Search-Based Endogenous Illiquidity and the Macroeconomy

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Outline

1. Intro
   - Motivation
2. The Model
   - Set-up
   - Households
   - Bargaining and Final Goods Producers
3. Results
   - Some Theoretical Results
   - Impulse Responses
4. Final Remark
   - Investment Shocks?
   - Conclusion

Motivation

- Asset liquidity
  - procyclical variation (turnover, bid-ask spreads....) ▸ cycle
  - holding of liquid assets against possible funding constraints, at least since Keynes (1936) and Tobin (1969)

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- But, abnormal asset price dynamics and we need endogenous asset liquidity
  - financial intermediation and markets as a matching function
  - what induces flight to liquidity and push down asset price in recessions?
  - the macro impacts and feedback?

Endogenous Search-Based Illiquidity

- Liquidity = saleable fraction of new or old assets
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- Two contributions: a tractable variant of RBC model...
  - liquidity-based asset pricing
  - amplification through imperfect substitutes between assets
- Adverse shocks to productivity or cost of matching

$\rightarrow$ Return from assets $\downarrow$

$\rightarrow$ Search for investment opportunities = demand $\downarrow$

$\rightarrow$ Resaleability $\downarrow$, Price $\downarrow$

$\rightarrow$ But different "flight to liquidity" dynamics

Literature

- Search-framework captures features of...
  - OTC markets for corporate bonds, Duffie, Garleanu, and Pedersen (2007)
  - investment banking fees for IPOs
  - monitoring and intermediation activity by banks, Beaubrun-Diant and Tripier (2013)

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  - Pure liquidity shocks = supply shocks, asset prices $\uparrow$
- Interaction between asset liquidity and macro
  - Bacchetta, Benhima, and Poilly (2015)
  - Rocheteau and Wright (2013), Guerrieri and Shimer (2012), Lagos and Rocheteau (2009)

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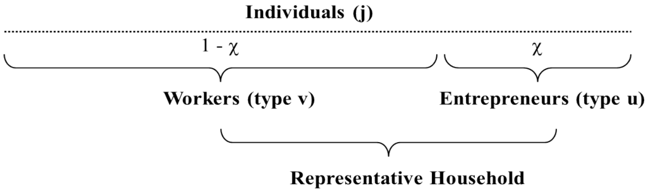
Environment

- Infinite time horizon.
- A continuum of households, final goods producers, and financial intermediaries.
- Household structure



- Only entrepreneurs have investment opportunities

A Model Comparison

Timing

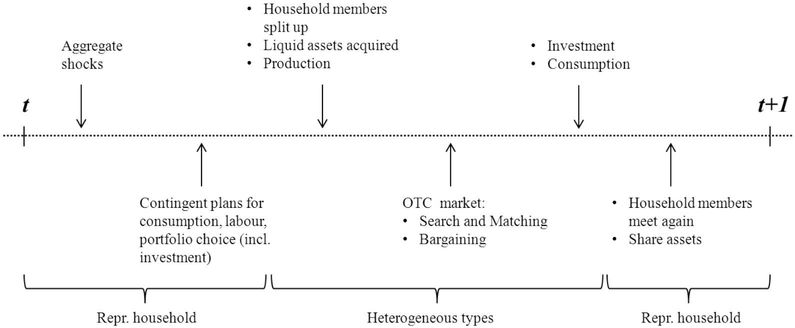


Figure: Timing

A Representative Household

- Preferences:

$$\mathbb{E}_t \sum_{s=0}^{\infty} \beta^{t+s} \left[\chi u(\frac{C_{u,t+s}}{\chi}) + (1-\chi) u(\frac{C_{v,t+s}}{1-\chi}) - \mu N_{t+s} \right]$$

- Portfolio

Table: Household's Balance Sheet

liquid bonds	$R_t B_t / P_t$	equity issued	$q_t S_t^I$
other's equity	$q_t S_t^O$		
capital stock	$q_t K_t$	net worth	$q_t S_t + R_t B_t / Pt$

$$S_t = \underbrace{S_t^O}_{\text{other's equity}} + \underbrace{K_t - S_t^I}_{\text{unmortgaged capital}}$$

