

The Impact of Retail Payment Innovations on Cash Usage

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Introduction

- Cash remains dominant payment choice for low-value transactions.
Why? Ease-of-use and Acceptance!
Arango, Huynh and Sabetti (2011): Cash, Debit and Credit.
- Payment innovations lead to lower cash usage?
i.e. Stored-value and contactless-credit cards.
These payment innovations mimic cash (ease-of-use).
- 2009 MOP Survey's Shopping Diary: showcases traditional shoppers (non-innovators) vs. users of contactless-credit and stored-value cards (payment innovators).
- Answer with programme evaluation methods:
YES!

2009 Method of Payments Survey

- Sampling frame was based on marketing access panels.
- Two-parts:
 - 1 Day 0: Survey Questionnaire (SQ).
Consists of 52 questions with about 6,800 respondents.
 - 2 Day 1-3: Three-day Diary Survey Instrument (DSI).
About 3,200 respondents yielded about 17,000 usable transactions.
- Market research firm constructed sample weights:
 - 1 Sample weights based on the Canadian Internet Usage Survey.
 - 2 Random digital dialing (OMNIBUS) survey with payments section.

Survey Questionnaire (SQ)

- Demographics: gender, age, income, education, employment, marital status, home ownership, family size, ethnicity and online/offline status.
- Payment Features:
 - Debit card features: monthly fees, free transactions.
 - Credit card features: rewards, revolver, interest rates.
- Payment Perceptions:
 - Ease of use, cost, risk/fraud, acceptance and record keeping.
- Cash holding.
- Cash inventory practices (ATM withdrawals).

Diary Survey Instrument (DSI)

- Cash holding at beginning of the diary.
- Transaction details:
 - Payment instrument choice,
 - Transaction value,
 - Type of good,
 - Payment instrument acceptance at the point-of-sale,
 - Top reasons for payment choice:
Ease, avoid fraud, avoid fees, rewards, payment delay and cashback.
- End-of-day check: # of transactions and cash balance.

Payment Innovation

- SQ contains questions regarding usage of contactless and stored-value cards.
- Sample is restricted to participants with three or more retail purchases over the three-day period.
- Not all adopters use these cards in DSI. Base usage decision in DSI as intervention.
 - Treatment group: users.
 - Control group: non-users.
- Further Contactless sample only included those with already a credit card.
- Results are robust to different treatment vs. control groups.

Cash Ratio

Two outcome measures of cash ratio (CR) from the DSI:

$$\text{Value Share} = \frac{\text{Total Cash Expenditure}}{\text{Total Expenditure}}.$$

$$\text{Volume Share} = \frac{\text{Total Cash Transactions}}{\text{Total Transactions}}.$$

Table 4: Cash Ratios in Value and Volume

	Value				Volume			
	NI	CTC	NI	SVC	NI	CTC	NI	SVC
Overall	0.317	0.127	0.368	0.173	0.484	0.337	0.521	0.293
Under 30K	0.466	0.178	0.498	0.296	0.597	0.239	0.613	0.363
30-80K	0.323	0.124	0.390	0.131	0.488	0.345	0.537	0.268
Over 80K	0.279	0.126	0.290	0.191	0.456	0.339	0.466	0.303
RK (-)	0.434	0.177	0.485	0.233	0.641	0.491	0.665	0.403
RK (+)	0.219	0.098	0.260	0.143	0.353	0.246	0.388	0.239
Accept (-)	0.262	0.117	0.295	0.156	0.440	0.289	0.463	0.296
Accept (+)	0.395	0.146	0.451	0.203	0.546	0.422	0.587	0.287

Note: Statistics are computed for respondents with three or more retail purchases in DSI. Numbers displayed in percent. NI: non-innovators, CTC: contactless-credit users, SVC: stored-value users.

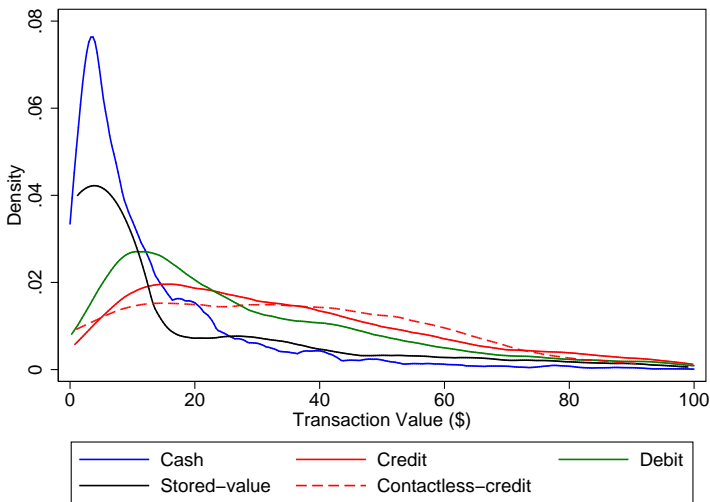
RK (+) denotes favorable view towards using cash for record-keeping purposes. Accept (+) denotes above average number of retail locations during diary accepted both debit and credit.

