An Empirical Analysis of Mental Accounting

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Goals

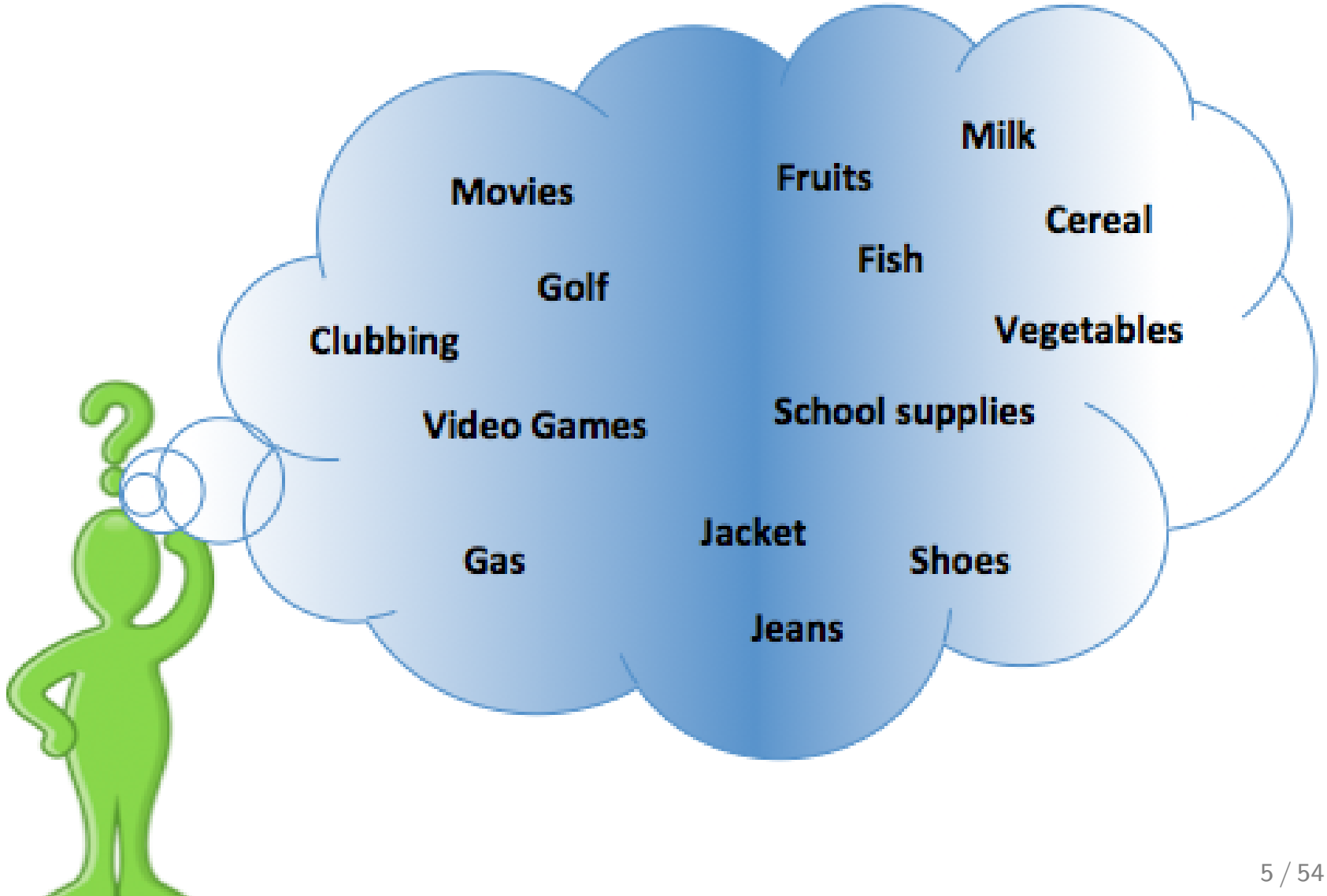
- Formulate an economic model of mental accounting to predict consumer expenditures
  - Model nests both mental accounting (bounded) and classical behavior (unbounded)
  - Derive stylized results of the model.
- Conduct the first large-scale empirical analysis of mental accounting using consumer financial transaction data
  - Estimate model using transaction-level data for pre-paid debit-card customers of a large American bank.
  - Investigate how often consumer "transfer" and "re-allocate" accounts?
- *(Future)* Translate mental accounting into innovations for financial service providers
  - Suggest new types of financial products that leverage mental accounts
  - Potentially help consumer make better financial decisions

Outline

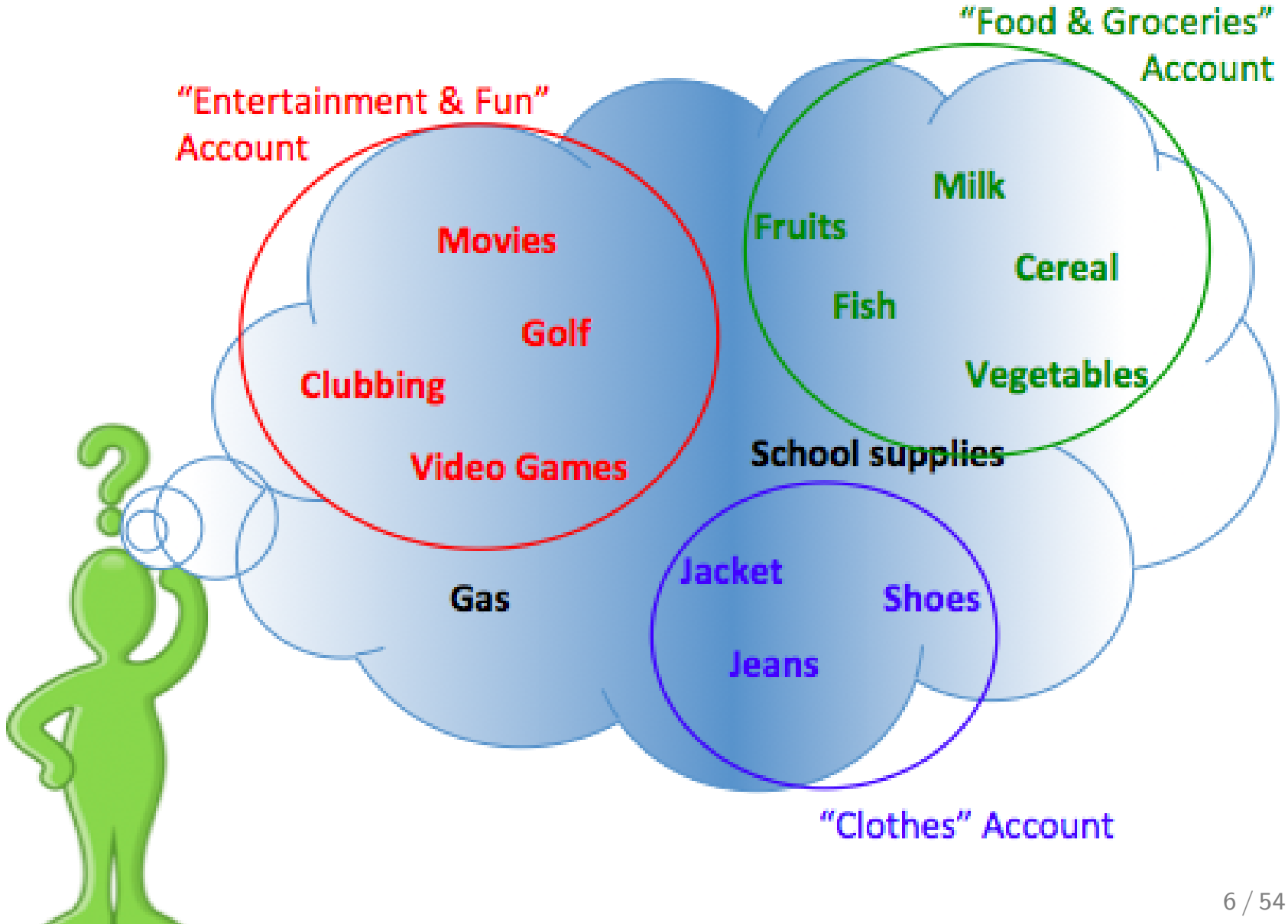
- Mental Accounting
- Data
- Model
- Empirical Results
- Conclusions

Mental Accounting

Consumer Decision Process



Consumer Decision Process



What is Mental Accounting?

