



Supplementary Materials for  
**Harnessing Naturally Occurring Data to Measure the Response of  
Spending to Income**

Michael Gelman, Shachar Kariv, Matthew D. Shapiro,\* Dan Silverman, Steven Tadelis

\*Corresponding author. E-mail: shapiro@umich.edu

Published 11 July 2014, *Science* **345**, 212 (2014)  
DOI: 10.1126/science.1247727

**This PDF file includes**

Materials and Methods  
Figs. S1 and S2  
Tables S1 to S3  
References

# Harnessing Naturally-Occurring Data to Measure the Response of Spending to Income

Michael Gelman, Shachar Kariv, Matthew D. Shapiro,  
Dan Silverman, Steven Tadelis

## Supplementary Online Materials

### Transaction and Balance Data

The sample we use is based on de-identified data that we obtain from Check and that was aggregated as described below. The sample contains a panel of approximately 75,000 Check users, selected at random from the pool of U.S.-based users who had at least one bank or credit card account, and covers 300 consecutive days spanning 2012 and 2013. The sample of users is not refreshed. The average monthly rate of attrition is approximately 1.0%. Check refreshes its data daily and records every financial transaction that was posted for each user in the sample. The analysis we perform does not use the raw data collected by Check but instead uses the de-identified data to create individual-level measures that are normalized using the individual's aggregated transactions across time. We describe this in more detail below. The information about transactions includes the type of account to which they were posted, the dates of the transactions, the amount of the transactions, an indicator for whether they were a credit or debit to the accounts, and a description. The data also include daily account balances for each account of each user. Table S1 and S2 provide summary statistics of the transaction and balance data where  $P_i$  denotes the  $i$ -th percentile.

The quantity of information is notable. In only ten months, the sample of 75,000 users

Table S1: Transactions and Accounts

	Mean	$P_5$	$P_{25}$	$P_{50}$	$P_{75}$	$P_{95}$
Daily transactions	4.54	1	2	3	6	13
Credit card	1.23	0	0	1	2	5
Checking account	3.03	0	0	2	4	11
Saving account	0.22	0	0	0	0	1
Accounts	5.84	2	3	5	8	12
Credit card	3.58	1	2	3	5	9
Checking account	1.35	0	1	1	2	3
Saving account	0.79	0	0	1	1	2

Notes: In total, the 57,731,354 transactions are generated from 72,902 unique users over the study period.

Table S2: Account Balances

Panel (a): Bank	Mean	$P_5$	$P_{25}$	$P_{50}$	$P_{75}$	$P_{95}$
All	\$14,415	\$100	\$700	\$2,200	\$7,900	\$55,400
Checking	\$6,969	\$100	\$500	\$1,400	\$3,800	\$23,100
Saving	\$6,476	\$0	\$0	\$400	\$2,500	\$25,200
Money Market	\$12,076	\$0	\$100	\$900	\$7,700	\$57,400
C.D.	\$12,734	\$0	\$0	\$500	\$4,000	\$39,200
Panel (b): Credit Card	Mean	$P_5$	$P_{25}$	$P_{50}$	$P_{75}$	$P_{95}$
Balance	\$7,228	\$200	\$1,400	\$3,600	\$8,500	\$26,100
Credit Limit	\$23,019	\$800	\$4,200	\$11,900	\$29,500	\$81,800
Utilization Ratio	0.48	0.02	0.15	0.45	0.78	1.00
Revolving Debt	\$5,828	\$1,200	\$2,100	\$3,500	\$6,700	\$18,000
APR	18.46%	10%	15%	18%	23%	27%

Notes: All figures are aggregated to the user level. Panel (a) and the first three lines of Panel (b) reflect average daily balances over the last seven months of the study period. The last three lines in Panel (b) reflect average daily balances over the study period. We drop extreme values over \$10m as well as business accounts. The amounts are conditional on a user having that particular type of account. There are 64,136, 47,798, 10,530, 4,100, and 69,834 users who have Checking, Saving, Money Market, C.D., and Credit Card accounts respectively. The last three rows of Panel (b) are conditional on having revolving debt. 35,922 users have revolving debt at some point during the sample period.

recorded more than 57 million transactions using an average of about six different accounts. The data show substantial variation across users. Saving accounts have an average balance of \$6,476, a median of \$400 and an interquartile range of \$0 to \$2,500. Debit and credit utilization levels are similarly heterogeneous, and credit cards are used, on average, about half as often as checking accounts.