Table 3: Who is using new payment instruments?

	NI	CTC	NI	SVC
Under 30K	0.104	0.041	0.159	0.041
30K-80K	0.433	0.369	0.450	0.378
Over 80K	0.462	0.590	0.391	0.581
High School	0.209	0.119	0.251	0.203
College	0.791	0.881	0.749	0.797
Average initial cash	79.32	76.68	77.10	64.30
Average total spending	221.18	260.92	205.43	247.11
Respondents	1779	126	2051	134

Note: Statistics are computed for respondents with three or more retail purchases in DSI. Income, education statistics are in proportions. Initial Cash Holdings and Total Spending in DSI are in dollars. Non-users of contactless-credit exclude respondents without access to a credit card. NI: non-innovators, CTC: contactless-credit users, SVC: stored-value users.

Figure 3: Distribution of Transaction Value



Note: These densities illustrate the probability of using a payment choice at certain transaction value. The transaction value is truncated at 100 dollars and the number of DSI transactions is 11,471.

Table 5: Transaction Type Across Payment Methods

	Cash	SVC	Debit	Credit	CTC
Groceries	0.327	0.243	0.426	0.327	0.562
Gasoline	0.043	0.067	0.088	0.124	0.235
Retail Goods	0.066	0.090	0.134	0.218	0.031
Services	0.028	0.010	0.031	0.049	0.019
Hobby/Sports	0.036	0.014	0.045	0.056	0.012
Entertainment/Meals	0.338	0.429	0.176	0.133	0.086
Other	0.162	0.148	0.100	0.093	0.056
Number of Transactions	5676	210	3391	2832	162

Note: Numbers are in proportions. Based on 12,271 transactions in DSI. CTC: contactless-credit, SVC: stored-value card.

Payment innovation and the cash ratio?

- Interested in the sign of δ from the following regression:

$$CR_i = \beta \mathbf{x}_i + \delta PI_i + u_i, \quad (1)$$

where CR_i is cash ratio, $PI_i = 1$ if individual uses a payment innovation and zero otherwise, and \mathbf{x}_i is a set of observables.

- The estimate of PI on CR, $\hat{\delta}$, will be accurate if:
 - 1 PI strictly exogenous or uncorrelated with u .
 - 2 u is purely random noise.

Challenge:

- Endogeneity problem: $PI \rightarrow CR$ or $CR \rightarrow PI$?
- Selection: PI is not randomly-assigned.

Example of bias

Suppose there exists some unobserved variable, eg. fear of big brother, denoted f that systematically influences both PI and CR:

$PI \leftarrow f \rightarrow CR$. Then the *true* equation is:

$$CR_i = \beta \mathbf{x}_i + \delta PI_i + \gamma f + \epsilon_i, \quad (2)$$

where previously $u_i = \gamma f + \epsilon_i$ where ϵ is the true random error. The estimate of $\hat{\delta}$ obtained from cash ratio (2) is *biased* :

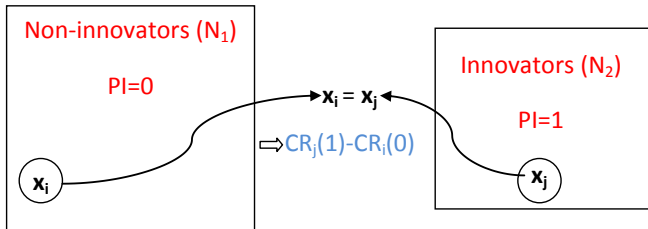
$$\delta^{(1)} = \delta^{(2)} + \underbrace{\text{corr}(PI, f)}_{\text{bias}}, \quad (3)$$

where $\text{corr}(PI, f) \leq 0$.

Propensity Score Matching

Create treatment and control group using statistical methods.

- Estimate the probability of having payment innovation.
- Use probabilities to compare similar individuals and look at the difference.



Observables in the Propensity Score

Let $p(Pi_i|\mathbf{x}_i)$ measure the probability individual i , with observable characteristics \mathbf{x}_i , is a payment-innovator.

