The demand for liquid asset with uncertain lumpy expenditures

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Introduction

Part of a project on *liquidity management* and *means of payments choice*

- Revisit classic inventory models for different economic agents
- Use simple cts time methods to think through the agents' decisions
- Confront / estimate models using micro datasets

This paper: objective and contributions

Introduce Large purchases in models of Liquidity management

Examples: durable purchases for households, or M&A for firms

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Three contributions

- Theoretical predictions differ starkly from classic inventory models

  – large expenditures “drive” adjustments, not a threshold rule ($M = 0$)

- Solve tricky math concerning the optimal policy

  – usual boundary approach is not sufficient

- Provide scheme to interpret (new) empirical regularities

  – currency demand and size of purchases in cash

  – liquid asset and durables / non-durables purchases

Applications: from Thai farmers to Wall Street

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- Currency
  - Survey of cash management practices Austria and Italy (cross section, retrospective questions)
  - Weekly Diary of cash purchases, and retrospective questions (Austria).
  - 10 year panel of monthly data from Thai villages (Townsend)
    net cash expenditures, withdrawals, deposits (in progress)
- Broad Liquid Asset management (say M2)
  - 35 months panel of 1,400 italian investors:
    administrative data on 26 accounts from Unicredit Bank.
- Demand of Liquid Asset by firms.

Related Literature

- For comparison, classic model of inventory management:
  - Tobin (1956), Baumol (1952), Miller and Orr (1966),
  - Eppen and Fama (1969), Constantinides and Richard (1978),
  - Frenkel and Jovanovic (1980), Harrison, Sellke, and Taylor (1983),
  - Harrison and Taskar (1983), Sulem (1986),
  - Bar-Ilan (1990) , Alvarez and Lippi (2009).
- Inventory models with information costs
  - Duffie and Sun (1990), Abel, Eberly, and Panageas (2007), Alvarez, Guiso, and Lippi (2011)
- Models with Jumps in cumulated net cash consumption:
  Bar-Ilan, Perry, and Stadje (2004) more general process for net cash.
- Early version of similar ideas: Whalen (1966).
- Alternative assumption about timing of shocks and withdrawals :
  Telyukova (2009) use it to explain hoarding more cash.

Baumol-Tobin Model with Large Purchases

Ingredients

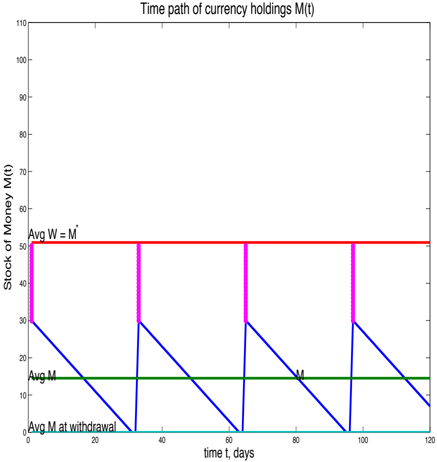
- Continuous cash expenditures c per unit of time (small purchases) .
- Expenditures z every $1/\kappa$ periods of time (large purchases) .
- Expected expenditures in cash per unit of time $e \equiv c + \kappa z$.
- M is average cash with opportunity cost R .
- n is number of adjustments per unit of time, each with fixed cost b .

$$\text{Minimize} \quad M\,R \,+\, b\,n$$

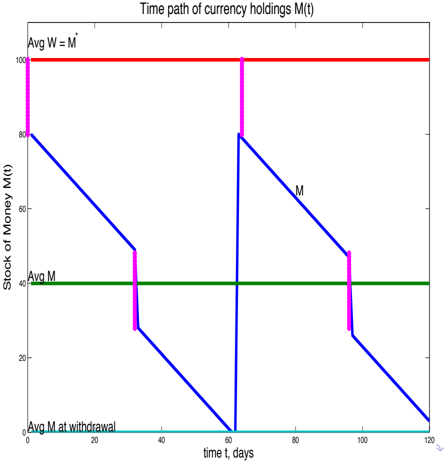
BT with jumps: alternative policies

Period: 120 days $c = 120, z = 20, \kappa = 4$

many transactions $n = 4$



few transactions $n = 2$



BT with jumps: Three possible patterns

Recall Baumol-Tobin: $\frac{W}{M} = 2$ and $n_{BT} = \sqrt{\frac{R\ (c+z\kappa)}{2\ b}}$

- withdraw more often than jumps: $n > \kappa$, optimal when $\kappa < \underline{\kappa}$

  $n = \sqrt{\frac{R\ c}{2\ b}} > \kappa\ , \quad n/n_{BT} < 1 \quad , \quad W/M = 2\ \frac{c+\kappa z}{c}$

- withdraw as often as jumps : $n = \kappa$, optimal when $\underline{\kappa} \leq \kappa \leq \bar{\kappa}(z)$:

  $n = \kappa, \qquad n/n_{BT} < 1 \qquad W/M = 2\ \frac{c+\kappa z}{c}$

- withdraw less often than jumps: $n < \kappa$, optimal when $\kappa > \bar{\kappa}(z) > \underline{\kappa}$

  $n = \sqrt{\frac{R\ (c+z\kappa)}{2\ b}} < \kappa\ , \qquad n/n_{BT} = 1 \qquad W/M = 2\ \frac{c+\kappa z}{c+z(\kappa-n)}$

Thresholds: $\underline{\kappa} \equiv \sqrt{\frac{R\ c}{2\ b}} \ < \ \bar{\kappa}(z) \equiv \frac{Rz+\sqrt{(Rz)^2+8bRc}}{4b}$

Main implication of lumpy purchases

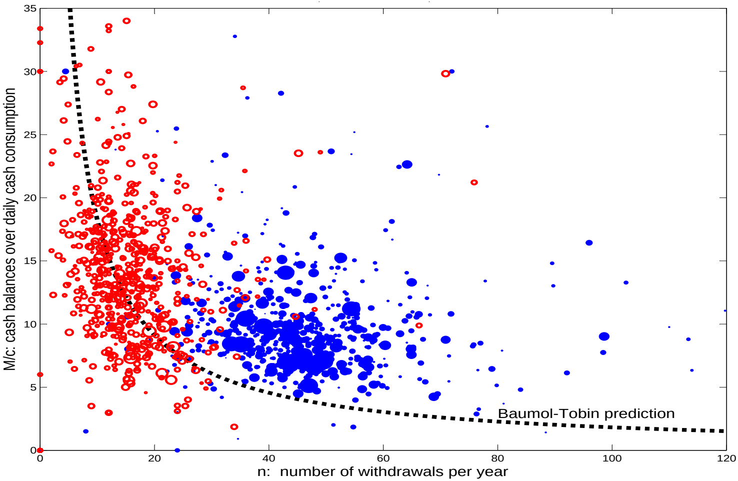
- Some expenditures have infinite velocity
  - Break the BT link between withdrawal size and avg. liquidity holdings
- Simple test of BT theory: use identity: $n \equiv \frac{e}{W}$ and relation $W = 2M$

Basic Empirical prediction of BT: $n_{BT} \equiv \frac{e}{2M}$

currency data   M2 data

Narrow aggregates: Currency (Italian households)

plot M/e vs n ; BT prediction $M/e = 1/(2n)$



Source: Alvarez Lippi (Ecta 2009) back

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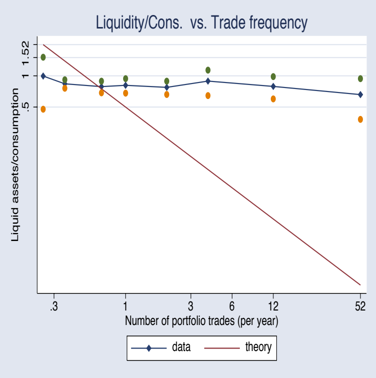
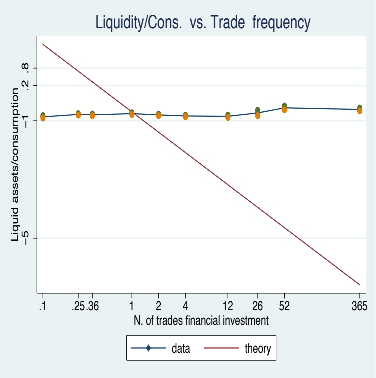
representative HH (SHIW 2004)



investor HH (Unicredit 2003)



Source: Alvarez Guiso Lippi (AER 2011)

back

Currency management statistics in Italy and Austria

- recall: $n/n_{BT} < 1 \iff W/M > 2$

identity $nW/e = 1$ in data

	ATM Card	Italy (2002)	Austria (2005)
Expenditure share paid w. currency	w/o	0.65	0.96
	w.	0.52	0.73
Currency: M/e (e per day)	w/o	17	15
	w.	13	15
M per Household	w/o	410	332
	w.	330	206
Currency at withdrawals $\underline{M}/M$	w/o	0.46	0.22
	w.	0.41	0.26
Withdrawal: W/M	w/o	2.0	2.4
	w.	1.3	1.6
# of withdrawals: n (per year)	w/o	23	21
	w.	58	68
Normalized: $\frac{n}{n_{BT}} = \frac{n}{e/(2M)}$ (e per year)	w/o	1.7	1.4
	w.	3.9	5.4
Fraction of households with $W/M > 2$	w/o	0.25	0.29
	w.	0.13	0.19
Fraction of households with $\frac{n}{n_{BT}} \equiv \frac{n}{e/(2M)} < 1$	w/o	0.50	0.57
	w.	0.19	0.31
# of observations	w/o	2,275	153
	w.	3,729	895

Stochastic Model w/Large expenditures

- In a period of length dt *net cash consumption*: $dC = c\, dt + z\, dN + \sigma\, dB$

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  - Expected net cash consumption: $\frac{1}{dt}\mathbb{E}(dC) = c + \kappa z \equiv e$,
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- adjust cash with NO cost with probability $p\,dt$ during period dt:
- Opportunity cost of cash R ; Fixed adjustment cost b

Optimal adjustment rule & Bellman equation

- withdraw if m hits zero , adjust cash to m^*.
- deposit if m hits m^{**}, adjust cash to m^*.
- if hit by free adjustment, withdraw or deposit and adjust cash to m^*.