Some Notation

- V: units quoted from buyers. κ_v: unit cost. ϕ_v fraction of successful match
- U: units quoted from sellers. κ_u: unit cost. ϕ_u fraction of successful match
- κ_v and κ_u measures the efficiency of the financial sectors
- effective prices and spreads

$$q_u \equiv q - \frac{\kappa_u}{\phi_u}, \quad q_v \equiv q + \frac{\kappa_v}{\phi_v},$$

$$q_v - q_u = \frac{\kappa_v}{\phi_v} + \frac{\kappa_u}{\phi_u}$$

Workers' Budget Constraint

- Workers

$$C_{v,t} + \kappa_v V_t + \frac{B_{v,t+1}}{P_t} = w_t N_{v,t} + r_t S_{v,t} - q_t \phi_{v,t} V_t + \frac{R_t B_{v,t}}{P_t},$$

$$S_{v,t+1} = (1-\delta) S_{v,t} + \phi_{v,t} V_t$$

Rearrange

$$C_v + q_v S_v' + \frac{B_v'}{P} = wL + rS_v + (1-\delta)\, q_v S_v + \frac{RB_v}{P} \qquad (1)$$

Entrepreneurs' Budget Constraint

- Entrepreneurs, $U = e[(1-\delta)S_u + I]$

$$C_{u,t} + I_{u,t} + \kappa_u U_t + \frac{B_{u,t+1}}{P_t} = r_t S_{u,t} + q_t \phi_{u,t} U_t + \frac{R_t B_{u,t}}{P_t}$$

$$S_{u,t+1} = (1-\delta)S_{u,t} + I_{u,t} - \phi_{u,t} U_t$$

Rearrange and substitute out investment

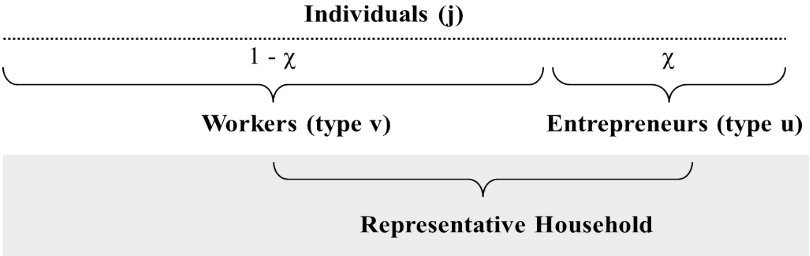
$$C_u + q_r S'_u + \frac{B'_u}{P} = rS_u + [\phi_u q_u + (1-\phi_u) q_r](1-\delta)S_u + \frac{RB_u}{P} \quad (2)$$

where

$$q_r \equiv \frac{1 - e\phi_u q_u}{1 - e\phi_u}$$

$$I = \frac{\chi\left[\left(r + e\phi_u q_u (1-\delta)\right)K + \frac{B}{P}\right] - C_u}{1 - e\phi_u q_u}. \quad (3)$$

Solution Strategy



HH Problem

Problem

$$J(S,B;\Gamma) = \max_{\{N,C_u,C_v,S'_u,S'_v,B'_u,B'_v\}} \chi u\left(\frac{C_u}{\chi}\right) + (1-\chi)\left[u\left(\frac{C_v}{1-\chi}\right) - \mu\frac{N}{1-\chi}\right] + \beta\mathbb{E}_\Gamma\left[J(S',B';\Gamma')\right]$$

$$s.t. \quad (1), \quad (2)$$

$$S_u = \chi S, \quad S_v = (1-\chi)S$$

$$B_u = \chi B, \quad B_v = (1-\chi)B$$

$$S' = S'_u + S'_v, \quad B' = B'_u + B'_v$$

Entrepreneurs can leverage up and $B'_u = 0$ because $q_r < 1 < q < q_v$. Leverage

Choose $e = 1$, i.e., $U = (1-\delta)S_u + I$ because q_r decreases with e.

