Excess Sensitivity of High-Income Consumers

Lorenz Kueng

Northwestern University and NBER

How do HHs respond to large, regular, predictable, and salient cash flows?

- important for effectiveness of stimulus programs
- many cash transfers are highly predictable
- predictability and salience generates sharp predictions:
  - $MPC^{pih} = 0$ for basic PIH under certainty
  - $MPC^{bs} \approx 0$ for basic buffer stock model

To answer this question I use

- repeated quasi-experiments from Alaska Permanent Fund Dividend (PFD) payments of about $5,000 per household
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Preview of Main Results

1. Large average MPC$\sim$25% for nondurables & services
2. Heterogeneous MPCs concentrated among higher-income HHs

Can **rule out** most **previous explanations** of excess sensitivity:

- Liquidity constraints and precautionary saving
  - most HHs have enough liquid assets to smooth dividend
- Inattention
  - dividend is very salient (media) and occurs regular every year
  - dividend is highly predictable months and years in advance
  - dividend completely predetermined one month in advance, but I find no anticipation effects ($\rightarrow$ excess smoothness)
- Expenditures vs. consumption
  - strictly nondurables also respond
  - intertemporal substitution only for durables, not non-durables
  - dividend is annual and not constant, hence more difficult to use for liquidity management (eg cons. commitments/predeterm. exp.)

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What might be going on? → Sufficient Statistics approach

- Derive welfare loss in PIH model from not smoothing
  - ∝ relative payment size (per inc) and behavioral response (MPC)
    - Potential loss 0.1%−4.2% → economic power of setting
    - Actual losses similar across HHs & very small (<0.1%)
    - Why? Relative payment size & MPC are negatively correlated
- **Intuition**:
  - High-income HHs for whom non-smoothing doesn't matter drive average response (MPC>50%)
  - Lower-income HHs that shouldn't respond don't (MPC<10%)
  - Lower-income HHs with low liquidity do more (MPC∼25%)

⇒ consistent with **near-rationality**: thinking fast & slow (?)

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2. Data
3. Spending Response using Transaction Data
4. External Validity using Survey Data
5. MPC Heterogeneity
6. Welfare Losses from Excess Sensitivity
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Alaska Permanent Fund Dividend (PFD) = annual payments from state's broadly-diversified wealth fund

- dividend size is independent of local economy

Important characteristics of PFD for excess sensitivity tests:

1. *nominally large* and *lump-sum*
   - eligibility predetermined by presence during *previous* year
   - dividend is \$1,700 on average per person! (in real \$ of 2014)
     - avg family size = 2.8 $\Rightarrow$ \$4,800 every October
2. *predetermined, regular*, and *salient*
   - based on June numbers, announced in Sept., paid in October
   - *highly predictable*: 5-year moving-average of fund's income
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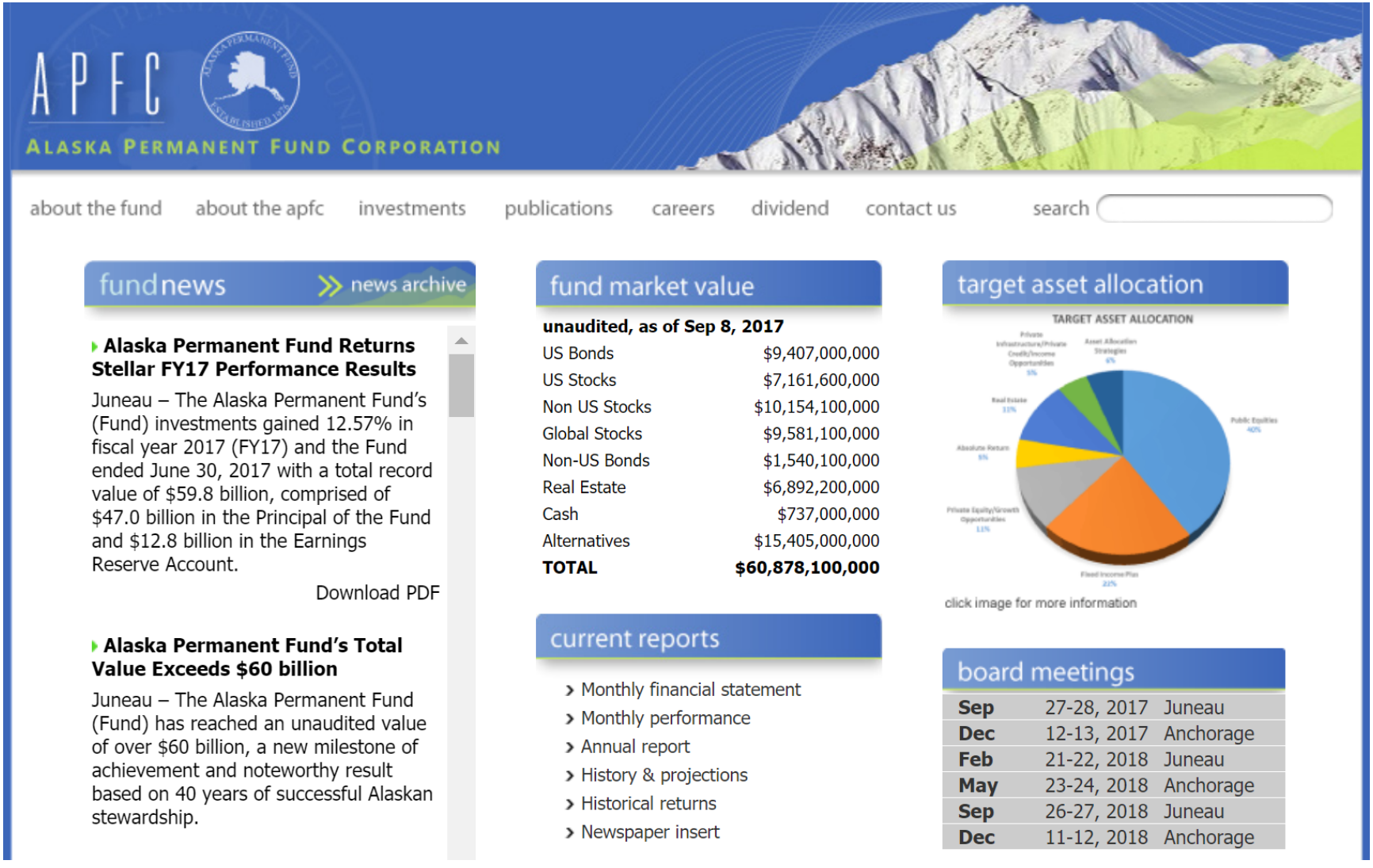
Independence from Local Economy: **Portfolio allocation** from Alaska Permanent Fund's website



APFC

ALASKA PERMANENT FUND CORPORATION

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fundnews

» news archive

Alaska Permanent Fund Returns Stellar FY17 Performance Results

Juneau – The Alaska Permanent Fund's (Fund) investments gained 12.57% in fiscal year 2017 (FY17) and the Fund ended June 30, 2017 with a total record value of $59.8 billion, comprised of $47.0 billion in the Principal of the Fund and $12.8 billion in the Earnings Reserve Account.

Download PDF

Alaska Permanent Fund's Total Value Exceeds $60 billion

Juneau – The Alaska Permanent Fund (Fund) has reached an unaudited value of over $60 billion, a new milestone of achievement and noteworthy result based on 40 years of successful Alaskan stewardship.

fund market value

unaudited, as of Sep 8, 2017

US Bonds	$9,407,000,000
US Stocks	$7,161,600,000
Non US Stocks	$10,154,100,000
Global Stocks	$9,581,100,000
Non-US Bonds	$1,540,100,000
Real Estate	$6,892,200,000
Cash	$737,000,000
Alternatives	$15,405,000,000
TOTAL	**$60,878,100,000**

current reports

- Monthly financial statement
- Monthly performance
- Annual report
- History & projections
- Historical returns
- Newspaper insert

