Divergent Risk-Attitudes and Endogenous Collateral Constraints

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Motivation: Narrative of the Crisis

- Narrative of financial crisis: excessive leverage, risk-taking and asset price growth
- Combination of:

1. *Institutional finance*: Limited enforcement disciplined through collateral constraints:

    a. growth collateral values

    b. anticipatory effects

2. *Valuation dis-agreement:* borrower risk-tolerant at the tails (large gambles)

$\rightarrow$more speculators are exposed, less they are risk sensitive and more leverage

- We build a model that rejoins the two: incentives + behavioral

Motivation: Minsky meets Kahneman

Debt markets (akin to commodity): *endogenous risk* (Minsky)

$\longrightarrow$ Borrowers/speculators: more prone to risk (Kahneman, Haig and List 2005, experimental evidence)
$\longrightarrow$ Limited enforcement + double ignorance $\Rightarrow$ collateral guarantee (Holmstrom 2014)
$\longrightarrow$ Borrower compensate lenders for bearing risk of changes in collateral values
$\longrightarrow$ Changes in the risk-tolerance distance $\Rightarrow$ compensation premium (debt shadow price)
$\longrightarrow$ Distance increases with exposure (gambles sensitive price of risk, Pratt 1964)

Asset price booms-busts

More leverage$\Rightarrow$more exposure to risky asset$\Rightarrow$risk-taking

Related literature

- *Leverage cycles with beliefs dis-agreement*: Geanakoplos 2008, Simsek 2013
- *Limited enforcement*:

- occasionally binding constraints: Mendoza 2010
- pecuniary or demand externalities: Jeanne and Korinek 2010, Korinek and Simsek 2016, Korinek and Davila 2017

- *Behavioral finance*: Kahneman and Tversky 1979, Kõszegi and Rabin 2006, Barberis and Huang 2001

a. lower risk-sensitivity on the tails (Yogo 2008)
b. kinked preferences: enhance volatility (Cochrane 2016, Epstein and Schneider 2005)
c. losses resonate more than gains: heightened de-leveraging

- *Time-dependent reference point (memory)*: Santoro et. al.2014

Model

- Borrowers and lenders differing in income process, discounting and risk-attitudes
- Borrowers:

1. More risk-tolerant, loss-averse with reference$\rightarrow$*diminishing risk-sensitivity on tails*
2. Collateral constraints: *risk-shifting behavior*$\rightarrow$warrant value
3. Occasionally binding collateral constraints (anticipatory effects)

- Role of **distance in marginal valuations**:

1. Booms ($>$ reference point): borrowers' *risk-tolerance* $\uparrow$, relaxes constraint
2. Distance in risk-sensitivity and *compensation premium* raises too
3. To compensate lenders borrowers need to engage in *risk-taking*

Lenders

$$\max_{\{C^l_t, B^l_t\}_0^\infty} \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t U^l \left(C^l_t, X_t \right) \right\}$$

$$s.to \quad C^l_t = w^l_t + R^f_t B^l_{t-1} - B^l_t$$

FOC:

$$U^l_C \left(C^l_t, X_t \right) = \beta \mathbb{E}_t \left\{ U^l_C \left(C^l_{t+1}, X_t \right) R^f_{t+1} \right\}$$

Borrowers

$$\max_{\{C_t^b, B_t^b, S_t^b\}_0^\infty} \mathbb{E}_0 \left\{ \sum_{j=0}^{\infty} \rho^j U^b(C_t^b, X_t) \right\}$$

$$\begin{aligned} s.to\ C_t^b &= w_t^b - R_t^f B_{t-1}^b + B_t^b + S_{t-1}^b(p_t + d_t) - S_t^b p_t \\ and\ R_{t+1}^f B_t^b &\le \phi S_t^b \mathbb{E}_t \{p_{t+1}\}. \end{aligned}$$

FOCs:

$$U_C^b(C_t^b, X_t) = \rho \mathbb{E}_t \left\{ U_C^b(C_{t+1}^b, X_{t+1}) R_{t+1}^f \right\} + \lambda_t R_{t+1}^f$$

$$p_t U_C^b(C_t^b, X_t) = \rho \mathbb{E}_t \left\{ U_C^b(C_{t+1}^b, X_{t+1})(p_{t+1} + d_{t+1}) \right\} + \lambda_t \phi \mathbb{E}_t \{p_{t+1}\}$$