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Bellman equation in inaction region (expected discounted cost)

$$\begin{aligned} rV(m) &= Rm - cV'(m) + \frac{\sigma^2}{2} V''(m) + p\left[V(m^*) - V(m)\right] \\ &\quad + \kappa \min\left[b + V(m^*) - V(m),\ V(m-z) - V(m)\right] \\ \text{for all} &\quad 0 \le m \le m^{**} \end{aligned}$$

boundary cond.

$$\begin{aligned} V(m^{**}) &= V(m^*) + b \ \text{ and } V'(m^{**}) = 0 : \ \text{pay cost and adjust,} \\ V(0) &= V(m^*) + b : \ \text{pay cost and adjust,} \\ m^* &= \arg\min_m V'(m) : \text{choice of } m^* \text{ is optimal .} \end{aligned}$$

The Bellman Equation

- Economics: for $m < z$ must withdraw after large consumption

  Mathematics: for $m < z$ Bellman Eqn is ODE

$$(r + p + \kappa) V(m) = Rm - cV'(m) + \frac{\sigma^2}{2} V''(m) + (p + \kappa) V(m^*) + \kappa b$$

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- Algorithm: solve DDE as a system of ODEs, recursively in segments: $[0, z]$, $[z, 2z]$, $[2z, 3z]$, ..., $[zJ, m^{**}]$

more math

The role of the Brownian shocks: $\sigma > 0$

Presence of $\sigma > 0$ allows inflows of cash. Appropriate for firms Miller and Orr (1966)), farmers (Alvarez - Townsend , 2011)

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- Households in Italy: very small frequency of deposits:
  - Not self-employed $\frac{\text{\# deposits}}{\text{\# withdrawals}} = \frac{n_D}{n} = 0.007$
  - Self-employed $\frac{\text{\# deposits}}{\text{\# withdrawals}} = \frac{n_D}{n} = 0.058$

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  - Self-employed $\frac{\text{\# deposits}}{\text{\# withdrawals}} = \frac{n_D}{n} = 0.058$
- Model with $\sigma = 0$, simplifies since agent keeps $m \in [0, m^{*}]$.

Large & Infrequent purchases (with $\sigma = 0$)

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  $z \downarrow 0, \ \kappa \uparrow \infty$ while $\kappa z / e$ constant $\implies$ standard model.

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  Define benchmark with NO large purchases s.t. $e_0 = c$ and $p_0 = p + \kappa$

  Several statistics as in benchmark case:

  $m^* = m_0^* \quad , \quad M = M_0 \quad , \quad \underline{M} = \underline{M}_0 \quad , \quad n = n_0 > p + \kappa$

  Larger withdrawals: $W = W_0 + \frac{\kappa}{n} z$ hence "fewer" withdrawals $\frac{n}{n_{BT}} < \frac{n_0}{n_{BT,0}}$.

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  comparative statics: optimal m_0^* decreasing in p_0 , increasing e_0

Large & infrequent purchases: testable moments

Observations on $\left\{\frac{M}{e}, \frac{W}{M}, \frac{\underline{M}}{M}, n\right\}$ identify 3 params $\left\{\frac{\kappa z}{e}, \kappa + p, \frac{R}{b/c}\right\}$.

$$\frac{\kappa z}{\kappa z + c} = 1 + \frac{1}{W/M}\left(\frac{\underline{M}/M}{\frac{\log(1-\underline{M}/M)}{\underline{M}/M} + 1}\right),$$

$$\kappa \leq p + \kappa = n\,\frac{\underline{M}}{M} \leq n\,,$$

$$z \geq m^* = M\left(\frac{\log(1-\underline{M}/M)}{1 + \frac{\log(1-\underline{M}/M)}{\underline{M}/M}}\right) \quad \text{and} \quad \frac{m^*}{c} = f\left(\frac{b/c}{R}, p + \kappa\right)$$

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\end{aligned}
$$

$z \geq m^*$ holds in Austrian diary dataset where $z > 400$ € are recorded

Austria: is the model consistent with evidence?