- Consumers partition consumption expenditure into mutually exclusive categories to regulate consumption behavior (think ... gas budget, grocery budget, entertainment budget, etc.)
- "Mental accounting" theory says that these categories are not equally fungible, and that each have exclusive savings components.
- Consumers target a pre-budgeted level of expenditure in each category.
- Consumers are loss averse. They are more likely to re-allocate their pre-budgeted desired expenditure levels in each category if they overspend rather than underspend.
- See Thaler 1985; Shefrin and Thaler 1988; Thaler 1990; Heath and Soll 1996; Prelec and Loewenstein 1998; Prelec and Simester 2001; Cheema and Soman 2006.

- Imagine that you have decided to see a play where admission is \$10 per ticket. As you enter the theater you discover that you have lost a \$10 bill. Would you still pay \$10 for a ticket for the play?

  88% report 'Yes'

- Imagine that you have decided to see a play and paid the admission price of \$10 per ticket. As you enter the theater you discover that you have lost the ticket. The seat was not marked and the ticket cannot be recovered. Would you pay \$10 for another ticket?

  46% report 'Yes'

Consequences of Mental Accounting

- The ways that individuals and households organize funds
  - Violates fungibility: money in one account is not a perfect substitute for money in another
  - Often, \$1 $\neq$ \$1
  - Perceived cost to the consumer may vary, even when the financial cost is held constant
- Consequences
  - Segregate gains ("Don't wrap all your gifts in one box.")
  - Integrate losses ("One big bill rather than several separate ones.")
  - Cancel losses against larger gains ("Voluntary purchases always have the gain from purchase that outweighs the loss of the cash.")
  - Segregate "silver linings" ("Give a rebate instead of lowering the price")

Thaler (1999) summarizes the mental accounting process as that of ex-ante and ex-post cost-benefit analysis: individuals must decide how much to devote to accounts ex-ante. They then engage in consumption and investment where they decide if the cost of overspending/underspending is worth the additional benefit of consuming or investing in the particular product.

Classical Model vs. Mental Accounting

Classical model:

- Consumers choose consumption and savings to maximize discounted flow of utility subject to a budget constraint.
- Consumers do not "keep track" of over- or underspending in different categories.
- Endogenous dynamics only driven by savings and investment.
- Two-stage budgeting can capture hierarchy of accounts

Mental accounting model:

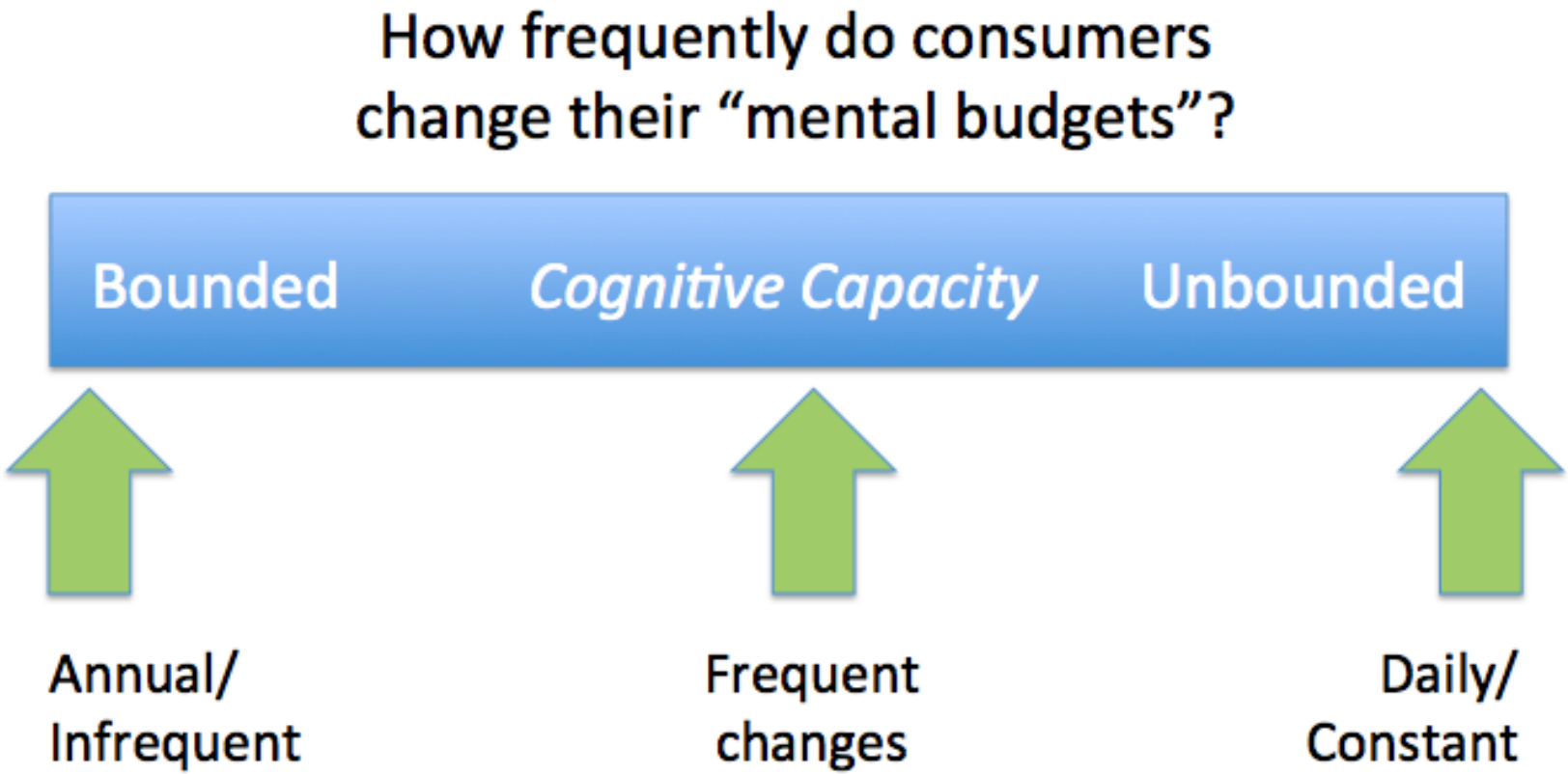
- Consumption and savings choices today are affected by last period's consumption and savings choices relative to a pre-set budget.
- Consumers "keep track" of over- or underspending in different categories and this "mental accounting" mechanism informs today's expenditure and budgeting decisions.
- Endogenous dynamics driven by mental account balances as well as savings and investment.

