Aggregate Precautionary Savings Motives

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Motivation: Macro Shocks as Sources of Risk

Business Cycles analysis: TFP not a source of *risk* for households,

- mostly small, *level* effect (Lucas 2003, Krusell-Smith 1998)
- vs all about risk (uncertainty shocks, Bloom 2009)

Other shocks? Changes in household credit over the business cycle

- large
- correlated with real and financial variables
- unevenly distributed across households (Mian-Rao-Sufi 2013)
- important during Great Recession and before (Mian-Sufi-Verner 2017)

Credit supply shocks as source of aggregate risk $\Rightarrow$ demand for insurance

Question: How strong is the *macro*economic precautionary savings motive associated with credit shocks, and how does it compare with the classical *micro*economic motive? How does it affect the macro and safe asset prices?

BHA Model with *Aggregate* Credit and Income Shocks

This paper: Bewley-Huggett-Aiyagari model with aggregate (unsecured) credit supply shocks and TFP shocks

- builds on Guerrieri-Lorenzoni 2017
- credit shocks at business cycle frequency, anticipated $\neq$ "MIT shocks", loose/tight regimes

Projection+Perturbation-based solution method (builds on Reiter 2009)

- measure *macro*economic PS $\equiv$ departure from certainty equivalence
- nonlinear (amplification)
- BC exercises tractable (variance decomposition, particle filtering): recover underlying shocks, their contribution to volatility

Model Ingredients

BHA model with aggregate credit and TFP shocks

- aggregate + idiosyncratic credit shocks $\Rightarrow$ cross-sectional distribution of stochastic borrowing constraints
- firms transmit TFP shocks to wages and profits (redistributed to hhs)
- borrowing constraint, prudence $\Rightarrow$ precautionary motive
- GE: real risk-free rate, wage endogenous

Consumption smoothing over the business cycle

- ***unsecured credit***, taxes and transfers, elastic labor supply

Households

Infinitely-lived households, continuum of measure 1:

$$\max_{\{c_{it}, n_{it}, b_{it+1}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{c_{it}^{1-\gamma}}{1-\gamma} - \psi \frac{n_{it}^{1+\eta}}{1+\eta} \right]$$

$$\text{s.t.} \quad c_{it} + \frac{b_{it+1}}{1+r_t} + \tau_{0t} \leq \left(1 - \tau_1\left(\theta_{it}\right)\right) w_t \theta_{it} n_{it} + b_{it} + T\left(\theta_{it}\right) + \pi_t$$

$$b_{it+1} \geq -\overline{\phi}_t \phi\left(\theta_{it}\right)$$

Idiosyncratic productivity $\Rightarrow$ cross-sectional distribution $\lambda_t\left(\theta, b\right)$:

$$\log \theta_{it+1} = \rho_\theta \log \theta_{it} + \sigma_\theta \epsilon^\theta_{it+1}, \quad \epsilon^\theta \overset{iid}{\sim} \mathcal{N}(0,1)$$

Credit:

$$\log \overline{\phi}_{t+1} - \log \overline{\phi} = \rho_\phi \left(\log \overline{\phi}_t - \log \overline{\phi}\right) + \sigma_\phi \epsilon^\phi_{t+1}, \quad \epsilon^\phi \overset{iid}{\sim} \mathcal{N}(0,1)$$

Firms

Competitive firms sector, static problem (efficient units of labor):

$$\max_{N_t} \pi_t = \underbrace{z_t N_t^{\alpha}}_{Y_t} - w_t N_t$$

Aggregate income (TFP):

$$\log z_{t+1} = \rho_z \log z_t + \sigma_z \epsilon_{t+1}^z, \quad \epsilon^z \overset{iid}{\sim} \mathcal{N}(0,1)$$

In equilibrium,

$$N_t w_t = \alpha Y_t$$
$$\pi_t = (1-\alpha) Y_t$$

Government

Collects progressive income taxes (distortionary) and issues one-period risk free bonds, to finance household transfers and debt payments

