Precautionary Savings, Liquidity Constraints, and Self-Control

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THREE IMPORTANT IDEAS

- Precautionary Saving
- Liquidity Constraints
- Self-Control Problems
Suppose for simplicity $\beta(1 + r) = 1$

Consumption Euler equation:

$$U'(C_t) = E_t U'(C_{t+1})$$

With quadratic utility:

$$C_t = E_t C_{t+1}$$

This implies certainty equivalence:

- $C_t$ depends only on $E_t C_{t+1}$ not $\text{var}_t(C_{t+1})$ (or any higher moments)
CERTAINTY EQUIVALENCE

- Suppose for simplicity $\beta(1 + r) = 1$
- Consumption Euler equation:

$$U'(C_t) = E_t U'(C_{t+1})$$

- With quadratic utility:

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- This implies certainty equivalence:
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- Very extreme model:
  - Savings behavior unaffected by uncertainty!!
  - Consumption smoothing and intertemporal substitution only forces affecting savings
    (same thing for linearized or log-linearized models)
**Quadratic Utility and Risk**

- With quadratic utility, utility cost of given variance of consumption independent of the level of consumption
  - Amount of curvature of utility independent of level
  - Jensen’s inequality term independent of the level

- But marginal utility falls with level of consumption

- Thus, with quadratic utility, consumers are willing to pay more to avoid a given amount of uncertainty (particular dollar coin toss) the richer they are

- Quadratic utility implies increasing absolute risk aversion
Common Utility Functions

- **Constant Relative Risk Aversion (CRRA):**

\[
U(C) = \begin{cases} 
\frac{C^{1-\gamma} - 1}{1-\gamma} & \text{if } \gamma \neq 1 \\
\log C & \text{if } \gamma = 1 
\end{cases}
\]

Relative Risk Aversion \( = -\frac{U''(C)C}{U'(C)} = \gamma \)

- **Constant Absolute Risk Aversion (CARA):**

\[
U(C) = -\frac{\exp(AC)}{A}
\]

Absolute Risk Aversion \( = -\frac{U''(C)}{U'(C)} = A \)
Increasing absolute risk aversion completely unrealistic

Implications for portfolio allocation:
- CRRA: Constant share in risky assets
- CARA: Constant dollar amount in risky assets
- IARA: Decreasing dollar amount in risky assets as wealth increases

In reality, richer people allocate larger share of wealth to risky assets

Suggests decreasing relative risk aversion (DRRA) (CRRA not such a bad approximation)

See Gollier (2001, ch 2.) for more detailed discussion of various forms of risk aversion.
Curvature of utility almost surely falls as consumption rises:

$$U'''(C_t) > 0$$

What does this imply about savings?

Marginal reduction in $$C_t$$ (increase in saving) increases utility.

This extra saving relative to certainty equivalent case is called precautionary saving.
**Precautionary Savings**

- Curvature of utility almost surely falls as consumption rises:
  
  $$U'''(C_t) > 0$$

- What does this imply about savings?

- With $U'''(C_t) > 0$, $U'(C_t)$ is convex

- If $C_t = E_t C_{t+1}$, then
  
  - $U'(C_t) < E_t U'(C_{t+1})$ (since $U'(E_t C_{t+1}) < E_t U'(C_{t+1})$)
  
  - Marginal reduction in $C_t$ (increase in saving) increases utility

- This extra saving relative to certainty equivalent case is called **precautionary saving**

(a)
Source: Romer (2019)
**Definition:** (Kimball, 1990) An agent is **prudent** if adding an uninsurable zero-mean risk to his/her future wealth raises his/her optimal savings.

**Proposition:** (Leland, 1968) An agent is prudent if and only if the marginal utility of future consumption is convex.
LIQUIDITY CONSTRAINTS

Figure 2 presents consumption (raw and smoothed) and income profiles for our entire sample when the family-size is held constant over the life-cycle. Even after correcting for the effects of cohort, time, and family, both profiles are still hump shaped and track each other early in life. Consumption lies above income over the late twenties. Given that the CEX wealth data, and better household wealth surveys, show modest increases in liquid wealth over these ranges, this feature seems likely due to misreporting of income or consumption. One possibility is underreporting the assistance that is provided by intergenerational transfers early in life. After these first few years, consumption rises with income from age 30 to age 45, when consumption drops significantly below income. This tracking is however a lot less than is observed in profiles constructed by simply averaging cross-sections because we control for changes in family size and cohorts effects.