Model predicts n/n_{BT} decreasing in z

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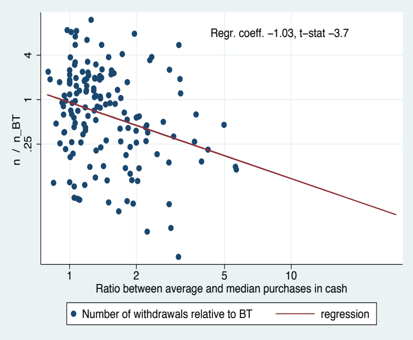
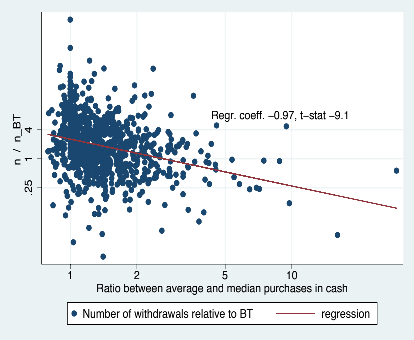
w/o ATM Card



w. ATM card



Two technical issues

- Shape of inaction set for general *sS* problem: union of disjoint intervals
  - Characterization and (counter) examples. Scarf K-convexity:
    Neave MS 70, Bar-Ilan IER 90, Chien-Levy PEIS 09
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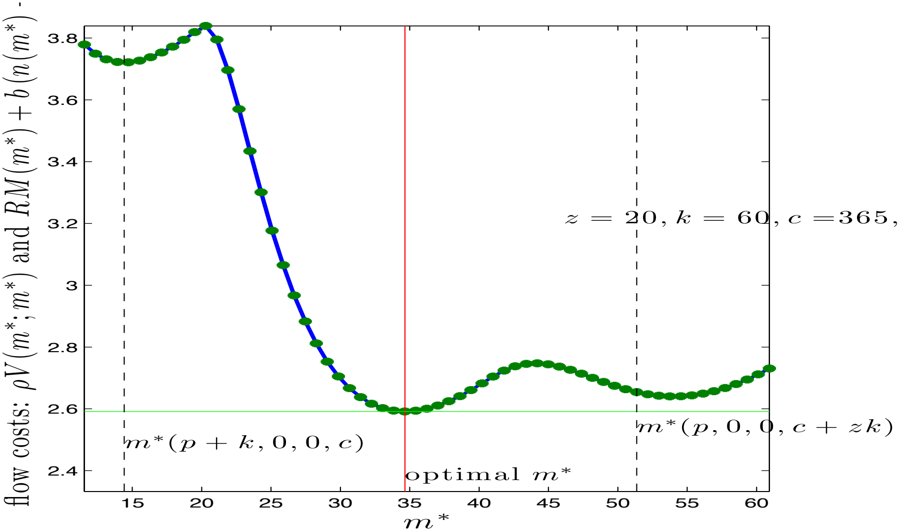
    due to continuous time & jumps in one direction
- Determination of threshold m^*
  - Local vs global minimum for m^*
  - No verification theorem (unlike the continuous path case)
  - Optimal value of m^* depend on size of κ

Deceptive first order conditions.....

Conditional value function $\rho V^*(m^*; m^*)$ vs. threshold m^* at $m = m^*$.



Broader aggregates (Alvarez Guiso Lippi, AER 11)

- Baumol-Tobin-Merton-Duffie-Sun applied to:
  - Expenditures only Non-durable goods
  - Financial trades and Liquid assets behave as in BT
- Grossman Laroque + CIA
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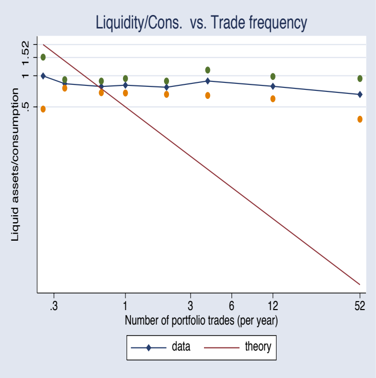
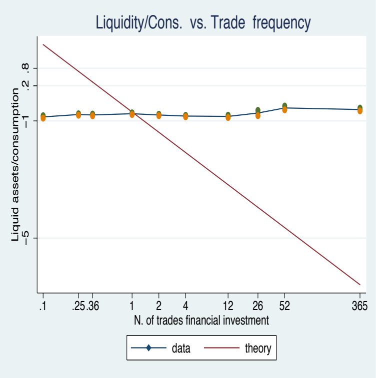
- Model in this paper has BOTH type of expenditures but
  - Exogenous process for expenditures.
  - Simple structure of adjustment costs.

Broad aggregates: M2 (Italian investors)

M2 / Non-Dur Cons vs Trading Frequency ; BT prediction $M/e = 1/(2n)$

representative HH (SHIW 2004) investor HH (Unicredit 2003)





Source: Alvarez Guiso Lippi (AER 2011) back

Broad aggregates (M2); multivariate analysis

Theory: Liquidity $M/e = 1/(2 \times \text{portfolio trade freq.})$

Dependent variable: (log) M/e ; Regressor: (log) asset trade frequency

	Shiw data		*Unicredit data*	
	bivariate[a]	Multivariate[b]	bivariate[a]	Multivariate[b*]
All investors	*(2,808 obs.)*		*(1,365 obs.)*	
Trade freq. (log)	0.005	0.03	0.10	0.13
	(0.02)	(0.02)	(0.02)	(0.02)
Equity investors	*(1,535 obs.)*		*(875 obs.)*	
Trade freq. (log)	0.06	0.06	0.08	0.11
	(0.03)	(0.03)	(0.03)	(0.03)

