Payment Choice with Consumer Panel Data

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August 2017, Helsinki

The views expressed here are those of the presenter and do not necessarily reflect the view of the Federal Reserve Board of Governors or its staff

Overview

- Focus of paper is on the shift from paper payments (cash, check) to digital payments (debit and credit cards)
  - Digital payments are superior in many ways: faster, cheaper to process, easier to track, less conducive to fraud
  - Adoption has been gradual: while some consumers use primarily digital payments, paper payments still play a large role
- Important policy questions
  - How quickly will consumers adopt new payment technologies? (e.g. faster payments)
  - If consumers are not flexible in their payment choice, does this give some agents undue bargaining power over others? (e.g. card networks over merchants)
- Paper examines consumer payment choices using a novel panel data set of grocery purchases

Research questions

- Short-term
  - What are the main factors that cause consumers to pick one payment instrument over another?
  - Do payment preferences vary substantially among consumers, and does accounting for such heterogeneity affect estimates of the main determinants of payment choice?
  - Is there simultaneous causality between transaction size and payment choice, and could it lead to biased results?
- Long-term
  - What are the main drivers of the trend toward digital payments?
  - What would happen if checks were withdrawn from the payments market?

Contributions

- New data source for studying payment choice: scanner data
  - Enables estimation of heterogeneity in tastes between households
  - Length of panel enables analysis of long-term behavior
- Frontier statistical tools used to perform the analysis
  - Expectation-maximization (EM) algorithm greatly reduces burden of estimating a discrete-choice model with fixed effects
  - Jackknife estimation procedure corrects for bias due to presence of incidental parameters
  - Two-stage residual inclusion (2SRI) procedure implements instrumental variable correction in a discrete-choice setting
- Findings contribute to payments literature
  - Evidence of single-homing informs theoretical literature on two-sided markets such as payment cards (Rochet & Tirole, 2006; Rysman, 2009)
  - Short-term payment choice is determined primarily by transaction size and heterogeneity in tastes between households
  - Long-term shift toward card payments is driven primarily by entry of card-preferring households and increasing transaction sizes, rather than by changing preferences within existing households