It is important not to use different deflators for income and consumption. This could break the relationship between cash on hand and consumption in nominal terms, which is the relationship predicted by the buffer-stock theory.
Liquidity Constraints

- Consumption smoothing over the life-cycle likely involves substantial borrowing early in life.
- Simple PIH/LCH model assumes people can borrow (unsecured) at same rate as they can save.
- Highly unrealistic:
  - Most household borrowing is secured (e.g., mortgages, car loans).
  - Interest rates on car loans and even mortgages substantially higher than on savings accounts.
  - Interest rates on unsecured consumer lending (i.e., credit cards) extremely high (~ 20%).
  - Limits on unsecured borrowing beyond which can’t go at any rate.
Liquidity Constraints

Two effects of liquidity constraints:

1. Less borrowing when they bind

2. Less borrowing even when they don’t bind because they may bind in the future
   - Bad shock tomorrow may cause low consumption due to binding liquidity constraint at that point
   - Consumer saves today to “self-insure” against this future bad shock
Liquidity constraints and prudence cause households facing uninsurable income risk to engage in **buffer stock saving** (i.e., self-insurance)

Other sources of saving:
- **Life-cycle saving** to smooth consumption over the life-cycle relative to life-cycle profile of income
- Saving due to **patience/impatience**. If \( 1/\beta \neq (1 + r) \) household will tilt consumption profile (down if impatient, up if patient)
HOW MUCH BUFFER STOCK SAVING?

Depends crucially on $\beta(1 + r)$

- If $\beta(1 + r) = 1$:
  - Households will eventually save themselves out of constraint
  - I.e., save enough that they will eventually never hit constraint
  - At that point, full consumption smoothing

- If $\beta(1 + r) < 1$
  - Households sufficiently impatient that they don’t eventually save themselves out of the constraint
  - Finite amount of buffer stock savings
  - Lack of full consumption smoothing even in the long run

- If $\beta(1 + r) > 1$: Asset holdings explode in the long run
Households maximize

\[ E_0 \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\gamma}}{1-\gamma}, \]

subject to

\[ W_{t+1} = R(W_t + Y_t - C_t) \]
\[ Y_t = P_t V_t \]
\[ P_t = P_{t-1} N_t \]

where \( V_t \) and \( N_t \) are i.i.d. log-normal random variables.

\( R \) is given exogenously (partial equilibrium)

Household income shocks are uninsurable

ZELDES-DEATON-CARROLL MODEL

- Problem Sets 3 and 4 ask you to solve two versions of this model
- Zeldes-Deaton-Carroll argue that model helps explain:
  - High MPC out of transitory windfalls
  - That consumption tracks income over the life-cycle
    (need impatient households for this)
- Sometimes called the “buffer stock model”
- General equilibrium version called Bewely-Aiyagari-Hugget model
  (i.e., interest rate is endogenous)
The first example uses distribution #2, the combination random walk/i.i.d. process. The time horizon is 15 periods, and the coefficient of relative risk aversion is set equal to three. Consumption as a function of initial financial assets is plotted as the middle line in Figure II. Both initial income and expected income in all future periods are equal to 100. The results, especially at low levels of assets, are quite striking. First, notice that the slope of the curve, which is equal to the marginal propensity to consume out of a transitory change in income, is considerably larger than that predicted by certainty equivalence. For example, a household with two years worth of expected income in the form of assets would have an MPC of over twice that which would be predicted by a certainty or certainty-equivalence model. A family with one year's worth of expected income as assets would have an MPC seven times as great as under CEQ. This fully optimizing unconstrained household exhibits dramatic "excess sensitivity" relative to the certainty-equivalence model.

Source: Zeldes (1989)
Basic Zeldes-Deaton-Carroll model very stylized

Is buffer stock saving important quantitatively?

