Measurement Error in Imputed Consumption

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VERY PRELIMINARY!

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Motivation

> *"One of the biggest impediments to further development of empirical research on intertemporal allocation seems to be the lack of good longitudinal data on expenditures and/or saving."*
>
> – Browning and Leth-Petersen (2003)

- Long-run and dis-aggregated consumption data are hard to find
- Unfortunately, consumption (+ time use) best measure of welfare
- Common to use survey-based measures (eg. CEX, PSID, HRS)
- Recently, access to financial services (eg. JPMorgan, TurboTax)

Alternative: Administrative Records

Some countries have detailed annual administrative data on income and assets

- Income tax registry
  - earned income
  - capital income
  - realized capital gains/losses
- Wealth tax registry
  - ideally detailed household balance sheet/portfolio
- Additional non-tax registries

Universal (eg. no top-coding), individualized, long-ish panels, presumably accurate

Most commonly used are Denmark, Norway, and Sweden

- Can sometimes link with other sources via SSN

Imputing Consumption: Basic Idea

- Can use snapshots of income and asset to impute individual annual consumption
- With sufficiently detailed data, budgets have to balance and consumption is the residual of the (simplified) budget constraint

$$W_t = (1 + r_t^p)W_{t-1} + E_t - C_t$$

$$\rightarrow \; C_t = E_t + \left[r^p \cdot W_{t-1} - \Delta W_t\right]$$

expenditures = earned income + net financial income (dis-saving)

C_t: consumption expenditures during period t
E_t: net earned income and transfers during period t (eg. salary)
W_t: end-of-period non-human portfolio wealth (eg. as of Dec 31)
r_t^p: portfolio return during period t

This Paper: Imputation Error from Financial Assets

Difficult to get high-quality data on E, W and r^p $\rightarrow$ admin records!

However, potential imputation errors due to incompleteness in administrative (asset) records remains:

- Substantial amounts of intra-year trading occur with public equity, and portfolio growth is very volatile
- Few admin data have complete intra-year trades/transactions (exception: Eika Mogstad Vestad 2017)

$\rightarrow$ Even with comprehensive *annual* snapshots, imputing equity gains/losses is often not straightforward

Preview of Results

We focus on the contribution of financial assets to imputation error (assuming other inputs are well measured in annual admin data)

We analyze 6 imputation methods, which differ by data requirements

We find:

1. Mean/median error often near zero
2. Significant errors for many types of imputation methods remains
   - Errors over 5-10% of annual income are common in both directions
   - Errors correlated with many aggregate statistics (eg. home prices) as well as individual wealth/income
   - Errors most severe at top of income/wealth distribution

We suggest ways to minimize impact of imputation errors

Data

Retail Investment Account Data

- Transaction-level retail investor data from major German bank
- Random sample of +100k investors from 2004-2015
  - Restrict to individuals who likely use only this bank
- Daily transactions and monthly financial asset positions (volume and price)
- Additional demographics (age, gender, etc.)
- Sample is not representative of German population ($< 50\%$ have brokerage account)
  - ... but representative of 'active' retail investors
  - ... higher-income & wealthier, more male, etc. (similar to sample in Barber and Odean 2000)
  - ... highly relevant for work on inequality

Imputing Consumption

&

Assessing Measurement Error

Our Approach

- Accounting for portfolio growth between years vs. between trades
  - → important distinction for budget constraint residual
- When no trades during year, everything is easy!
- But many investors turn over 25-50% of portfolio each year!

3 Equivalent Ways to Impute Consumption

1. 'Flow' approach

$$\begin{aligned} C_t &= CI_t^{net} - S_t^{net} + E_t^{net} \\ &= CF_t' A_{t-1} - P_t' \Delta A_t - Fees_t + (E_t - Taxes_t) \end{aligned} \tag{1}$$

- $CI_t^{net} = CF_t' A_{t-1} - Tax_t^{CI} - Tax_t^{W}$ = net capital income
- $S_t^{net} = P_t' \Delta A_t + Tax_t^{CG} + Fees_t$ = net active saving
- $E_t^{net} = E_t - Tax_t^{E}$ = net earned income

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2. 'Stock' approach (using $\Delta W_t = P_t' \Delta A_t + \Delta P_t' A_{t-1}$)

$$C_t = CF_t' A_{t-1} + \Delta P_t' A_{t-1} - \Delta W_t - Fees_t + (E_t - Taxes_t) \tag{2}$$

