005)	0.138	(0.005)
Education	-0.125	(0.003)	0.151	(0.003)
Male	-0.138	(0.007)	0.155	(0.007)
Urban	0.000	(0.010)	-0.004	(0.010)
Married	0.014	(0.008)	0.026	(0.008)
Number of transactions	0.000	(0.001)	-0.010	(0.001)
Value of transactions	-0.006	(0.003)	0.017	(0.003)
Credit score	0.003	(0.008)	-0.007	(0.008)
Credit fixed effects, ξ_{cc}	0.601	(0.007)		
Debit fixed effects, ξ_{dc}			0.625	(0.007)
Observations	12,029		12,029	
R-squared	0.561		0.573	

Note: The estimation method is ordinary least squares.

back

APPENDIX: Issuers

Table: Issuers markups as share of transaction value, p_{bj}

	mean	median	min	max	s.d.
$\widehat{(\text{IF} - B - MC)},\ N_I = 1$	0.0035	0.0035	0.0035	0.0035	0.0000
$\widehat{(\text{IF} - B - MC)},\ N_I = 2$	0.0018	0.0018	0.0018	0.0018	0.0000
$\widehat{(\text{IF} - B - MC)},\ N_I = 5$	0.0007	0.0007	0.0007	0.0007	0.0000
$\widehat{(\text{IF} - B - MC)},\ N_I = 10$	0.0004	0.0004	0.0004	0.0004	0.0000
$\widehat{(\text{IF} - B - MC)}_b,\ N_I = 1$	0.0086	0.0056	0.0006	0.1741	0.0124
$\widehat{(\text{IF} - B - MC)}_b,\ N_I = 2$	0.0043	0.0028	0.0003	0.0870	0.0062
$\widehat{(\text{IF} - B - MC)}_b,\ N_I = 5$	0.0017	0.0011	0.0001	0.0348	0.0025
$\widehat{(\text{IF} - B - MC)}_b,\ N_I = 10$	0.0009	0.0006	0.0001	0.0174	0.0012

Note: Top rows are for uniform pricing, bottom rows are for individual buyer pricing.

- A monopolist issuer, when
  - restricted to set one price, retains about 19% of the interchange fee;
  - discriminating consumers, retains about 48% of the interchange fee.

back

APPENDIX: Acquirers

Table: Acquirer markups as share of transaction value, p_{bj}

	mean	median	min	max	s.d.
$(f - \widehat{\text{IF} - MC^a}),\ N_A = 1$	0.0108	0.0108	0.0108	0.0108	0.0000
$(f - \widehat{\text{IF} - MC^a}),\ N_A = 2$	0.0054	0.0054	0.0054	0.0054	0.0000
$(f - \widehat{\text{IF} - MC^a}),\ N_A = 5$	0.0022	0.0022	0.0022	0.0022	0.0000
$(f - \widehat{\text{IF} - MC^a}),\ N_A = 10$	0.0011	0.0011	0.0011	0.0011	0.0000
$(f_s - \widehat{\text{IF} - MC_s^a}),\ N_A = 1$	0.0327	0.0262	0.0013	0.2888	0.0328
$(f_s - \widehat{\text{IF} - MC_s^a}),\ N_A = 2$	0.0163	0.0131	0.0007	0.1444	0.0164
$(f_s - \widehat{\text{IF} - MC_s^a}),\ N_A = 5$	0.0065	0.0052	0.0003	0.0578	0.0066
$(f_s - \widehat{\text{IF} - MC_s^a}),\ N_A = 10$	0.0033	0.0026	0.0001	0.0289	0.0033

Note: Top rows are for uniform pricing, bottom rows are for individual seller pricing.