Difficult Financial Behaviors for Economics

Classical model:

- Why do people spend more with credit cards than cash?
- Why use both cash and credit cards?
- Why do people have money in savings but carry balances on their credit cards?
- Why do people spend a dollar earned from salary differently than a gift, bonus, gambling, ...

Our Research Problem



We want to model the number of times individuals explicitly update their mental account budgets. *Do you think consumers budget: once, annually, monthly, weekly?*

Current Mental Accounting Features in Practice

Why Do We Care? Some Financial Services Examples ...

- Wal-Mart's prepaid card contains an opt-in feature where individuals save at zero nominal interest, but are entered into a lottery for a chance to win $\$1,000$.
- "mint.com" allows users to set a budget for specific consumption categories and then receive cell phone or email alerts if expenditure approaches the budget.
- Retailers with information about consumer mental accounting practices could offer time-targeted coupons to consumers who are approaching their budget.

PNC's Virtual Wallet

Specific examples of mental accounting features:

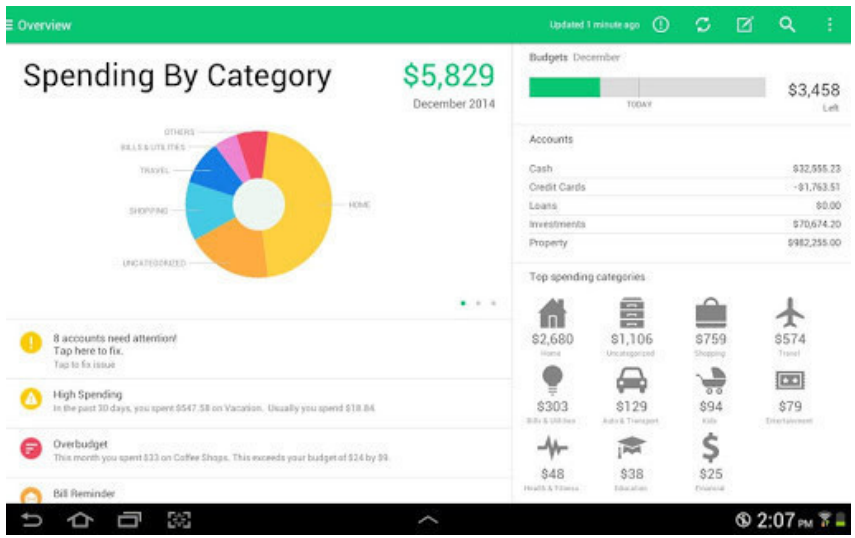
- Wish Lists: Explicitly generated "account" that allows consumers to "transfer" money towards a specific target
- Spending Zones: Consumers can setup alerts associated with accounts or events to warn or notify them
- Punch the Pig: Consumers receive auditory feedback and gamification of savings

Walmart's MoneyCard Vault

- Consumers that use Walmart's reloadable prepaid debit card can transfer money to a reserve (or "vault")
- The reserve does not show up in their balance
- Each dollar a customer saves in the vault equals one entry to win one of 500 cash prizes every month ($25 prize or one $1,000 grand prize)
- Launched in Aug 2016. Vault usage is up more than 130%. Vault users save 35% more.

Mint Money Management

- Free, web-based personal financial management service.
- Offers services that allow users to track bank, credit card, investment, and loan balances and transactions through a single user interface.
- Allows them to create budgets and set financial goals.
- Used by more than 20 million users.



Data

Example of Our Transaction Data

Time	Payee	Type	Amount	Assigned Category of Transaction	Potential Mental Account
1May2013 – 1	Starbucks #56819 3618 Forbes Ave., Pittsburgh	Credit Card	$6.83	Dining	Morning Coffee
1May2013 – 2	EatUnique 305 S Craig St., Pittsburgh	Debit Card	$10.21	Dining	Lunch from Office
1May2013	~~Mrs. Smith~~	Check	$20.00	Check	Piano Teacher
1May2013	Giant Eagle #040 5550 Centre Ave., Pittsburgh	Debit Card	$53.35	Groceries	Weekly grocery trip
1May2013	Carnegie Mellon University	Direct Deposit	$2,315.92	Income	Salary
2May2013	Mobile Deposit (from ~~Acct 018468290~~)	Deposit	$18.99	Deposit	Money from friend
2May2013	~~alanmontgomery@cmu.edu~~	POPMoney	$25.00	Deposit	Winning
2May2013	Verizon	BillPay	$92.18	Utility	Cell phone
2May2013	West Penn Electric	BillPay	$45.89	Utility	Home
3May2013	ATM Deposit; PNC #2999 4612 Forbes Ave., Pittsburgh	ATM	$100.00	Cash	Money for Date Night

Prepaid Debit Cards

We decide to focus on a smaller subset of consumers. Specifically those that use prepaid cards, which we expect are most likely to use mentally accounting. Also, we only have to deal with a single channel.

- Prepaid cards are often used to target the 67 million Americans who are "unbanked or underbanked"
- 46% Americans report they would have trouble coming up with $400 in an emergency (2015 Fed Res Board)