target asset allocation

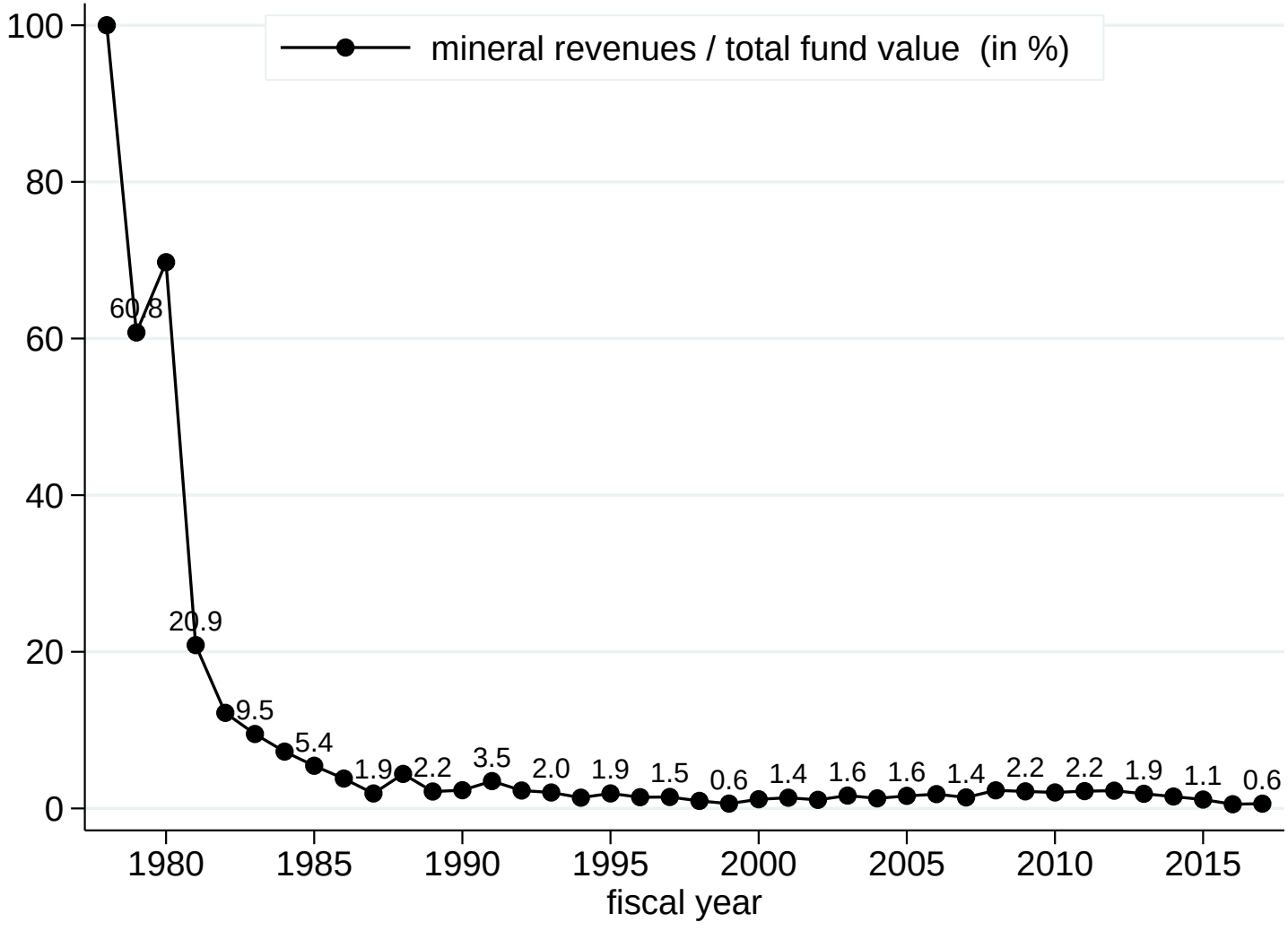
TARGET ASSET ALLOCATION

click image for more information

board meetings

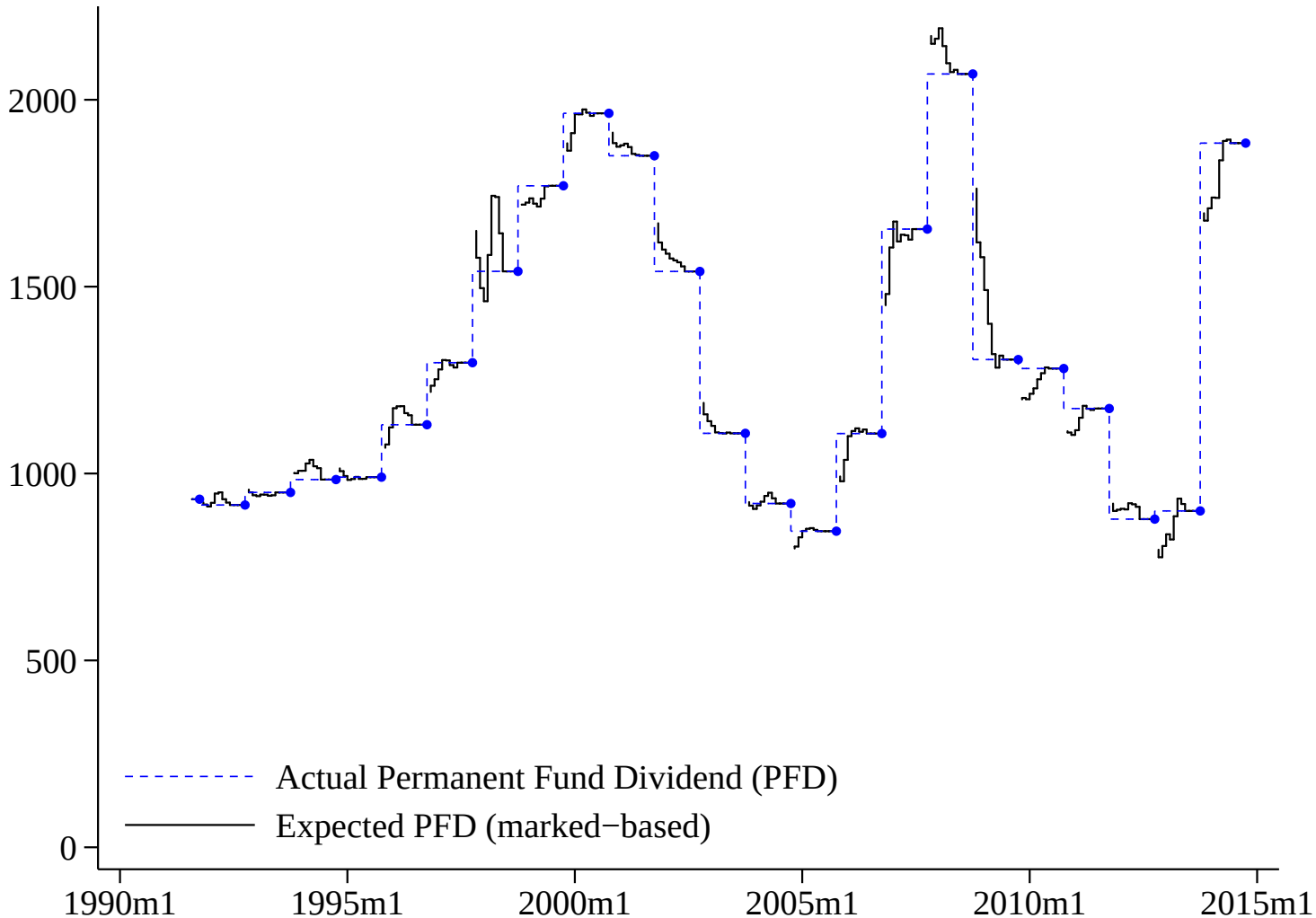
Sep	27-28, 2017	Juneau
Dec	12-13, 2017	Anchorage
Feb	21-22, 2018	Juneau
May	23-24, 2018	Anchorage
Sep	26-27, 2018	Juneau
Dec	11-12, 2018	Anchorage

Independence from Local Economy: **Oil Revenue** is only small fraction of fund's market value

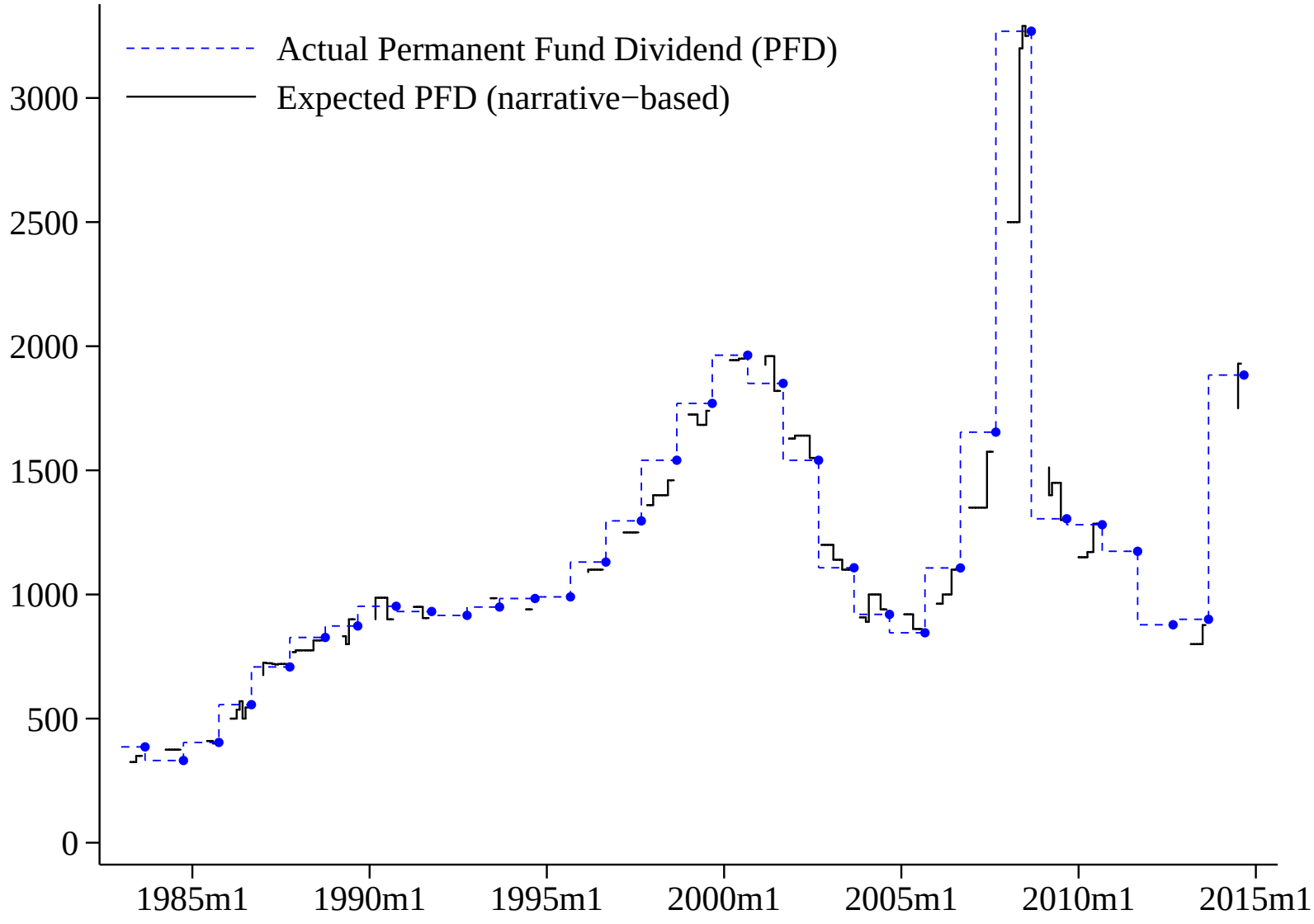


Size & Predictability: **Divided Forecast** using dividend rule set in state law based on APF's 'income from assets'

$$PFD_t = \frac{0.5 \times 0.21 \times \sum_{s=t-4}^{t} (\text{Income from Assets})_s}{\text{Number of Eligible Applications}}$$

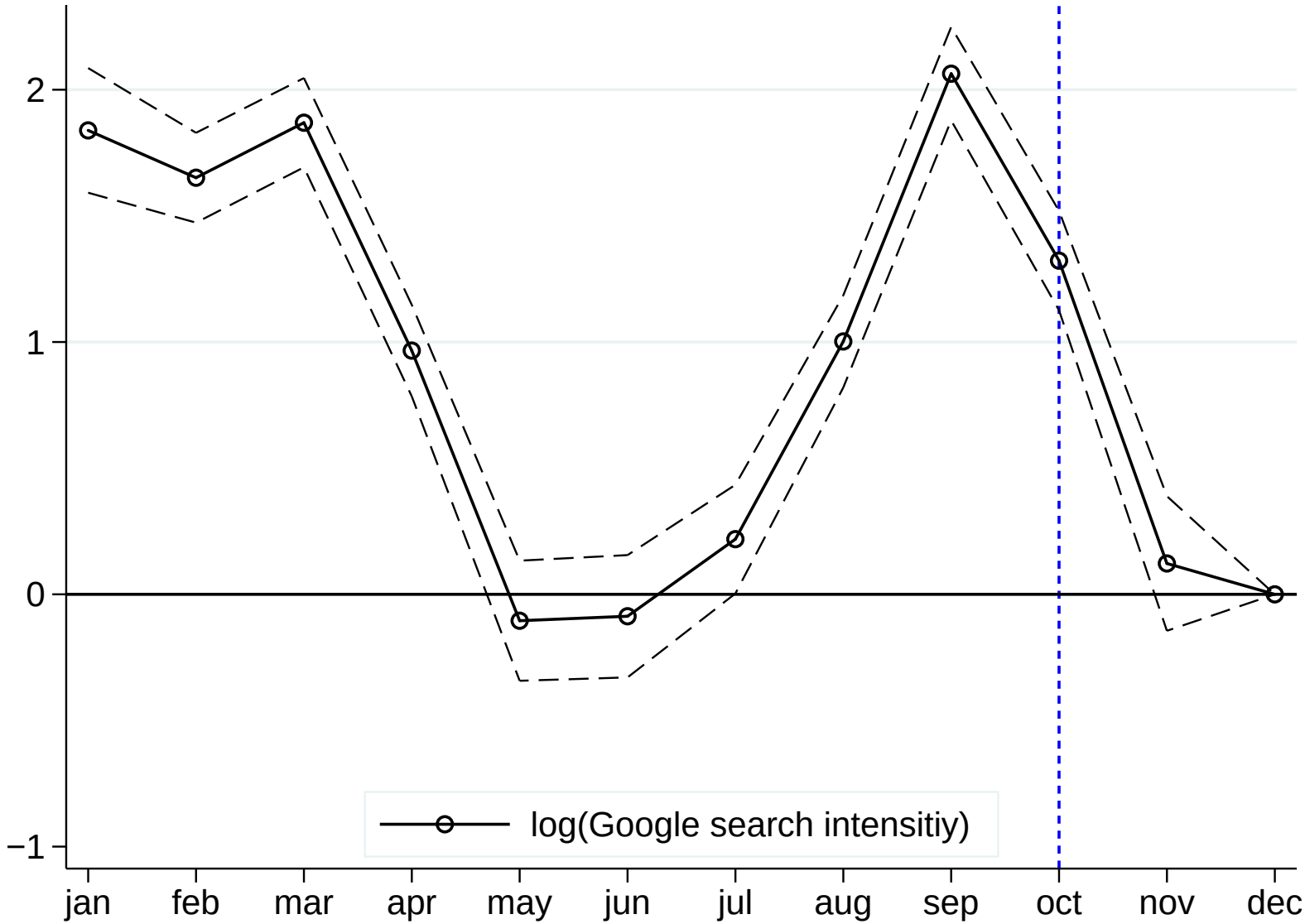


Salience: Dividend forecast by **Local Newspapers** (narratives)



Salience: **Google Searches** for term "Permanent Fund"

$$\log(\text{Google Searches})_t = \sum_m \text{Month}_m + \alpha + \gamma \cdot t$$



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Household Spending Data

1. New transaction data from user accounts at a large **personal finance website** from 2010-2014
   - 1,400 Alaskan users that receive dividend via direct deposit (treatment group)
   - 2,200 users from state of Washington (control group)

2. **Consumer Expenditure Survey** (CE) to check external validity of new data and results
   - fewer Alaskan households: $\sim$ 80 per year (only in one MSA)
   - longer time series: 1980-2013

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Pros and Cons of Account-Level Data vs. Surveys

Advantages

- Automatic, passive data collection
- No recall bias and other survey measurement error
- Easy to identify Permanent Fund Dividend income
- Long(ish) high-frequency panel of expenditures and income

Disadvantages

- Non-representativeness
- Less demographic information
- Households with multiple users
- Unlinked accounts
- Mapping merchant codes to expenditures categories
- Dealing with uncategorized transactions, checks and cash transactions (ATM withdrawals)