- A monopolist acquirer, when
  - restricted to set one price, earns about 1.08% of transaction value;
  - discriminating merchants, earns about 3.27% of the price.

back

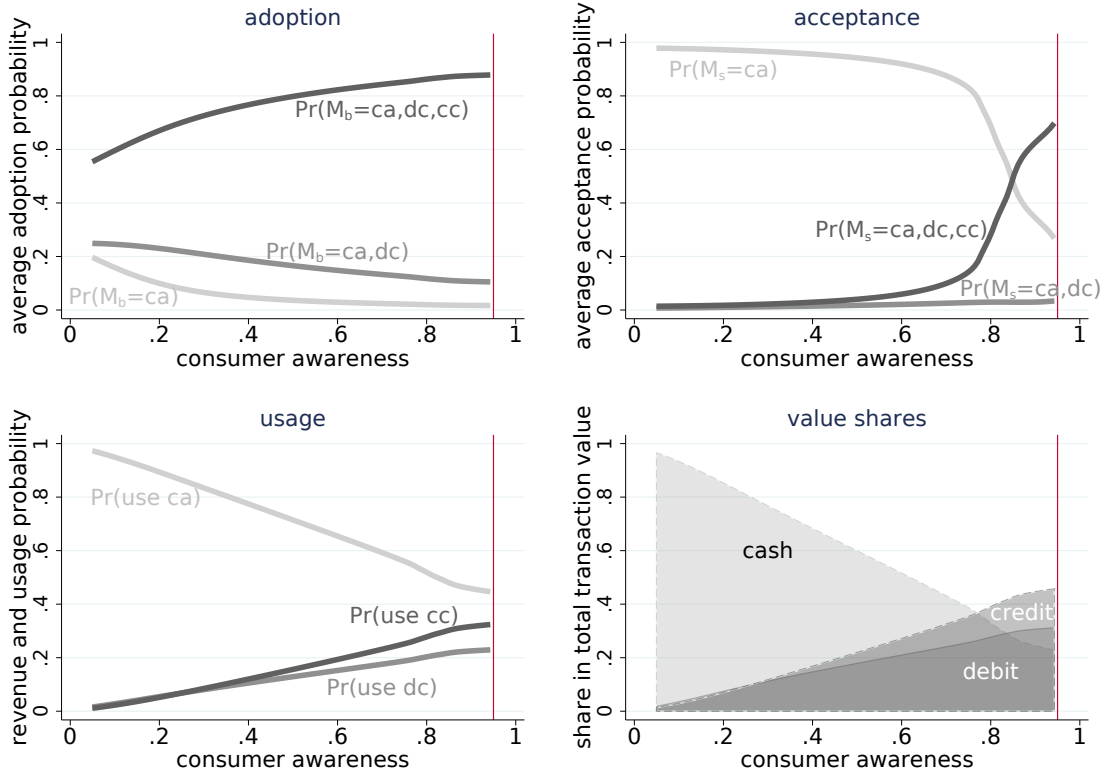
APPENDIX: Definitions of surpluses

- **Consumers**: $WF_b = \sum_b \mathbb{E}\left[\max_{\mathcal{M}'_b \in \mathcal{M}} EU_b(\mathcal{M}'_b) - F_{b,\mathcal{M}'_b}\right]$, where $EU_b(\mathcal{M}_b)$ is total expected utility in the usage stage given $\mathcal{M}_b$.
- **Merchants**: $WF_s = \sum_s \mathbb{E}\left[\max_{\mathcal{M}'_s \in \mathcal{M}} \left\{\mathrm{E}\Pi_s(\mathcal{M}'_s) - F_{s,\mathcal{M}'_s}\right\}\right]$, where $\mathrm{E}\Pi_s(\mathcal{M}_s)$ is expected profit in the usage stage given $\mathcal{M}_s$.
- **Issuer**: $WF_I = \sum_s \sum_b \sum_j P^*_{bj,cc} \times p_{bj} \times \left(\mathrm{IF} - B - MC^I\right)$, where $P^*_{bj,cc}$ is equilibrium usage probability, B are rewards, and MC^I is marginal cost.
- **Acquirer**: $WF_A = \sum_s \sum_b \sum_j P^*_{bj,cc} \times p_{bj} \times \left(f_s - \mathrm{IF} - MC^A_s\right)$, where f_s is MSC, IF is the interchange fee level, and MC^A is marginal cost.
- **Network**: $WF_N = 2 \times \sum_s \sum_b \sum_j \mathrm{NAF} \times P^*_{bj,cc}$, where $NAF = 0.01$ is the network access fee.