Preferences specification

- Kõszegi and Rabin 2006

$$U^i(C_t^i, X_t) = \alpha W^i(C_t^i) + (1-\alpha)\mathcal{W}^i(C_t^i, X_t)$$

$$\mathcal{W}^i(C_t^i, X_t) = \begin{cases} \Lambda \frac{\left| \frac{(C_t^i)^{(1-\gamma)}}{1-\gamma} - \frac{(X_t)^{(1-\gamma)}}{1-\gamma} \right|^{1-\theta}}{1-\theta}, & \text{if } C_t^i < X_t, \\ \frac{\left(\frac{(C_t^i)^{(1-\gamma)}}{1-\gamma} - \frac{(X_t)^{(1-\gamma)}}{1-\gamma} \right)^{1-\theta}}{1-\theta}, & \text{if } C_t^i \geq X_t, \end{cases}$$

→*Arrow-Pratt coefficient* declines with size of the exposure: *increasing risk-tolerance*

→*At the kink infinite price of risk*:

- Sharpe ratio closer to Hansen and Jagannathan bounds
- Sharper leverage/de-leverage

Borrowers' IMRS

$$m^b_{t,t+s} = \rho^s e^{-\gamma \hat{g}{}^b_{t+s}} \frac{k(\hat{y}{}^b_{t+s})}{k(\overset{\wedge}{y^b}_t)}$$

where $k(\hat{y}{}^b_t)$. *Under power reference-dependent utility (i.e.,* $\theta \in [0;1)$ *and* $\Lambda > 1$*):*

$$k(\hat{y}{}^b_t) = \begin{cases} \Lambda \left| \frac{(C^b_t)^{(1-\gamma)}}{1-\gamma} - \frac{(X^b_t)^{(1-\gamma)}}{1-\gamma} \right|^{-\theta}, & \text{if } \hat{y}{}^b_t < 0, \\ \left(\frac{(C^b_t)^{(1-\gamma)}}{1-\gamma} - \frac{(X^b_t)^{(1-\gamma)}}{1-\gamma} \right)^{-\theta}, & \text{if } \hat{y}{}^b_t \geq 0, \end{cases}$$

Shadow price of debt

$$\lambda_t^{'} = \mathbb{E}_t\left\{m_{t,t+1}^{l}\right\} - \mathbb{E}_t\left\{m_{t,t+1}^{b}\right\}$$

Borrowers' stochastic discount factor (Tallarini 2000, Yogo 2008, consumption growth, $\hat{g}{}_t^{b} \sim N(\mu, \sigma^2)$)

$$\mathbb{E}_t\left\{m_{t,t+1}^{b}\right\} = \rho \exp\left\{-\gamma\mu + \frac{(\gamma\sigma)^2}{2}\right\}\Xi_t(\gamma,\Lambda)$$

where:

$$\Xi_t(\gamma,\Lambda) = \begin{cases} \left[\frac{1}{\Lambda} + (1-\frac{1}{\Lambda})F(\gamma\sigma + \frac{\overset{\wedge}{\kappa}_{t+1}-\mu}{\sigma})\right] & \text{if } \hat{y}_t < 0 \\ \left[1 + (\Lambda-1)F(\gamma\sigma + \frac{\overset{\wedge}{\kappa}_{t+1}-\mu}{\sigma})\right] & \text{if } \hat{y}_t \geq 0 \end{cases}$$

$\Rightarrow$**Higher on the right of reference level and risk-tolerance declines as exposure raises**

Asset price

$$
\begin{aligned}
p_t \quad = \quad & \mathbb{E}_t \left\{ m^b_{t,t+1} d_{t+1} \right\} + \\
& + \mathbb{E}_t \left\{ \sum_{i=1}^{T} m^b_{t+i,t+i+1} d_{t+i+1} \prod_{j=1}^{i} K_{t+j-1,t+j} \right\} + \\
& + \mathbb{E}_t \left\{ \prod_{i=0}^{T} K_{t+i,t+i+1} p_{t+T} \right\}
\end{aligned} \tag{1}
$$

where $K_{t,t+i} = m^b_{t,t+i} + \phi \lambda'_{t+i-1}$.

