

Explaining adoption and use of payment instruments by US consumers

Sergei Koulayev Marc Rysman
Scott Schuh Joanna Stavins

Keystone Strategy Boston University

FRB-Boston

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Introduction

- We estimate a structural model of household adoption and use of payment instruments
 - ex: cash, check, credit, debit.
- We distinguish between adoption and usage decisions.
- We evaluate substitution patterns across payment instruments.
 - We highlight how patterns differ in response to changes in adoption and usage costs.
 - And across income levels.
- We show the importance of flexibly modeling demand.

Motivation

- Recent regulation affects interchange fees for payment instruments
 - Debit cards in the US (Durbin Amendment)
 - Credit cards in Europe and Australia
- Banks may respond by changing usage fees (rewards) or adoption fees (annual fees)
- Example: Banks are expected to reduce rewards, but Wells Fargo announced an annual fee for debit card.
- How will consumers respond?

Motivation II

- Fed has few models upon which to base decisions.
- Consumers' choice may differ from preferences of the social planner
 - Consumers face few explicit costs for payment choice
 - Social planner recognizes costs that consumers may not.
 - Ex 1: SP may prefer digital payments to cash or check.
 - Ex 2: SP may believe credit cards lead to consumer problems.
- To evaluate regulation, we must know how consumers substitute between payment instruments.
- Substitution patterns may differ based on whether regulations affect usage or adoption costs.

Relevant papers

- Discrete-continuous models.
 - Heckman (1979), Dubin & McFadden (1984), Hendel (1999) and others.
- Bundled choices.
 - Gentzkow (2007), Crawford and Yurukoglu (2009).
- Payment choices.
 - Schuh and Stavins (2010), Bank of Canada, others.

Survey of Consumer Payment Choice

- Boston Fed and RAND Corporation panel
- Household fills out detailed survey:
 - Which payment *instruments* do they have?
 - How much they use the instrument in various *contexts*?
- Attitudes towards instruments – rate them on various dimensions (ease of use, set-up cost, security, etc.)
- First year of data: 2008.
- We only look at households that have checking accounts – 92% of sample.
- 997 households.

Instruments

- Cash
- Check
- Debit card
- Credit card
- Stored Value Card
- Bill pay – check
- Bill pay – electronic deduction
- Bill pay – income deduction

Adoption rates by payment instrument.

paper		card			bill pay		
cash	check	debit	credit	stored value	on-line banking	direct bank acct deduct	income deduction
100%	100%	80%	78%	17%	52%	73%	18%

Contexts

	Bill Pay			Retail			
	Automatic	Online	In person	Online	Essential	Non-essential	Other
mean	6.0	6.5	7.6	6.8	19.1	9.8	12.8
std dev	11.2	10.5	12.8	11.4	23.5	15.7	15.0

Instruments and Contexts

	Bill Pay			Retail			Other
	Automatic	Online	In person	Online	Essential	Non-essential	
cash			1.1		6.2	3.1	3.8
check			4.0	1.6	1.0	0.7	2.8
debit card	1.6	1.6	1.3	2.1	7.5	3.6	3.3
credit card	1.4	1.1	1.2	1.6	4.2	2.2	2.8
store value card				0.1	0.2	0.1	0.1
online bank bill pay		2.1					
direct bank deduct	2.3	1.7		1.3			
income deduction	0.8						

Notes: 997 Observations.

Attitudes

	security	setup	accept	cost	control	records	speed	ease
cash	2.6	4.3	4.6	4.3	3.9	2.5	4.3	4.1
check	2.9	3.7	3.6	3.7	3.2	4.1	2.9	3.4
debit card	2.9	3.9	4.3	3.8	3.6	4.0	4.0	4.2
credit card	3.0	3.7	4.5	2.7	3.5	4.2	4.0	4.3
stored value cd	2.7	3.4	3.8	3.3	3.3	2.9	3.7	3.7
bank bill pay	3.3	3.4	3.2	3.7	3.6	3.9	3.8	3.6