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Summary Statistics

Table 1: Summary Statistics

A. PFW Sample	State of Alaska			State of Washington		
	Mean	Median	St.Dev.	Mean	Median	St.Dev.
Permanent Fund Dividend						
- annual payments	1,999	1,417	1,357	--	--	--
- per annual afer-tax income	2.8%	2.1%	3.9%	--	--	--
- per annual total expenditures	4.7%	3.6%	3.9%	--	--	--
Quarterly Expenditures						
- nondurables and services	8,441	7,179	5,858	8,049	6,531	6,103
- durables (paid for with a credit card)	3,116	2,235	3,036	2,971	2,074	3,019
- other items in total expenditures	13,017	8,651	15,607	12,849	8,229	16,060
- total expenditures	24,576	19,177	20,993	23,910	18,067	21,719
Income						
- annual after-tax income	99,716	82,294	74,056	96,380	76,872	76,653
- annual before-tax income (imputed) [1)]	119,757	92,267	104,573	116,922	87,702	108,066
Net Financial Assets						
- bank accounts ('cash-on-hand')	40,903	11,715	85,484	61,234	21,911	107,198
- taxable (brokerage) accounts	150,708	8,751	461,182	229,808	28,021	599,532
- tax-deferred accounts	164,086	33,952	366,360	164,686	42,666	327,013
- total net financial assets	366,055	108,034	770,065	468,000	153,332	870,699
Demographics						
- family size	2.80	2	1.37	2.61	2	1.37
- age	32.18	31	10.67	30.93	31	10.27
- education (years of schooling)	15.34	16	2.22	16.03	16	2.12
Number of households	1,379			2,167		

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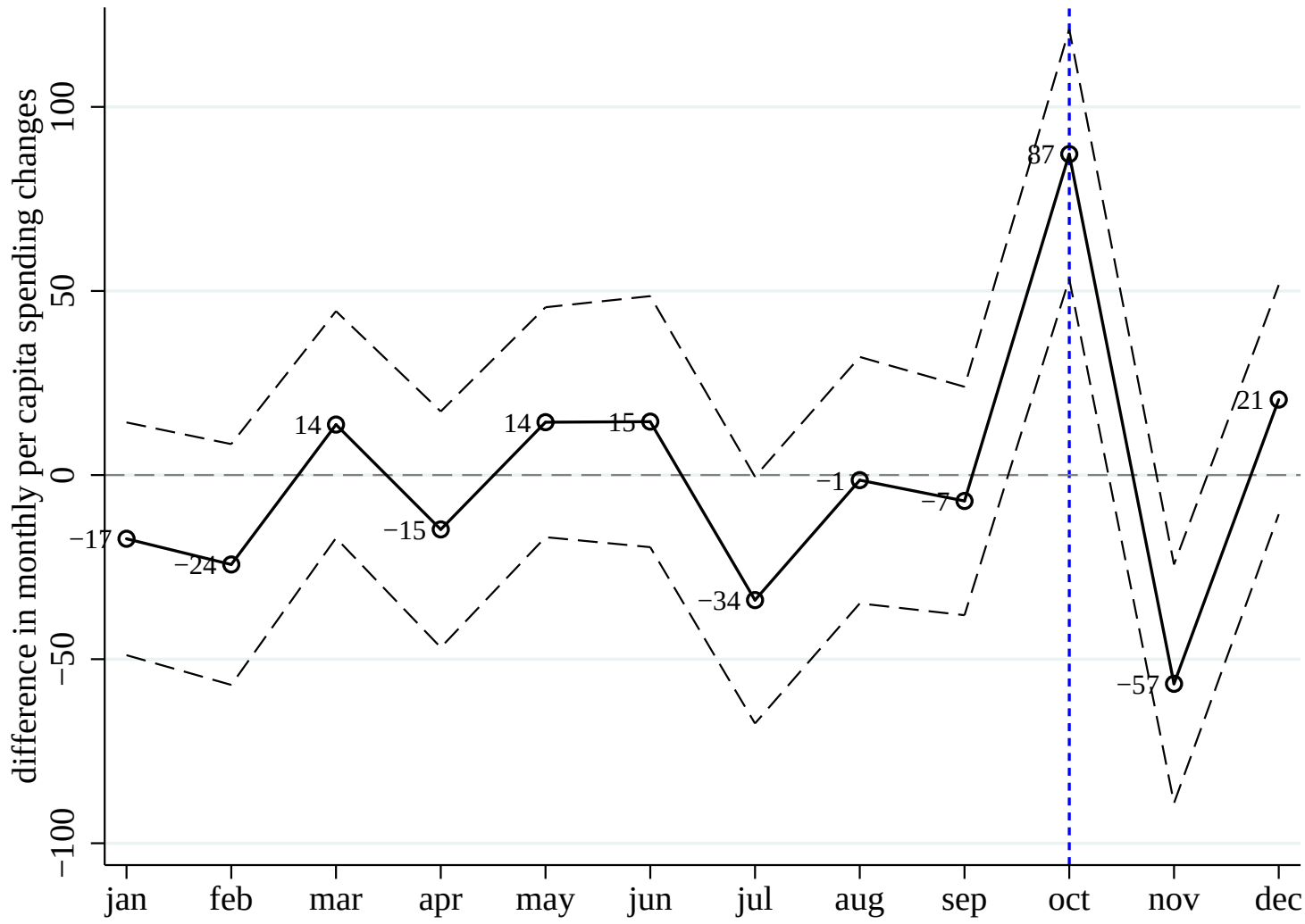
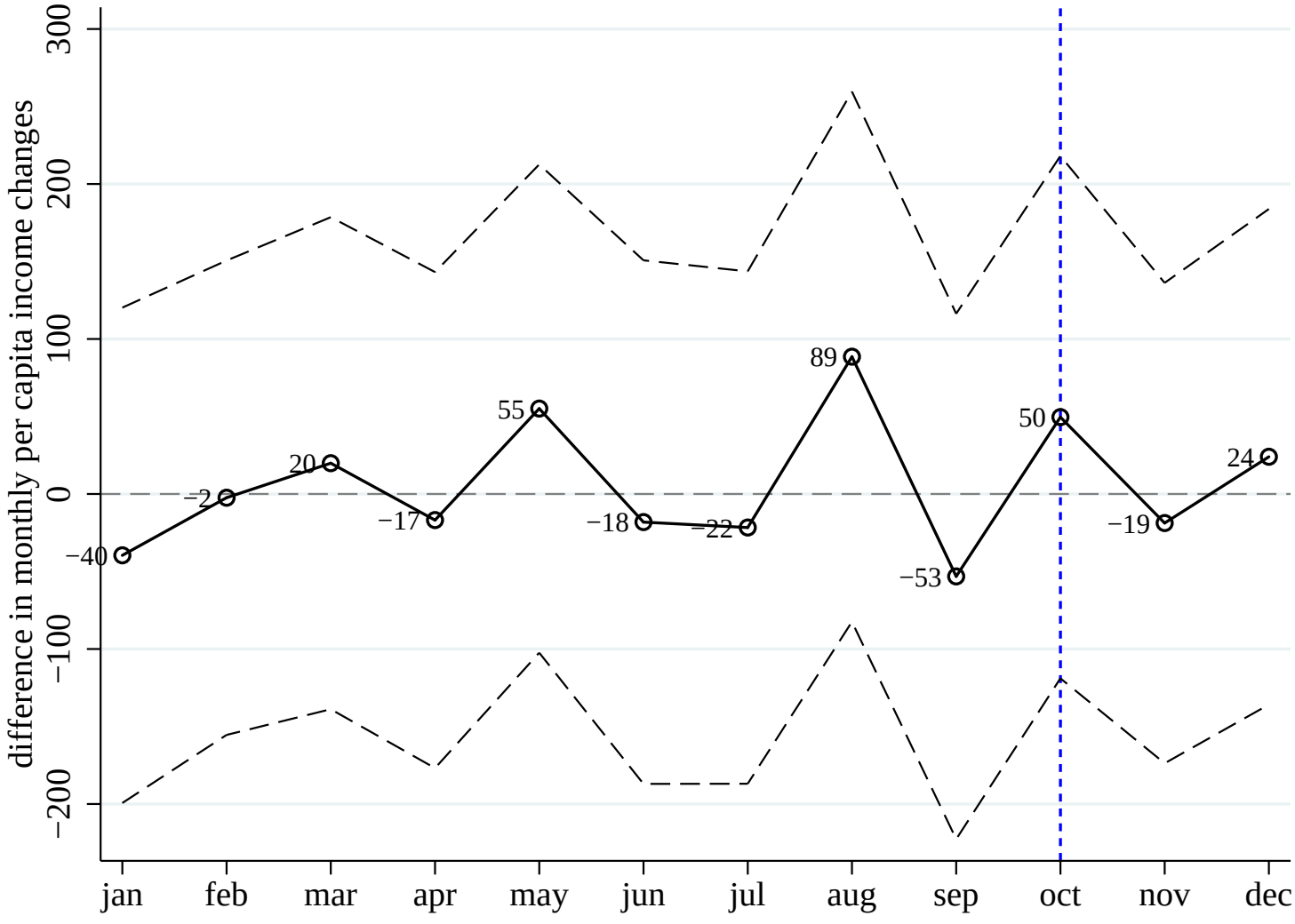
Nonparametric Evidence of Excess Sensitivity: Average nondurables changes per cap, Alaska vs. Washington (**Diff-in-Diff**)



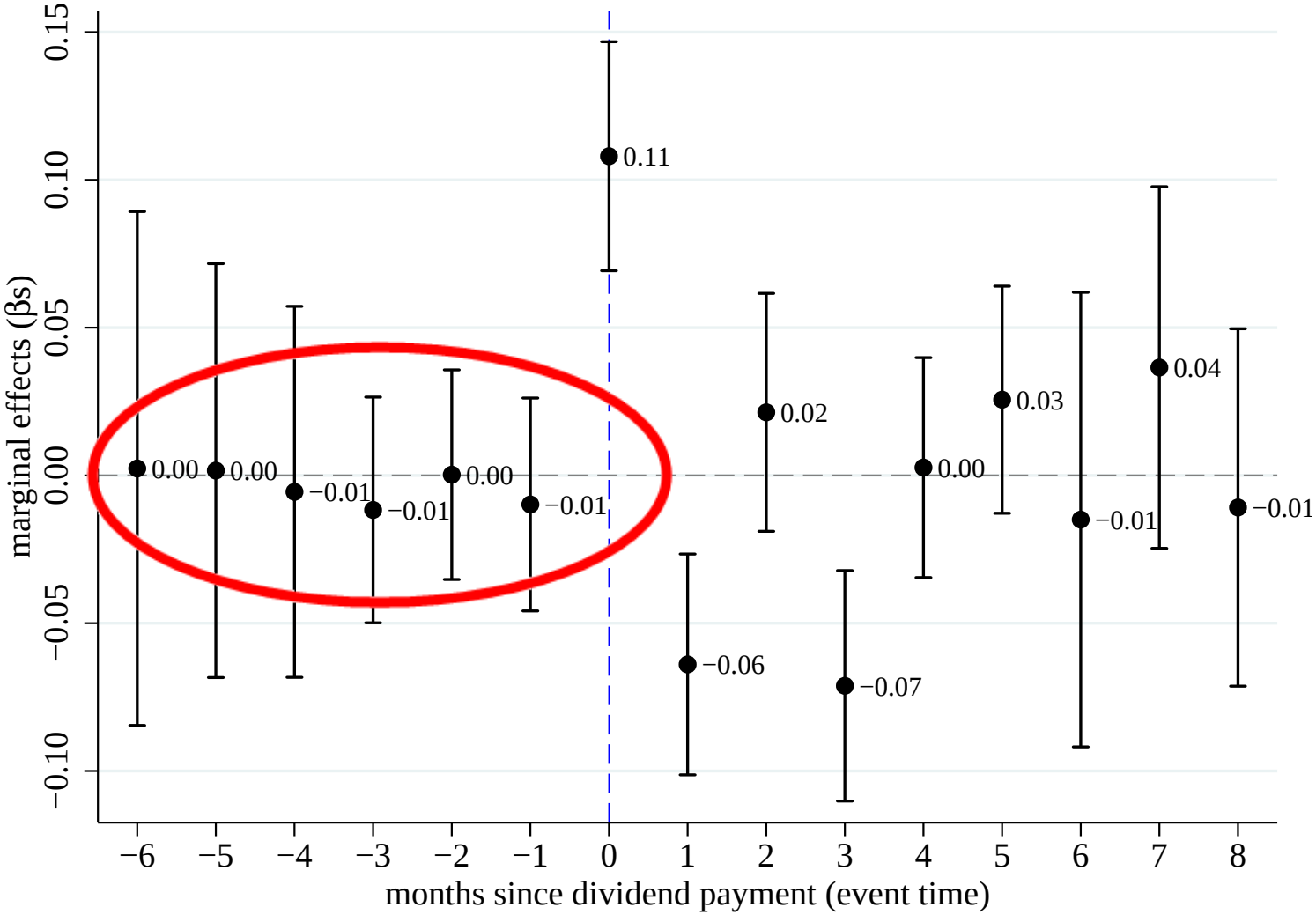
Implies MPC of 12% after one month, 24% after one quarter