$\longrightarrow$Raises as λ'_t raises: warrant value of asset under binding constraint

$\longrightarrow$Raises as $m^b_{t+i,t+i+1}$ raises: on the right of the reference point

Asset returns

$$\mathbb{E}_t \left\{ R^s_{t+1} \right\} = \frac{R^f_{t+1} \left[1 - \rho Cov(m^b_{t,t+1}, R^s_{t+1}) - \lambda^{'}_t \phi \mathbb{E}_t \left\{ \frac{p_{t+1}}{p_t} \right\} \right]}{\rho (1 - R^f_{t+1} \lambda^{'}_t)}$$

Risk-premium between $\mathbb{E}_t \left\{ R^s_{t+1} \right\}$ and R^f_t:

$$\Psi_t = \frac{\left[1 - \rho Cov(m^b_{t,t+1}, R^s_{t+1}) - \lambda^{'}_t \phi \mathbb{E}_t \left\{ \frac{p_{t+1}}{p_t} \right\} \right]}{\rho (1 - R^f_{t+1} \lambda^{'}_t)}$$

The Sharpe ratio

$$\frac{\mathbb{E}_t\left\{Z_{t+1}\right\}}{\sigma_z} = \left[\begin{array}{c} \frac{Var(m^b_{t,t+1})}{(\mathbb{E}_t\left\{m^b_{t,t+1}\right\})^2} + 2\lambda^{'}_t \frac{\mathbb{E}_t\{Z_{t+1}\}}{\sigma^2_z}\frac{\mathbb{E}_t\{\Sigma_{t+1}\}}{(\mathbb{E}_t\left\{m^b_{t,t+1}\right\})^2} \\ + \frac{(\lambda^{'}_t)^2}{(\mathbb{E}_t\left\{m^b_{t,t+1}\right\})^2}\frac{(\mathbb{E}_t\{\Sigma_{t+1}\})^2}{\sigma^2_z} \end{array}\right]^{\frac{1}{2}} \tag{2}$$

where $Z_t = R^s_t - R^f_t, \Sigma_t = \phi\mathbb{E}_t\left\{\frac{p_{t+1}}{p_t}\right\} - R^f_t, \sigma^2_z = Var(R^s_t - R^f_t)$.

$\longrightarrow$ *Counter-cyclical*:

1. Declines when $\mathbb{E}_t\left\{m^b_{t,t+1}\right\}$ raises (on the right of reference level)
2. Raises as $\lambda^{'}_t$ raises: higher risk-premium to be transferred to lenders, borrowers shall extract larger returns

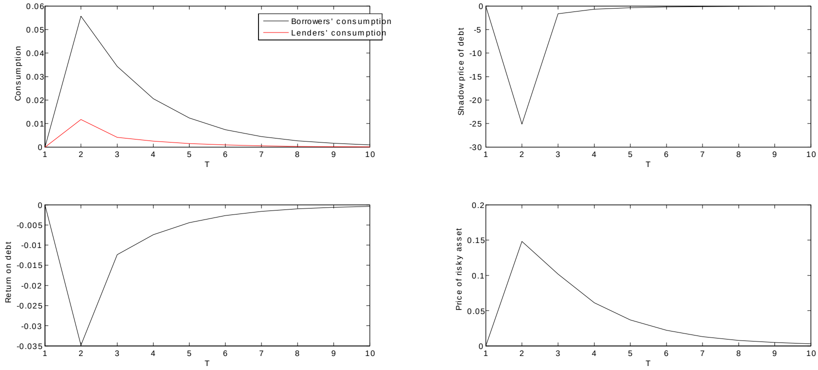
Quantitative analysis

- Policy function iterations with **Markov switching regimes**→*non-linearity* and *anticipatory effects*