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3. 'Return' approach (doesn't require A and P separately, only W)

$$C_t = r_t^p \cdot W_{t-1} - \Delta W_t - Fees_t + (E_t - Taxes_t) \tag{3}$$

CF_t: vector of cash flows from assets (eg. dividends) during t

P_t: vector of asset prices at end of period t

A_t: vector of portfolio assets and liabilities

W_t: financial wealth, $W_t = P_t' A_t$

$Taxes_t$: total taxes, $Tax_t^{E} + Tax_t^{CI} + Tax_t^{CG} + Tax_t^{W}$

Intra-Year Trading

Important:

These equations only hold between two trades! (= 'period')

With intra-year trading, need to integrate over all trading dates, t_n

$$C_t = \sum_{n=1}^{N_t} \left[CF'_{t_n} A_{t_{n-1}} - P'_{t_n} \Delta A_{t_n} \right] - Fees_t + (E_t - Taxes_t) \qquad (4)$$

t_0: January 1
t_n: intra-year trading date
t_{N_t}: December 31

'Financial Consumption'

Focus on contribution of financial portfolio to imputation error, which we call 'FinCon':

$$
\begin{aligned}
FinCon_t &\equiv C_t - RealCon_t - CashCon_t - (E_t - Taxes_t) \qquad (5)\\
&= \sum_{n=1}^{N_t} \left[CF'_{t_n} A_{t_{n-1}} - P'_{t_n} \Delta A_{t_n} \right] - Fees_t \\
&= \sum_{n=1}^{N_t} \left[CF'_{t_n} A_{t_{n-1}} + \Delta P'_{t_n} A_{t_{n-1}} \right] - \Delta W_t - Fees_t \\
&= \sum_{n=1}^{N_t} r^p_{t_n} \cdot W_{t_{n-1}} - \Delta W_t - Fees_t.
\end{aligned}
$$

Why? Because these items are typically well measured in admin data and we don't observe them (well) in our data

RealCon: contribution of real assets (eg. home) to imputed consumption

CashCon: contribution of cash

Sources of Error

(i) Missing or incomplete trading fees
- Admin data typically don't have fees

(ii) Missing or incomplete cash flows from assets (eg. dividends)

(iii) Missing intra-year transaction (gains or losses)

(iv) Price errors in intra-year portfolio changes

(v) Incorrect assumptions about portfolio composition and returns

(vi) Neglecting portfolio growth altogether

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Define imputation error from portfolio contribution to C_t:

$$\epsilon_t = \widehat{FinCon}_t - FinCon_t = \widehat{C}_t - C_t$$

Imputation Errors, $\epsilon_t = \widehat{C}_t - C_t$

We analyze **6 types of imputations** (from most to least data intense):

(i) No trading fees: $\epsilon_t^{(i)} = Fees_t$

(ii) No cash flows: $\epsilon_t^{(ii)} = -\sum_n CF'_{t_n} A_{t_{n-1}}$

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(iii) No intra-year gross trades

Ex: Buy 12 at €10, then sell 9 at €5 → only obs. net gain of 3 at €10
$\epsilon_t^{(iii)} = -\big[3 \cdot 10 + \big(12 \cdot 10 - 9 \cdot 5\big)\big] = 45$: neglected intra-year loss

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$\epsilon_t^{(v)} = r_t^{DAX} W_{t-1} - \sum_n r_{t_n}^p W_{t_{n-1}}$