2004 SHIW and 2003 Unicredit surveys. M/c = $M2$ / non-durable consumption; for the Unicredit consumption is imputed. [a]Regression coefficient of bivariate OLS. [b] controls (all in logs): household income, age, size, income risk dummy, self-employed, gov. employment

Italian data: Liquid Asset and Sale of Financial Assets

$$\Delta M_{jt} = \sum_{k=0}^{4} \beta_k F^S_{jt-k} + \sum_{k=0}^{4} \gamma_k F^P_{jt-k} + \delta SFA_{jt} + h_j + u_{jt}$$

- ΔM_{jt} change in Liquid Asset of investor j at t.
- F^S_{jt} sales of financial asset of investor j at t
- F^P_{jt} purchases of financial asset of investor j at t
- SFA_{jt} investor j total financial assets (level)
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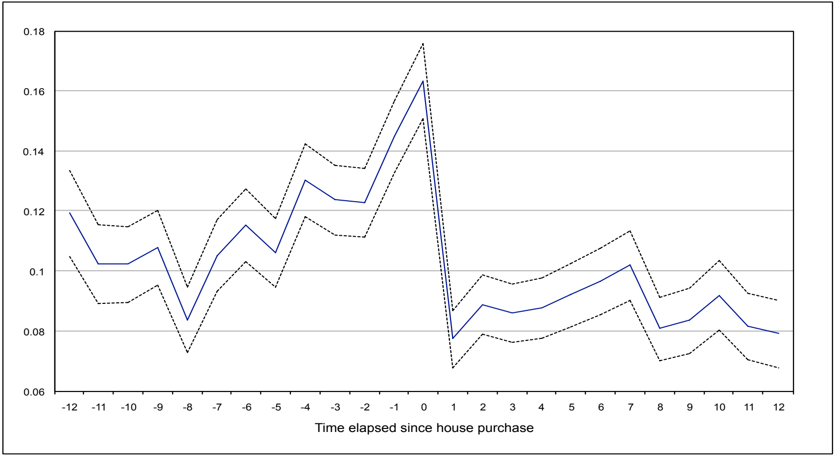
- Investors trade asses about every 6 - 9 months....
- .....yet two months after asset sale 65 cents are spent (vs 16 - 32 cents)

Mortgage approval and financial asset sales (Italy)

vertical axis: fraction that sell financial assets



– – – –– line ± one standard error bands

Source: *Unicredit* monthly administrative records of 26 accounts for each of 40,000 investors.

Concluding remarks

Simple model to improve our understanding of liquidity management

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- Bates, Kahle, and Stulz (2009) panel regressions of liquid asset to total asset for of U.S. manufacturing firms from 1980 to 2006....

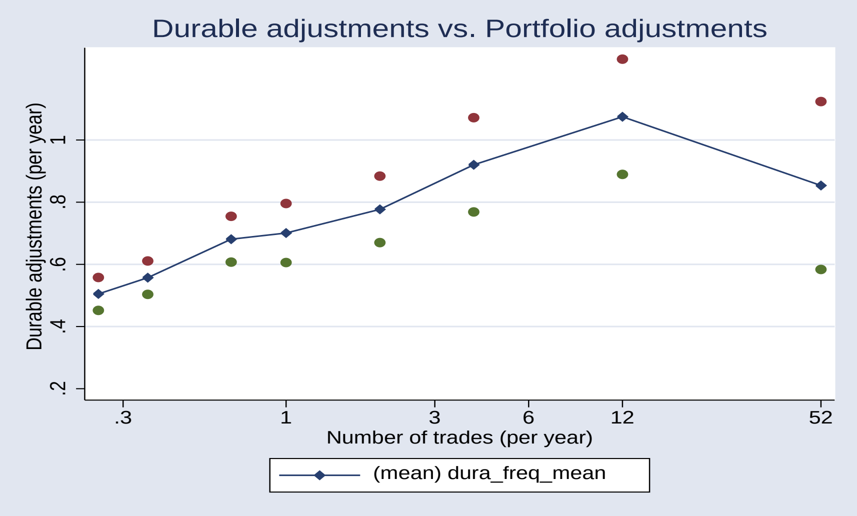
  .... find negative coefficient on the ratio of acquisitions to assets... we interpret this as measure of z

Table: Fraction of Investors who adjusted the durables stock in 2004

	Precious & Antiques	Cars & other[c]	Furniture & appliances	All	Housing [a,c]
All investors					
	0.09	0.15	0.37	0.47	-
% purchases[b]	97	83	-	95	
By Investor type					
Portfolio adjust.					
$<$ *1 per year*	0.07	0.13	0.34	0.42	0.05
$\geq$ *1 per year*	0.12	0.20	0.45	0.57	0.07

Source: Bank of Italy survey - SHIW 2004, [a] during the last 5 years, among homeowners [b] adjustment that are purchases, [c] survey only ask about purchases.