Nonparametric Evidence of Excess Sensitivity: Not driven by corresponding changes in other income (excluding dividend)



Excess Sensitivity: No anticipation effects

$$\Delta c_{it}^{nd} = \sum_s \beta_s \cdot PFD_{i,t-s} + \gamma \Delta \text{inc}_{it} + \delta \text{liq}_{it} + \text{time,state,fam\_size FEs} + \epsilon_{it}$$



Excess Sensitivity: Large response in month of dividend

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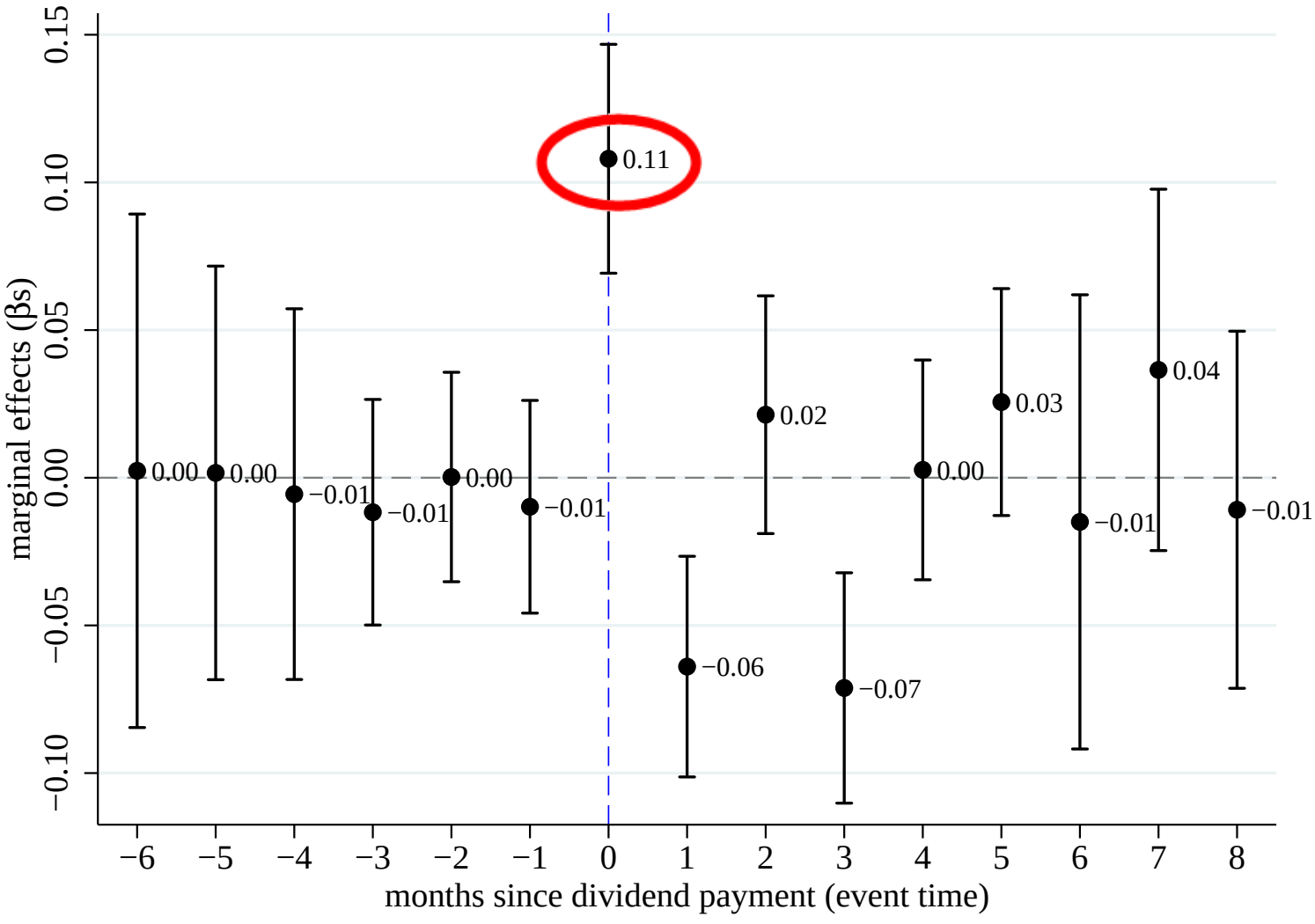
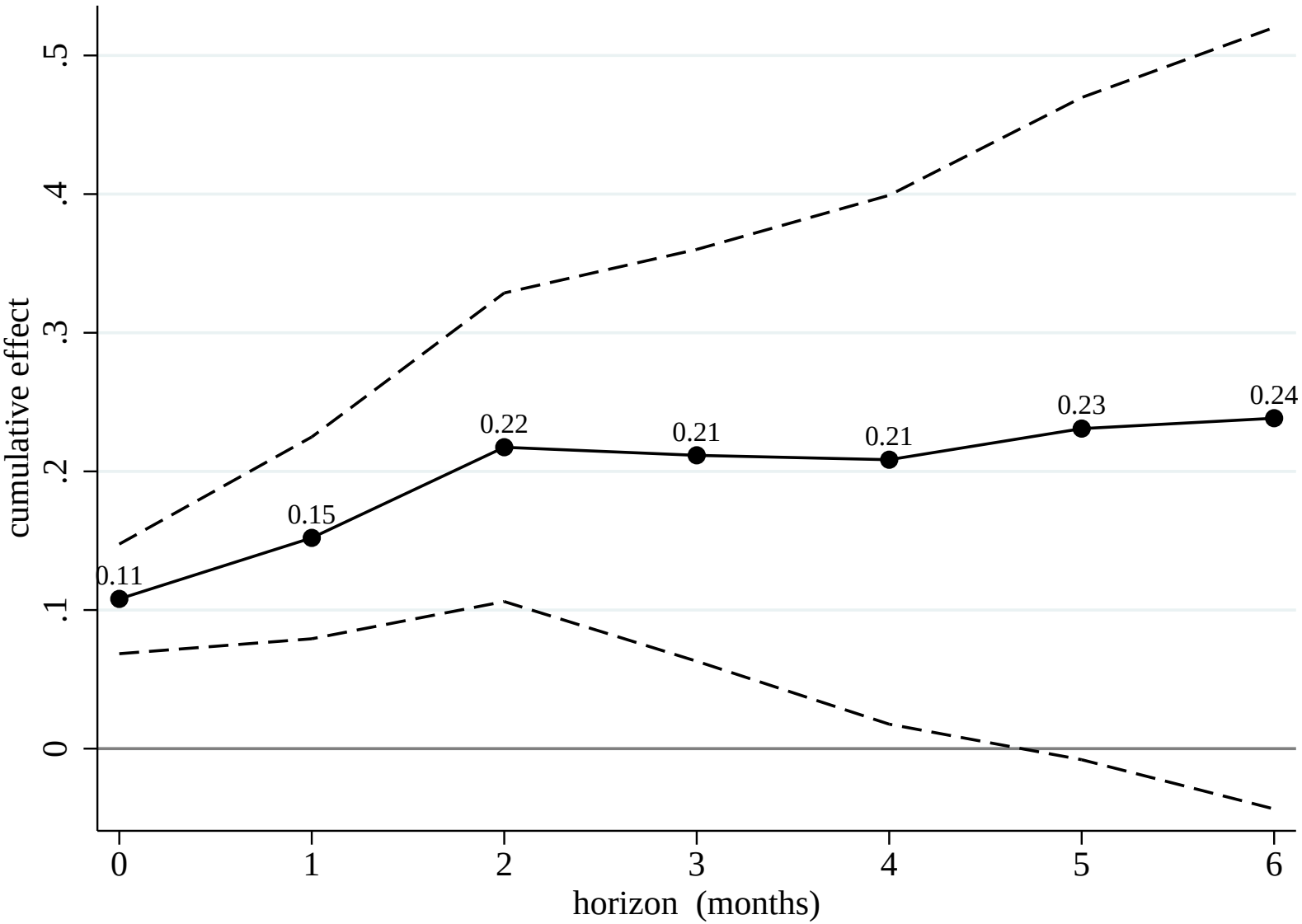


Excess Sensitivity: Cumulative MPC ∼25%, stable after 1 quarter



Excess Sensitivity: Robustness of quarterly MPC

$$\Delta c_{it}^{nd} = \beta \cdot PFD_{it} + \text{time,state,fam\_size FEs} + \lambda' x_{it} + \epsilon_{it}$$

Table 2: Excess Sensitivity

	A. MPC of Nondurables				
Specification:	main effects	liquid assets and current income	permanent income	FE estimator	state x time FE
Dependent variable: quarterly nondurables	Δc_{it}	Δc_{it}	Δc_{it}	c_{it}	Δc_{it}
	(1)	(2)	(3)	(4)	(5)
Permanent Fund Dividend payments	0.280***	0.258***	0.264***	0.240***	0.276***
	(0.044)	(0.043)	(0.044)	(0.035)	(0.070)
Family size FE	Yes	Yes	Yes	Yes	Yes
Time FE (year-by-quarter)	Yes	Yes	Yes	Yes	
State FE	Yes	Yes	Yes		
Liquid assets		Yes	Yes	Yes	Yes
Current income (level and change)		Yes	Yes	Yes	Yes
Permanent income			Yes		
Household characteristics			Yes	Yes	Yes
Household FE				Yes	Yes
State x time FE					Yes
Observations	44,577	44,577	44,577	47,787	44,577
R-squared	0.106	0.127	0.129	0.680	0.140

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External validity implementing same analysis using the CE

I obtain similar results after taking into account

1. dividend has to be imputed in the CE
2. different sample composition

Table 3: External Validity using the Consumer Expenditure Survey (CE)

	A. Comparing CE and PFW				
		PFW Sample			
Dependent variable: Δc_{it}, quarterly nondurables	CE Sample (1)	using the observed PFD (2)	using the imputed PFD (3)	dealing w/ sample composition (4)	IV imputed with observed PFD (5)
PFD payments		0.262***			
		(0.044)			
PFD x family size x Alaska	0.079**		0.201***	-0.013	0.227***
	(0.036)		(0.033)	(0.057)	(0.038)
PFD x family size x Alaska x income/$100,000				0.185***	
				(0.053)	
Control variables			same as Table 2, Column 2		
Observations	385,800	44,577	44,577	44,577	44,577
R-squared	0.006	0.129	0.129	0.130	0.129
Predicted MPC at average CE income				0.104***	
				(0.039)	

Comparison with Hsieh (AER 2003): Non-Classical Meas. Error

$$\Delta \ln(c_{it}) = \beta \cdot \frac{\text{PFD}_t \times \text{Family Size}_i}{\text{Family Income}_i} + \gamma x_{it} + \epsilon_{it}$$