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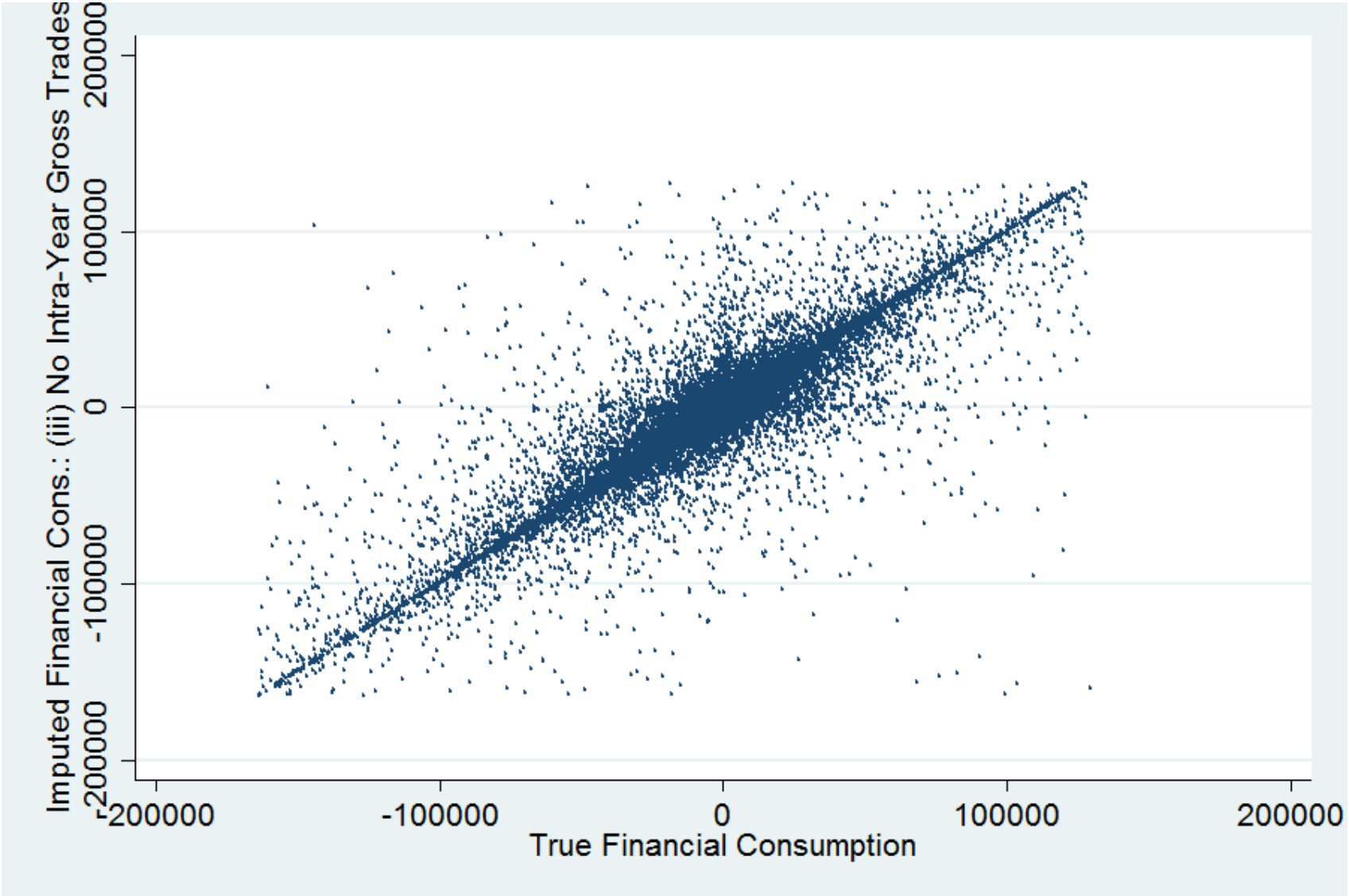
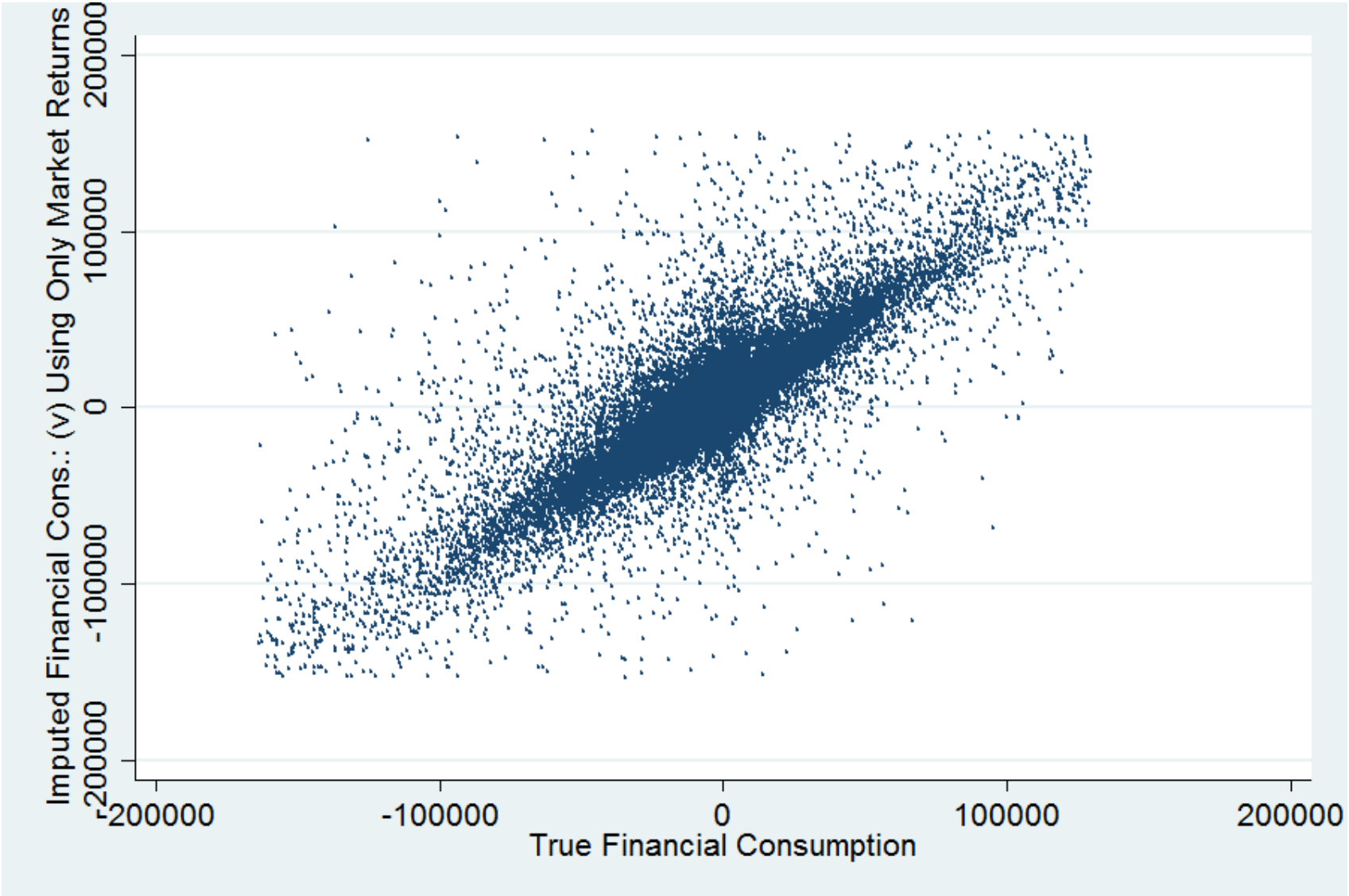
(i) Neglecting Trading Fees *Overestimates* Consumption