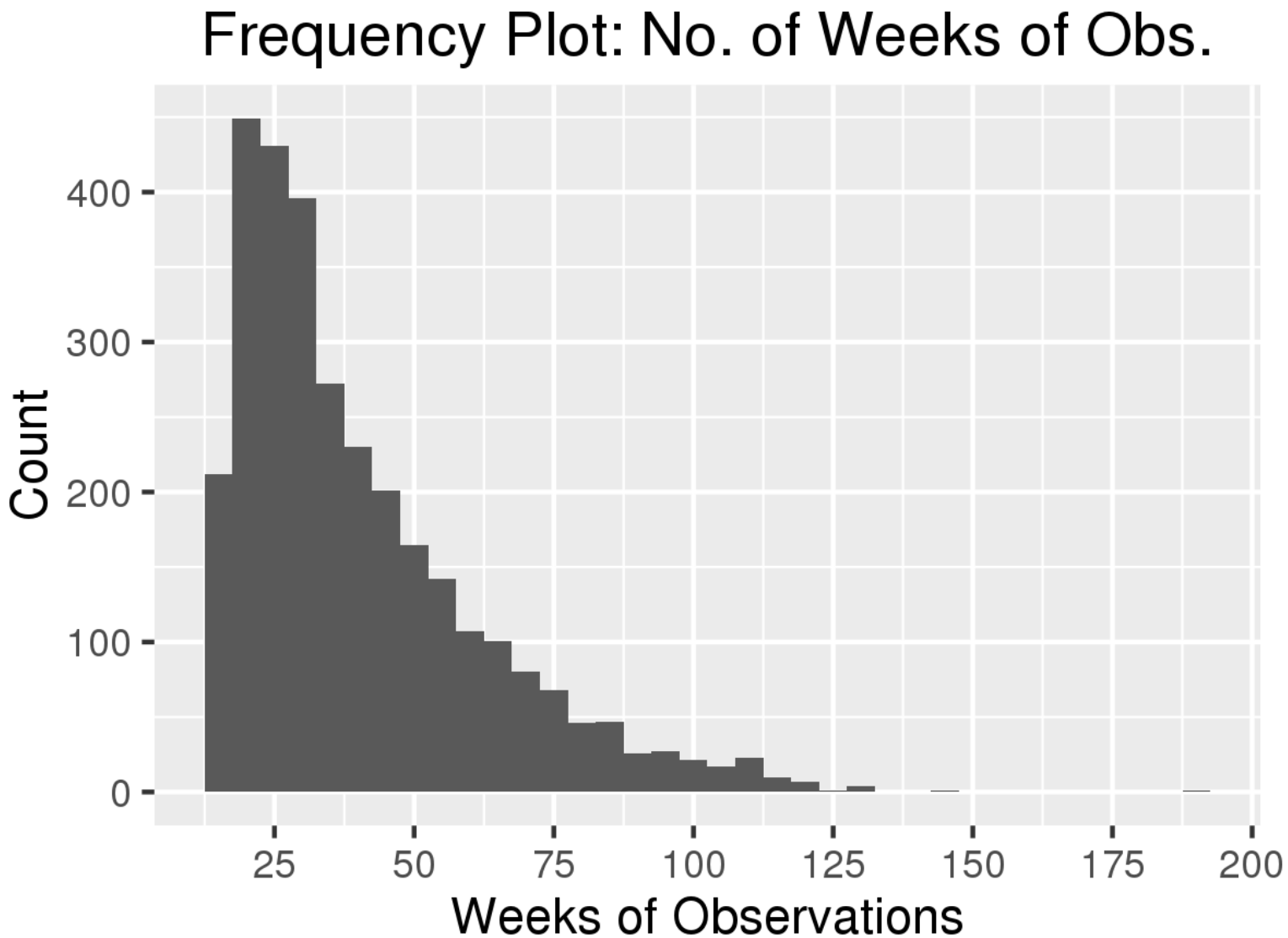
Data Summary

- 3,085 pre-paid debit card customers from a large bank with at least 16 weeks of observed transactions
- All customers receive weekly income on Fridays
- We sum up transactions to the weekly level.
- Categorize expenditure by first 2 digits of Visa merchant categories:
  1. Restaurants and bars (58xx)
  2. Auto parts and gasoline (55xx)
  3. Grocery stores (54xx)
  4. All other expenditure
- All customers have at least one transaction in each week of the sample.
- For each customer, we observe ≥ 30 expenditure transactions over the sample period.
- Range of observations: October 1, 2013 to January 31, 2016.

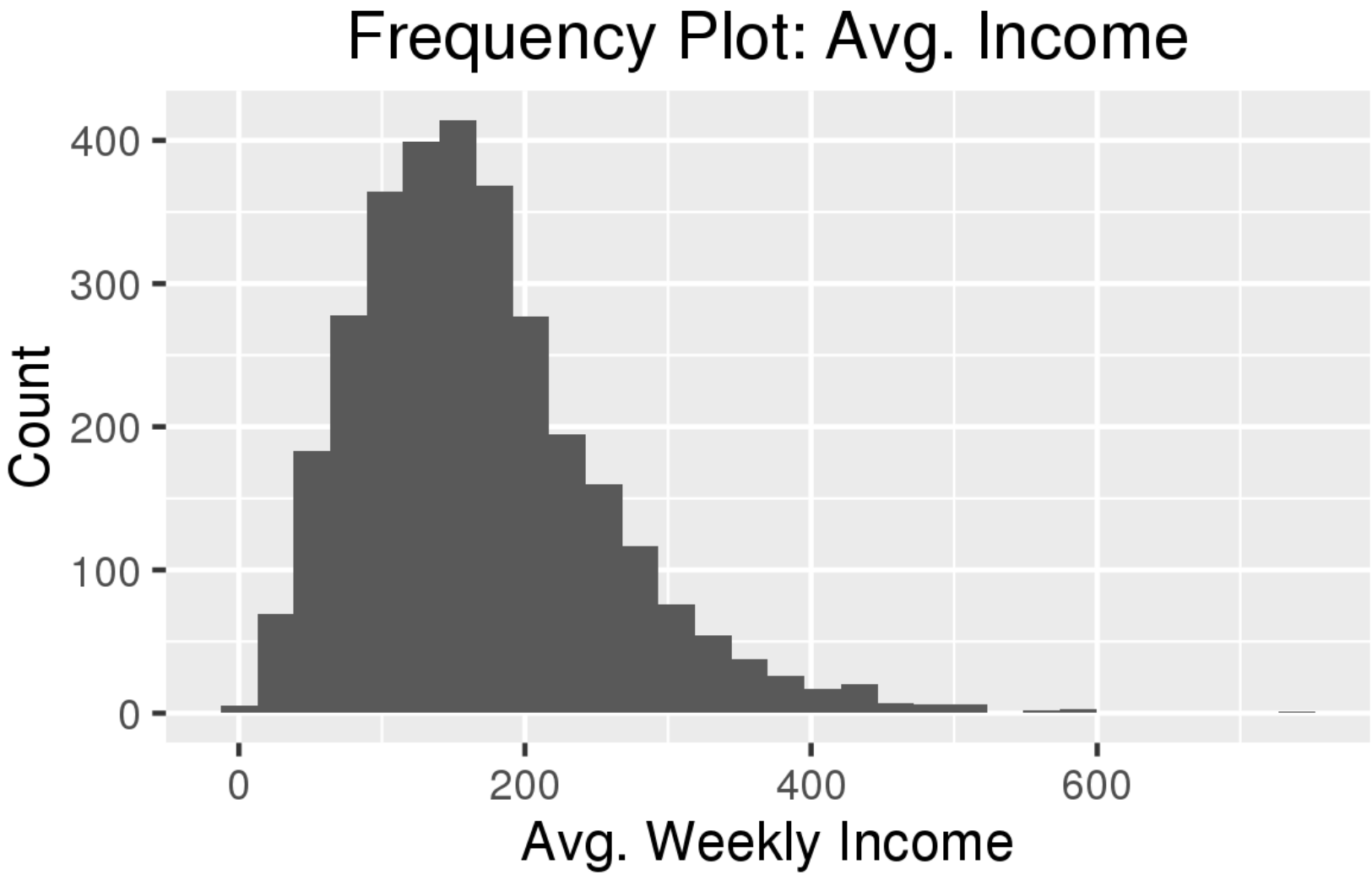
Table: Pre-paid Debit Card Data: Summary Stats Over Individual Means

		Individual Means: Real Values					
	Obs.	Balance	Income	Rest.	Gas	Groc.	Other
Min	16	-1630.72^*	8.29	0	0	0	1.07
Max	192	9016.87	1046.46	97.57	134.35	250.01	642.07
Mean	40.30	105.11	167.86	9.79	16.76	14.53	127.51
S.D.	22.10	330.59	87.07	9.59	15.89	17.32	75.00
Median	33	41.46	155.50	7.13	12.08	9.31	115.38

** NOTE: These are not the actual running balances! Running balances are computed in deflated real terms so as to satisfy the model's accounting identity. In the data, nominal balances are always positive.*


Frequency Plot: No. of Weeks of Obs.
Count
400
300
200
100
0
25
50
75
100
125
150
175
200
Weeks of Observations

Average Income Distribution



Empirical Evidence for Mental Accounting

Some Evidence of Mental Accounting

All of the following variables are assumed individual-level:

- Let s_{jt} be the share of expenditure from income, L_t in category j for period t. Sample mean is $\overline{s_j} = \frac{1}{T}\sum_{t=1}^{T} s_{jt}$.
- Loss-averse mental accounting would suggest that *on average*, consumers underspend rather than overspend relative to their pre-set budget.
- x_{jt} is actual expenditure in $\widetilde{x}_{jt} = \overline{s_j} L_t$ is predicted expenditure
- Agents more likely to underspend than overspend.