Data

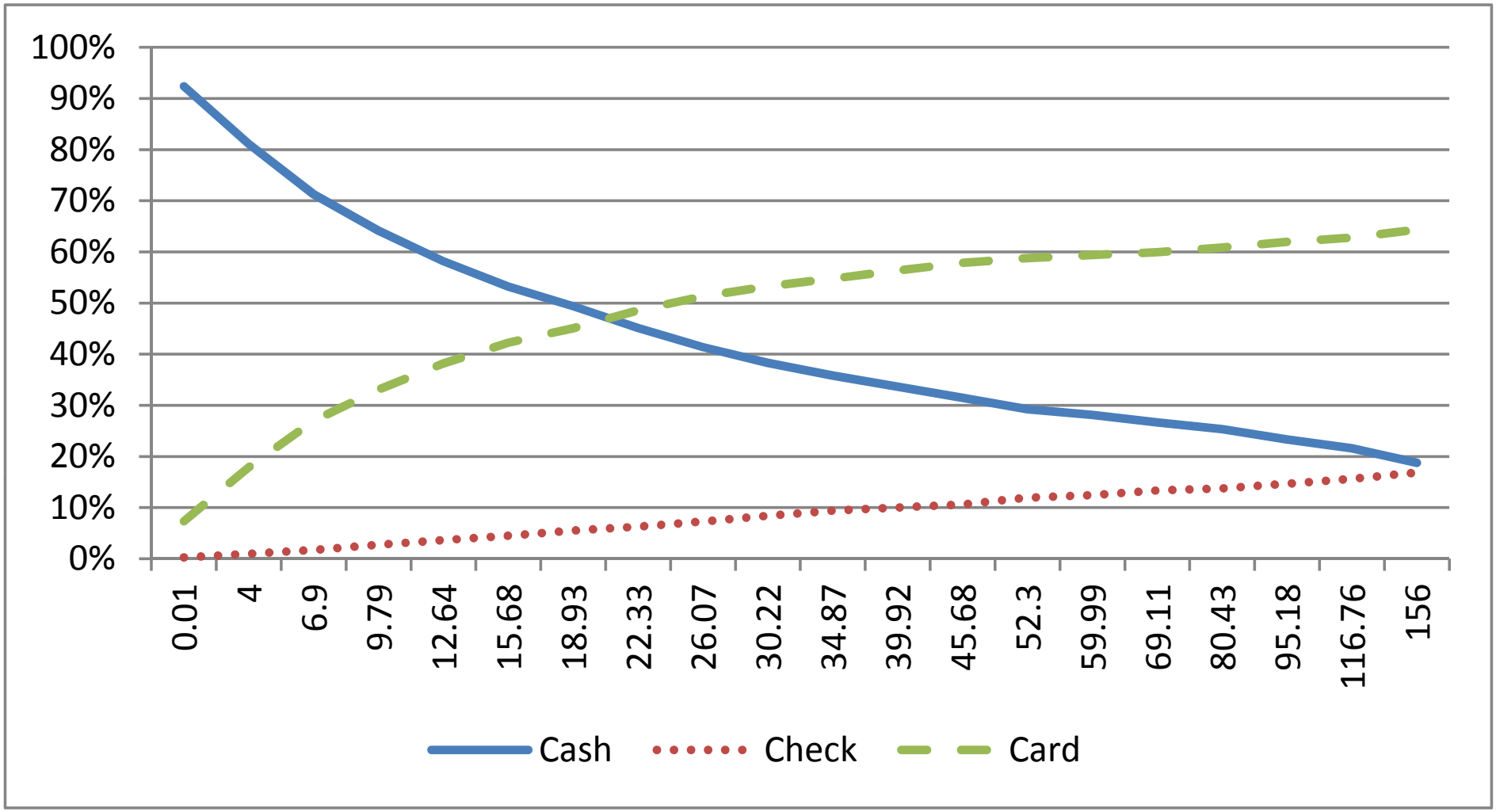
- Home-Scan database compiled by A.C. Nielsen
  - Unbalanced panel
  - Time frame: 2006 - 2008
  - Over 13,000 households
  - Over 1.34 million transactions
  - Important variables: payment choice (cash, check, card), time and date, household ID, store ID, shopper demographics
- Advantages
  - Panel nature allows for the use of fixed effects to capture unobserved heterogeneity in tastes between households
  - Panel nature enables instrumenting for potential endogeneity bias due to simultaneous causality between transaction size and payment choice
  - Directly-observed demographics (e.g. household size, income) allow for more accurate estimates of their impact on payment choice
- Limitations
  - Limited to grocery trips including calorie-rich consumer packaged foods