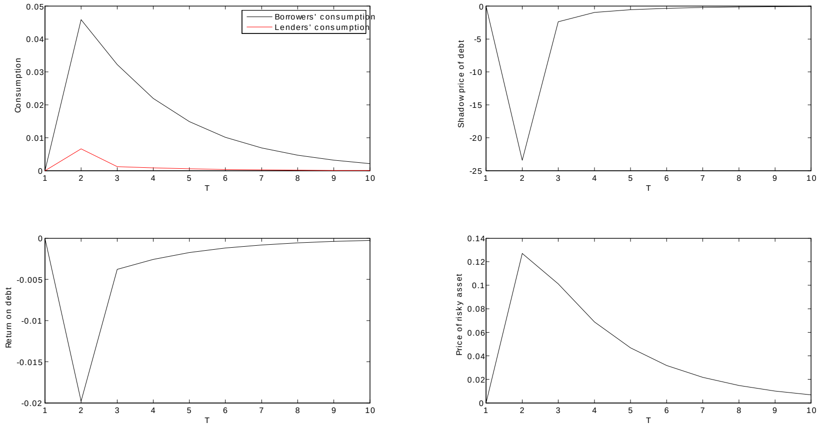
- occasionally binding constraints
- kinked preferences

- Long run: limiting risk-averse behavior, distance in discount factors
- Income shocks estimated through PSID data

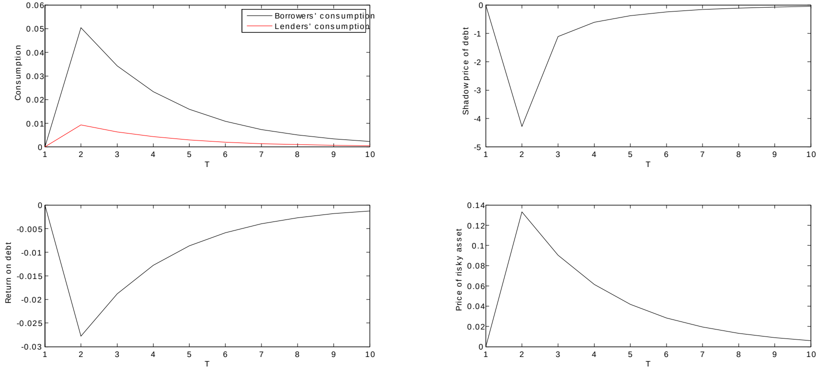
Impulse responses: dividend shock



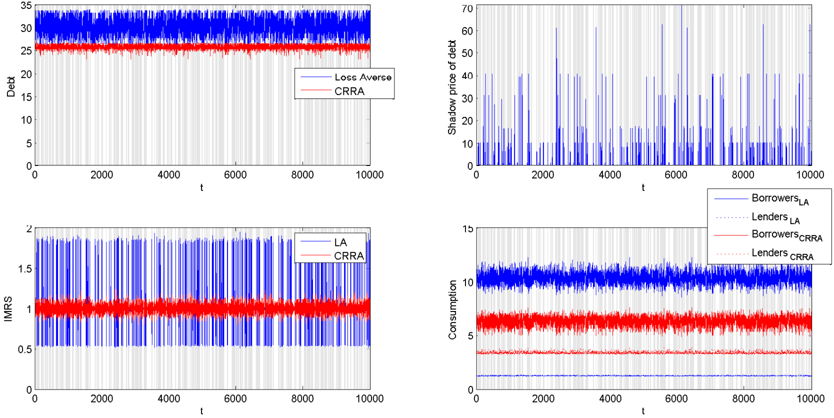
Impulse responses: borrowers' income shock



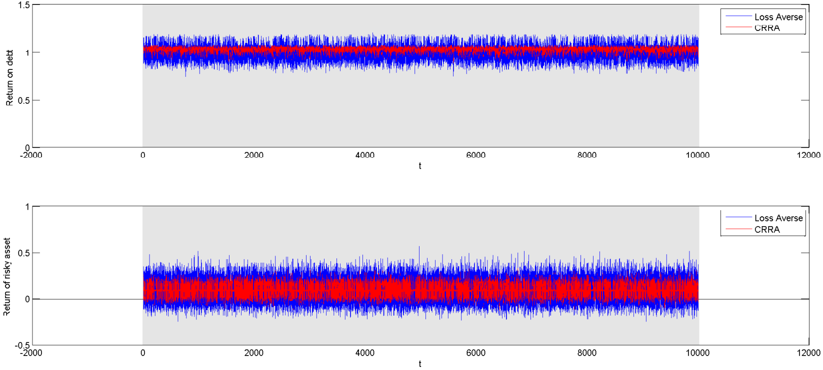
Impulse responses: lenders' income shock