Budget constraint holds every period, taxes adjust

Competitive Equilibrium

Hhs policy functions c_t, b'_t, n_t; firms' policy functions N_t; prices r_t, w_t; government taxes τ_{0t} and aggregate shocks $\overline{\phi}_t, z_t$, s.t.:

(i) Hhs optimality

$$c_t(\theta, b)^{-\gamma} = \beta(1 + r_t)\mathbb{E}_t\left[c_{t+1}(\theta, b)^{-\gamma}\right] + \mu_t(\theta, b)$$
$$(1 - \tau_1(\theta))\, w_t \theta c_t(\theta, b)^{-\gamma} = \psi n_t(\theta, b)^{\eta}$$

(ii) Firms optimality

$$w_t = \alpha z_t \left(\frac{1}{N_t}\right)^{1-\alpha}$$

(iii) Government budget constraint

$$\tau_{0t} = \int T(\theta)\, d\lambda_t(\theta, b) + B\frac{r_t}{1 + r_t} - \int \tau_1(\theta)\, w_t \theta n_t(\theta, b)\, d\lambda_t(\theta, b)$$

Competitive equilibrium (cont'd)

(iv) Markets for goods, bonds, labor clear

$$\int c_t(\theta, b)\, d\lambda_t(\theta, b) = Y_t$$
$$\int b'_t(\theta, b)\, d\lambda_t(\theta, b) = B$$
$$\int \theta n_t(\theta, b)\, d\lambda_t(\theta, b) = N_t$$

(v) **Distribution**'s law of motion consistent with choices

$$\lambda_{t+1}\left(\tilde{\Theta}, \tilde{\mathcal{B}}\right) = \int_{\Theta \times \mathcal{B}} Q_{\overline{\phi}_t, z_t}\left((\theta, b), \left(\tilde{\Theta}, \tilde{\mathcal{B}}\right)\right) d\lambda_t(\theta, b)$$
$$\text{where} \quad Q_{\overline{\phi}_t, z_t}\left((\theta, b), \left(\tilde{\Theta}, \tilde{\mathcal{B}}\right)\right) = \mathbf{1}\left\{b'_t(\theta, b) \in \tilde{\mathcal{B}}\right\} \sum_{\theta' \in \tilde{\Theta}} \Pi_\theta\left(\theta' | \theta\right)$$

(v) Shocks' laws of motion

Departure from Linearity and Certainty Equivalence

Equilibrium: solve expectational difference equation

$$\mathbb{E}_t\left[\mathcal{F}\left(\mathbf{y_t}, \mathbf{y_{t+1}}, \mathbf{x_t}, \mathbf{x_{t+1}}, \epsilon^{\phi}_{t+1}, \epsilon^{z}_{t+1}\right)\right] = 0$$

$$\begin{aligned} \Rightarrow \quad \text{predetermined variables } \mathbf{x_{t+1}} &= \mathbf{h}\left(\mathbf{x_t}, \eta\right) + \eta \begin{pmatrix} \mathbf{0} \\ \sigma_\epsilon \epsilon^{\phi}_{t+1} \\ \sigma_z \epsilon^{z}_{t+1} \end{pmatrix} \\ \text{jump variables } \mathbf{y_t} &= \mathbf{g}\left(\mathbf{x_t}, \eta\right) \end{aligned}$$

Departure from Linearity and Certainty Equivalence

First-order approximation (no agg PS motive):

$$\text{predetermined variables} \quad \widehat{\mathbf{x_{t+1}}} = \mathbf{h_x}(\mathbf{x},0)\,\widehat{\mathbf{x_t}} + \eta \begin{pmatrix} \mathbf{0} & \mathbf{0} \\ \sigma_\phi & 0 \\ 0 & \sigma_z \end{pmatrix} \begin{pmatrix} \mathbf{0} \\ \epsilon^{\phi}_{t+1} \\ \epsilon^{z}_{t+1} \end{pmatrix}$$

$$\text{jump variables} \quad \widehat{\mathbf{y_t}} = \mathbf{g_x}(\mathbf{x},0)\,\widehat{\mathbf{x_t}}$$