back

APPENDIX: Consumer Awareness

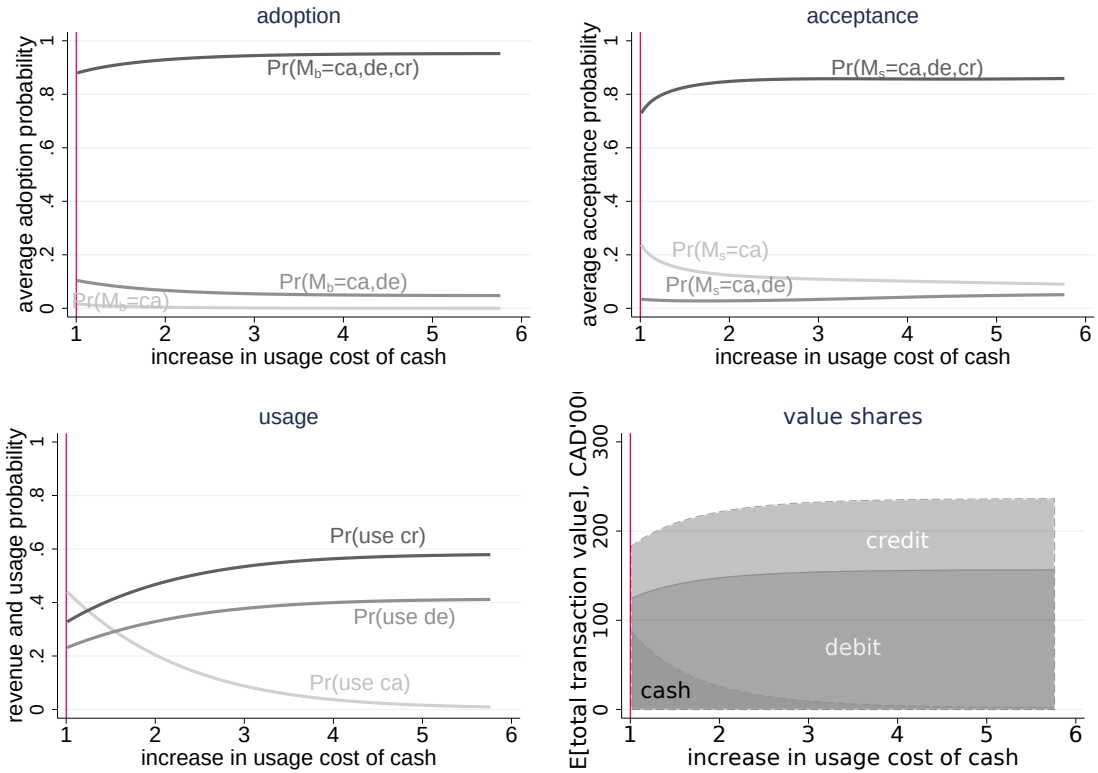
Figure: Equilibrium responses to changes in consumer awareness



- Increase in uncertainty drives equilibrium usage probabilities
  - for debit and credit cards to 0, and for cash to 1.
- Despite low usage probabilities consumers, adopt cards
  - potentially for reasons unrelated to payments at the POS.

APPENDIX: Cashless Society

Figure: Equilibrium response to an increase in the usage cost of cash



- It takes almost a 6-fold $\Uparrow$ in usage cost of cash for both sides
  - to drive its equilibrium usage probability to below 1%;
  - e.g., a 5-minute withdrawal trip becomes a 30-minute journey.

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