Demographics

var	min	mean	med	max	std
age	16	48.68	49	85	14.15
male	0	0.44	0	1	0.50
citizen	0	0.98	1	1	0.14
hh-size	0	1.13	1	9	1.40
white	0	0.89	1	1	0.32
black	0	0.07	0	1	0.25
asian	0	0.03	0	1	0.17
latino	0	0.04	0	1	0.20
married	0	0.65	1	1	0.48
single	0	0.15	0	1	0.35
edu-hs	0	0.14	0	1	0.35
edu-sc	0	0.34	0	1	0.47
edu-c	0	0.28	0	1	0.45
edu-pgs	0	0.22	0	1	0.41

Top adoption bundles

Share	card			bill pay		
	debit	credit	stored value	on-line banking	direct bank acct deduct	income deduction
23%	1	1	0	1	1	0
12%	1	1	0	0	1	0
8%	1	1	0	1	1	1
6%	0	0	0	0	0	0
5%	1	1	1	1	1	0
4%	1	1	0	1	0	0
4%	1	1	0	0	0	0
3%	1	0	0	0	1	0

Model

- Two-stage model
- Stage 1: HH picks bundle of instruments
- Stage 2: HH picks usage of each instrument in different contexts

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- Two-stage model
- Stage 1: HH picks bundle of instruments
- Stage 2: HH picks usage of each instrument in different contexts
- Our model handles rich correlation in unobserved terms across contexts, instruments, stages
- Adoption of one instrument affects value of other instruments through usage (but not adoption).

Stage 1

- J payment instruments, $j = 1, \dots, J$
- b is a set of payment instruments.
- B is a set of all possible sets of instruments.
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- Our case: 8 instruments - 6 for choice $\rightarrow 2^6 = 64$ elements of B .

Stage 2

- Consumer i faces a sequence of L payment opportunities.
- At each l , consumer i chooses:
 - instrument $j \in b_i$ and
 - context $c \in C$.
- Utility to i from choosing jc is:

$$U_{ijcl} = \delta_{ijc} + \varepsilon_{ijcl}^u$$

- Can choose no purchase: $U_{i0l} = \varepsilon_{i0l}$
- $\varepsilon_{ijcl} \sim EV$.

Stage 2

- Share of payments to jc :

$$s_{ijc} = \frac{\exp(\delta_{ijc})}{\sum_{k \in b_i} \sum_{d \in C} \exp(\delta_{ikd})}$$

- Average value of a payment opportunity:

$$v_i(b) = E[v_{ij}(b_i)] = \ln \sum_{j \in b} \sum_{c \in C} \exp(\delta_{ijc}) + \gamma$$

Stage 1

- Value of i adopting bundle b :

$$V_{ib} + \varepsilon_{ib}^a = \sum_{j \in b} \lambda_{ij} + \alpha v_i(b) + \varepsilon_{ib}^a.$$

- λ_{ij} is adoption cost
- $\varepsilon_{ib}^a \sim EV$
- No interaction in adoption costs

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- No interaction in adoption costs
- Probability of i adoption b :

$$\Pr(b_i) = \frac{\exp(V_{ib})}{\sum_{k \in B} \exp(V_{ik})}.$$

Estimation

- Parameterize δ_{ijc} and λ_{ij}

$$\delta_{ijc} = \mathbf{x}_{ijc}\beta_\delta + \nu_{ijc}$$

$$\lambda_{ij} = \mathbf{z}_{ij}\beta_\lambda + \omega_{ij}$$

- ν_{ijc} and ω_{ij} unobserved
- $\{\nu_{\mathbf{i}}, \omega_{\mathbf{i}}\} \sim \mathbf{N}(\mathbf{0}, \Sigma)$
- $\theta = \{\beta_\delta, \beta_\lambda, \alpha, \Sigma\}$ to be estimated.

Likelihood

- Likelihood:

$$\mathcal{L}_i(\vec{y}_i^*, b_i^* | \theta) = \int_{\nu_i} \int_{\omega_i} \Pr(y_i^*, b_i^* | \theta, \nu_i, \omega_i) f(\nu_i, \omega_i) d\omega_i d\nu_i$$

- \vec{y}_i^* vector of number of transactions allocated to each jc in data.
- b_i^* observed bundle choice

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- \vec{y}_i^* vector of number of transactions allocated to each jc in data.
- b_i^* observed bundle choice
- In practice, we simulate $\{\nu_i, \omega_i\}$.