Summary statistics

Table: Summary statistics

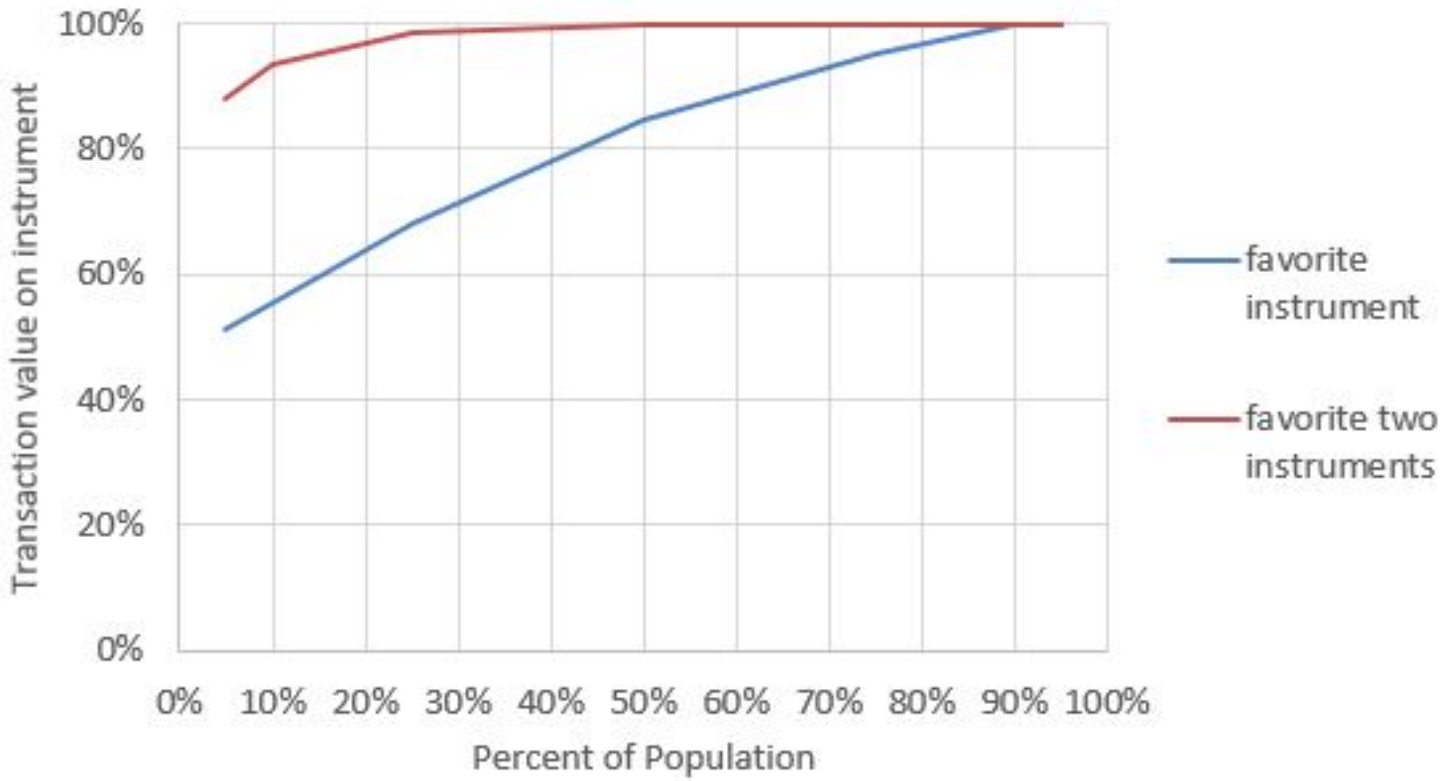
	Use share		Average
	Transactions	Value	Expenditure
Cash	47.9%	32.7%	$35.26
Check	6.6%	10.2%	$70.20
Card	45.5%	57.1%	$64.91

Summary statistics: Pay type by transaction size



Data trends: Single-homing

- Analysis of spending on favorite instrument, following Rysman (2007)
- Evidence of moderate single-homing, heterogeneity across households



Data trends: Switching

- Are households' favorite instruments constant over time?
- Data trends suggest switching is relatively rare

Table: Transition matrix for favorite payment instrument by household-quarter

	Cash	Check	Card
Cash	86.4%	1.9%	11.7%
Check	11.7%	77.4%	10.9%
Card	8.7%	1.1%	90.2%

Data trends: Impact of payment choice on transaction size

- Data trends suggest transaction size increases after households begin using a payment card - the *ticket lift* phenomenon

Table: Household shopping patterns, before and after card adoption

	Average transaction size			Number of
	Before adoption	After adoption	Overall	households
Card-adopting households	$35.34	$40.94	$38.69	325
All households			$40.06	13,574

Regression analysis: modeling approach

- We employ a multinomial probit discrete choice model

$$W_{im} = \alpha_m + \theta^x_m ln(x_i) + \boldsymbol{\theta^d_m d}_i + \mu_{im} + \boldsymbol{\theta^s_m s}_i + \theta^l_m y_{i-1m} + \epsilon_{im} \quad (1)$$

where:

- $m \in \{cash, check, card\}$
- W_{im} is the total utility household h_i receives from using method of payment m during shopping trip i
- α_m is the standalone utility each household gets from choosing method of payment m
- $\theta^x_m ln(x_i)$ is the utility resulting from choosing payment method m for a transaction size $ln(x_i)$
- $\boldsymbol{\theta^d_m d}_i + \mu_{im}$ is the household-specific utility that household h_i gets from choosing method of payment m; the first part is attributable to observable household demographic characteristics $\boldsymbol{d}_i$, while the second part is unobserved
- $\boldsymbol{\theta^s_m s}_i$ is the utility from shopping trip with characteristics $\boldsymbol{s}_i$
- y_{i-1m} is an indicator variable for whether payment method m was chosen in shopping trip $i-1$
- $\epsilon_{im} \sim N(0,1)$ is the error term