Add:
- Realistic life-cycle income process with retirement
- Longevity risk
- Health expenses
- Taxes and government transfer programs
Figure 3a

Average Consumption and Earnings by Age

No High School Degree

Cons. all uncertain ($1 floor)
Earnings
Cons. all certain
Cons. only lifetime uncertain
Earnings


Consumption does not equal earning for young in certainty case because of medical expenses.

gamma=3, delta=.03
Figure 2a
Average Assets by Age
No High School Degree

all uncertain ($1 floor)
all uncertain ($7000 floor)
only lifetime uncertain
all certain

gamma = 3, delta = .03

Precautionary savings and liquidity constraints:

- Yield life-cycle consumption profile the tracks income substantially
- Can contribute substantially to asset accumulation
Go one step further than Hubbard-Skinner-Zeldes 94
Estimate the preference parameters
5.3. Life Cycle Profiles

Figure 2 presents consumption (raw and smoothed) and income profiles for our entire sample when the family-size is held constant over the life-cycle. Even after correcting for the effects of cohort, time, and family, both profiles are still hump shaped and track each other early in life. Consumption lies above income over the late twenties. Given that the CEX wealth data, and better household wealth surveys, show modest increases in liquid wealth over these ranges, this feature seems likely due to misreporting of income or consumption. One possibility is underreporting the assistance that is provided by intergenerational transfers early in life. After these first few years, consumption rises with income from age 30 to age 45, when consumption drops significantly below income. This tracking is however a lot less than is observed in profiles constructed by simply averaging cross-sections because we control for changes in family size and cohorts effects.

It is important not to use different deflators for income and consumption. This could break the relationship between cash on hand and consumption in nominal terms, which is the relationship predicted by the buffer-stock theory.

Source: Gourinchas-Parker (2002)
### TABLE III
STRUCTURAL ESTIMATION RESULTS

<table>
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<tr>
<th>MSM Estimation</th>
<th>Robust Weighting</th>
<th>Optimal Weighting</th>
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<tr>
<td><strong>Discount Factor (β)</strong></td>
<td>0.9598</td>
<td>0.9569</td>
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<tr>
<td>S.E.(A)</td>
<td>(0.0101)</td>
<td></td>
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<tr>
<td>S.E.(B)</td>
<td>(0.0179)</td>
<td>(0.0150)</td>
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<tr>
<td><strong>Discount Rate (β⁻¹ − 1)(%)</strong></td>
<td>4.188</td>
<td>4.507</td>
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<tr>
<td>S.E.(A)</td>
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</tr>
<tr>
<td>S.E.(B)</td>
<td>(1.949)</td>
<td>(1.641)</td>
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<td><strong>Risk Aversion (ρ)</strong></td>
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<tr>
<td>S.E.(A)</td>
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<tr>
<td>S.E.(B)</td>
<td>(0.1707)</td>
<td>(0.1137)</td>
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<tr>
<td><strong>Retirement Rule:</strong></td>
<td></td>
<td></td>
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<tr>
<td>γ₀</td>
<td>0.0015</td>
<td>5.68 \times 10^{-6}</td>
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<tr>
<td>S.E.(A)</td>
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<tr>
<td>S.E.(B)</td>
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<td>γ₁</td>
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<tr>
<td>S.E.(A)</td>
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<tr>
<td>S.E.(B)</td>
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<td>(0.0511)</td>
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<tr>
<td>χ²(A)</td>
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</tr>
<tr>
<td>χ²(B)</td>
<td>174.10</td>
<td>185.67</td>
</tr>
</tbody>
</table>

*Note: MSM estimation for entire group. Standard errors calculated without (A) and with (B) correction for first stage estimation. Cell size is 36,691 households. The last row reports a test of the overidentifying restrictions distributed as a Chi-squared with 36 degrees of freedom. The critical value at 5% is 50.71. Efficient estimates are calculated with a weighting matrix \( \hat{Ω} \) computed from the robust estimates.*