Simulation

- Draw values of $\{\nu_{ijc}^s, \omega_{ij}^s\}$

$$\hat{\mathcal{L}}_i(\vec{y}_i^*, b_i^*; \theta) = \frac{1}{ns} \sum_{s=1}^{ns} \Pr(\vec{y}_i^* | b_i^*, \nu_i^s, \omega_i^s, \theta) \Pr(b_i^* | \nu_i^s, \omega_i^s, \theta)$$

where:

$$\Pr(\vec{y}_i^* | b_i^*, \nu_i^s, \omega_i^s, \theta) = \sum_{j \in b_i^*} \sum_{c \in C} \left(\frac{\delta_{ijc}^s}{\sum_{k \in b_i^*} \sum_{d \in C} \delta_{ikd}^s} \right)^{y_{ijc}^*}$$

$$\Pr(b_i^* | \nu_i^s, \omega_i^s, \theta) = \frac{\exp(V_{ib_i^*}^s)}{\sum_{k \in B} \exp(V_{ik}^s)}$$

Parameterization

- Draw $\{\varepsilon_{ijc}^1, \varepsilon_{ij}^2, \varepsilon_{ic}^3\}$ from standard normal.

$$\nu_{ijc} = \sigma_1 \varepsilon_{ijc}^1 + \sigma_j \varepsilon_{ij}^2 + \sigma_c \varepsilon_{ic}^3$$

$$\omega_{ij} = \sigma_{2j} \varepsilon_{ij}^2$$

- Estimate $\{\sigma_1, \sigma_{2j}, \sigma_j, \sigma_c\}$.
- $\sigma_1, \sigma_j, \sigma_c$ determine correlation within usage
- σ^{2j} determines correlation across the two stages.

Comparison

- Heckman
- Hendel

Results

- Explanatory variables in usage:
 - Context-instrument dummies
 - age, gender, black, employed, married, education
 - income-instrument interactions
 - debt dummies interacted with credit, debit
- Explanatory variables in adoption:
 - instrument dummies
 - interactions with instrument dummies
 - income, education, employment, computer-use

Mean values in usage equation

	Bill Pay			Retail			Other
	Automatic	Online	In person	Online	Essential	Non-essential	
cash			-6.25 (0.02)		-3.83 (0.01)	-4.85 (0.02)	-4.28 (0.01)
check			-4.31 (0.01)	-5.60 (0.02)	-5.74 (0.02)	-6.31 (0.03)	-4.68 (0.01)
debit card	-5.47 (0.02)	-5.49 (0.02)	-5.78 (0.02)	-5.25 (0.02)	-3.61 (0.01)	-4.47 (0.02)	-4.25 (0.02)
credit card	-6.06 (0.02)	-6.29 (0.02)	-6.22 (0.02)	-5.68 (0.02)	-4.40 (0.02)	-5.14 (0.02)	-4.75 (0.02)
store value card			-8.44 (0.19)	-7.44 (0.10)	-6.24 (0.07)	-7.31 (0.12)	-7.28 (0.09)
online bank bill pay		-4.38 (0.02)					
bank acct deduct	-4.72 (0.02)	-4.97 (0.02)		-5.43 (0.02)			
income deduction	-4.47 (0.04)						

Notes: Standard errors are in parenthesis. 997 observations.

Demographics in usage

variable	instrument	usage only	full	retail only	no debt sample
age	check	1.12 (0.02)	1.14 (0.02)	0.48 (0.03)	1.48 (0.03)
	debit	0.28 (0.02)	-0.43 (0.02)	0.05 (0.03)	-0.45 (0.02)
	credit	0.63 (0.02)	0.24 (0.02)	0.01 (0.03)	0.33 (0.02)
male	debit	-0.22 (0.01)	0.21 (0.01)	-0.32 (0.02)	-0.53 (0.02)
	credit	0.11 (0.01)	0.09 (0.01)	0.27 (0.02)	-0.14 (0.01)
black	debit	-0.07 (0.03)	0.27 (0.03)	0.24 (0.04)	-0.98 (0.04)
	credit	0.30 (0.03)	0.38 (0.03)	-0.05 (0.05)	-1.07 (0.15)
married	debit	-0.12 (0.01)	-0.16 (0.01)	0.03 (0.02)	-0.52 (0.02)
	credit	0.00 (0.01)	0.31 (0.01)	-0.02 (0.02)	0.22 (0.02)
employed	debit	0.02 (0.01)	-0.06 (0.01)	0.26 (0.02)	-0.56 (0.02)
	credit	-0.16 (0.01)	-0.30 (0.01)	-0.08 (0.02)	0.06 (0.02)
education	debit	-0.08 (0.01)	-0.11 (0.01)	-0.11 (0.01)	-0.20 (0.01)
	credit	0.22 (0.01)	0.35 (0.01)	0.26 (0.01)	0.16 (0.01)
	bank bill pay	0.07 (0.01)	0.01 (0.01)		0.21 (0.02)
	bank ded.	0.08 (0.01)	0.10 (0.01)		0.06 (0.01)