(ii) Neglecting Cash Flows *Underestimates* Consumption

(iii) Neglecting Intra-Year Gross Trades



(v) Just Using Market Returns



What Drives Imputation Errors?

Implications of Imputation Error

- Are imputation errors classical measurement error?
  - Is this just a matter of precision or also bias?

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Next:

1. Check across different subgroups of data
   - Are these errors bigger or more skewed?
2. Check whether errors are correlated with other common covariates
   - Use regressions to test for systematic error patterns

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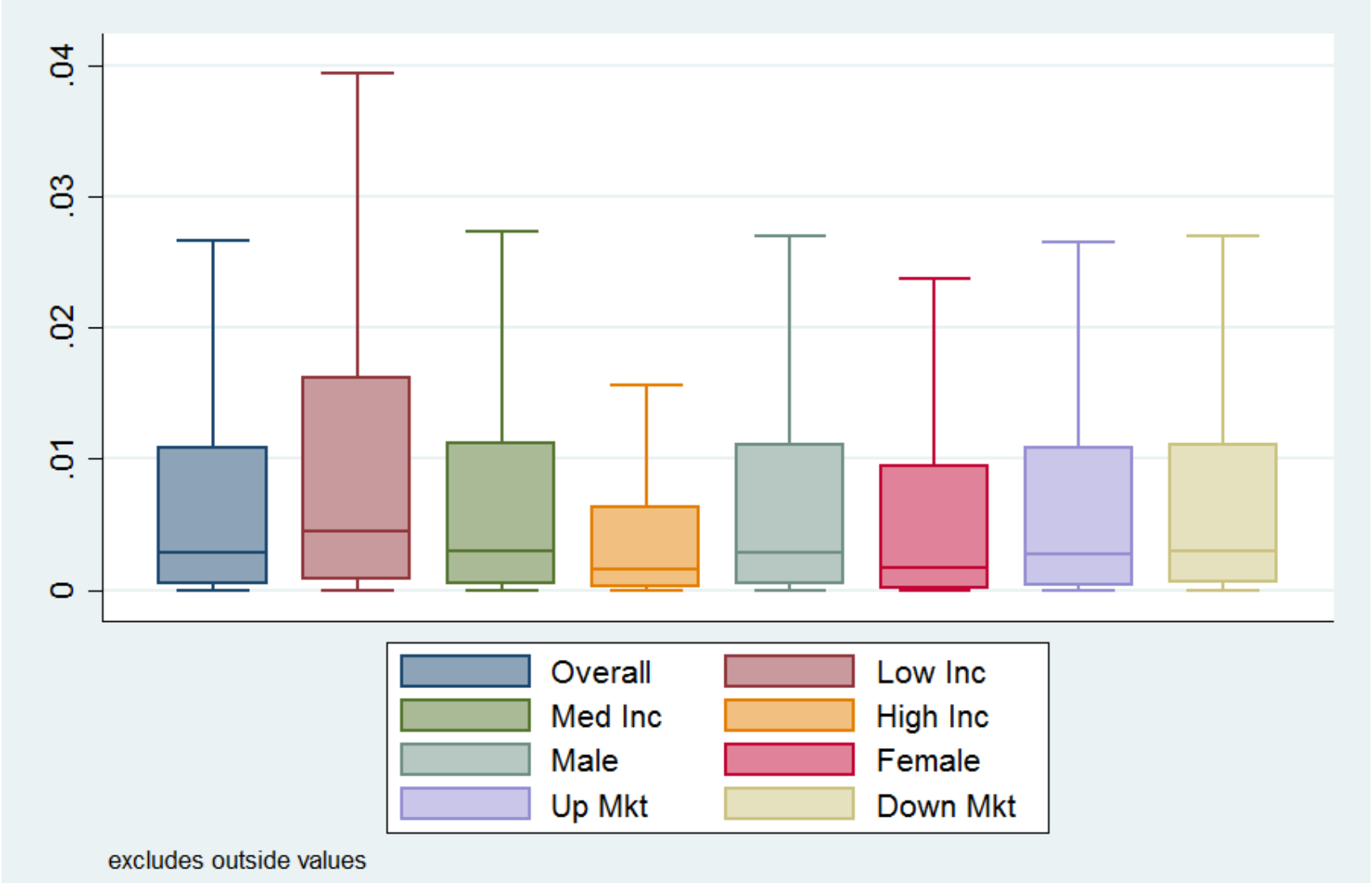
(i) No Trading Fees: Diff. Across Groups & Periods