Liquidity Service

- Let $\rho \equiv \frac{q_v}{q_r}$ measures risk-sharing. Optimality conditions:

$$u'(c_v)\,w = \mu$$

$$u'(c_u) = \rho u'(c_v)$$

$$\mathbb{E}_\Gamma\left[\frac{\beta u'(c_v')}{u'(c_v)}[\chi\rho' r_u' + (1-\chi)r_v']\right] = 1,$$

$$\mathbb{E}_\Gamma\left[\frac{\beta u'(c_v')}{u'(c_v)}(\chi\rho' + 1 - \chi)\frac{R'}{\pi'}\right] = 1$$

  where $r_u' = [r' + (1-\delta)(\phi' q_u' + (1-\phi')q_r')]/q_v$, $r_v' = [r' + (1-\delta)q_v']/q_v$, and $\pi = P/P_{-1}$.

- Liquidity premium in steady state:
  - $\rho > 1$ and the real interest rate $R/\pi < 1/\beta$.

Final Goods Markets and Financial Markets

- Final goods producers

$$Y = e^{z_a} F(K, L) = e^{z_a} K^{\alpha} N^{1-\alpha}$$

Then, $w = e^{z_a} F_N(K, N)$ and $r = e^{z_a} F_K(K, N)$

- The total matches M and endogenous buying and selling probabilities:

$$M \equiv \xi U^{\eta} V^{1-\eta}$$

$$\phi_v \equiv \frac{M}{V} = \xi \left(\frac{V}{U}\right)^{-\eta}, \quad \phi_u \equiv \frac{M}{U} = \xi \left(\frac{V}{U}\right)^{1-\eta}$$

- Cost of matching $\kappa_u = \bar{\kappa}_u e^{z_\kappa}$ and $\kappa_v = \bar{\kappa}_v e^{z_\kappa}$
- Note: z_a and z_κ are exogenous

Asset Price

Value of buyers and sellers

$$-J_m^v = -q + \beta \mathbb{E}_\Gamma \left[\frac{J_S(S', B'; \Gamma')}{u'(c_v)} \right]$$

$$J_m^u = q - \phi_u^{-1} + \beta \left(\phi_u^{-1} - 1 \right) \mathbb{E}_\Gamma \left[\frac{J_S(S', B'; \Gamma')}{u'(c_u)} \right]$$

Intermediaries choose q to maximize

$$\omega \ln \left(J_m^u \right) + (1 - \omega) \ln \left(-J_m^v \right)$$

Lemma

Let $\gamma \equiv \frac{\omega}{1-\omega} \frac{\kappa_v}{\kappa_u}$, *the bargaining solution is* $\rho = \gamma\theta$. *Equivalently,*

$$q = \frac{\gamma \phi_u \left(1 + \frac{\kappa_u}{\omega} \right) - \kappa_v}{\xi^{\frac{1}{1-\eta}} \phi_u^{\frac{\eta}{\eta-1}} \left[1 + \left(\gamma (\xi^{-1} \phi_u)^{\frac{1}{1-\eta}} - 1 \right) \phi_u \right]}. \tag{4}$$

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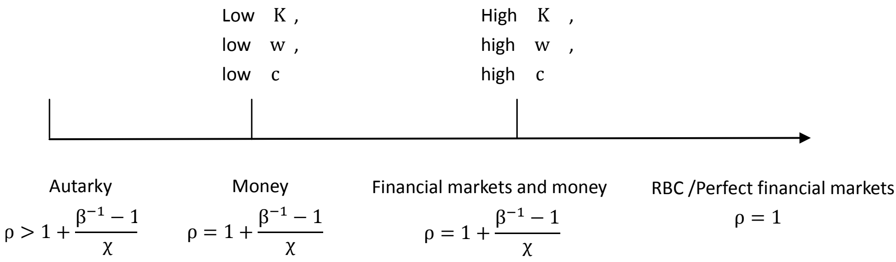