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Income interactions in usage

	usage only	full	retail only	no debt sample
cash	0.12 (0.02)	0.05 (0.01)	-0.07 (0.02)	-0.004 (0.02)
check	0.45 (0.02)	0.45 (0.02)	0.19 (0.03)	0.27 (0.02)
debit card	0.64 (0.02)	0.07 (0.02)	0.03 (0.02)	0.32 (0.02)
credit card	0.12 (0.02)	0.18 (0.02)	0.25 (0.03)	0.66 (0.02)
store value card	-1.17 (0.07)	-0.68 (0.05)		-0.57 (0.13)
online bank bill pay	0.60 (0.04)	0.75 (0.03)	-0.16 (0.03)	0.44 (0.05)
bank acct deduct	0.24 (0.02)	0.31 (0.02)		0.23 (0.02)
income deduct	0.27 (0.09)	0.19 (0.10)		0.57 (0.09)

Notes: Standard errors are in parenthesis. 997 observations.

Instrument ratings in usage equation

	usage only	full	retail only	no debt sample
security	0.011 (0.002)	0.015 (0.002)	0.016 (0.003)	0.020 (0.003)
acceptance	0.013 (0.003)	0.001 (0.003)	0.0001 (0.006)	0.003 (0.005)
cost of use	0.115 (0.003)	0.097 (0.003)	0.055 (0.005)	0.034 (0.003)
control of pay time	0.040 (0.002)	0.050 (0.002)	0.033 (0.004)	0.030 (0.003)
record keeping	0.062 (0.003)	0.032 (0.003)	0.064 (0.005)	0.168 (0.004)
speed	-0.020 (0.003)	0.009 (0.004)	-0.004 (0.006)	0.041 (0.004)
ease of use	0.113 (0.003)	0.149 (0.004)	0.066 (0.006)	0.117 (0.004)

Notes: Standard errors are in parenthesis. 997 observations.

Debt variables in usage

variable	instrument	usage only	full	retail only	no debt sample
overdraft	debit	0.44 (0.09)	0.44 (0.09)	0.24 (0.08)	0.50 (0.12)
	credit	-0.04 (0.09)	-0.05 (0.09)	-0.05 (0.09)	-0.04 (0.13)
debt revolver	debit	0.45 (0.10)	0.45 (0.11)	0.34 (0.09)	
	credit	-0.58 (0.09)	-0.56 (0.09)	-0.34 (0.09)	
debt amount	debit	-0.08 (0.08)	-0.09 (0.08)	-0.06 (0.09)	
	credit	0.02 (0.07)	0.02 (0.07)	0.03 (0.07)	
debt X income	debit	0.02 (0.03)	0.03 (0.03)	0.01 (0.04)	
	credit	0.00 (0.03)	0.001 (0.03)	-0.01 (0.03)	
debt X edu	debit	0.003 (0.01)	0.002 (0.01)	0.004 (0.01)	
	credit	-0.004 (0.01)	-0.005 (0.01)	-0.003 (0.01)	