Box plots show error relative to individual annual income, $\epsilon_{it}/\bar{E}_i$



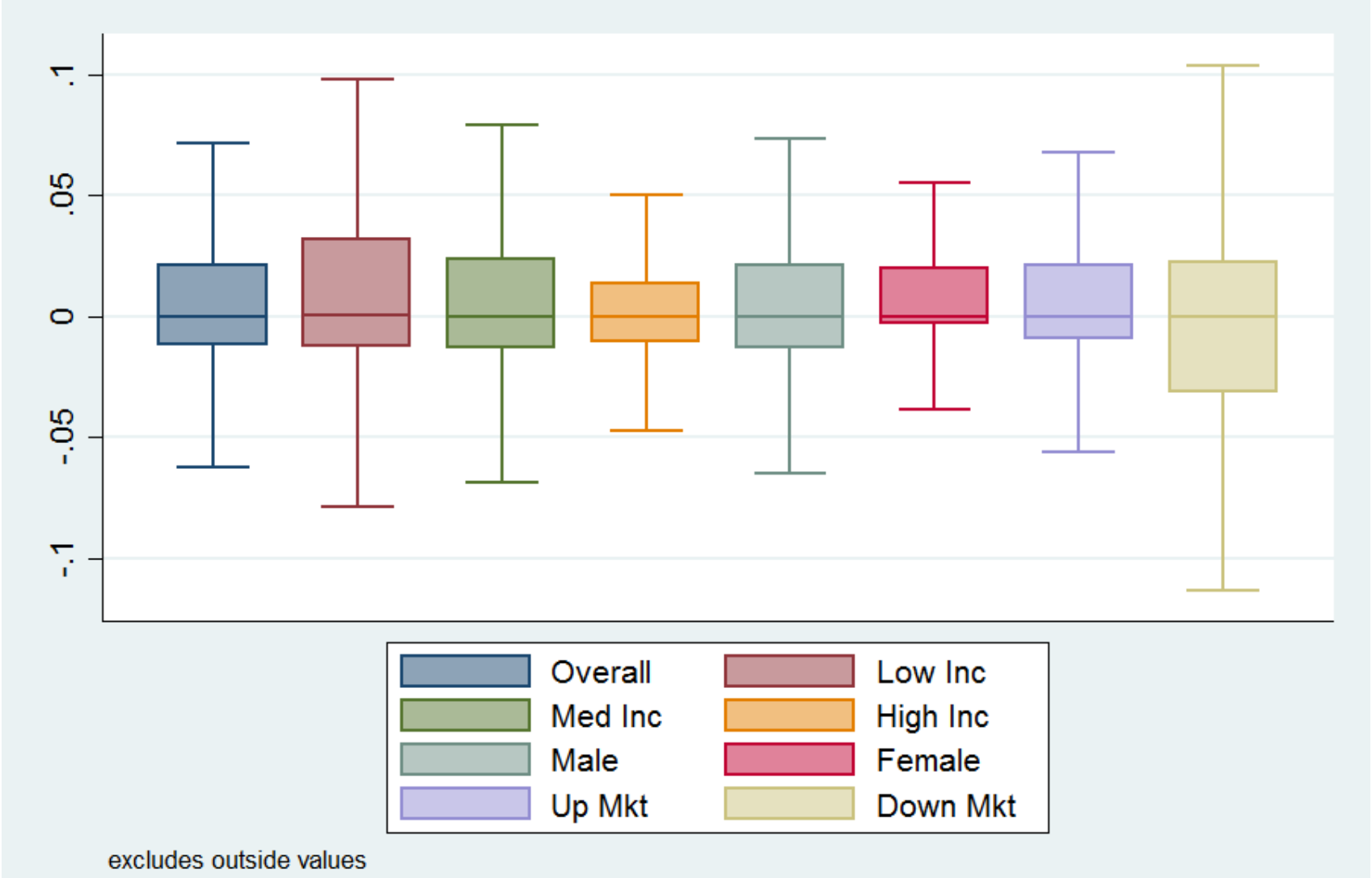
Note: upper 'adjacent value' is closest obs to 3rd quartile + 1.5 × inter-quartile-range