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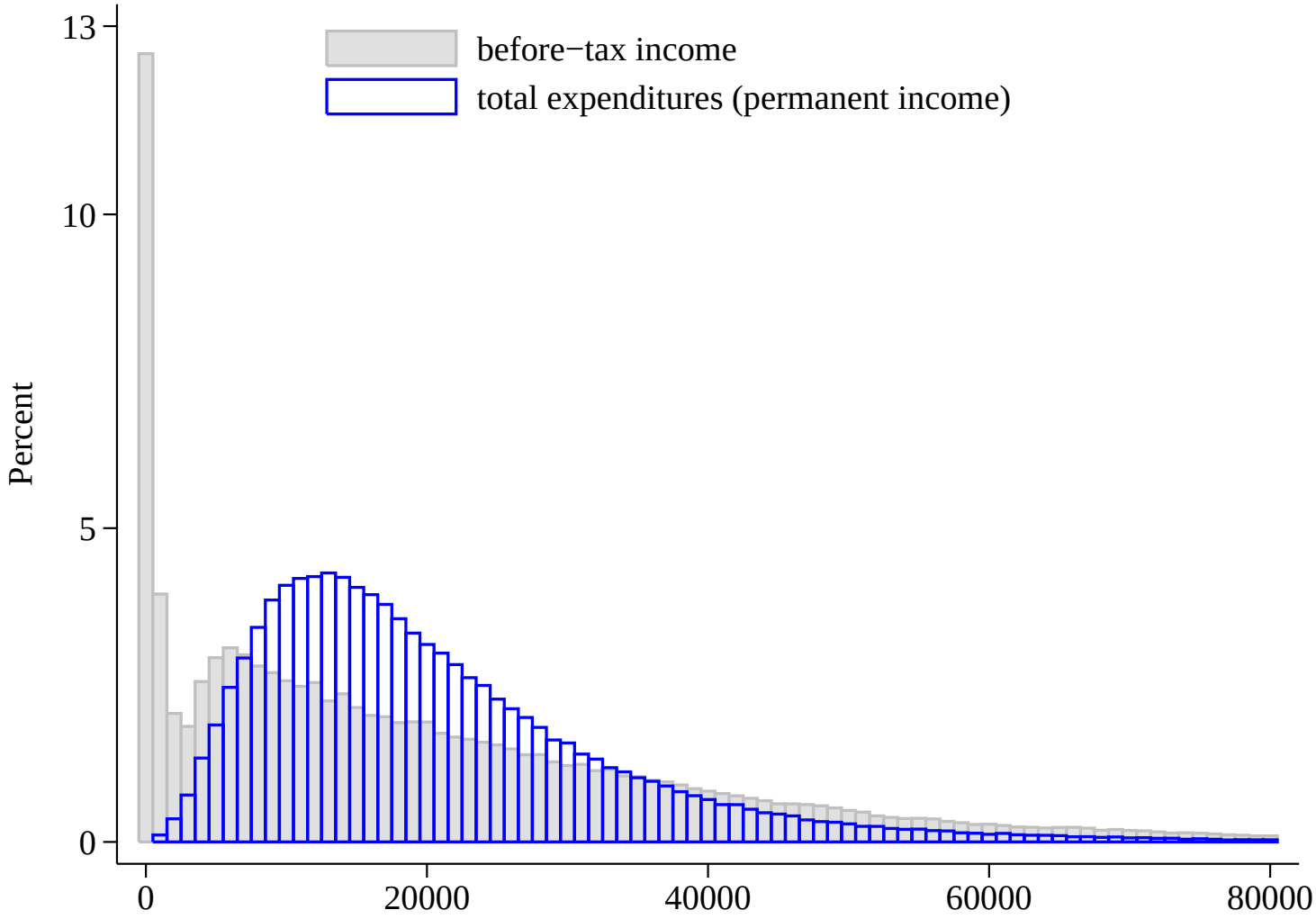

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	B. Comparison with Hsieh (2003) using CE				
Dependent variable: $\Delta\ln(c_{it})$, quarterly nondurables	Hsieh (2003)	replication	normalize w/ total expend.	attenuation factor and full sample	IV curr. income w/ perm. income
	(6)	(7)	(8)	(9)	(10)
PFD x family size x Alaska / before-tax income	-0.003	-0.003			
	(0.033)	(0.005)			
PFD x family size x Alaska / total expenditures			0.123	0.136***	0.076***
			(0.086)	(0.032)	(0.023)
Household characteristics	Yes	Yes	Yes	Yes	Yes
Family size	Yes	Yes	Yes	Yes	Yes
Time FE				Yes	Yes
State FE				Yes	Yes
Inverse total expenditures				Yes	Yes
Number of observations (rounded)	806	800	800	559,400	458,000
Number of Alaskan CUs (rounded)	806	800	800	2,800	2,300
R-squared	--	0.009	0.013		

Comparison with Hsieh (AER 2003): Non-Classical Meas. Error

$$\Delta \ln(c_{it}) = \beta \cdot \frac{\text{PFD}_t \times \text{Family Size}_i}{\text{Family Income}_i} + \gamma x_{it} + \epsilon_{it}$$

Table 3: External Validity using the Consumer Expenditure Survey (CE)

	B. Comparison with Hsieh (2003) using CE				
Dependent variable: $\Delta\ln(c_{it})$, quarterly nondurables	Hsieh (2003)	replication	normalize w/ total expend.	attenuation factor and full sample	IV curr. income w/ perm. income
	(6)	(7)	(8)	(9)	(10)
PFD x family size x Alaska / before-tax income	-0.003	-0.003			
	(0.033)	(0.005)			
PFD x family size x Alaska / total expenditures			0.123	0.136***	0.076***
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Household characteristics	Yes	Yes	Yes	Yes	Yes
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Outline

1. The Alaska Permanent Fund Dividend
2. Data
3. Spending Response using Transaction Data
4. External Validity using Survey Data
5. **MPC Heterogeneity**
6. Welfare Losses from Excess Sensitivity
7. Conclusion

Table 4: MPC Heterogeneity

Dep. var.: nondurables Δc_{it}	A. Liquidity		B. Income	
Interaction measure:	liquid assets	cash-on-hand ratio	current income	permanent income
	(1)	(2)	(3)	(4)
PFD payments x 1st quintile	0.270***	0.357***	0.117**	0.080
	(0.065)	(0.059)	(0.051)	(0.072)
PFD payments x 2nd quintile	0.283***	0.253***	0.079	0.163***
	(0.057)	(0.065)	(0.068)	(0.055)
PFD payments x 3rd quintile	0.237***	0.292***	0.291***	0.163**
	(0.085)	(0.101)	(0.070)	(0.069)
PFD payments x 4th quintile	0.181*	0.190*	0.371***	0.304***
	(0.106)	(0.098)	(0.105)	(0.092)
PFD payments x 5th quintile	0.341***	0.207**	0.572***	0.761***
	(0.093)	(0.095)	(0.113)	(0.116)
Family size FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Quintile FE (main effects)	Yes	Yes	Yes	Yes
Income change	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Observations	44,577	44,577	44,577	44,577
R-squared	0.128	0.128	0.129	0.130
p value of test $\beta_1 = \beta_5$	0.5132	0.1557	0.0001	0.0000

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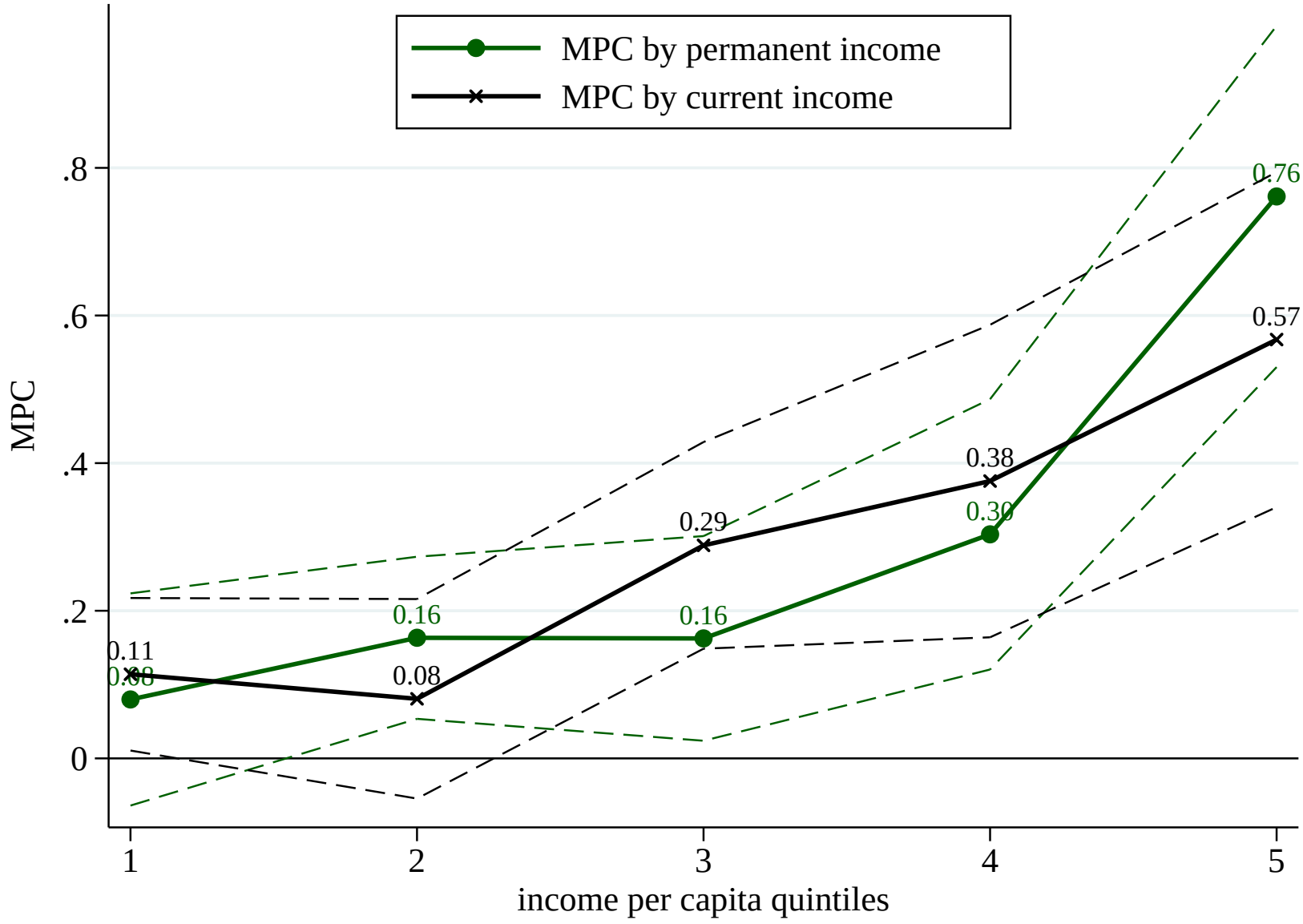
What drives MPC heterogeneity? Mostly income per capita



Outline

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2. Data
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5. MPC Heterogeneity
6. **Welfare Losses from Excess Sensitivity**
7. Conclusion

What can explain this large excess sensitivity?

- Liquidity-to-income ratio does predict lower MPC, but most is left unexplained
- Liquidity is only source of MPC heterogeneity in standard model, not income

- Calculate **welfare loss** from not smoothing dividend in PIH
  - **Potential loss** from fully spending PFD in the 4^{th} quarter (c_i^{htm}) instead of fully smoothing (c_i^{pih})

$$PotentialLoss(c_i^{htm}, c_i^{pih}) \approx \left(\frac{PFD_i}{c_i^{pih}}\right)^2 \cdot \frac{\gamma}{2} \cdot \frac{T-1}{T^2}$$

  - **Actual loss** also depends on behavioral response (MPC)

$$Loss(c_i, c_i^{pih}) \equiv \frac{\Delta w}{w} \approx (MPC_i)^2 \cdot PotentialLoss(c_i^{htm}, c_i^{pih})$$

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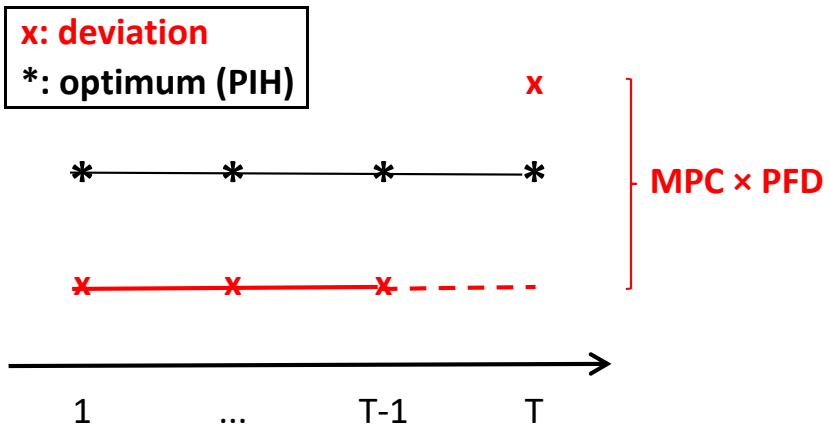