Source: Gourinchas-Parker (2002)
Results

- Reasonable discount rate of 4%
  (Carroll-Samwick 97 had suggested larger rates were needed)
- Reasonable IES of about 2 (sensitive to weighting matrix)
- Reasonable MPC in retirement of 7% per year
with our estimates in hand, we can address how well the stochastic model fits the life-cycle consumption profile. the first panel of figure 5 plots the simulated and actual consumption data along with the income profile. the stochastic life-cycle model does a much better job at fitting the consumption profile than the consumption profile with constant growth rate of \((1/p) \ln(\beta R)\) that would obtain under the certainty-equivalent. the consumption profile from the fitted model

\[ \beta = 0.95, \quad \rho = 0.514, \quad \gamma_1 = 0.071, \quad \gamma_0 = 0.001 \]

alternative interpretation for a low \(\gamma_0\) is that households have a low propensity to consume out of illiquid wealth at retirement.\(^{34}\) It should be noted that both estimation methods reject the overidentifying restrictions at the 5% level. the 95% critical value for a \(\chi^2(36)\) is 50.71 and the chi-square always exceeds 150. this is not entirely surprising, given the number of moments we use (40) and the few parameters of the model. the estimated model should still be taken seriously however. as we now discuss, the model does much better in an economic sense than the CEQ-LCH model with which this section begins.

For instance, if the ratio of illiquid wealth to permanent income, \(h\), were equal to 6, the marginal propensity to consume out of illiquid wealth would be a mere 0.35%. The content downloaded from 160.39.33.139 on Sun, 12 Apr 2015 02:24:22 UTC

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Level of cash on hand at age $t$ that is expected to remain unchanged:

$$\bar{x}_t = E_t[x_{t+1} | x_t = \bar{x}_t]$$

- If $x_t > \bar{x}_t$ households dissave on average
- If $x_t < \bar{x}_t$ households build up assets on average
Target cash-on-hand
(normalized)

Parameters:
$\beta = 0.960, \rho = 0.514, \gamma_1 = 0.0071, \gamma_0 = 0.001$

Figure 6.—Normalized target cash-on-hand by age.

Source: Gourinchas-Parker (2002). Cash-on-hand normalized by permanent income.
Define life-cycle consumption as consumption under complete insurance markets

Use this concept to construct:

- Life-cycle savings / wealth
- Buffer-stock savings / wealth
CONSUMPTION OVER THE LIFE CYCLE

75

life-cycle consumption:

\[ S_{fC,t} = \frac{(R - 1)}{RW_{tc}} + Y_{tL}C_{i-t} \]

Precautionary saving is the complement of life-cycle saving.

The first panel of Figure 7 plots the precautionary and life-cycle liquid saving of the average household. Given the estimated discount rate and the profile of expected income, young consumers facing no income risk would like to borrow large amounts, so life-cycle saving is negative early in life. Young households in fact hold a positive buffer stock of wealth in response to income risk, so that precautionary saving is positive early in life. In the early to mid forties, in accordance with our previous discussion, life-cycle saving becomes larger than precautionary saving. Households begin to build their liquid wealth for retirement purposes. As asset levels increase, the expected variance of consumption declines, decreasing the precautionary saving motive. Since households that face income uncertainty save more early in life due to risk, they are able to consume more and save less when older, leading to negative precautionary saving late in life. This discussion

Thousands of 1987 dollars

Panel A: Life Cycle and Buffer Saving

Life Cycle Saving

Buffer Saving

Panel B: Life Cycle and Buffer Wealth

Total Wealth

Buffer Wealth

Life Cycle Wealth

FIGURE 7.—The role of risk in saving and wealth accumulation.

Source: Gourinchas-Parker (2002)
Can uninsurable income risk explain comovement of consumption and income over the life-cycle?
Can uninsurable income risk explain comovement of consumption and income over the life-cycle?

Yes!

Households are impatient
(want downward sloping consumption profiles)

Consumption constrained by income early in life

Households save for retirement later in life
Standard incomplete markets models can’t match large estimated spending responses of consumption to tax rebates.

Argue that incorporating illiquid wealth into model is key:
- Liquid assets (-1.5% real return)
- Illiquid asset (2.3% real return)
- Unsecured debt (6% real interest rate)

Two types of hand-to-mouth agents:
- Poor hand-to-mouth (no illiquid wealth, no liquid wealth)
- Wealthy hand-to-mouth (have illiquid wealth, no liquid wealth)

This model generates much higher rebate responses.
**Consumer Regret**

- Common for people to display dissatisfaction with their choices
  - I am not saving enough for retirement
  - I eat too much and exercise too little
  - I spend too much time surfing the internet and work too little