Regression analysis: identification and estimation

- Challenge #1: potential incidental parameters problem (Baltagi, 2003)
  - Problem: when employing individual fixed effects in a non-linear model, estimates could be biased if there is an insufficient number of observations for each individual
  - Solution: bias-correcting jackknife estimation procedure described by Dhane Jochmans (2015), related to Hahn Newey (2004)
- Challenge #2: instrumental variables in a discrete-choice model
  - Problem: potential of simultaneous causality between payment choice and transaction size
  - Solution: instrument for transaction size using day-of-week variable, using the two-stage residual inclusion (2SRI) estimation (Terza *et al*, 2008)
- Challenge #3: estimation procedure
  - Problem: traditional non-linear procedures used to estimate binary choice models are not computationally tractable when the number of coefficients (including fixed effects) gets large
  - Solution: expectation-maximization (EM) estimator (Chen, 2014)

Regression results: short-term payment choice

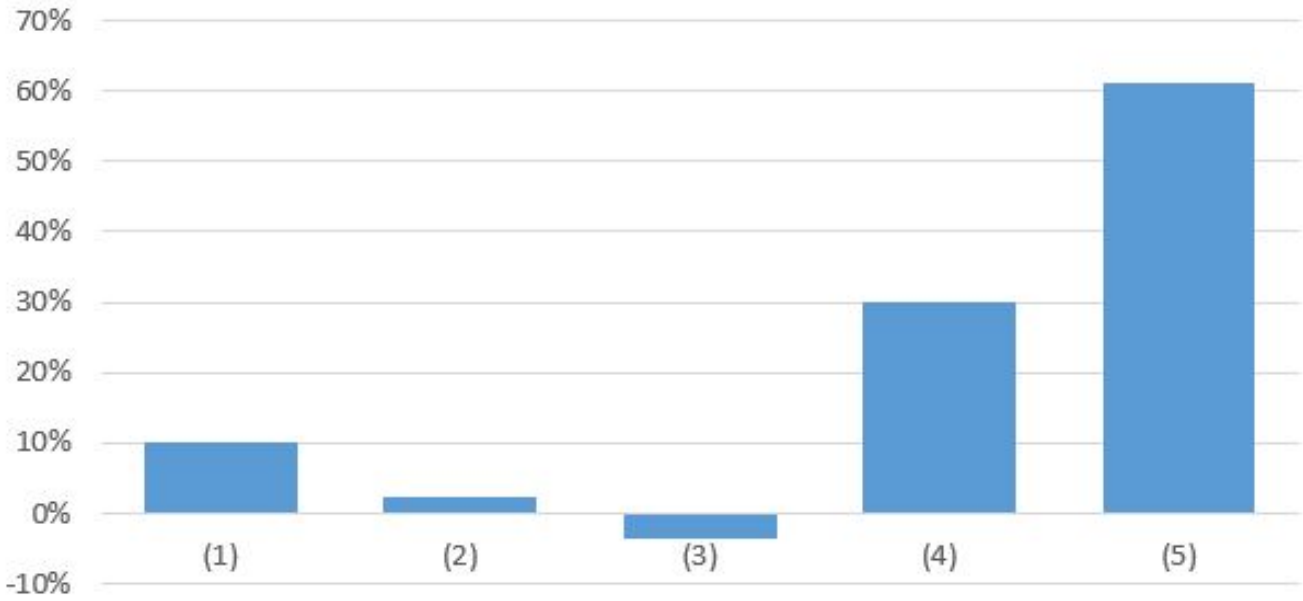
	(1)	(2)	(3)	(4)
			coefficients	
$\hat{\theta}_{check}$	0.787	0.811	0.812	0.728
	(0.0140)	(0.0114)	(0.0108)	(0.0285)
$\hat{\theta}_{card}$	0.665	0.678	0.708	0.523
	(0.0096)	(0.0081)	(0.0074)	(0.0215)
			marginal effects (ppt)	
cash	-0.190	-0.175	-0.156	-0.126
check	0.049	0.045	0.039	0.044
card	0.141	0.130	0.117	0.082
Demogr vars		X	X	X
Trip vars		X	X	X
Lagged choice		X	X	X
Fixed effects			X	X
Instr Var				X
Pseudo-R^2	0.147	0.390	0.736	0.747

Notes: Coefficients on $\hat{\theta}_{cash}$ are normalized to zero and not reported above. Standard errors are in parenthesis. The number of observations is 1,341,226. Marginal effects on $P(m = \cdot)$ calculated based on a 1% increase in $ln(x_i)$, measured at sample means.