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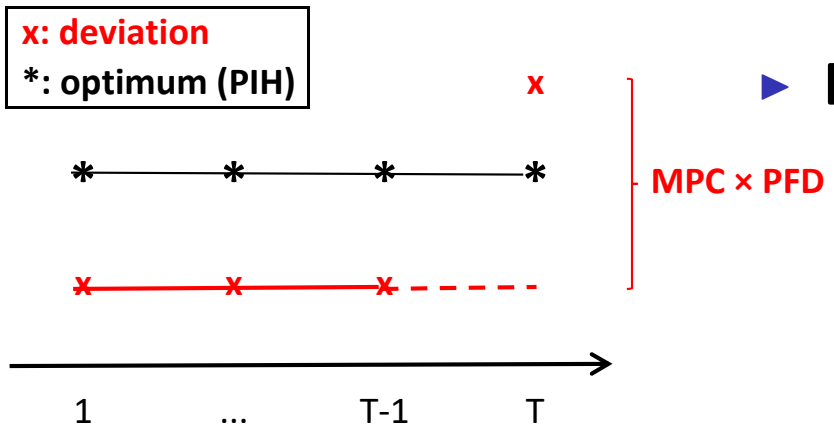

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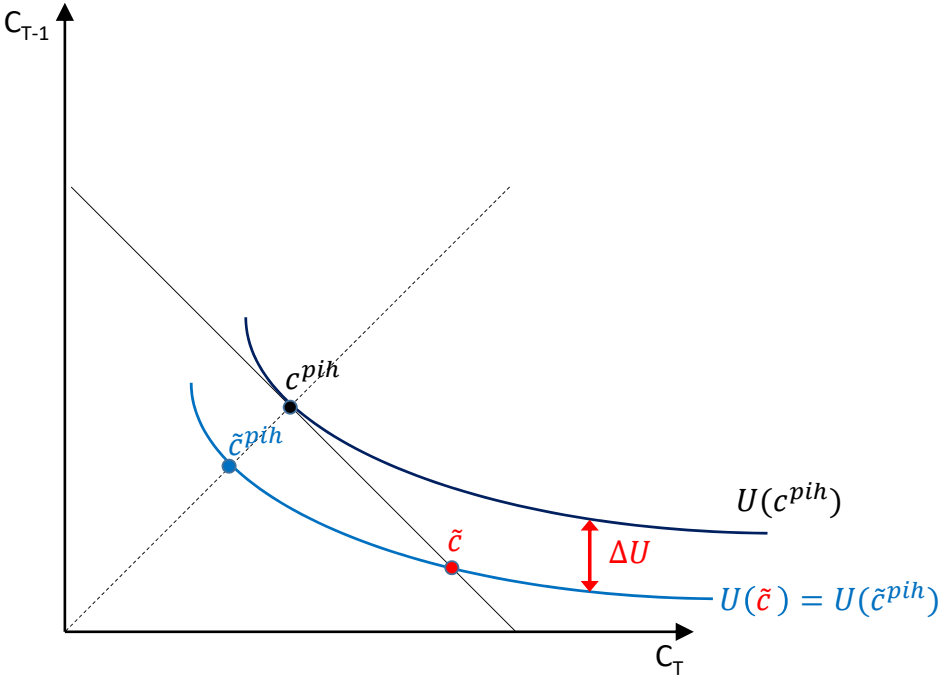
$$\Delta U \approx \frac{1}{2}\frac{\partial^2 U}{\partial c^2} \times (\tilde{c} - c^{pih})^2$$



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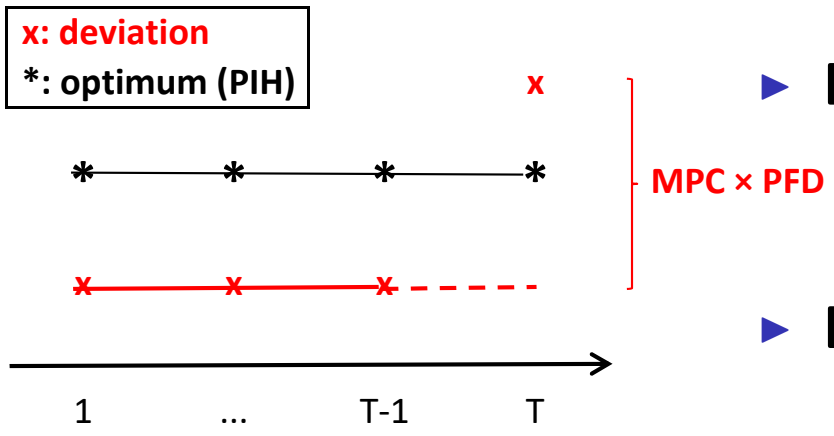

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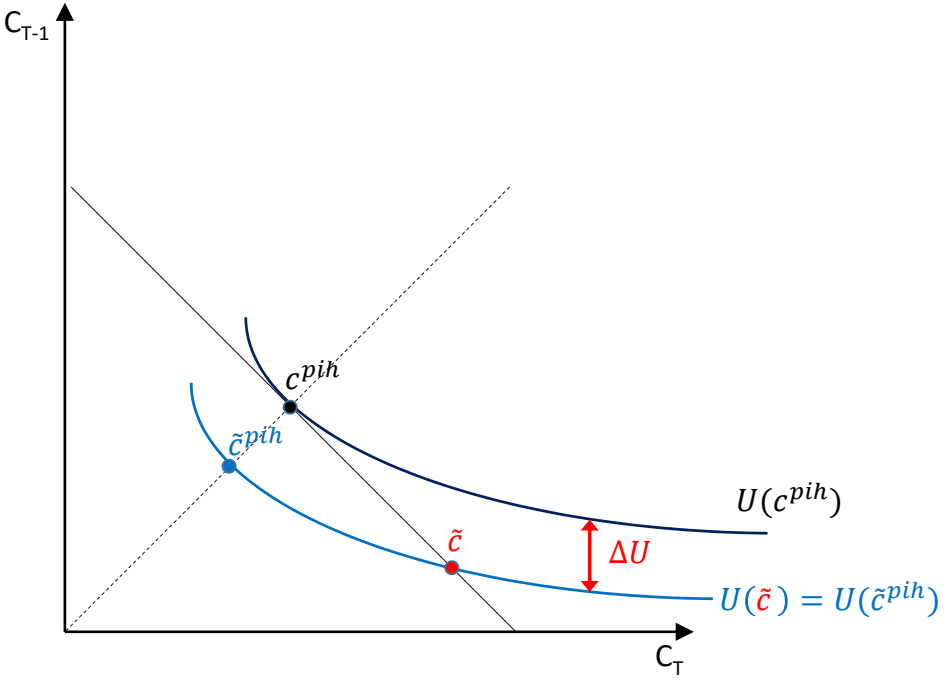
$$\tilde{c}^{pih} = \frac{\tilde{w}}{w} c^{pih} \rightarrow U(c^{pih}) \propto U(\tilde{c}^{pih}) = U(\tilde{c})$$



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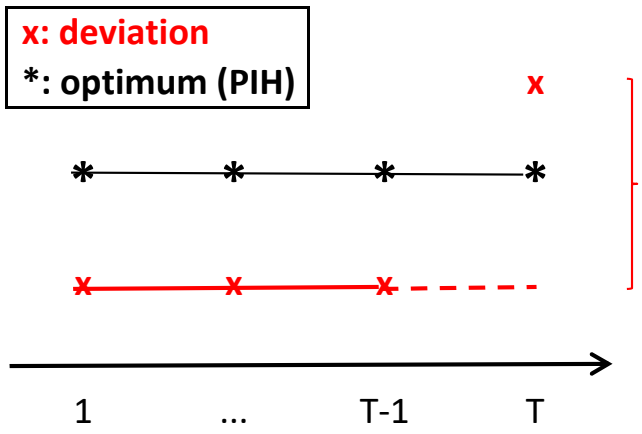

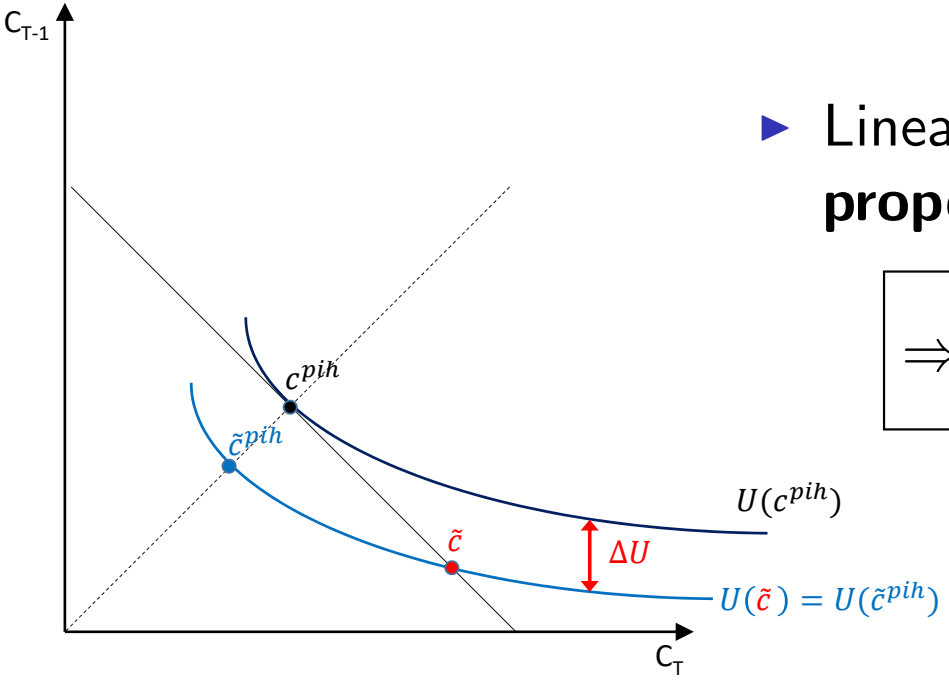

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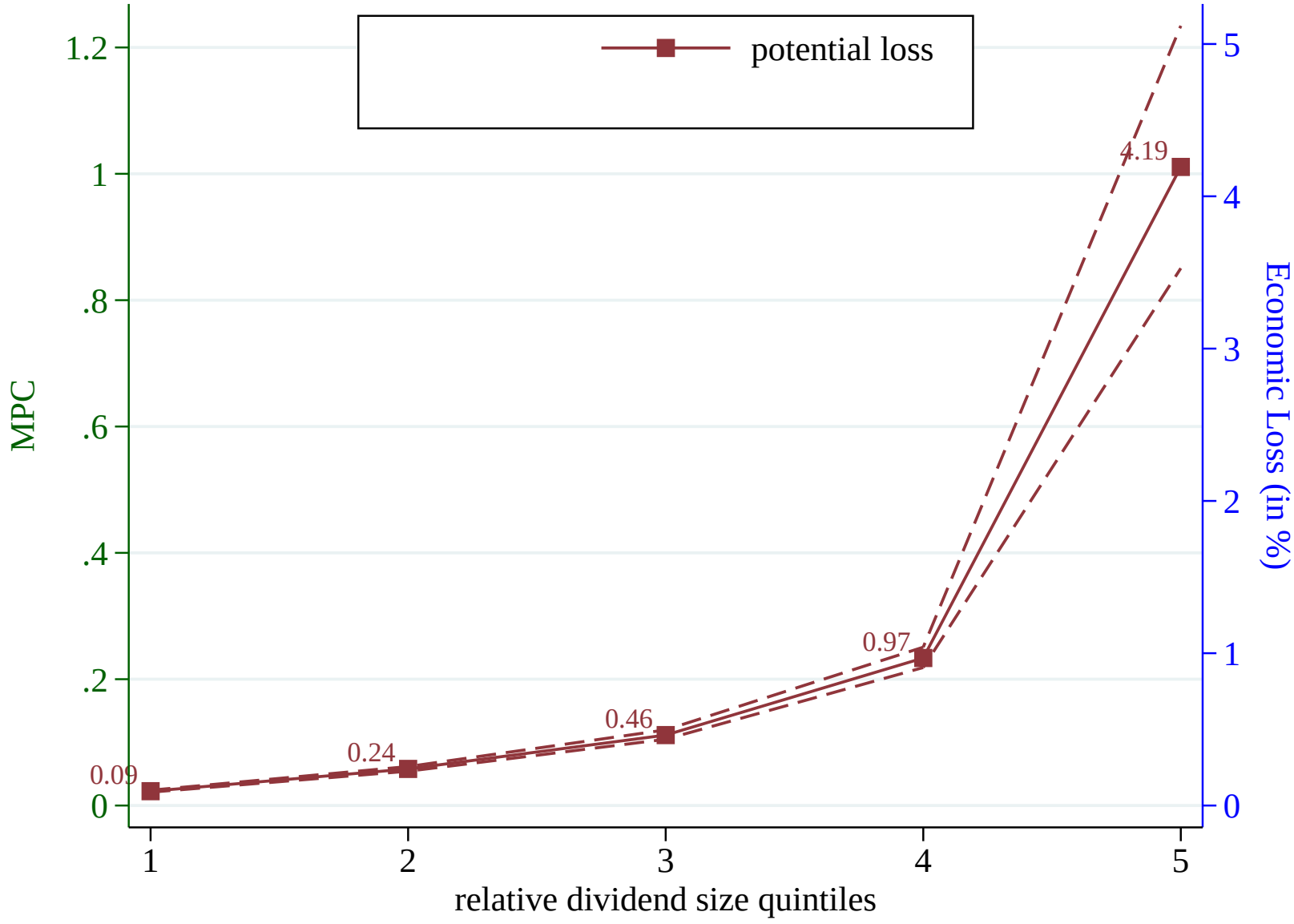
$$\tilde{c}^{pih} = \frac{\tilde{w}}{w} c^{pih} \rightarrow U(c^{pih}) \propto U(\tilde{c}^{pih}) = U(\tilde{c})$$