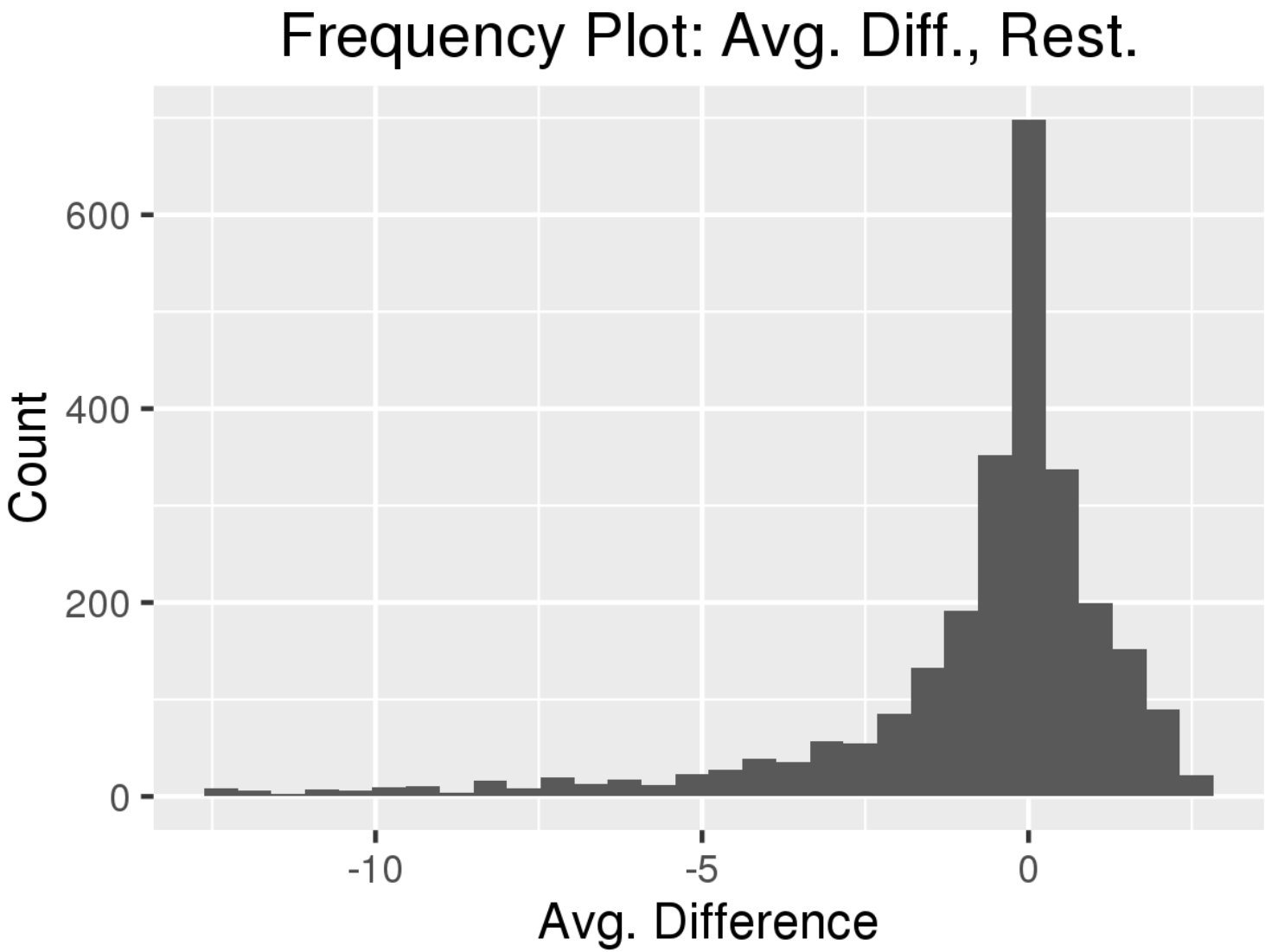
Table: Diff. from Predicted Value: $\frac{1}{I \cdot T}\sum_{i=1}^{I}\sum_{t=1}^{T}(x_{jt} - \widetilde{x}_{jt})$

	Rest.	Gas	Groc.	Other
Mean	-9.15	-6.58	-3.13	-50.67
SD	204.47	100.65	71.98	1669.74

Return: Estimation

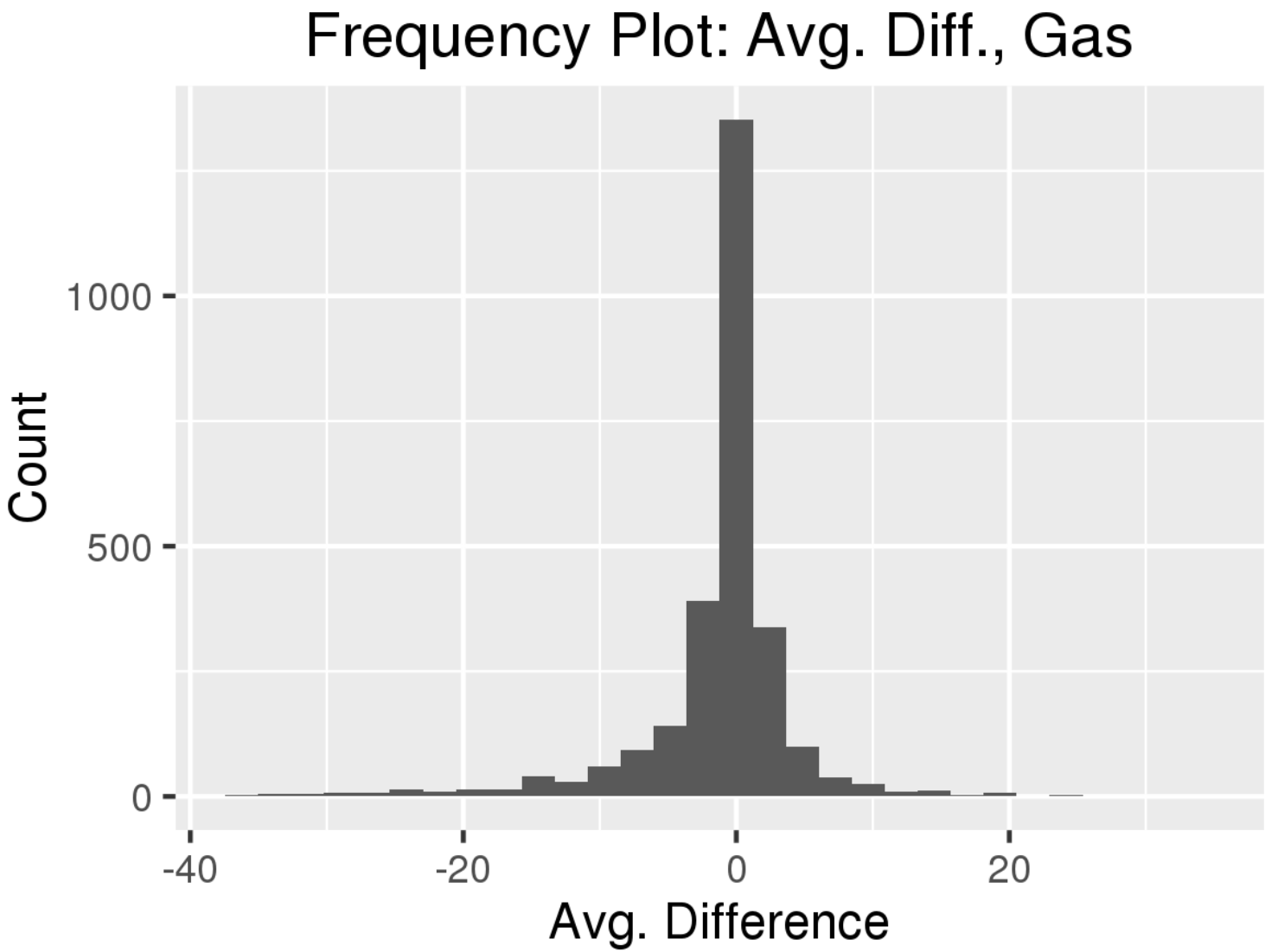
Restaurant Expenditure: Deviation from Predict