Many observed characteristics from the SQ-DSI:

- Demographics: income, education, age, region, family size, gender, homeowner, urban, survey method.
- Perceptions: ease of use, fear of fraud, cost, recordkeeping.
- Diary-level data aggregated and computed relative to group mean (income and region):
 - Spending behavior (as share of transactions): AM/PM, weekend, merchant card acceptance.
 - Spending behavior (as share of total expenditures): groceries, entertainment, retail goods/services purchases.
 - Initial cash holdings (before starting the first day).

Table 7: Logit Propensity Score Estimates

	Contactless-Credit		Stored-Value	
	Demo	Full	Demo	Full
30K-80K	0.038	0.035	0.052**	0.054**
	0.03	0.03	0.03	0.03
Over 80K	0.044	0.04	0.073**	0.081***
	0.03	0.03	0.03	0.03
Family size over 3	0.045***	0.046***	0.019	0.021
	0.02	0.02	0.02	0.02
Credit Card Revolvers	-0.072***	-0.063***	-0.015	-0.022
	0.02	0.02	0.02	0.02
Fear of Fraud		-0.060**		0.038*
		0.02		0.02
Cost		0.070**		-0.070**
		0.03		0.03
Entertainment		-0.008*		0.005
		0		0
Retail goods		-0.008**		0.004
		0		0
Merchant card acceptance		0.027		0.018
		0.02		0.02
Respondents	1905	1905	2185	2185

*, **, *** denotes statistical significance at the 10, 5 and 1 % levels respectively.

Table 8: Contactless-credit Impact on Cash

	Value		Volume	
	Demo	Full	Demo	Full
ATE_{OLS}	-0.156 (-0.199 -0.112)	-0.155 (-0.203 -0.108)	-0.166 (-0.225 -0.107)	-0.138 (-0.203 -0.074)
ATT_{OLS}	-0.132 (-0.170 -0.094)	-0.115 (-0.154 -0.076)	-0.123 (-0.173 -0.073)	-0.100 (-0.146 -0.053)
ATE_{PSM}	-0.145 (-0.188 -0.102)	-0.144 (-0.186 -0.101)	-0.142 (-0.198 -0.085)	-0.134 (-0.194 -0.075)
ATT_{PSM}	-0.138 (-0.175 -0.100)	-0.125 (-0.163 -0.087)	-0.124 (-0.175 -0.074)	-0.109 (-0.161 -0.058)
\widehat{RB}	1.69	1.67	2.29	2.19

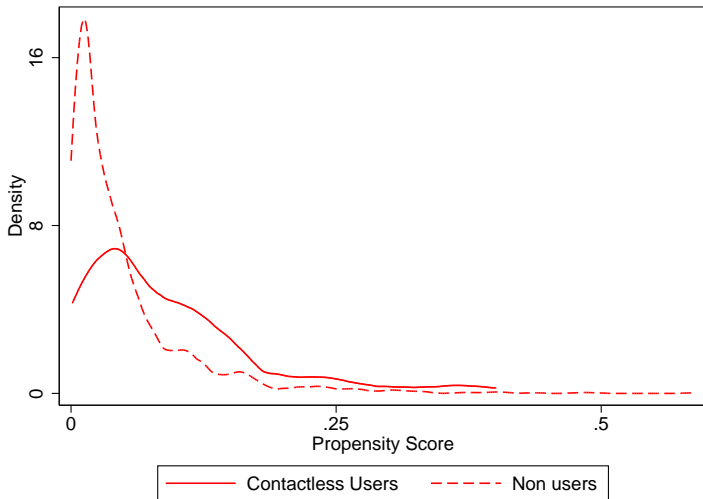
Note: We provide estimates for both OLS and PSM-kernel matching. 95 percent confidence intervals displayed in parentheses and are constructed with 1000 bootstrapped replications. The labels **Demo** denotes only demographics observables while **Full** includes demographics plus aggregated DSI level variables.