- One reaction:
  - This is stupid. What you do are you actual preferences
  - What you say are some imagined idealized preferences
  - Everyone says they want to be fit and work really hard
  - But the costs of achieving these goals actually outweigh the benefits for many people
An alternative reaction:

- Consumer regret is due to self-control problems
- Arises due to present biased preferences that give rise to preference reversals
An alternative reaction:

- Consumer regret is due to **self-control problems**
- Arises due to present biased preferences that give rise to preference reversals

Consider the following choice for a worker:

1. 15 minute break today
2. 20 minute break tomorrow
An alternative reaction:

- Consumer regret is due to self-control problems
- Arises due to present biased preferences that give rise to preference reversals

Consider the following choice for a worker:

1. 15 minute break today
2. 20 minute break tomorrow

Now consider this choice:

1. 15 minute break in 100 days
2. 20 minute break in 101 days
An alternative reaction:

- Consumer regret is due to self-control problems
- Arises due to present biased preferences that give rise to preference reversals

Consider the following choice for a worker:

1. 15 minute break today
2. 20 minute break tomorrow

Now consider this choice:

1. 15 minute break in 100 days
2. 20 minute break in 101 days

Choosing option 1 from the first set but option 2 from the second set indicates time-discounting that is not independent of horizon
Figure 1
Discounting as a Function of Time Delay and Money Amount.

Source: Benzion et al. (1989).

Source: Loewenstein and Thaler (1989). Based on experiments where subjects are asked how much they need to be compensated to delay receiving a reward.
Hyperbolic Discounting

Exponential discounting:
- Discount function: \( \beta^t : 1, \beta, \beta^2, \beta^3, \text{ etc.} \)
- Discount rate independent of horizon
- Degree of patience independent of horizon

Hyperbolic discounting:
- Discount function: \( 1/t \) or \( 1/(1 + \alpha t) \) or \( 1/(1 + \alpha t)^{-\gamma/\alpha} \)
- Quasi-hyperbolic discount function: \( \beta \delta^t : 1, \beta \delta, \beta \delta^2, \beta \delta^3, \text{ etc.} \)
- Non-constant rate of discounting
- More impatient about short run than long run
Figure 1
Discount Functions

Exponential: $\delta^7$, with $\delta = 0.944$; hyperbolic: $(1 + \alpha \tau)^{-\gamma/\alpha}$, with $\alpha = 4$ and $\gamma = 1$; and quasi-hyperbolic: $[1, \beta \delta, \beta \delta^2, \beta \delta^3, \ldots]$, with $\beta = 0.7$ and $\delta = 0.957$.

Source: Angeletos et al. (2001)
Suppose an agent makes a state-contingent plan at time 0 about optimal current and future actions. But when the future arrives, the agent can reoptimize. Will they want to change their plan?
Suppose an agent makes a state-contingent plan at time 0 about optimal current and future actions.

But when the future arrives, the agent can reoptimize.

Will they want to change their plan?

If the agent discounts future utility exponentially, then they will not change their choices even if able to reoptimize.

Their preferences are time consistent (aka dynamically consistent).
If an agent’s discount function is not exponential, then they will want to change their plan when allowed to reoptimize at a later date.

Their preferences are **time inconsistent** (aka dynamically inconsistent).

Hyperbolic and quasi-hyperbolic preferences are time inconsistent.
Consider following choice:

- Small reward $S$ at time $t_1$
- Bigger reward $B$ at a later time $t_2$

Suppose agent has hyperbolic preferences

Plot present utility from each option as a function of time
Figure 2
Non-Exponential Discounting.

Source: Ainslie (1975).

Hyperbolic discounting can explain the following type of behavior:

- On Monday: “I’ll work hard tomorrow.”
- On Tuesday: “I’ll work hard tomorrow.”
- Etc.

People with hyperbolic preferences want instant gratification today but simultaneously want to make patient investments tomorrow.
Useful to think of a person as having different selves, one for each point in time.

Earlier selves wish to force later selves to act patiently.

Later selves maximize their own preferences (which are different).