Figure: Outliers Excluded at 98^{th} Percentile

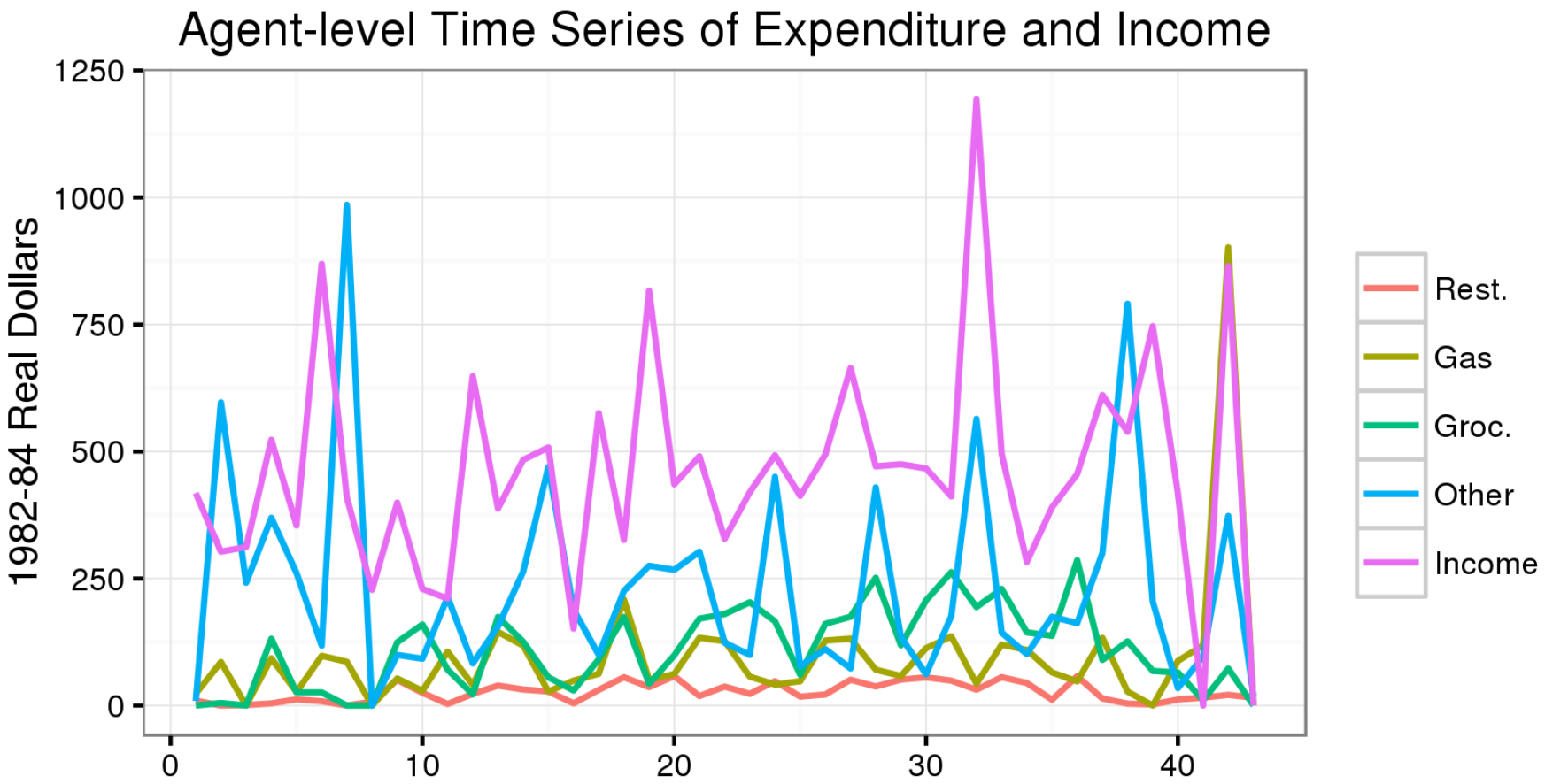


Gasoline Expenditure: Deviation from Predict

Figure: Outliers Excluded at 98^{th} Percentile



Real Weekly Expenditure for a Selected Consumer



A budgeting example – expenditure

Let x_j be purchase amount and A_j be the running mental account balance in category j. We illustrate mental accounting with a consumer's real weekly expenditure and hypothetical account budget. Here, we let the budget be average expenditure in the given category and assume $A_j = 0$ in the first period listed:

		Expenditures (Selected User)					
		Week 1		Week 2		Week 3	
Item	Budget	x	A	x	A	x	A
Gas	\$94.48	\$145.00	-\$50.52	\$117.97	-\$74.01	\$27.45	-\$6.98
Groc.	\$110.16	\$174.46	-\$64.30	\$125.60	-\$79.74	\$55.73	-\$25.31

Notice how after overspending significantly for 2-periods, the consumer underspends in period 3 reducing the "negative balance" on his mental account. Return: Illustration of Mechanics

A budgeting example – reallocation

Now assume after Week 2 consumer decides to rebudget:

- She can choose to "carry forward" her mental account balances or "reallocate."
  a. If she carries forward, in Week 3, she consumes less to bring her negative mental account balances closer to 0.
  b. Or she could "reallocate" by taking money from another account and adding it to the negative mental account balance in gas, for example, effectively clearing her balance.
- Previous slide illustrates example (a), since Week 3 expenditure decreases as if to accommodate a negative mental account balance.

Model

- Choice variables in period t:
  - Consumption in J categories, q_{jt}.
  - Budget shares in each category for next period, $\theta_{j,t+1}$.
  - Balances B_{t+1} via period cash holdings z_t.
- Expenditure in each category subject to a different, linearly independent constraint (similar to subset demand functions Deaton and Muellbauer (1980)).
- Individuals update their budget shares infrequently.
- Individuals are more likely to choose $\theta_{j,t+1} \neq \theta_{jt}$ if $A_{jt} << 0$ (mental account balance is negative).
- All dynamics act through choices of $\theta_{j,t+1}$, $j \in \{1, \ldots, J+1\}$.