Table 9: Stored-value Card Impact on Cash

	Value		Volume	
	Demo	Full	Demo	Full
ATE_{OLS}	-0.115 (-0.168 -0.061)	-0.115 (-0.164 -0.066)	-0.148 (-0.194 -0.102)	-0.153 (-0.196 -0.110)
ATT_{OLS}	-0.097 (-0.140 -0.055)	-0.102 (-0.143 -0.061)	-0.136 (-0.176 -0.096)	-0.137 (-0.176 -0.099)
ATE_{PSM}	-0.128 (-0.174 -0.082)	-0.119 (-0.165 -0.072)	-0.157 (-0.199 -0.114)	-0.145 (-0.187 -0.102)
ATT_{PSM}	-0.115 (-0.158 -0.072)	-0.099 (-0.142 -0.056)	-0.153 (-0.194 -0.112)	-0.131 (-0.174 -0.089)
\widehat{RB}	1.47	1.37	2.55	2.31

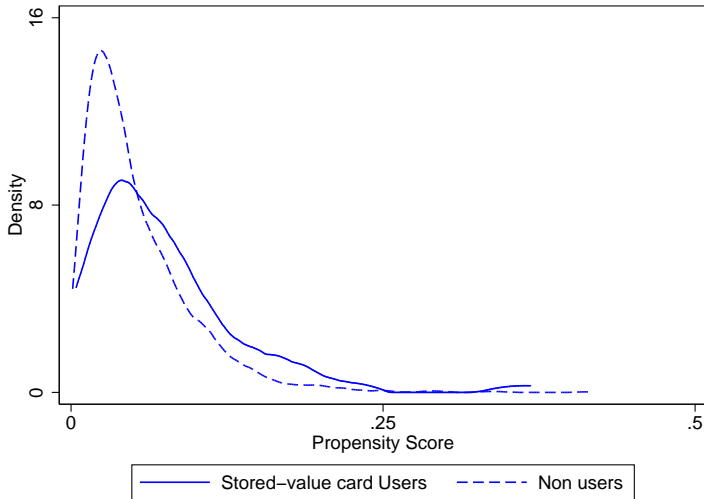
Note: We provide estimates for both OLS and PSM-kernel matching. 95 percent confidence intervals displayed in parentheses and are constructed with 1000 bootstrapped replications. The labels **Demo** denotes only demographics observables while **Full** includes demographics plus aggregated DSI level variables.

Figure 4: Overlap for Contactless Credit Card



Note: Logit propensity scores displayed for the FULL model.

Figure 5: Overlap for Stored-Value Card



Note: Logit propensity scores displayed for the FULL model.

Robustness to unobserved factors?

Cannot test the *unconfoundness* assumption \Rightarrow sensitivity analysis.

Scale the propensity score unobservable (u_i) by a scalar γ :

$$p(Pl_i|\mathbf{x}_i) = F(\beta\mathbf{x}_i + \gamma u_i).$$

Compare two individuals i and j and there propensities (log-odds ratio):

$$\mathbf{x}_i = \mathbf{x}_j \implies \frac{p(Pl_i|\mathbf{x}_i)}{p(Pl_j|\mathbf{x}_j)} = \Gamma.$$

Γ denotes the Rosenbaum Bound (RB). A value of $\Gamma = 2$ implies that for two comparable people some unobserved factor causes an individual be twice as likely as the other to become a payment innovator.

Table 10: Linking RB to Observed Characteristics

CTC	1.50	1.75	2.00	2.25	$\hat{\beta}$	s_k	mean
Acceptance	0.81	1.12	1.39	1.62	0.53	0.41	1.08
Cost	0.57	0.79	0.98	1.15	1.39	0.22	0.34
Fraud	0.50	0.69	0.86	1.00	1.19	0.30	0.45
SVC							
Acceptance	1.14	1.58	1.95	2.28	0.35	0.44	1.10
Cost	0.61	0.85	1.05	1.23	1.33	0.22	0.33
Fraud	0.81	1.12	1.39	1.62	0.72	0.30	0.46

The impact from a hidden variable which leads to \widehat{RB} can be couched in terms of an observed continuous characteristic, as in Bharath et al. (2011).

$$\exp(\hat{\beta}_k \times s_k \times n) = \widehat{RB}.$$

For an observable x_k , where $\hat{\beta}_k$ denotes the estimated coefficient, s_k is the variable s.d., n yields number of s.d. which are displayed above for each level of Γ .

Summary

- Contactless-credit leads to about 12-16% decline in cash value and 10-14% in cash volume shares, compared to difference-in-means estimates of 19% in value and 15% volume.
- Stored-value card leads to 10-12% decline in cash value and 13-15% cash volume shares, compared to difference-in-means estimates of 20% in value and 23% in volume.

Economic interpretation of ATE:

- 1 Non-innovator of contactless spend \$221 with average cash ratio of 0.317. Implies cash spending decrease by \$32.
- 2 Non-innovator of SVC spend \$205 with average cash ratio of 0.368. Implies cash spending decrease by \$24.
- 3 In terms of volume it would lead to one less cash transaction.