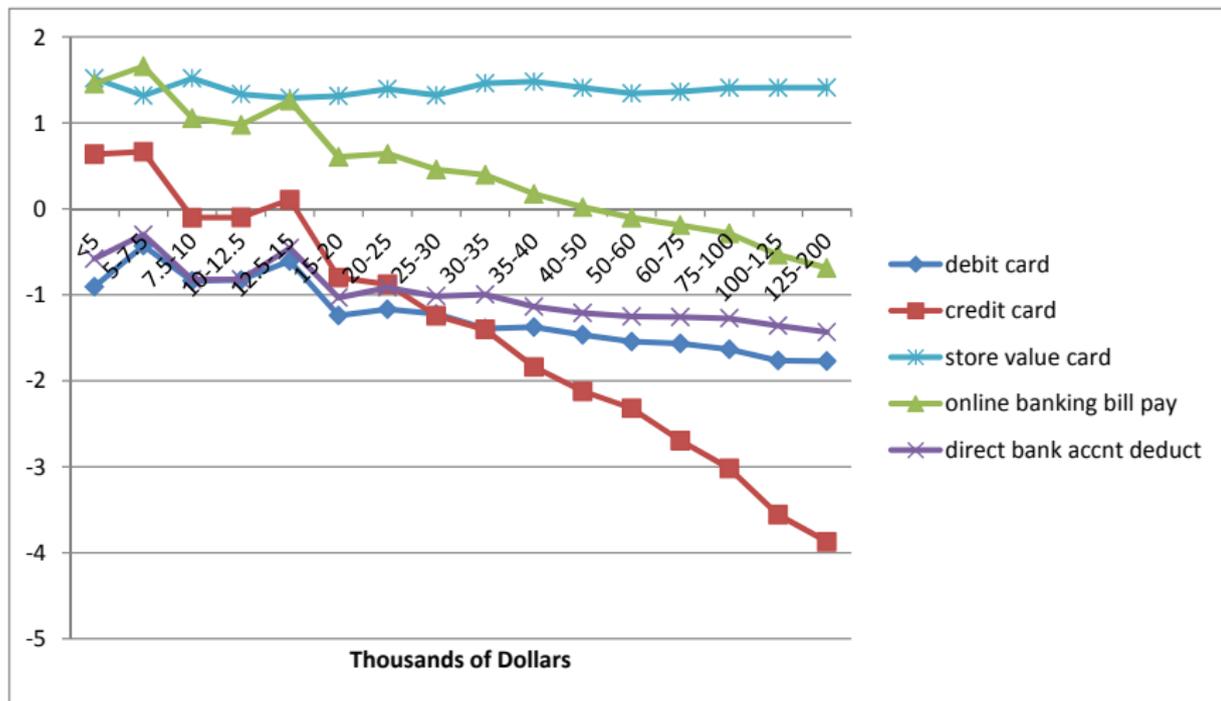
Notes: Standard errors are in parenthesis. 997 observations.

Instrument dummies in adoption equation

	card			bill pay		
	debit	credit	stored value	on-line banking	direct bank acct deduct	income deduction
full	-1.29 (0.10)	-1.84 (0.13)	1.39 (0.09)	0.26 (0.09)	-0.99 (0.10)	1.43 (0.09)
no debt sample	-0.82 (0.10)	-0.44 (0.13)	0.62 (0.10)	-0.59 (0.10)	1.40 (0.09)	1.59 (0.11)
retail only	-1.41 (0.13)	-1.79 (0.13)	1.47 (0.09)			

Notes: Standard errors are in parenthesis. 997 observations.