(i) No Trading Fees: Things to Note

- Error relatively small, both average and dispersion
  - inter-quartile range ∼1% of income
  - fees seem bigger issue for wealth accumulation than cons. flow
- Higher income have smaller error relative to income
  - trading fees have a large fixed cost component
- Women have smaller errors than males
  - women trade less frequently, consistent with previous literature
  - however, difference is economically small
- Little difference across market conditions

(iii) No Gross Trades: Diff. Across Groups & Periods

Box plots show error relative to individual annual income, $\epsilon_{it}/\bar{E}_i$



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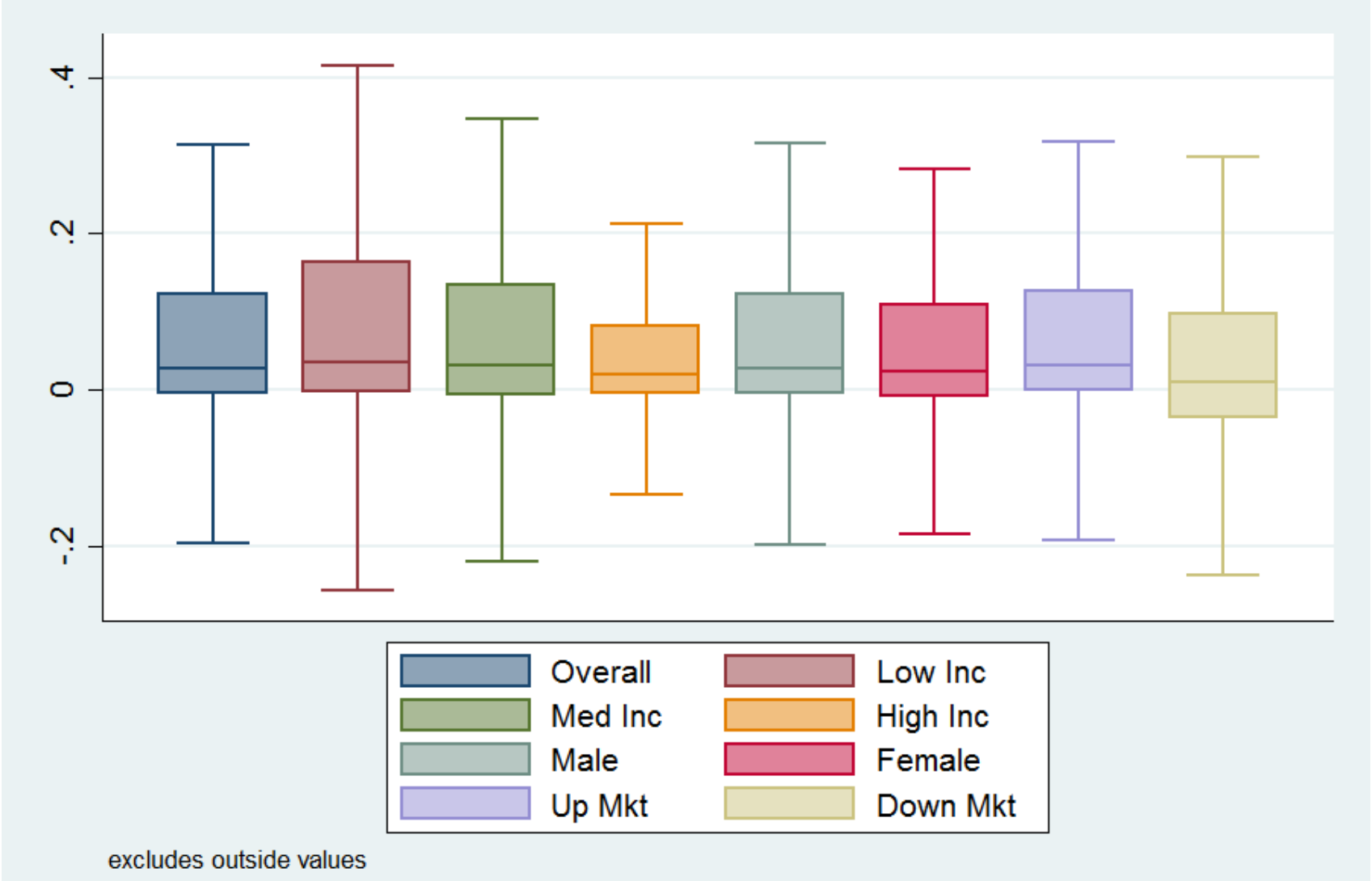
(iii) No Gross Trades: Things to Note