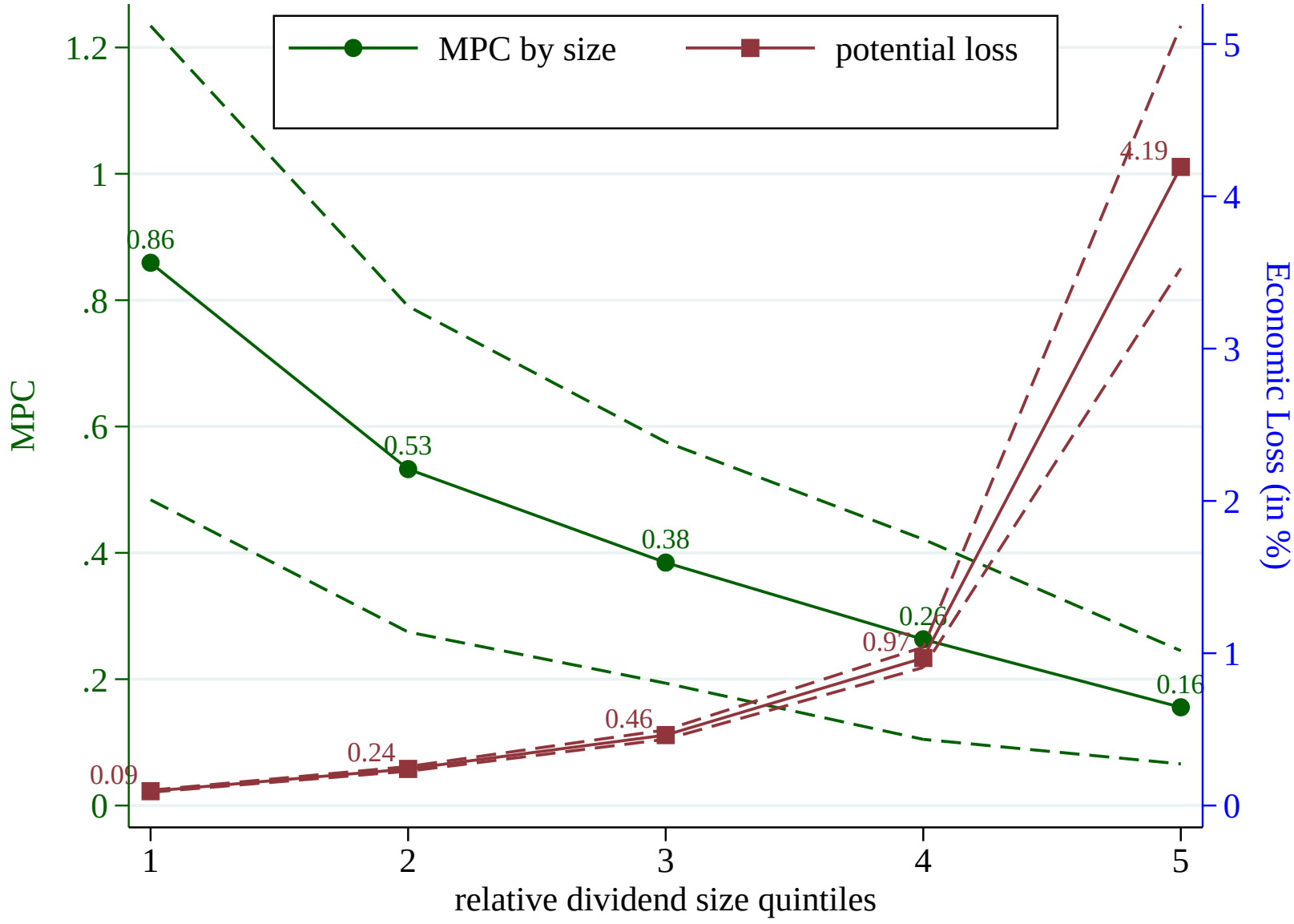
- Linearize U around c^{pih} and use **proportionality** of $\tilde{c}^{pih}$ and c^{pih}

$$\Rightarrow Loss(\tilde{c}, c^{pih}) \equiv \frac{\tilde{w} - w}{w} \approx \ldots$$

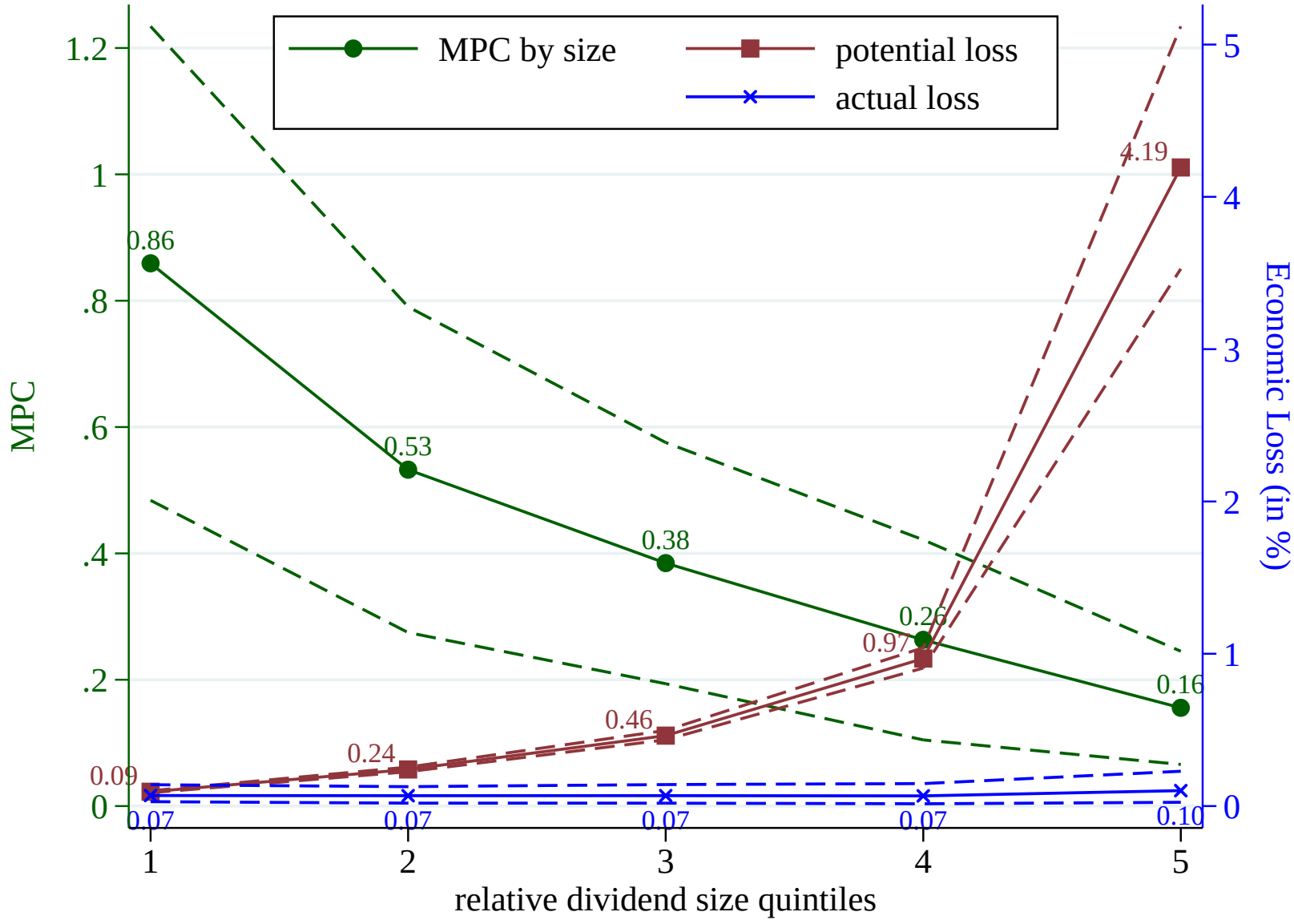
Potential-loss statistic by relative payment size quintiles (γ=2, T=4)



MPC declines when potential loss increases



Is this near-rational behavior? ⇒ calculate actual losses



Payment scaling matters empirically: relative vs. nominal size

Table 4: MPC Heterogeneity

Dep. var.: nondurables Δc_{it}	C. Dividend Size			
Interaction measure:	PFD payments divided by perm. income	PFD payments divided by current income	PFD payments: level	PFD payments: quadratic
	(5)	(6)	(7)	(8)
PFD payments x 1st quintile	0.859***	0.602***	0.524***	
	(0.191)	(0.181)	(0.163)	
PFD payments x 2nd quintile	0.533***	0.386***	0.195*	
	(0.132)	(0.110)	(0.106)	
PFD payments x 3rd quintile	0.385***	0.344***	0.235**	
	(0.097)	(0.094)	(0.113)	
PFD payments x 4th quintile	0.263***	0.281***	0.275***	
	(0.081)	(0.071)	(0.070)	
PFD payments x 5th quintile	0.156***	0.170***	0.264***	
	(0.046)	(0.048)	(0.055)	
PFD payments				0.257***
				(0.098)
(PFD payments/100)^2				0.017
				(0.197)
Family size FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Quintile FE (main effects)	Yes	Yes	Yes	
Income change	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Observations	44,577	44,577	44,577	44,577
R-squared	0.129	0.129	0.129	0.128
p value of test $\beta_1 = \beta_5$	0.0188	0.0002	0.1166	

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Table 5: Relative Payment Size vs. Cash-on-Hand

Dep. var.: Δc_{it}, nondurables		PFD payments x cash-on-hand quartiles 1st	2nd	3rd	4th	F test p value
PFD pay. x relative size quartiles	1st	1.177***	0.751**	0.464*	0.943***	$\beta_{11} = \beta_{14}$
		(0.276)	(0.295)	(0.282)	(0.301)	0.5503
	2nd	0.469***	0.410*	0.396*	0.635***	$\beta_{21} = \beta_{24}$
		(0.124)	(0.227)	(0.208)	(0.185)	0.4406
	3rd	0.451***	0.291**	0.194	0.168	$\beta_{31} = \beta_{34}$
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	4th	0.247***	0.242***	0.089	-0.014	$\beta_{41} = \beta_{44}$
		(0.061)	(0.062)	(0.093)	(0.125)	0.0525
Control variables		same as Table 2 Col. 2 plus quartile FE				
Observations		44,577				$\beta_{11} = \beta_{44}$
R-squared		0.130				0.0001
F test		$\beta_{11} = \beta_{41}$	$\beta_{12} = \beta_{42}$	$\beta_{13} = \beta_{34}$	$\beta_{14} = \beta_{44}$	
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Conclusion

Main findings

1. Large average excess sensitivity even to large payments
2. Potential-loss statistic predicts higher-income HHs MPCs
3. Low liquidity-to-income continues to predict higher MPCs
4. Actual ex-post losses are similar and small $\Rightarrow$ **near-rationality**

Implications and next steps

- Modeling near-rational behavior is important next step: Why do high-income HHs spend dividend?
- Targeting low-income HHs might not be the only way to stimulate the economy

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Appendix

Disaggregated spending: Excess sensitivity across categories, including strictly nondurables