Asset Price and Costs of Intermediation

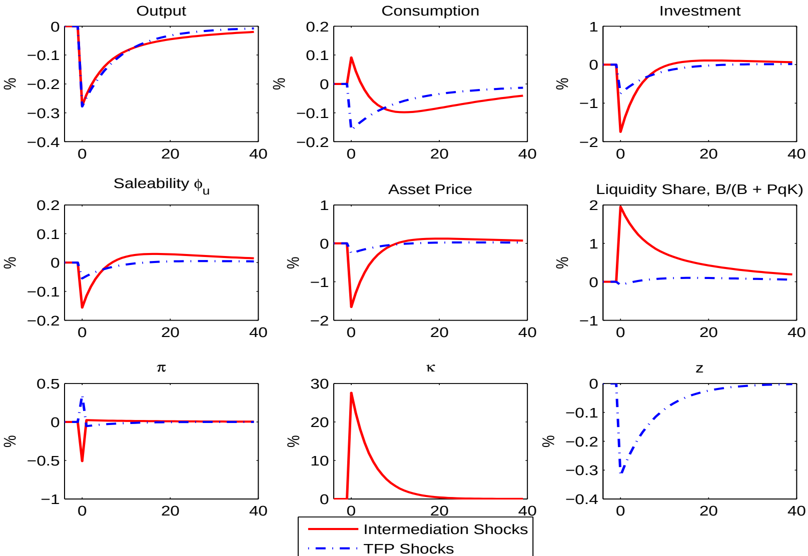
Proposition

Suppose the ratio of $\bar{\kappa}_v/\bar{\kappa}_u = g$ is fixed. Under some regularity conditions, then in steady state asset price q drops when $\bar{\kappa}_v$ and $\bar{\kappa}_u$ increase.

Proposition

Under some regularity conditions, q correlates positively with asset saleability ϕ_u (i.e. $\frac{\partial q}{\partial \phi_u} > 0$) and negatively with the purchase rate ϕ_v (i.e. $\frac{\partial q}{\partial \phi_v} < 0$).

Equilibrium Responses to Shocks



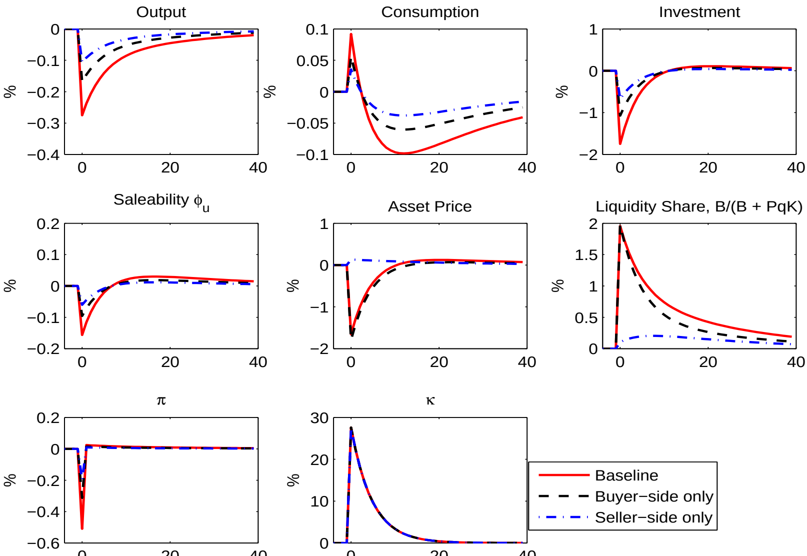
A Negative Productivity Shock (cont.)

- What do we learn?
- When productivity drops
  - → Investors search less; demand for assets drops
  - → Harder to sell and price drops
- However: no robust flight to liquidity
  - → persistent TFP shock; future investment unattractive
  - → no hedging against future illiquidity
  - → liquidity share drops

An Intermediation Cost Shock (cont.)

- What do we learn?
- Cost of matching ↑: liquidity and price drop
  - → less investment; decrease supply of financial assets
  - → households substitute away from costly search
  - → large demand drops endogenously
- Hedging: liquidity share increases
  - → capital still highly productive; future investment attractive
  - → flight to liquidity to hedge
- Output decreases because of drop of employment

Shocks to One Side of the Market



Cycle Statistics

Table: Cycle statistics with only aggregate productivity shocks

	Relative volatility $\frac{\sigma_x}{\sigma_y}$		Correlation $\rho(x, y)$		1st auto-co
Variable x	Data	Model	Data	Model	Data
Output	0.02	0.02	1.00	1.00	0.89
Consumption	0.44	0.67	0.88	0.98	0.80
Investment	3.45	2.43	0.96	0.98	0.85
Liquidity Share	3.44	0.87	-0.58	-0.27	0.89
Asset Price	5.23	0.79	0.50	0.88	0.81

Note: The volatility of output (y) is reported as is. The relative volatilities and correlations of other variables are measured against y.