- Substantial amount of error!
  - both over- and underestimate consumption significantly
  - inter-quartile range ∼3%
  - top and bottom 10% error is around 5-10% of annual income!
  - however, fairly centered around zero
- Again, large differences across income, but also by gender
  - more frequent trading (relative to income)
- Now, down markets show much bigger spread
  - market volatility increases in down markets
  - retail investors bad at timing market, consistent with prev. lit

(v) Market Return: Diff. Across Groups & Periods

Box plots show error relative to individual annual income, $\epsilon_{it}/\bar{E}_i$



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(v) Market Return: Things to Note

- Error gets even larger when assuming market returns
  - inter-quartile range ∼12%!
- Moreover, median errors are now positive
  - retail investors underperform market!
  - hold undiversified portfolios
- Similar pattern across groups as before
  - under-performance bigger in up markets
  - DAX not a good proxy for average portfolio, which also contains bonds

Implications of Imputation Error

- Are imputation errors classical measurement error?
  - Is this just a matter of precision or also bias?

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Significant Correlation with Business Cycles

	(iii) No Intra-Year Trades			(v) Only Market Returns		
	ϵ_{it}	$\epsilon_{it}/\bar{E}_i^{net}$	$\lvert\epsilon_{it}/\bar{E}_i^{net}\rvert$	ϵ_{it}	$\epsilon_{it}/\bar{E}_i^{net}$	$\lvert\epsilon_{it}/\bar{E}_i^{net}\rvert$
	(1)	(2)	(3)	(4)	(5)	(6)
Real GDP Growth	-865.7	-0.0168	0.229***	34,392***	0.628***	0.202***
	(1,153)	(0.0351)	(0.0260)	(1,718)	(0.0509)	(0.0364)
Observations	51,862	24,748	24,748	50,862	24,321	24,321
R^2	0.073	0.088	0.348	0.243	0.260	0.434
Individual FE	YES	YES	YES	YES	YES	YES
Annual Market Return (DAX)	1,706***	0.0330***	-0.00771**	6,122***	0.107***	0.00113
	(177.2)	(0.00504)	(0.00345)	(338.3)	(0.00984)	(0.00638)
Observations	50,648	24,169	24,169	50,862	24,321	24,321
R^2	0.078	0.094	0.350	0.248	0.264	0.434
Individual FE	YES	YES	YES	YES	YES	YES
Real Home Price Growth	3,936.7***	0.0999**	0.125***	93,239***	1.971***	0.901***
	(1,380.3)	(0.0430)	(0.0462)	(3,139.1)	(0.0954)	(0.0776)
Observations	36,640	17,198	17,198	35,906	16,888	16,888
R^2	0.108	0.114	0.417	0.295	0.326	0.495
Individual FE	YES	YES	YES	YES	YES	YES

1 SD increase in mkt return (HP) increases error by 0.5-2% (0.25-5%) of income

Significant Correlation with Business Cycles

- Most of this is driven by stock market and house prices
  - asset markets are correlated, hence also indiv. portfolio return

  $\rightarrow$ upward bias if we estimate MPC out of housing wealth

Variation Across Individual Characteristics

Individual characteristics:

- Trading Activity
- Wealth
- Income

Higher Absolute Error Among Heavy Traders

	(iii) No Intra-Year Trades			(v) Only Market Returns		
	ϵ_{it}	$\epsilon_{it}/\bar{E}_i^{net}$	$\lvert\epsilon_{it}/\bar{E}_i^{net}\rvert$	ϵ_{it}	$\epsilon_{it}/\bar{E}_i^{net}$	$\lvert\epsilon_{it}/\bar{E}_i^{net}\rvert$
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Turnover Value)	-153.0***	-0.00268***	0.0159***	510.2***	0.0121***	0.0171***
	(18.24)	(0.000512)	(0.000694)	(32.61)	(0.00102)	(0.000938)
Observations	46,308	22,166	22,166	45,302	21,718	21,718
R^2	0.084	0.098	0.388	0.322	0.336	0.482
Mean of Dep Var	72.9	0.002	0.057	3922	0.083	0.135
Year FE	YES	YES	YES	YES	YES	YES
Individual FE	YES	YES	YES	YES	YES	YES