Table 2: Excess Sensitivity

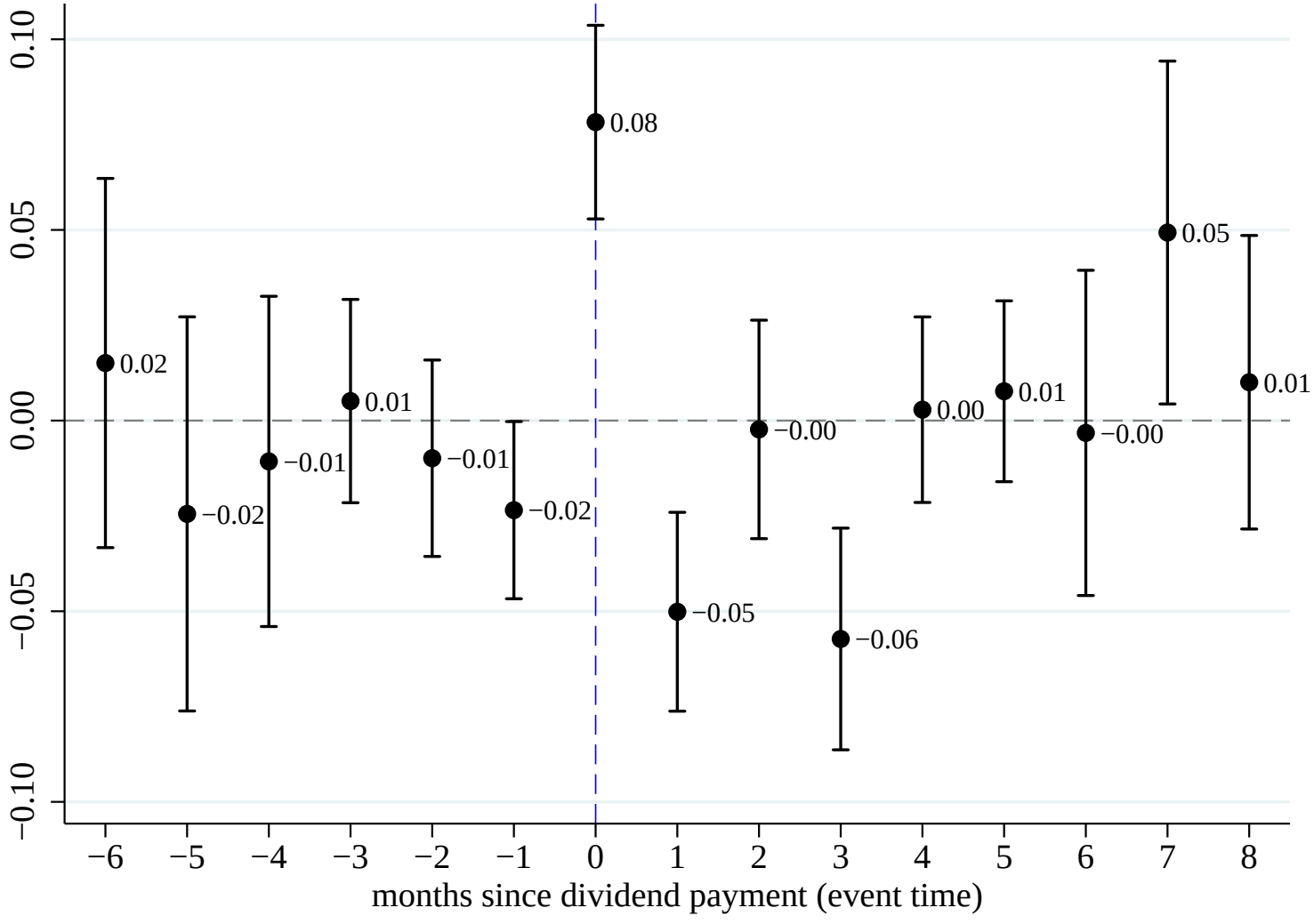
	B. Disaggregated and Total Expenditures				
Specification:	same as in (4)				
Dependent variable:	food at home	food away	kids activities	cash withdraw.	total expenditures
	(6)	(7)	(8)	(9)	(10)
Permanent Fund Dividend payments	0.066***	0.019***	0.007**	0.028*	0.727***
	(0.009)	(0.005)	(0.003)	(0.014)	(0.130)
Observations	47,787	47,787	47,787	47,787	47,787
R-squared	0.691	0.640	0.526	0.313	0.675

Following the money:

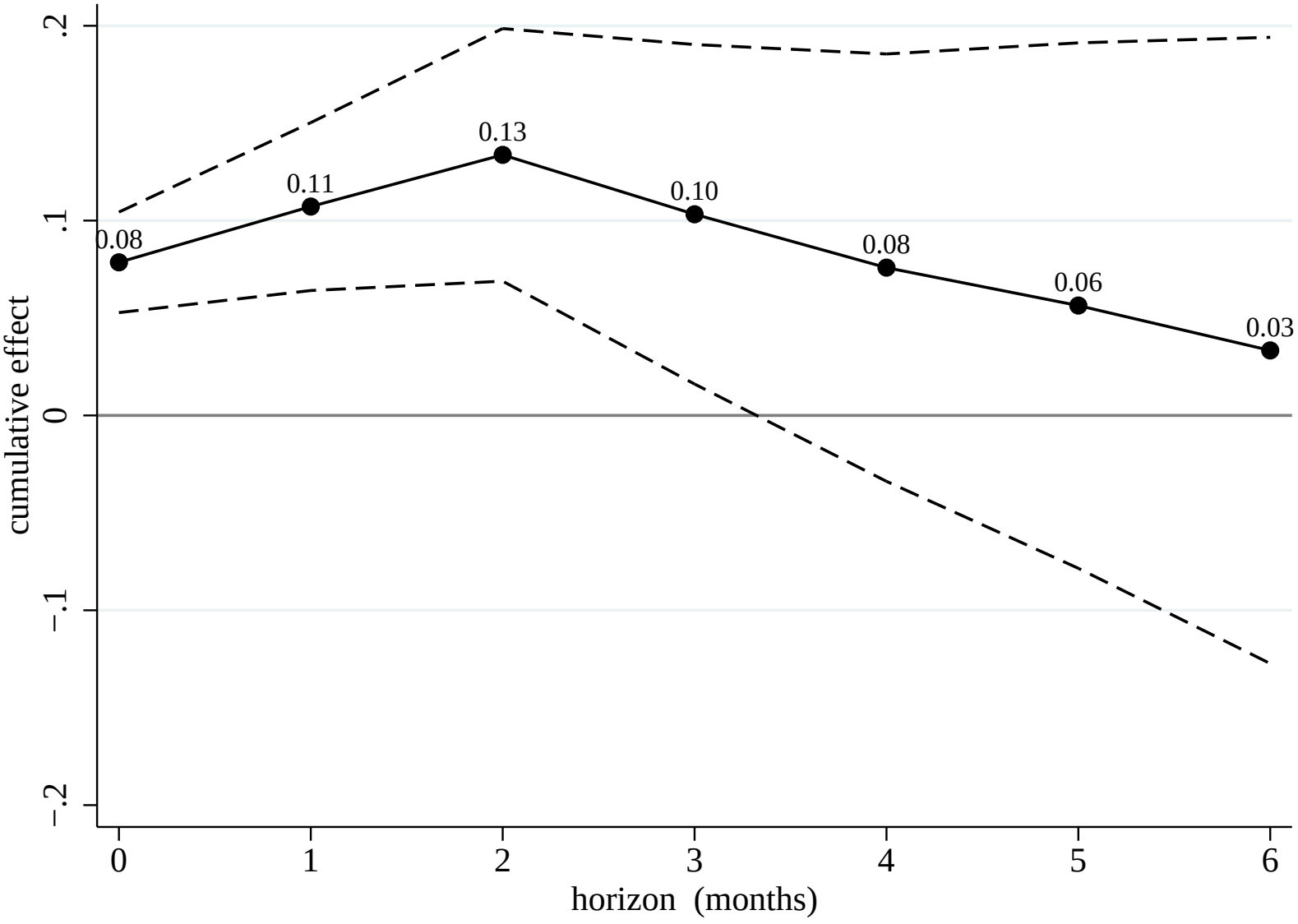
- I estimate that the marginal tax rate on PFD income in the PFW sample is 22% (due in the following year).
- The MPC of total expenditures is 73%.
- The remaining 5% remains in the bank account or is transferred to investment account.

Durables: Small anticipation effect

$$\Delta c_{it}^{dur} = \sum_s \beta_s \cdot PFD_{i,t-s} + \gamma \Delta \text{inc}_{it} + \delta \text{liq}_{it} + \text{time,state,fam\_size FEs} + \epsilon_{it}$$



Durables: Cumulative MPC – strong intertemporal substitution



Robustness

Table A.4: Excess Sensitivity - Robustness

Dependent variable: Δc_{it} or $\Delta \ln(c_{it})$, quarterly nondurables	baseline	all PFDs, incl. checks & delayed	only partial PFD received	only full PFD received	incl. Alaskans without PFD	family size = # of users	Alaskans only	using $\Delta \ln(c_{it})$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PFD payments	0.264***	0.286***	0.257***	0.268***	0.285***	0.288***	0.252***	
	(0.044)	(0.043)	(0.088)	(0.046)	(0.041)	(0.055)	(0.065)	
PFD payments / family income								0.319***
								(0.093)
Family size FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Liquid assets	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Current income (level and change)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Permanent income	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	44,577	45,407	32,540	41,454	50,210	35,046	16,012	44,577
R-squared	0.129	0.129	0.128	0.125	0.128	0.127	0.139	0.223

Derivig **Potential Loss of Deviating from Smoothing:**

Standard, frictionless life-cycle model's optimal consumption plan

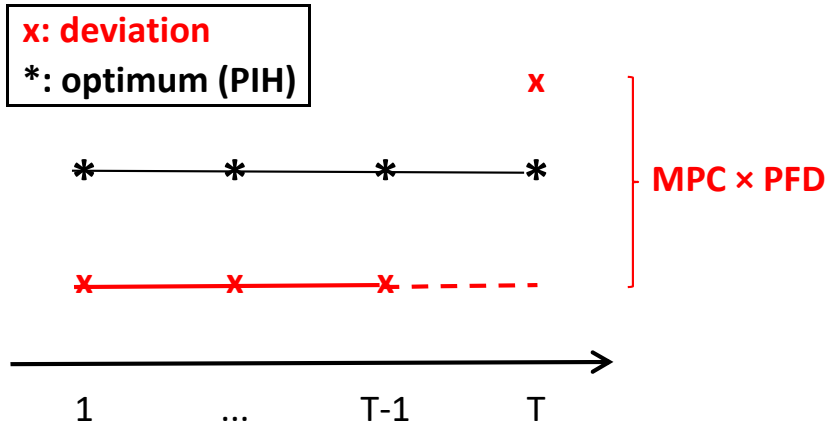
$$c_w^{pih} = \arg\max_c \left\{ U(c) = \sum_t \delta^t u(c_t) : \ p'c \leq w \right\}$$

Money-metric proportional wealth loss (Gabaix Laibson 2002):

- 2nd-order approx. of utility U around optimum c_w^{pih} and evaluating at deviation $\tilde{c}_w$ that satisfies budget constraint, $p'\tilde{c}_w = w$
- 1st-order approx. of $U(c_w^{pih})$ in wealth w, and evaluating at $U(c_{\tilde{w}}^{pih}) = U(\tilde{c}_w)$ with $u(c) = c^{1-\gamma}/(1-\gamma)$ and $\omega_t^{pih} = \frac{\delta^t u(c_t^{pih})}{U(c^{pih})}$

$$Loss(\tilde{c}, c^{pih}) \equiv -\frac{\tilde{w} - w}{w} \approx \frac{\gamma}{2} \sum_t \omega_t^{pih} \left(\frac{\tilde{c}_t - c_t^{pih}}{c_t^{pih}} \right)^2$$

For simplicity, assume finite horizon and $r = \delta = 0 \Rightarrow c_{it}^{pih} = c_i^{pih}$



Start with hand-to-mouth (MPC=1) as extreme alternative plan:

$$\tilde{c}_{it}^{htm} = \begin{cases} c_i^{pih} - \frac{PFD_i}{T} & \text{if no dividend paid} \\ c_i^{pih} + (1 - \frac{1}{T}) \cdot PFD_i & \text{if dividend paid} \end{cases}$$

Observed deviation $\tilde{c}_i$ is scaled version, ie "$\tilde{c}_{it} = MPC_i \times c_{it}^{htm}$"

$$\Rightarrow \quad Loss(\tilde{c}_i, c_i^{phi}) \approx (MPC_i)^2 \times \left(\frac{PFD_i}{c_i^{pih}} \right)^2 \cdot \frac{\gamma}{2} \cdot \frac{T-1}{T^2}$$