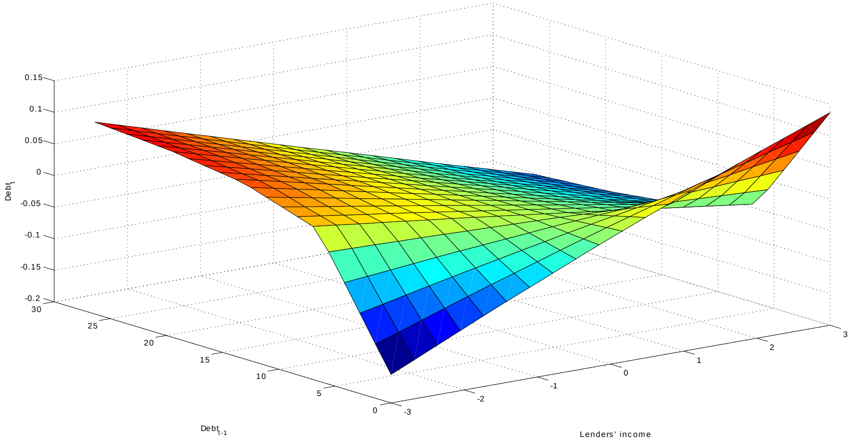
Simulated Series



Simulated Series



Policy function: for past debt and lenders' income



Model-data comparison

Table: **Comparison model-based versus empirical moments of selected variables. All values are in percentage terms.**

	Model	U.S.		U.K.	
		1960-2016	1980-2016	1970-2016	1980-2016
R_t^s	7.651	7.05	9.35	7.17	8.23
Vol R_t^s	9.300	16.19	15.57	19.34	15.55
R_t^f	2.627	$3.43^*, 1.42^{**}$	4.30, 1.70	1.22, 1.43	2.40, 2.62
Vol R_t^f	7.573	2.36, 2.41	2.22, 2.71	4.25, 4.37	2.85, 3.04
EP	5.024	3.62, 5.63	5.05, 7.65	5.95, 5.77	5.83, 5.62
Vol. EP	14.167	15.6, 15.9	16.4, 16.3	19.5, 19.6	15.1, 15.1
Vol B_t	6.711	5.28^{***}	5.28	4.06	4.06
$Corr(R_t^s, \frac{C_t}{C_{t-1}})$	0.7145	0.41	0.47	0.22	0.29

*Based on corporate bond rate

**Based on money market rate;***Debt data are available only from 1996.

Robustness

Table: **Model-based moments under alternative parametrizations. All values are in percentage terms.**

Statistics	Model	Model
	$\phi = 0.65$	$\gamma = 2.5$
Exp ret risky asset, R_t^s	7.583	7.698
Vol risky asset, R_t^s	8.931	9.114
Exp ret risk-free, R_t^f	2.712	2.778
Vol risk-free, R_t^f	7.807	7.611
Equity premium	4.871	4.920
Vol. equity premium	14.076	13.993
Vol of debt, $B_t{}^*$	6.762	6.6675
Corr$(R_t^s, \frac{C_t}{C_{t-1}})$	0.72582	0.71806

Models' correlations: excessive leverage and asset growth

Table: **Model correlations computed for the full sample of simulated series with occasionally binding constraints.**

Model correlations	$\gamma = 3$	$\gamma = 2.5$	$\gamma = 5$
$Corr(\Delta p_t, \Delta m_t)$	0.54634	0.53707	0.56927
$Corr(\Delta B_t, \Delta m_t)$	0.29241	0.30820	0.27989
$Corr(C_t^b, R_t^s)$	0.52000	0.50550	0.50689
$Corr(C_t^l, R_t^s)$	0.50000	0.49114	0.49336

Conclusions

- Endogenous leverage and risk cycles
- Determinants: institutional finance, anticipatory effects and divergent risk-attitudes
- Accounts for leverage cycle, matches well empirical regularities
- Future research:

- endogenous preferences
- exchange rate markets
- prudential regulation