Cycle Statistics

Table: Cycle statistics with only intermediation shocks

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Consumption	0.44	0.79	0.88	0.44	0.80
Investment	3.45	4.61	0.96	0.78	0.85
Liquidity Share	3.44	7.85	-0.58	-0.96	0.89
Asset Price	5.23	4.36	0.50	0.75	0.81

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Business Cycle Accounting?

- Shi(2012): aggregate productivity shocks are always needed
- Matching-cost shocks: not productivity shocks

$$C + I + \kappa_v V + \kappa_u U = Y$$

- Investment-specific technology shocks that will change equilibrium employment.
  - related to Chari et al (2007), financial shocks that can be both investment and labor wedges.
- Equity premium puzzle?

Takeaways

- Endogenous spectrum of liquidity premia
  - procyclical asset liquidity and prices
- Matching cost push shocks
  - robust flight to liquidity
  - many stylized business cycle facts
- Further work
  - financial intermediaries' balance sheets?
  - implementation of constrained efficient allocation?
  - financial development and growth?

Appendix

Appendix

Asset Liquidity?

- During recessions...
  - ... assets are harder to sell and their prices drop
  - ... firms and banks re-balance towards highly liquid government bonds/money (flight to liquidity)

- Why are fluctuations in asset liquidity important?
  - Adverse effects on financing, investment, employment...

- However, is asset illiquidity an endogenous or exogenous phenomenon?

- What drives pro-cyclical liquidity, flight to liquidity in recessions, and the impacts on investment and employment?