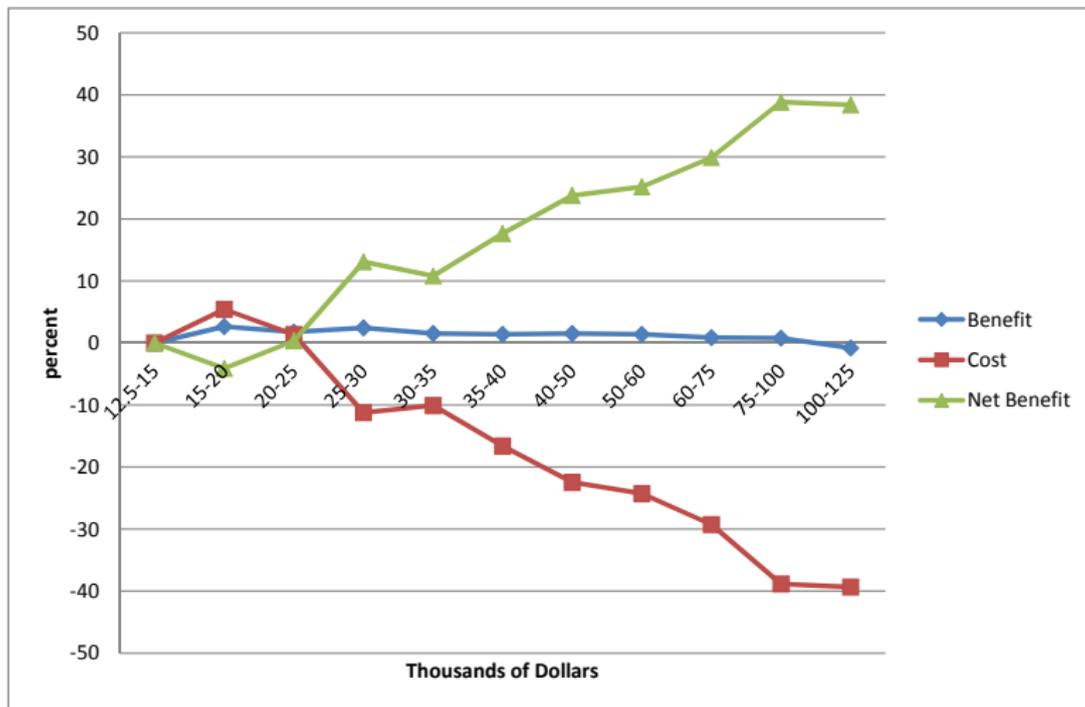
Adoption costs by income



Correlation in unobserved terms

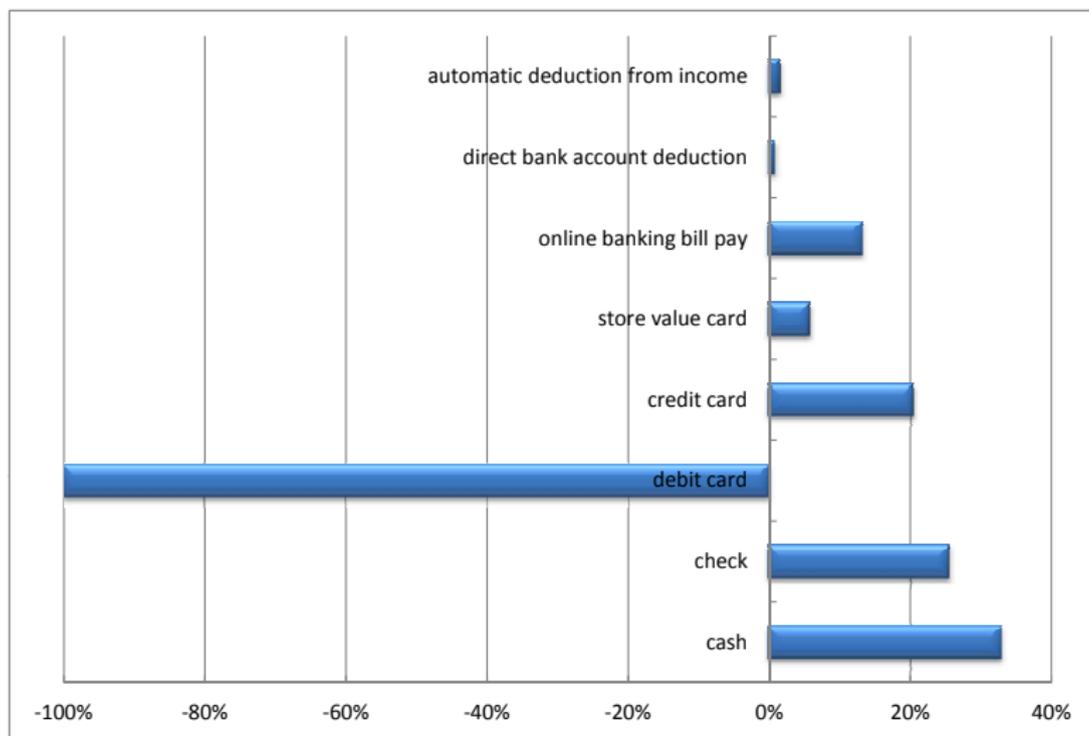
	Bill Pay			Retail			Other
	Automatic	Online	In person	Online	Essential	Non-essential	
debit card	0.74 (0.06)	0.81 (0.06)	0.79 (0.06)	0.68 (0.05)	0.96 (0.08)	0.88 (0.07)	0.95 (0.08)
credit card	0.59 (0.25)	0.65 (0.28)	0.63 (0.27)	0.54 (0.23)	0.79 (0.34)	0.71 (0.31)	0.78 (0.33)
store value card			0.02 (0.06)	0.01 (0.04)	0.17 (0.66)	0.03 (0.10)	0.09 (0.34)
online bank bill pay		0.79 (0.13)					
bank acct deduct	-0.45 (0.30)	-0.50 (0.33)		-0.41 (0.27)			
income deduction	0.001 (0.01)						