## **Income, Cash, and Transfer Measures**

We derive two measures of income: The first sums all transactions that represent credits to a user's non-credit-card accounts, excluding transfers from one account to another. The second isolates only those transactions that credit paychecks and Social Security payments, using a list of keywords commonly found in the description field. See Fig. 1 in the paper. Paychecks are identified using the following keywords: "direct", "dir dep", "dirdep", "salary", "treas 310 fed", "fed sal", "payroll", "ayroll", "payrl", "payrl", "payroll", "pr payment", "adp", "dfas-cleveland", "dfas-in."<sup>1</sup> Social Security payments are identified using the key word "soc sec." A paycheck or Social Security payment is classified as regular in frequency if the median number of days between its arrival is from 13 to 15 or from 26 to 34 and if its coefficient of variation is less than 0.5.

To identify ATM or cash withdrawals, we use keywords "atm" or "cash" and "withdrawal." We exclude ATM withdrawals that have "purchase" in them. Those transactions are purchases with ATM cards and are therefore classified as spending.

To identify transfers, we use keywords "transfer", "xfer", "tfr", "xfr", and "trnsfr."

---

<sup>1</sup>ING direct transactions and direct deposit advances identified by the keywords "ing direct", "direct deposit advance", and "dir dep adv" were not included in the data because they appear not to be payroll-related in general.

## Spending Measures

Fig. S1 shows the distribution of three spending measures, both for the entire sample and for those users whose accounts appear especially well-linked to the application.<sup>2</sup> Fig. S1 (a) and (b) show total spending. Fig. S1 (c) and (d) show *non-recurring* spending. Finally, Fig. S1 (e) and (f) isolate spending on certain fast food and coffee shops.<sup>3</sup> The main text provides descriptions of how these three measures are derived from the raw transaction data.

The combined content and frequency of the spending measures shown in Fig. S1 has no analogue in other data sources. In particular, unlike other sources, the Check data allow us to isolate irregular spending using the actual amount and pattern of spending, rather than an a priori categorization based on goods and services.<sup>4</sup> While these measures cannot be directly compared with those from other data sources, we can make qualitative assessments of their features. We note first that well-linked users exhibit fewer weeks with very low expenditure because they are less likely to spend from accounts that go unobserved by the app. Second, the approximate lognormal shape of the distributions of aggregate spending among linked users in Fig. S1 (b) and (d) is typical, and the spike at zero for fast food and coffee shops spending in

---

<sup>2</sup>Well-linked users are defined as those for whom we have at least 80% coverage of their credit card balance payments both as credits to the card, and as debits to a checking account. The denominator in this coverage is the number of credit card balance payments that are recorded on a user's credit card. The numerator is the number of payments of the same amount that show up in the user's checking account. This ratio proxies for whether users are linking their major accounts on Check.

<sup>3</sup>The non-case sensitive keywords are starbucks, dunkin, coffee, mcdonalds, kfc, taco bell, burger king, wendy's, subway, jack in the box, and panera.

<sup>4</sup>The CEX, which is the leading survey of expenditure in the U.S., conducts two separate surveys, a quarterly retrospective survey and a daily diary collected over two-week intervals. The measures of spending in the two surveys do not completely overlap; the daily diary emphasizes small, and frequently purchased items that would be hard to recall in the retrospective. The CEX, thus, cannot be used to calculate total or non-recurring expenditure at a weekly frequency. The American Life Panel (ALP) is an Internet survey that collects monthly self-reports of expenditure, in 25 categories, from approximately 2,000 respondents. These 25 categories capture high to medium frequency purchases. The Nielsen Panel of Consumers (Homescan) provides weekly expenditure data primarily for products with a Universal Product Code, or barcode. These expenditures, concentrated in the grocery and mass merchandise sectors, represent merely 40% of all expenditure on goods included in the government's measure of inflation. Thus, neither the ALP or the Homescan data can be used to measure total expenditure or non-recurring expenditure at daily and weekly frequency, nor do they have income closely aligned with the spending data.

Fig. S1 (e) and (f) is to be expected.