Budgeting Example Decision Process

$A_{j,t}$ are over/under expenditure balances from last period. ζ_{jt} is *iid* exogenous shock. L_t is income.

$$p_{jt}q_{jt} = (\theta_{jt}L_t + A_{j,t})\zeta_{jt} \tag{1}$$
$$= \theta_{jt}L_t + A_{j,t} - A_{j,t+1} \tag{2}$$

Cash holdings from income:

$$z_t = \theta_{J+1,t}L_t + A_{J+1,t} - A_{J+1,t+1} \tag{3}$$

Law of Motion of B_t:

$$B_{t+1} = z_t + R_t B_t \tag{4}$$
$$= L_t - \sum_{j=1}^{J} p_{jt}q_{jt} + R_t B_t \tag{5}$$

Dynamic Budgeting Within the Model

Consumers update their desired expenditure shares θ_{jt} infrequently.

- Let k_t denote the number of consumption categories for which the consumer changes his budget each period.
  $k_t \in \{0, 1, 2, \ldots, J\}$
- Whenever the consumer decides to make a change such that $\theta_{jt} \neq \theta_{j,t+1}$, we always allow changes to be made to $\theta_{J+1,t}$ (the savings/liquidity category).
- The number of changes the consumer makes each period corresponds to a Poisson distribution truncated at J:

$$k_t = \sum_{j=1}^{J} \mathbf{1}\{\theta_{j,t+1} \neq \theta_{jt}\} \sim \text{Poisson}_{\{0,1,\ldots,J\}}(\lambda_k) \qquad (6)$$

Model Restrictions

We use an additively separated logged version of the period-utility function from Kim, Allenby, and Rossi (2002) along with a money-in-the-utility-function component for z_t featured in Walsh (2010):

$$u_t = \sum_{j=1}^{J} \alpha_j \ln(q_{jt} + 1) + \alpha_{J+1} \ln(z_t + M + R_t B_t) \qquad (7)$$

where M is a borrowing limit and R_t is the real-interest rate on money balance holdings.

In equilibrium, individuals choose q_{jt} to satisfy (1) then choose $\theta_{j,t+1}$ to maximize expected indirect utility (7) for period $t+1$ after substituting in (1). Equilibrium Description

- Do not observe k_t, θ_{jt}, A_{jt}, or ζ_{jt}, $\forall j, t$
- Observe expenditure $x_{jt} = q_{jt}p_{jt}$, not quantities.
- Want estimates of λ_k (Poisson mean) and α_j, $j \in \{1, \ldots, J+1\}$.
- Have to solve optimization problem k_t times for each t without observing k_t, for each individual consumer.
- $\lambda_k \to \{k_t\}_{t=1}^{T} \to \{(\theta_{1t}, \ldots, \theta_{J+1,t})\}_{t=1}^{T}$ involves a mapping from integers to real numbers and the policy function is analytically intractable.
- Bayesian techniques highly burdened by auto-correlation.

Empirical Results

We use a multistep Simulated Method of Moments (SMM) algorithm (see McFadden 1989; Gouriéroux and Monfort 1996)

- We set independent sample size (agent level) $S = 128$, the number of CPU's available to us on a shared-memory 64-bit computer, and parallelize over stored values of ζ_{jt} and A_{j0}.
- For a subsample of $I = 1589$ individuals, avg. estimation time for each individual about 20 minutes.