- Transaction size is a strong determinant of payment choice, with higher values resulting in higher *check* and *card* use
- Estimates of the coefficient on transaction size will be biased upward unless the researcher accounts for:
  - household-specific preferences
  - simultaneous causality between payment choice and transaction size

Long-term: Drivers of the shift toward card payments

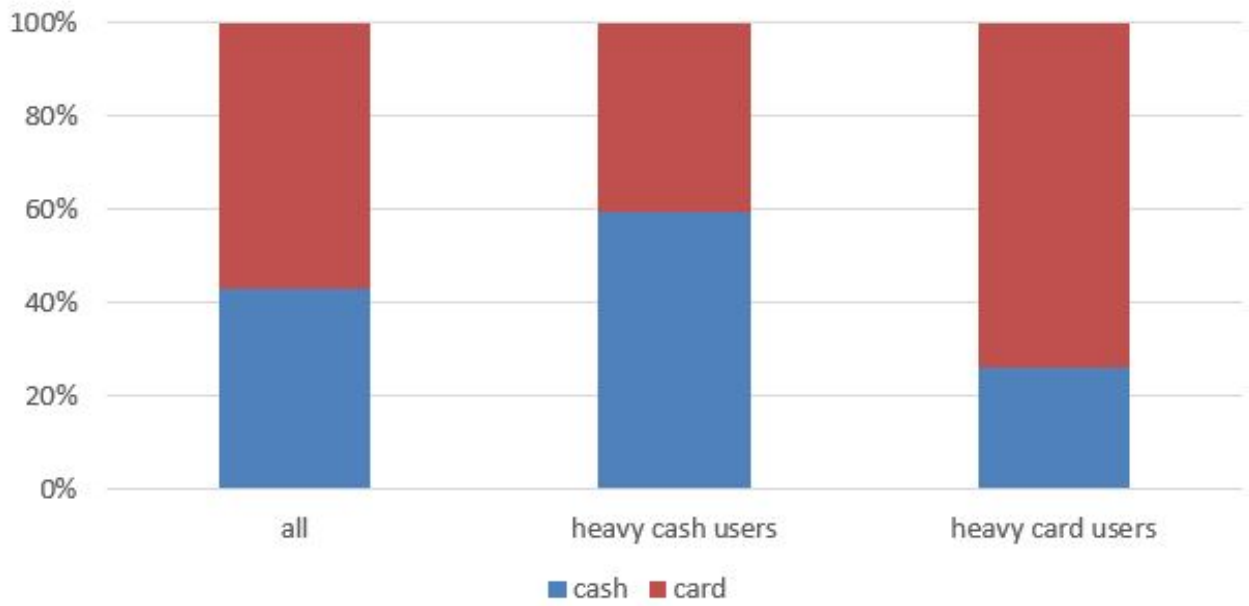
Figure: Contribution to explaining the growth in popularity of cash between 2006 and 2008, by contributing factor



- Main drivers of the shift toward cards were (4) the change in the mix of households in our sample, and (5) the growth in transaction size per shopping trip
- Changes in (1) household preferences because of observable demographic characteristics, (2) observable shopping trip characteristics, and (3) unobserved household preferences contributed little to the shift towards cards

Long-term: Move away from check to cash and card

Figure: Substitution of check users into cash and card, by intensity of instrument usage



- Withdrawing checks from the payment market would result in a similar gain in the number of cash and card payments
- Heterogeneity between households once again plays a key role - heavy cash users will mostly substitute cash for checks, while heavy card users will mostly substitute card for checks

Conclusions

- Data trends suggest moderate single-homing, though its extent differs substantially across households
- Households rarely switch favorite payments over time
- Transaction size is a key determinant of payment choice
- Estimated coefficients on transaction size will be biased upward unless the researcher accounts for (a) household-specific preferences and (b) simultaneous causality between payment choice and transaction size
- Long-term shift toward card payments is driven primarily by entry of card-preferring households and increasing transaction sizes, rather than by changing preferences within existing households
- Withdrawing checks from the payment market would result in a similar long-term gain in the number of cash and card payments

Thank you