## **Heterogeneity of Excess Sensitivity**

In the main text we documented heterogeneity of excess sensitivity by levels of liquidity. Here we see evidence of similar heterogeneity by level of credit utilization. Fig. S2 plots estimates of  $\beta_{kc}$  for non-recurring spending, by terciles of credit utilization. We define credit utilization as the ratio of the average daily balance on all credit cards to the average daily credit limit summed across those cards. The average utilization ratio in the first, second, and third terciles of this measure is 0.22, 0.58 and 0.90, respectively. The results show that excess sensitivity is by-and-large a phenomenon of those near the limit of their ability to borrow with credit cards. While almost all Check users have access to credit, many are close to their borrowing limits. Among those close to the limit, excess sensitivity is much greater.

## **Summary of Comparison with Other Studies**

Table S3 compares estimates of the marginal propensity to consume (MPC) or elasticity across studies.

Table S3: Comparison of results with previous studies

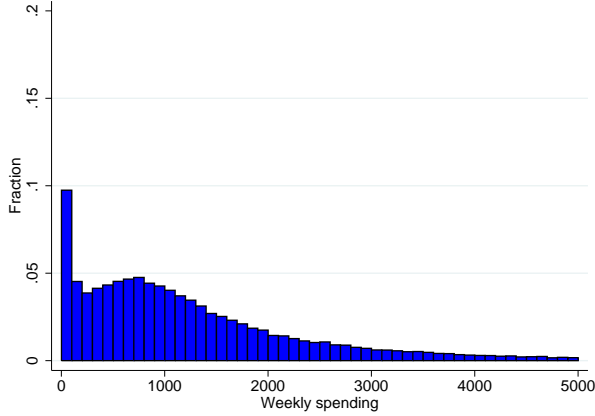
Study	Spending	Data	Frequency	Observations	Estimate	Confidence Intervals Range	Confidence Intervals Length
Parker (1999)	Non-Durable	CEX	Quarterly	133,820	Elasticity	[0.22 – 1.01]	0.79
Souleles (1999)	Total	CEX	Quarterly	4,525	MPC	[0.21 – 1.08]	0.87
Hseith (2003)	Non-Durable	CEX	Quarterly	806	Elasticity	[-0.06 – 0.07]	0.13
Stephens (2003)	Total	CEX-D <sup>1</sup>	Weekly	56,649	Elasticity	[-0.16 – 0.67]	0.84
JPS (2006)	Non-Durable	CEX	Quarterly	4,739	MPC	[-0.33 – 0.71]	1.04
PSJM (2013)	Non-Durable	CEX	Quarterly	10,362	MPC	[-0.03 – 0.55]	0.58
Broda, Parker (2014)	Total	Neilsen	Weekly	28,937	MPC	[0.01 – 0.02]	0.01
GKSST (2014)	Total	Check	Daily	5,371,244	Elasticity	[0.69 – 0.74]	0.05
GKSST (2014)	Non-Recurring	Check	Daily	5,371,244	Elasticity	[0.41 – 0.44]	0.03
GKSST (2014)	Total	Check	Daily	5,371,244	MPC	[0.06 – 0.08]	0.02
GKSST (2014)	Non-Recurring	Check	Daily	5,371,244	MPC	[0.00 – 0.01]	0.01

Notes: Confidence intervals are for estimates of the percent change in consumption with respect to a percent change in income (“elasticity”) and the change in consumption with respect to a change in income (“MPC”) for various studies. The last two columns present the range and length of the 95% confidence interval for these estimates.

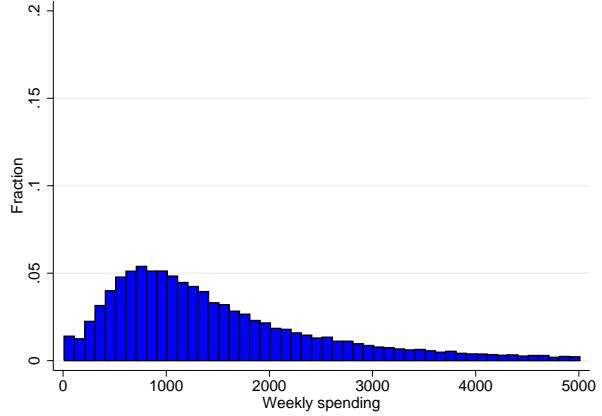
<sup>1</sup>Stephens (2003) utilizes the diary portion of the CEX (CEX-D). The diary is collected at a daily frequency and then aggregated to weekly for the cited analysis.