Cost versus benefits of debit by income



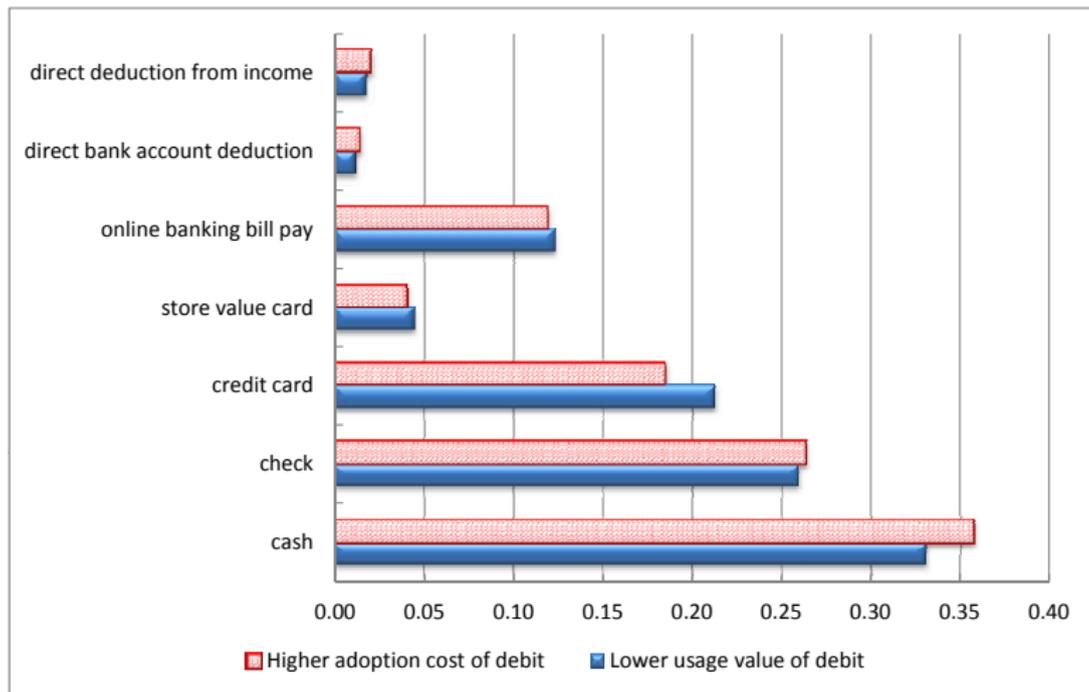
Elasticities to higher usage cost of debit