Household problem becomes a game between different selves.
Two Types of Hyperbolics

- Sophisticates: Understand that future selves will want to act differently
  - Want to constrain actions of future selves
  - Want access to commitment devices

- Naifs: Act under false belief that future selves will carry out current plan
  - Helps explain procrastination among other things
  (Akerlof, 1991; O’Donoghue and Rabin, 1999)
HYPERBOLIC DISCOUNTING AND CONSUMPTION

- Key references:
  - Angeletos et al. (2001), Laibson, Repetto, Tobacman (2003), Laibson, Maxted, Repetto, Tobacman (2015, but originally ca. 2001)

- Build sophisticated life-cycle consumption savings model

- Compare model with exponential and hyperbolic discounting

- Ask whether hyperbolic discounting helps explain the data
Hyperbolic Discounting and Consumption

- Model very similar to Kaplan-Violante (2014) (liquid assets, illiquid assets, credit card borrowing)
- Conclusions radically different
- Laibson et al. (2015) estimate:
  - Exponential discounting: $\beta = 0.63$ (annual)
  - Hyperbolic discounting: $\beta = 0.35$ and $\delta = 0.97$
- Kaplan-Violante (2014) calibrate $\beta = 0.941$
KAPLAN-VIOLANTE VS. LAIBSON ET AL.

- Main difference seems to lie in moments used

- Kaplan-Violante:
  - Target a fraction of credit card borrowers of 26%
  - Compromise between fraction with negative net liquid wealth and fraction actually borrowing on credit cards
  - Many people simultaneously have liquid assets and credit card debt

- Laibson et al.
  - Target fraction of credit card borrowers of 75%
Hyperbolic discounting helpful in explaining simultaneous:
- High borrowing on credit cards at high interest rates
- Large saving for retirement

Agents with hyperbolic discounting can simultaneously display highly patient and impatient behavior
**Figure 2**  
Simulated Mean Income and Consumption

Source: Angeletos et al. (2001).
Figure 4
Mean Illiquid Assets of Households with Exponential and Hyperbolic Discount Functions

Source: Angeletos et al. (2001).
Source: Angeletos et al. (2001).
Kaplan-Violante: Agents hold illiquid wealth because of high return

Laibson et al.: Agents hold illiquid wealth for two reasons:
  - High return
  - Commitment device: Constrains impatient future selves
Table 1
Percentage of Households with Liquid Assets Greater than One Month of Income

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Simulated Data</th>
<th>Survey of Consumer Finances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exponential</td>
<td>Hyperbolic</td>
</tr>
<tr>
<td>ALL AGES</td>
<td>0.73</td>
<td>0.40</td>
</tr>
<tr>
<td>20–29</td>
<td>0.52</td>
<td>0.34</td>
</tr>
<tr>
<td>30–39</td>
<td>0.72</td>
<td>0.39</td>
</tr>
<tr>
<td>40–49</td>
<td>0.72</td>
<td>0.38</td>
</tr>
<tr>
<td>50–59</td>
<td>0.76</td>
<td>0.43</td>
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<tr>
<td>60–69</td>
<td>0.91</td>
<td>0.42</td>
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<tr>
<td>70+</td>
<td>0.77</td>
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<td>0.37</td>
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<tr>
<td></td>
<td>0.62</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Sources: Authors’ simulations and 1995 SCF.
Notes: The table reports the fraction of households who hold more than a month’s income in liquid wealth. Definition 1 includes cash, checking and savings accounts. Definition 2 includes definition 1 plus money market accounts. Definition 3 includes definition 2 plus call accounts, CDs, bonds, stocks and mutual funds.

Source: Angeletos et al. (2001).
Table 2  
Share of Assets in Liquid Form

<table>
<thead>
<tr>
<th>Age Group</th>
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<th>Survey of Consumer Finances</th>
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<tr>
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<td>ALL AGES</td>
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<td>20–29</td>
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<tr>
<td>70+</td>
<td>0.57</td>
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</table>

Sources: 1995 SCF and authors’ simulations.
Notes: Asset share is liquid assets divided by total assets—liquid assets plus illiquid assets. The three different definitions used for liquid assets are the same as in Table 1. Three complementary definitions are used for illiquid assets. Illiquid assets include money market accounts, call accounts, CDs, bonds, stocks, and mutual funds if these assets were not included in the relevant liquid asset definition. In addition, illiquid assets include IRAs, defined contribution plans, life insurance, trusts, annuities, vehicles, home equity (net of mortgage), real estate, business equity, jewelry, furniture, antiques, and home durables.