Figure S1: Distribution of Weekly Spending

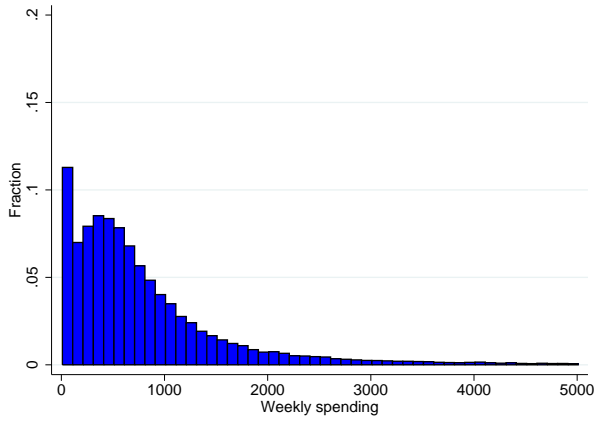
(a) Total (Full sample)



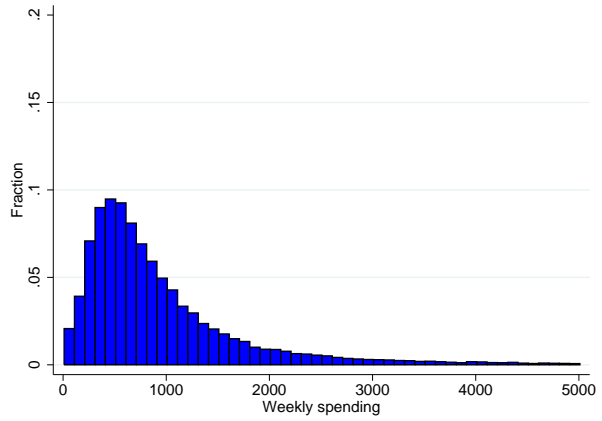
(b) Total (Linked users)



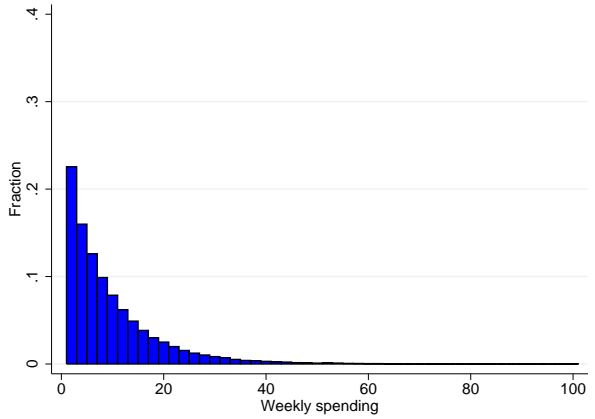
(c) Non-Recurring (Full sample)



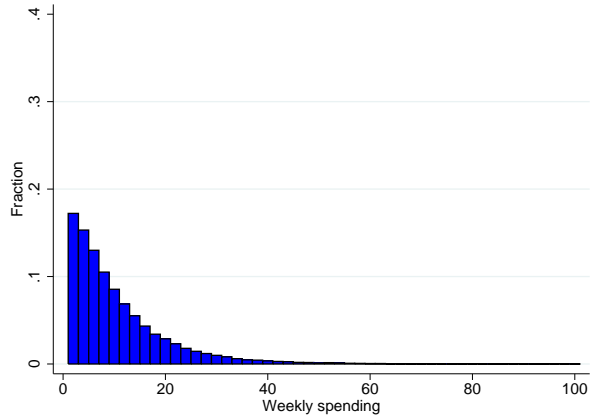
(d) Non-Recurring (Linked users)



(e) Fast Food and Coffee Shop (Full sample)