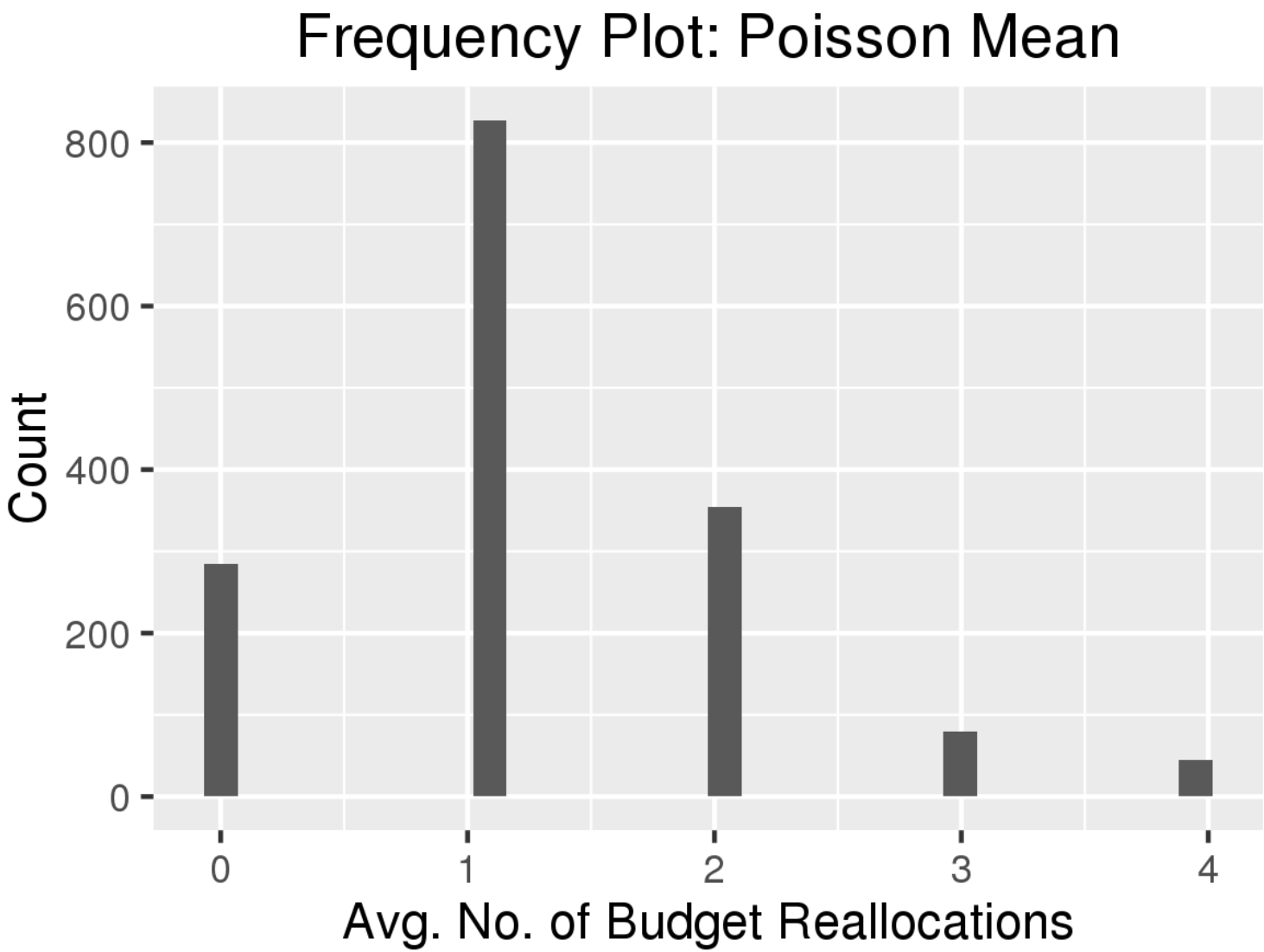
Estimation Details

Table: Summary Statistics for Individual Parameter Values

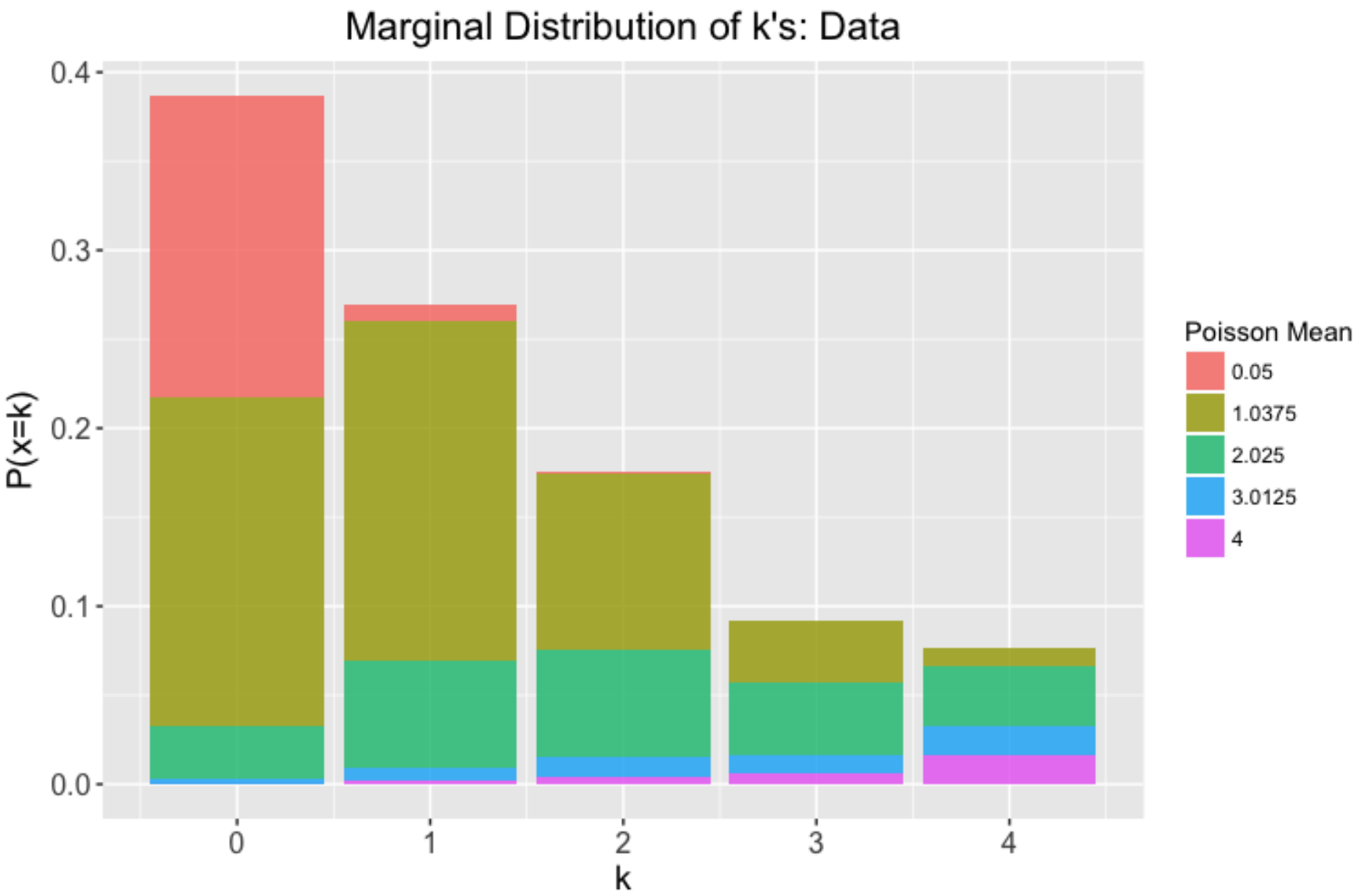
	α_1	α_2	α_3	α_4	α_5	λ_k
Min	0	0	0	0.170	-0.72	0.05
Max	0.57	0.64	0.806	1	26.902	4
Mean	0.076	0.12	0.093	0.714	1.53	1.263
S.D.	0.069	0.098	0.085	0.163	2.006	0.885
Median	0.060	0.096	0.070	0.725	0.940	1.038

NOTE: All parameters are estimated at individual level. Reported results are averages over $I = 1589$ *individuals.*
α_j, $\forall j \in \{1, \ldots, 4\}$ are in order: *restaurants*, *gasoline*, *groceries*, and *other expenditure*. α_5 is the balance-holding preference parameter. λ_k is Poisson mean.

Exponential Distribution of λ_k



Distribution of Budget Changes



- Most individuals infrequently update their mental account budgets and seek to stick to a long run plan.
- A few "change" all of their budgets every period. Observationally, this is equivalent to engaging in no mental accounting.

Why Do We Care?

- Can banks monetize this process in order to offer individuals category-specific loans tailored to their own budgeting behavior?
- Can banks leverage this information to *improve* consumer welfare?
- If mental accounts are latent to the consumer (not just the researcher), can we leverage transaction information to inform consumers so that they engage in welfare improving behavior?

Big Impact Takeaways ...

- Behavioral economic phenomena CAN be incorporated into classical economic decision problems that lend themselves to tractable estimation procedures.
- Big data provides us with opportunities to examine consumer behavior within both behavioral and neo-classical constructs in order to understand which models best describe consumer behavior in the real world.

Conclusions

- Our results suggest that the mental accounting framework, whereby individuals make infrequent updates to category-specific budgets, describes individual expenditure behavior well.
- Most individuals infrequently update their mental account budgets and seek to stick to a long run plan.
- Some individuals appear to have "sticky" mental accounts, changing infrequently, $\lambda_k \approx 0$.
- Others "change" all of their budgets every period. Observationally, this is equivalent to engaging in no mental accounting.
    - Does NOT mean that these individuals are "rational" in the neo-classical sense.
    - Could be that they are just "myopic," and do not consider how present consumption behavior impacts the future.

Near Term Goals

- Finish estimation on entire dataset and extend the SMM sample size to $S = 1000$.
- Analyze properties of estimator by engaging in resampling and comparing higher-order distributional moments.

- Can banks monetize this process in order to offer individuals category-specific loans tailored to their own budgeting behavior?
- Consider more statistically efficient estimation routines. Are Bayesian and likelihood-based routines possible to implement in a reasonable amount of time?
- Take model to a dataset that features explicit datapoints for individual's desired budgets to overcome the latency problems limiting our estimation inference.

Long-Term Goals

Research

- What is the empirical evidence for mental accounting?
- How do we operationalize mental accounting:
  - When are mental accounts opened? Closed? Or Transfers made?
  - When do consumers "budget"? An initial allocation? Weekly when they receive a paycheck? Monthly? Annually?
  - Are accounts transitory (e.g., an account for "trip to Tahiti") or permanent ("vacations")
  - Is there randomness in when accounts are used? (e.g., small amounts go to Misc, rushed financial decision not accounted properly)
- Can the marketer influence a mental account?

Innovations in Financial Services

- Collaborative opportunities for banks to work with consumers to achieve financial goals
- New product opportunities that integrate ?nudges? to improve financial decision making (manage spending and decrease ?)
- Overcome "irrational" behavior (over-spending/under-saving, loans from high interest sources)

Innovations for Retail Managers

- How to compete in markets when prices are increasing and consumers are over-budget?

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