Second-order approximation:

$$\widehat{\mathbf{x_{t+1}}} = \mathbf{h_x}(\mathbf{x},0)\,\widehat{\mathbf{x_t}} + \underbrace{\frac{1}{2}\mathbf{h_{xx}}(\mathbf{x},0)\,\widehat{\mathbf{x_t}}^2} + \underbrace{\frac{1}{2}\mathbf{h}_{\eta\eta}(\mathbf{x},0)\,\eta^2} + \eta \begin{pmatrix} \mathbf{0} & \mathbf{0} \\ \sigma_\phi & 0 \\ 0 & \sigma_z \end{pmatrix} \begin{pmatrix} \mathbf{0} \\ \epsilon^{\phi}_{t+1} \\ \epsilon^{z}_{t+1} \end{pmatrix}$$

$$\widehat{\mathbf{y_{t+1}}} = \mathbf{g_x}(\mathbf{x},0)\,\widehat{\mathbf{x_t}} + \underbrace{\frac{1}{2}\mathbf{g_{xx}}(\mathbf{x},0)\,\widehat{\mathbf{x_t}}^2}_{\textbf{nonlinear}} + \underbrace{\frac{1}{2}\mathbf{g}_{\eta\eta}(\mathbf{x},0)\,\eta^2}_{\textbf{non-certainty equivalence (agg PS)}}$$

Calibration

Parameter	Explanation	Value	Target/source
β	Discount factor	0.9925	Risk-free rate $r = 2.40\%$
γ	Coefficient of relative risk aversion	5	–
η	Curvature of disutility of working	2	Frisch elasticity $= 1/2$
ψ	Disutility of working	11.5	Normalize $Y = 1$
$\overline{\phi}$	Average credit shock	2.6	Unsecured debt-to-GDP 0.18 (FRB)
$\phi(\theta)$	Credit limit function	$(1, 1.03, 1.06, 1.08, 2.33)$	Debt dispersion across incomes (SCF)
α	Cobb-Douglas parameter	2/3	Labor share of 2/3
$\tau_1(\theta)$	Tax function	$(0.05, 0.13, 0.17, 0.20, 0.28)$	Tax disp. across incomes (CPS)
$T(\theta)$	Transfer function	$(1, 0.43, 0.24, 0.17, 0.13)$	Transfer disp. across incomes (CPS)
B	Bond supply	6	Liquid assets-to-GDP 1.78 (FRB)
ρ_θ	Persistence of productivity shock	0.977	AC wage process (Kopecki-Suen,2010)
σ_θ	Std. dev. of productivity shock	0.12	Std. dev. wage process
ρ_ϕ	AC credit shock	0.99	AC risk-free rate 0.65
σ_ϕ	Std. dev. credit shock	0.025	Std. dev. risk-free rate 1.9%
ρ_z	Persistence TFP shock	0.86	AC TFP
σ_z	Std. dev. TFP shock	0.0128	Std. dev. TFP

Result #1: Decomposing Precautionary Savings Motives

Measuring PS (demand for insurance): how much lower is equilibrium risk-free rate relative to absence of shocks?