Adjustment frequency: durable vs. portfolio



Source: Bank of Italy survey - SHIW 2004

Durable trade vs. asset trade frequency

Dependent variable: (log) durable trade freq. on (log) asset trade frequency

	All investors (2,808 obs.)		*Equity investors* (1,535 obs.)	
	bivariate[a]	Multivariate[b]	bivariate[a]	Multivariate[b]
Trade freq.	0.27	0.16	0.16	0.09
(log)	(0.03)	(0.03)	(0.04)	(0.04)

—[a]Regression coefficient of bivariate OLS. —[b]Includes (all in logs): household income, age, size.

Durable adjustment frequency: add buys and sells of each type of durable $(0, 1, ..., 4)$.

Source: Bank of Italy survey - SHIW 2004

Portfolio Trades in Unicredit Data

- Use *administrative data Unicredit investors*:
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- Liquid Asset = Checking account (+ time deposits)
- Financial Asset = Remaining 25 accounts (equity, bonds, m. funds, ...)
- In the model, all Financial Trades have net cash flows.
- In the Unicredit/SHIW surveys Financial Trades may include rebalancing.

Statistics on annual number of asset sales

	All Asset Sales N_{Sj}		Asset sales ≥ 500		Asset sales ≥ 1000	
	Median	Mean (sd)	Median	Mean (sd)	Median	Mean (sd)
Total sample	1.03	1.40 (1.29)	1.03	1.17 (1.11)	0.70	1.06 (1.03)
Stockholders (total)	1.71	1.81 (1.28)	1.37	1.53 (1.13)	1.02	1.40 (1.07)
Stockholders (direct)	1.71	1.97 (1.30)	1.37	1.69 (1.19)	1.37	1.55 (1.12)

- UCS adm data: 35 months, 26 accounts, 1500 investors.
- Asset sale = at least 1 of 25 financial asset (accounts) sold in month.
- Trade = some asset sold or some asset purchased.
- Infrequent and large trades.

Statistics on annual number of total trades

	Median		Mean		Std Dev
Liquid Assets =	Checking	Broad	Checking	Broad	Checking
All trades (N_{Tj}) Of which asset Sales (N_{Sj}) Of which asset Purchases (N_{Pj})	3.4 1.4 2.4	3.4 1.4 2.4	4.5 2.0 3.6	4.5 2.0 3.5	3.7 2.0 3.6
Stockholders (N_{Tj}) (direct+indirect)	5.1	5.1	5.8	5.8	3.6
Stockholders (N_{Tj}) (direct)	5.8	5.5	6.0	6.0	3.4

- Broad Measure of Liquid Asset = Checking + Time Deposits ($\approx$ M2)

Ratio of rebalancing trades on total trades

	Number of trades with some rebalancing			Number of trades with only rebalancing		
	Median	Mean	Std dev	Median	Mean	Std dev
Whole sample	0.13	0.18	0.21	0	0.017	0.07
Stockholders (direct+indirect)	0.21	0.25	0.22	0	0.022	0.09
Stockholders (direct)	0.21	0.25	0.22	0	0.018	0.08

- Trade some rebalancing : simultaneous sale and purchase of asset.
- Trade only rebalancing : value of sale = value purchase of assets.

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Panel of bank account of 40,000 Unicredit investors

- Same panel data used for rebalancing but for 40,000 Investors
- Indicator of final approval of Mortgage (about 800 in 35 months)
- Compute fraction of asset sales prior and after obtaining mortgage.
- Compute average asset sales prior and after obtaining mortgage.
- **Prior to mortgage approval more frequent and larger sales of assets.**
- Robust to controls (Probit and Tobit regressions)

back to test

Table: Timing of assets sales and house purchases back

Regressor	Probit estimates for asset sale decision: Coefficient	Standard error	Tobit estimates of size of asset sold: Coefficient	Standard error
Obtained mortgage:				
α_0 : current	0.070***	0.012	34413.8***	3889.2
α_1 : lag 1	0.053***	0.012	26985.6***	4075. 6
α_2 : lag 2	0.029***	0.011	12338.9***	4437.1
α_3 : lag 3	0.027***	0.011	14200.6***	4457.9
α_4 : lag 4	0.030***	0.011	15696.9***	4489.7
α_{-1}: lead 1	-0.010	0.010	-6863.4	5103.3
α_{-2}: lead 2	0.003	0.010	3993.9	4868.3
α_{-3}: lead 3	-0.001	0.010	288.3	5015.2
Time dummies and				
β : Investor total assets	1.51e-07***	1.24e-08	0.124***	0.006
λ: Stockholder	0.094***	0.003	42174.19***	2294.0
N. observations	31247		31247	
Pseudo R^2	0.07		0.0164	

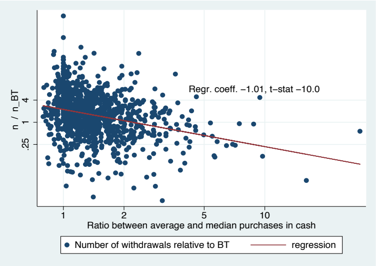
Table: Cash Management and Large Purchases in Austria