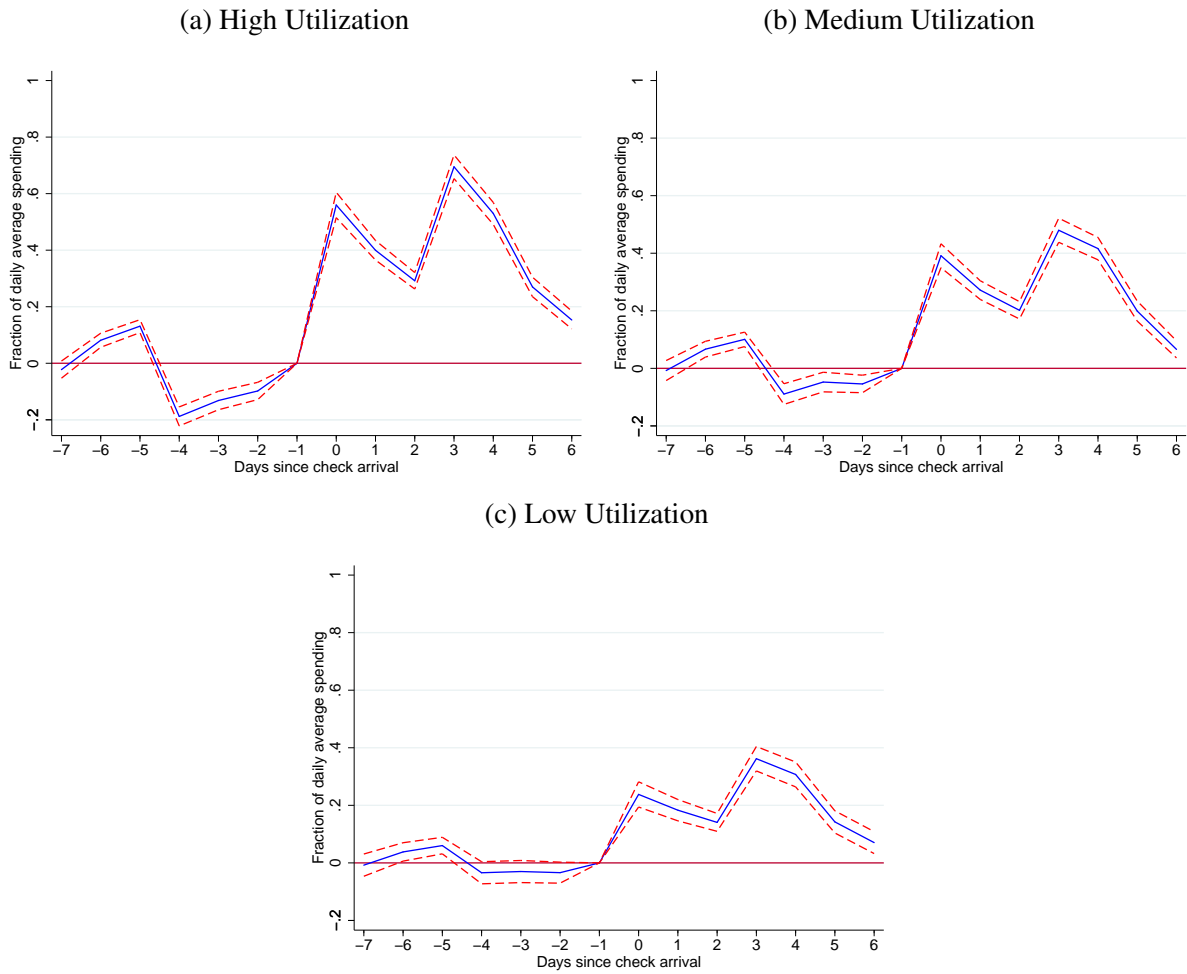
(f) Fast Food and Coffee Shop (Linked users)



Notes: The figure contains data from 72,182, 50,510, 72,101, 50,462, 59,261, and 46,004 users out of a total 72,902 for panels (a), (b), (c), (d), (e), and (f) respectively.



Figure S2: Response of Non-Recurring Spending to Income: Credit Utilization Rate



Notes: The utilization ratio is calculated conditional on carrying a debt balance. Solid line represents regression coefficients from Equation (1). Dashed lines are 95% confidence intervals. Estimates based on 852,709, 911,118, and 922,390 total observations from 3,832, 3,993, and 4,012 users for panels (a),(b), and (c) respectively.