- (BHA) *micro* motive (idiosyncratic income): borrowing constraints, idiosyncratic income risk, prudence: -70%
- *macro* (credit supply): level of current and future borrowing constraints: -0.1% (historical) to -20% (Great Recession)
- *macro* (TFP): same shocks across hhs, small, low persistence: $\approx$0%

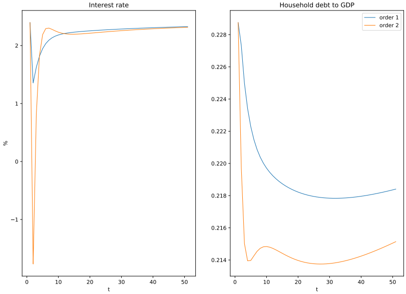
Volatile Credit Supply → "Post-GR Symptoms"

- **stochastic steady state** ≠ deterministic (no certainty equivalence)
- higher demand for insurance decreases debt and return on safe assets

Variable (bench, dev)	$\sigma_\phi = 0$	$\sigma_\phi = 0.025$ (hist.)	$\sigma_\phi = 0.05$	$\sigma_\phi = 0.075$	$\sigma_\phi = 0.10$ (GR)
Risk-free rate	2.397%	-0.2%	-1.4%	-7.4%	-25.4%
Wage	1.491	0%	+0.07%	+0.3%	+0.9%
Profits	0.333	0%	0%	-0.6%	-1.5%
Hours (efficiency)	0.447	0%	-0.2%	-0.7%	-2.5%
Consumption	1.000	-0.1%	-0.1%	-0.5%	-1.6%
Debt/GDP	0.229	-0.4%	-2.7%	-12.5%	-45%

Result 2: Nonlinear Response to Macro Shocks

- BHA models w/ 1st order perturbation (Winberry 2018, Ahn et al 2017), focused on TFP: nonlinearities irrelevant
- 2nd order: true, but only for TFP; **response to one-time credit shock** highly nonlinear
- failure of Krusell-Smith 1998 "near-aggregation" result for agg shocks hitting the cross-sectional distribution (directly or indirectly)



Credit Supply versus TFP

Financial and real effects of **credit supply volatility**

- Debt and risk-free rate lower, consumption and hours (efficiency units) slightly lower
- *Flexible labor supply*: deleveraging (+) vs. wealth effect for rich/productive (-): latter dominates when hhs expect credit shock to be mean-reverting (not permanent as with perfect foresight)
- Higher costs of business cycles than Lucas 2003 if BC associated with credit cycles

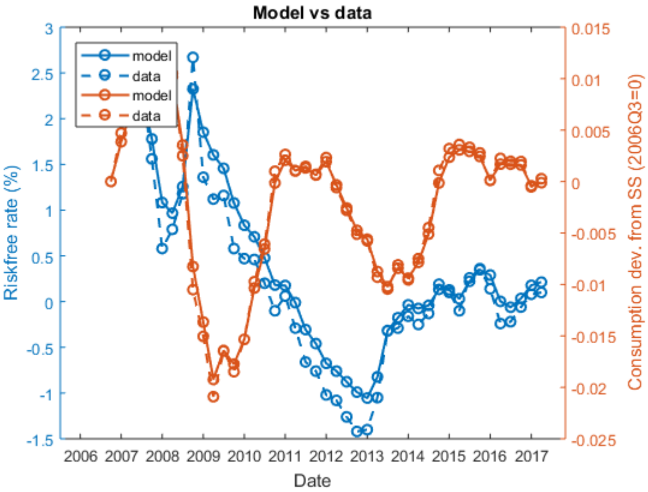
TFP volatility is PS-neutral

- economically, consistent with Lucas 2003
- computationally, with Fernández-Villaverde et al 2016