	All (1048 Obs)		w/ATM card (895 Obs.)		w/o ATM card (153 Obs.)	
Those that usually make large purchases (> 400 euros) in cash[a]						
% persons that use cash for large purchase	46%		37%		96%	
	mean	median	mean	median	mean	median
Withdrawal to Money: W/M	2.0	1.1	1.9	1.0	2.1	1.3
# withdrawals relative to BT[b]: n/n_{BT}	3.5	1.2	4.4	1.5	1.5	0.7
Normalized cash at withdrawals $n\underline{M}/M$[c]	13.4	4.5	17.5	6.3	4.0	2.6
Those that usually do NOT make large purchases (> 400 euros) in cash[a]						
% persons that do not use cash for large purchase	54%		63%		4% (6 obs!!)	
	mean	median	mean	median	mean	median
Withdrawal to Money: W/M	1.6	1.0	1.5	1.0	10.4	2.1
# withdrawals relative to BT[b]: n/n_{BT}	5.9	1.9	6.0	1.9	0.9	0.7
Normalized cash at withdrawals $n\underline{M}/M$[c]	20.6	7.8	20.8	8.0	3.8	2.9

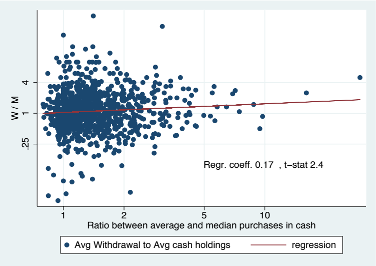
- [a] Based on a question about how individual usually paid for items that cost more than 400 euros. Two options are available, either currency or other payment methods. Total number of respondents is 1048.
- [b] # of withdrawals n relative to Baumol-Tobin benchmark, $n_{BT} = e/(2\ M)$ Based on a diary of all transactions during a week. This the week is right after the month corresponding to the question on large transactions above.
- [c] the variable $n\underline{M}/M$ is the the product of the number of withdrawals n and the ratio of the average cash at the time of withdrawal, $\underline{M}$ to the average cash holdings.

Figure: Austria: the inventory model statistics vs. e_a/e_m

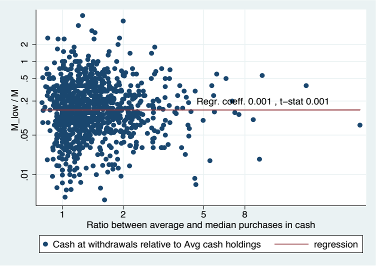
n/n_{BT}



W/M



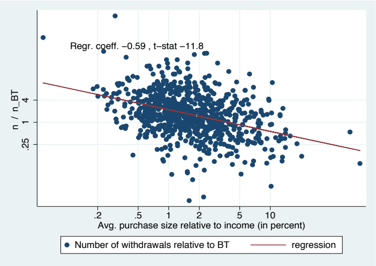
$\underline{M}/M$



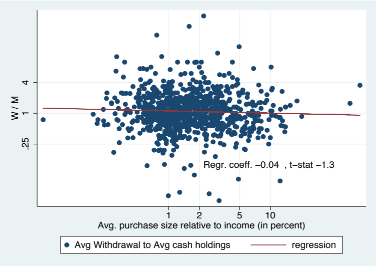
e_a/e_m = avg / median purchase in cash

Figure: Austria: the inventory model statistics vs. e_a/y

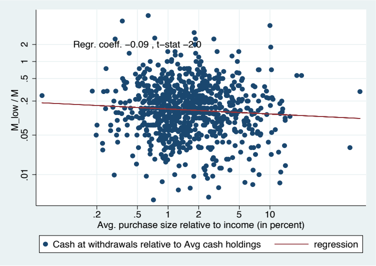
n/n_{BT}



W/M

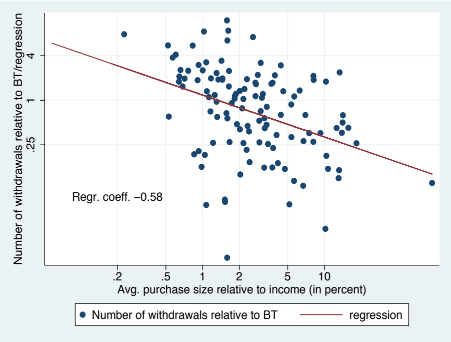


$\underline{M}/M$

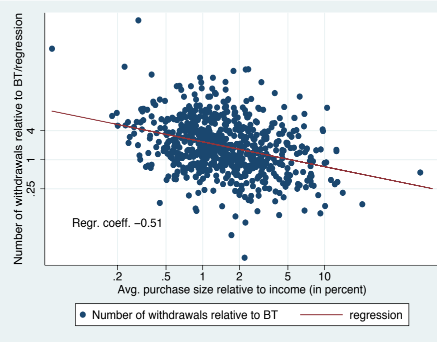


e_a/y = avg purchase / income

w/o ATM Card



w. ATM card



Solving the BE: recursion

- Bellman equation given $\{m^*, m^{**}\}$ solves in each J segments:

- $V(m) = V_j(m)$ for $m \in [zj\ ,\ \min\{z(j+1), m^{**}\}]\ ,\ j = 0, ..., J-1$
- $V_j(m) = A_j + D_j(m - zj) + \sum_{k=1,2} \sum_{i=0}^{j} B_{j,i}^{k}\ e^{\lambda_k (m-zj)}\ (m - zj)^i$
- λ_k solves $r + p + k = -c\lambda + \frac{\sigma^2}{2}\lambda^2$ for $k = 1, 2$.
- coefficients $\{A_j, D_j, B_{j,i}^k\}_{j=0,1,2,...,J-1,\ i=1,...,j,\ k=1,2}$ solve block recursive system of linear equations.

- To solve for $\{m^*, m^{**}\}$ use form of Bellman equation:

$V'(m^*) = 0$ and $V'(m^{**}) = 0$ (necessary, but not sufficient conditions).

back

Currency vs Cons paid cash and Withdrawals

Dependent Variable $\log(M/c)$				
	without ATM card		*with ATM card*	
	bivariate	multivariate	bivariate	multivariate
$\log n$	-0.24***	-	-0.25***	-
$\log n$	-	-0.22***	-	-0.24***
	(900 obs.)	*(900 obs.)*	*(2326 obs.)*	*(2325 obs.)*
Dependent Variable $\log(W/c)$				
	without ATM card		*with ATM card*	
	bivariate	multivariate	bivariate	multivariate
$\log n$	-0.39***	-	-0.52***	-
$\log n$	-	-0.40***	-	-0.52***
	(2250 obs.)	*(2249 obs.)*	*(1256 obs.)*	*(1255 obs.)*

2004 SHIW and 2003 Unicredit surveys. M/c = $M2$ / non-durable consumption; for the Unicredit consumption is impued. —[a]Regression coefficient of bivariate OLS. —[b] controls (all in logs): household income, age, size.

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Table: Temporal pattern of changes in the liquid and investments assets

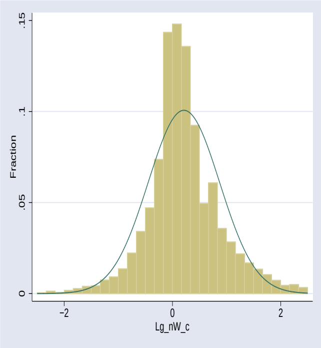
Change in liquid asset in a month ΔM		
Regressors	Coefficient	Standard Error
Flow of investment sales:		
β_0: current	0.703***	0.0057
β_1: lag 1	-0.23***	0.0062
β_2: lag 2	-0.16***	0.0065
β_3: lag 3	0.002	0.006
β_4: lag 4	-0.03	0.0065
Flow of investment purchases:		
γ_0: current	-0.65***	0.0065
γ_1: lag 1	0.020***	0.007
γ_2: lag 2	-0.076***	0.007
γ_3: lag 3	0.056***	0.007
γ_4: lag 4	-0.011**	0.006
Investor total assets:		
δ :	0.092***	0.0025
N. observations	31622	
R^2	0.47	

Measurement error

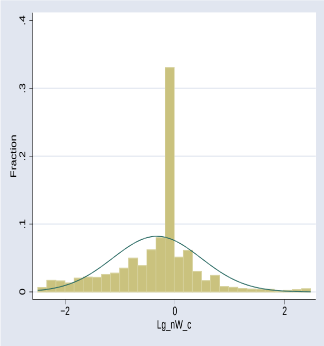
Read errors of fit as measurement error.

A property of inventory models (Accounting identity): $Log\left(n\,\frac{W}{e}\right) = 0$

Household w. ATM



Household w/o ATM



Free withdrawal opportunities p

- We argue elsewhere (Alvarez-Lippi Eca 09) that:
  - Small and frequent withdrawal, $\frac{W}{M} < 2$, $\frac{n}{n_{BT}} > 1$ and
  - Substantial cash at hand at time of withdrawal, $\frac{\underline{M}}{M} >> 0$
- Are consistent with introducing p:
  average free withdrawals opportunities per year.
- Agent withdraw everytime that it is free, regardless of level of cash, so:
  $\underline{M} > 0$ and $W/M < 2$.

Free withdrawal opportunities *p*

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  - Small and frequent withdrawal, $\frac{W}{M} < 2$, $\frac{n}{n_{BT}} > 1$ and
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  average free withdrawals opportunities per year.
- Agent withdraw everytime that it is free, regardless of level of cash, so:

  $\underline{M} > 0$ and $W/M < 2$.
- We think this feature helps understand the "average" values, and the difference between those with and whitout ATM cards.
- Yet, we found other form of heterogeneity interesting,

  we explore if it is due to large purchases.

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