Doubling portfolio turnover increases spread by ∼1.5%

Trading and Imputation Error

- Individuals who trade the most are the most difficult to impute consumption for!
- Easy to screw up gains/prices/fees/dividends
- For buy-and-hold individuals, imputation of consumption is more accurate

Error Much More Pronounced Among Wealthy

	(iii) No Intra-Year Trades			(v) Only Market Returns		
	ϵ_{it}	$\epsilon_{it}/\bar{E}_i^{net}$	$\lvert\epsilon_{it}/\bar{E}_i^{net}\rvert$	ϵ_{it}	$\epsilon_{it}/\bar{E}_i^{net}$	$\lvert\epsilon_{it}/\bar{E}_i^{net}\rvert$
	(1)	(2)	(3)	(4)	(5)	(6)
Mkt. Ret.*Eq. Quintile 1	-98.78	-0.00542	-0.0436***	-1,029***	-0.0346***	-0.0735***
	(168.8)	(0.00629)	(0.00564)	(263.2)	(0.00975)	(0.00893)
Mkt. Ret.*Eq. Quintile 2	721.1***	0.0144*	-0.0299***	1,151***	0.00905	-0.0549***
	(261.1)	(0.00835)	(0.00667)	(309.0)	(0.0124)	(0.0101)
Mkt. Ret.*Eq. Quintile 3	2,299***	0.0496***	-0.00537	2,827***	0.0704***	-0.0380***
	(326.8)	(0.00984)	(0.00773)	(480.7)	(0.0153)	(0.0113)
Mkt. Ret.*Eq. Quintile 4	3,337***	0.0604***	0.0137	9,427***	0.189***	0.0303**
	(436.8)	(0.0118)	(0.00887)	(741.0)	(0.0217)	(0.0147)
Mkt. Ret.*Eq. Quintile 5	3,043***	0.0471***	0.0364***	28,179***	0.386***	0.204***
	(652.5)	(0.0145)	(0.0110)	(1,539)	(0.0386)	(0.0261)
Observations	50,648	24,169	24,169	50,862	24,321	24,321
R^2	0.080	0.096	0.353	0.277	0.279	0.442
Individual FE	YES	YES	YES	YES	YES	YES

20% DAX return (∼1SD) associated with ↑ $\epsilon^{(v)}$ of 8% of income in 5^{th}Q, but only 0.2-0.7% in bottom two quintiles

Errors *Within* Individual Increase with Income

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	ϵ_{it}	$\epsilon_{it}/\bar{E}_i^{net}$	$\lvert\epsilon_{it}/\bar{E}_i^{net}\rvert$	ϵ_{it}	$\epsilon_{it}/\bar{E}_i^{net}$	$\lvert\epsilon_{it}/\bar{E}_i^{net}\rvert$
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Income)	258.2**	0.00205	0.00592***			
	(103.7)	(0.00176)	(0.00166)			
ln(Inc)*Eq. Quintile 1				76.66***	0.000950*	-0.00118**
				(27.31)	(0.000524)	(0.000459)
ln(Inc)*Eq. Quintile 2				104.4***	0.00193***	0.000837*
				(28.01)	(0.000554)	(0.000479)
ln(Inc)*Eq. Quintile 3				193.5***	0.00329***	0.00215***
				(30.56)	(0.000596)	(0.000516)
ln(Inc)*Eq. Quintile 4				266.5***	0.00450***	0.00372***
				(33.41)	(0.000652)	(0.000549)
ln(Inc)*Eq. Quintile 5				285.5***	0.00533***	0.00527***
				(36.95)	(0.000708)	(0.000637)
Observations	24,729	24,748	24,748	24,729	24,748	24,748
R^2	0.079	0.091	0.352	0.086	0.097	0.363
Year FE	YES	YES	YES	YES	YES	YES
Individual FE	YES	YES	YES	YES	YES	YES

Small effect on estimated income-MPC since stock market not very correlated with income in Germany in this period, 2004-2015.

Recommendations for Researchers

Recommended Corrective Steps

1. Get more data, especially intra-year transactions
   (Example: Eika Mogstad Vestad 2017)

If this is not possible, we recommend the following:

2. Control for frequent traders or measures of individual risk-taking
3. Control for stock market behavior and business cylce
4. Focus on lower end of income/wealth distribution
   (eg. below 90^{th} percentile)

Conclusion

Conclusion

- Measurement error in imputed consumption form financial wealth can range between minimal to substantial
- Important to consider market growth during period of study
- More of an issue:
  - for wealthier individuals
  - for frequent traders
  - for men
  - in down markets

Thanks!