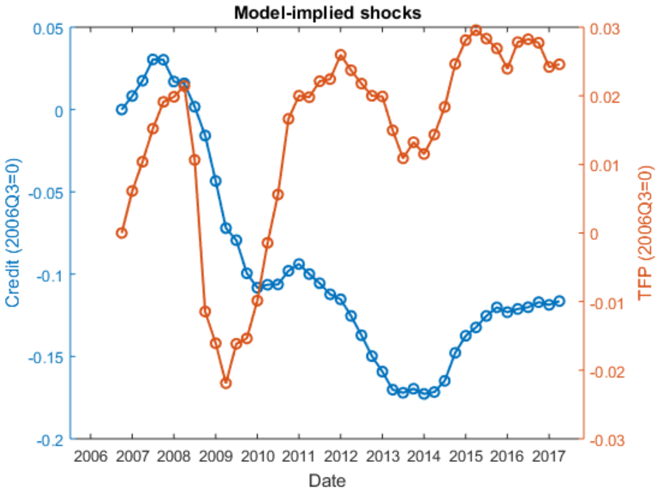
Contribution to Macro Volatility

Variable:	Credit supply	TFP
Bond price	59%	41%
Hours (efficient)	52%	48%
Wage	21%	79%
Profits	59%	41%
Consumption	59%	41%

Risk-free Rate and Consumption around GR



Structural Shocks



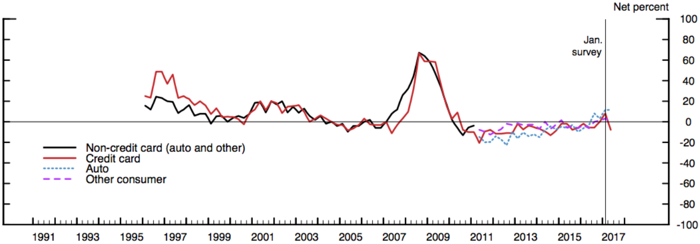
Conclusion

BHA model with aggregate credit supply and TFP shocks

- perturbation-based solution method to measure departure from certainty equivalence and linearity
- credit supply shocks generate large PS motive, dwarf TFP shocks $\rightarrow$ low debt, risk-free rates
- as important as TFP in driving business cycle
- TFP has recovered since GR, but structural measure of credit supply still low

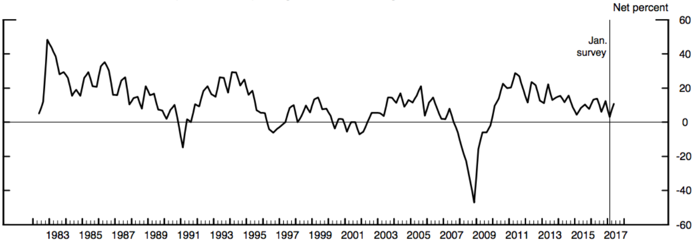
Banks' Willingness to Lend

Net Percent of Domestic Respondents Tightening Standards for Consumer Loans



Note: For data starting in 2011:Q2, changes in standards for auto loans and consumer loans excluding credit card and auto loans are reported separately. In 2011:Q2 only, new and used auto loans are reported separately and equally weighted to calculate the auto loans series.

Net Percent of Domestic Respondents Reporting Increased Willingness to Make Consumer Installment Loans



Related literature

- **Macroeconomic response to credit crises**
  - Justiniano-Primiceri-Tambalotti 2015; Guerrieri-Lorenzoni 2017; Jones-Midrigan-Philippon 2018; Favilukis-Ludvigson-Van Nieuwerburgh 2017; Kaplan-Mitman-Violante 2019; Boz-Mendoza 2014
- **Cost of business cycles**
  - Lucas 2003; Nakajima-Ríos-Rull 2014
- **Precautionary savings**
  - Carroll-Samwick 1998; Parker-Preston 2005; Pflueger-Siriwardane-Sunderam 2017
- **Perturbation-based solutions of BAH with aggregate risk**
  - Reiter (2009); Kim-Kim-Schaumburg-Sims 2008; Ahn-Kaplan-Moll-Winberry-Wolf 2017; Winberry 2018

Projection + 2nd Order Perturbation

Problem: solve for 2nd order coefficients

Solution: combine Reiter 2009, Sims 2001, Kim-Kim-Schaumburg-Sims 2008

- `gensys2` reduces dimensionality w/ linear transformations
- derivatives computed exactly (automatic differentiation)
- cross-sectional distribution is a state variable
- global, fully nonlinear solution of det. SS; quadratic agg. dynamics
- flexible