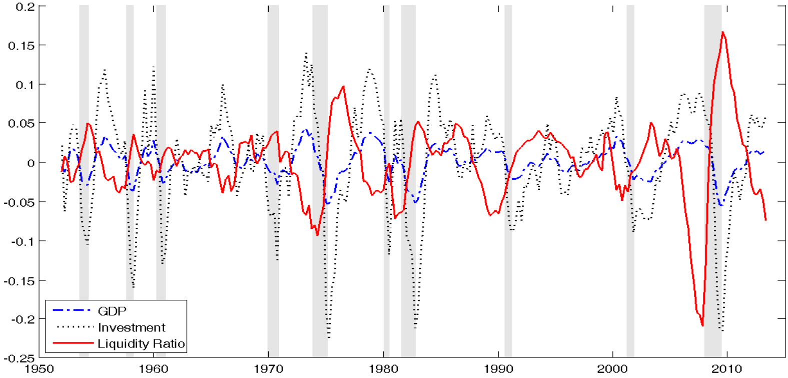
Outline

5 Data

6 Model
- Leverage
- Bargaining

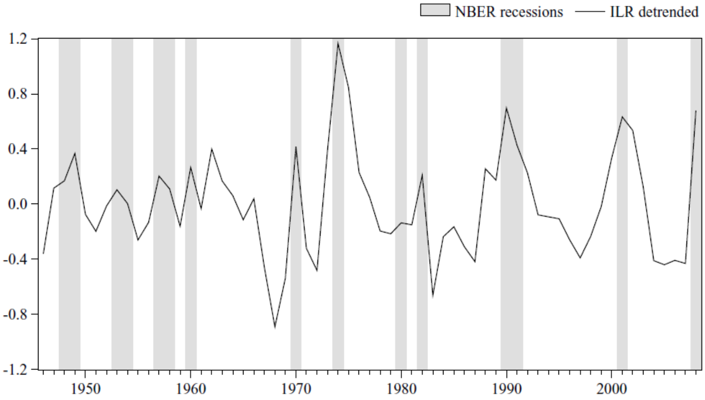
The Liquidity Share

back

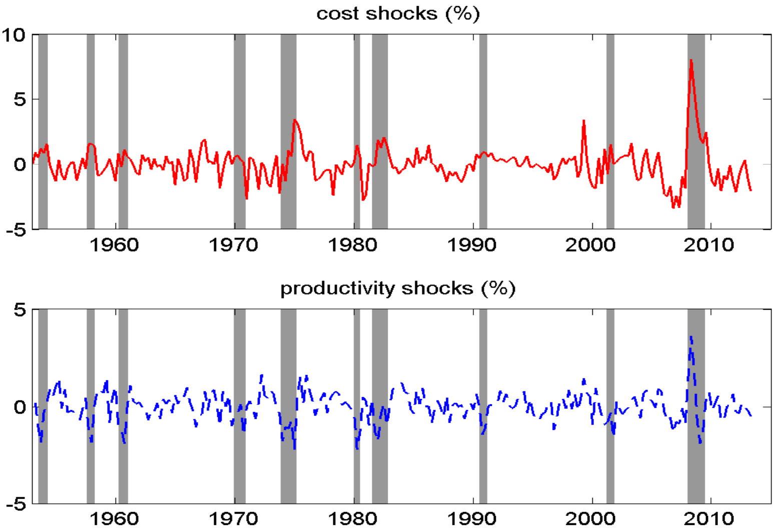


(Market) Liquidity Cycles: Naes et al. 2011 JF

Back



Back Out Shocks



Outline

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Entrepreneurs' leverage

Rearrange the budget constraint of entrepreneur, one can express

$$S'_u = \chi \frac{(r + (1-\delta)q_\chi)\, S + R\frac{B}{P}}{q_r} \tag{5}$$

back

Bargaining - value

Problem

Buyers' Value $J^v(s_v, b_v, b'_v, v, m_v)$

$$J = \int_{j\in u} u(c_j)\, dj + \int_{j\in v} \left[u(c_j) - \frac{\mu}{1+\nu} n_j^{1+\nu} \right] dj + \mathbb{E}_\Gamma \left[J\left(S', B'; \Gamma'\right) \right] \quad s.t.$$

$$c_v + \kappa_v v + \frac{b'_v}{P} = wn_v + rs_v + qm_v + \frac{Rb_v}{P}$$

$$s'_v = (1-\delta)s_v - m_v$$

$$S' = \int_{j\in v} s'_j dj + \int_{j\in u} s'_j dj, \quad B' = \int_{j\in v} b'_j dj + \int_{j\in u} b'_j dj$$

Bargaining - Value (cont.)

Problem

Sellers' Value $J^u(s_u, b_u, b'_u, u, m_u)$

$$J^u = \int_{j\in u} u(c_j)\,dj + \int_{j\in v}\left[u(c_j) - \frac{\mu}{1+\nu} n_j^{1+\nu}\right] dj + \mathbb{E}_\Gamma\left[J\left(S', B'; \Gamma'\right)\right] \quad s.t.$$

$$c_u + \kappa_u u + \frac{b'_u}{P} = rs_u + (1-\delta)\, s_u + \left(q - \frac{1}{\phi_u}\right) m_u + \frac{Rb_u}{p}$$

$$s'_u = \left(\frac{1}{\phi_u} - 1\right) m_u$$

$$S' = \int_{j\in v} s'_j dj + \int_{j\in u} s'_j dj, \quad B' = \int_{j\in v} b'_j dj + \int_{j\in u} b'_j dj$$

back

Nash Bargaining

Choose q to maximize $\omega \ln\left(J_m^u\right) + (1-\omega)\ln\left(-J_m^v\right)$ The marginal value of additional match for a buyer (worker) is thus given by

$$\begin{aligned} -J_m^v &= -u'(c_v)q + \beta\mathbb{E}_\Gamma\left[J_S\left(S',B';\Gamma'\right)\frac{\partial S'}{\partial s_v'}\frac{\partial s_v'}{\partial\left(-m_v\right)}\right] \\ &= -u'(c_v)q + \beta\mathbb{E}_\Gamma\left[J_S\left(S',B';\Gamma'\right)\right], \end{aligned}$$

and for a seller (entrepreneur) by

$$\begin{aligned} J_m^u &= u'\left(c_u\right)\left(q - \frac{1}{\phi_u}\right) + \beta\mathbb{E}_\Gamma\left[J_S\left(S',B';\Gamma'\right)\frac{\partial S'}{\partial s_u'}\frac{\partial s_u'}{\partial m_u}\right] \\ &= u'(c_u)\left(q - \frac{1}{\phi_u}\right) + \beta\mathbb{E}_\Gamma\left[J_S\left(S',B';\Gamma'\right)\left(\frac{1}{\phi_u} - 1\right)\right]. \end{aligned}$$

back