holding adoption fixed



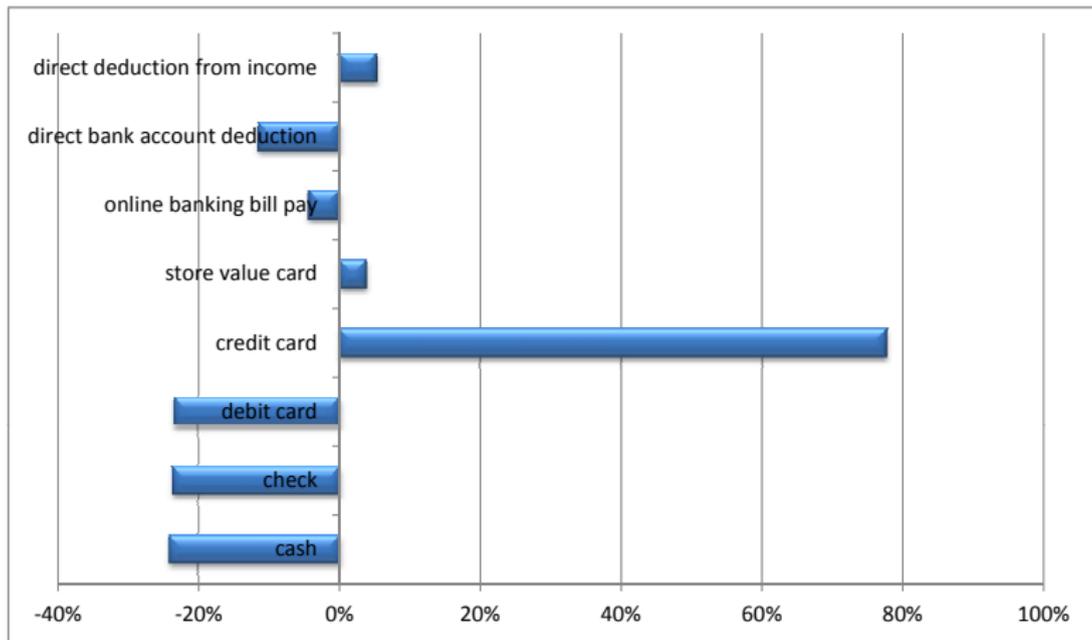
Elasticities to higher usage and adoption cost of debit

Allowing for adoption to change

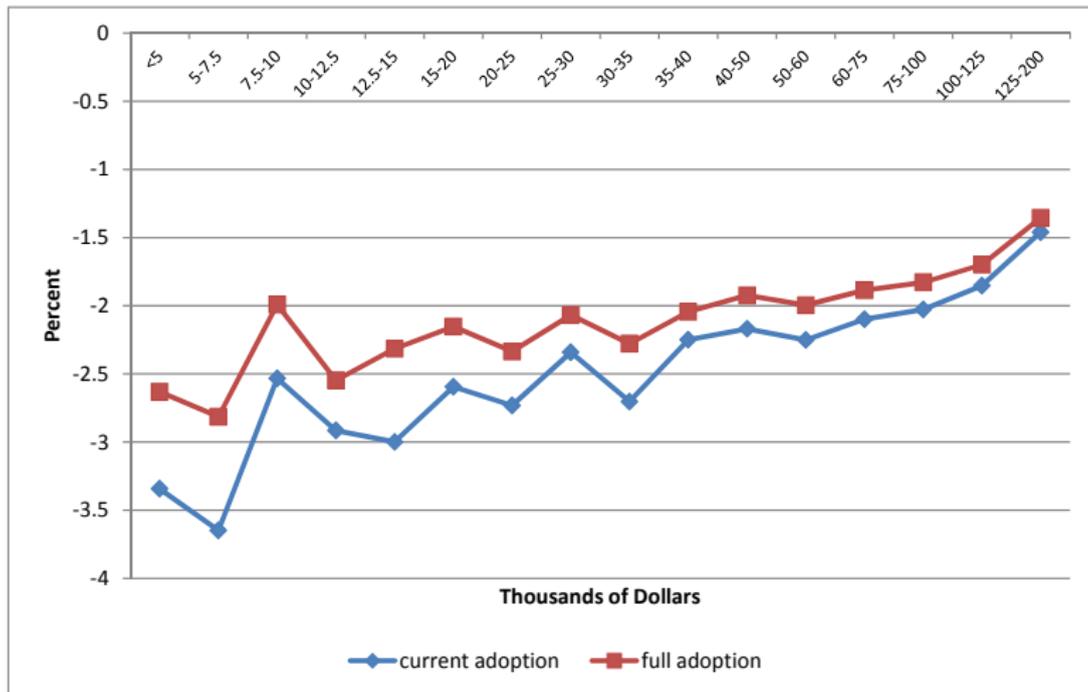


Elasticities to higher cost of all bank products

holding adoption fixed



Welfare change from higher cost of debit



Conclusion

- In this paper, we saved the world.