A Macro-Finance model with Realistic Crisis Dynamics

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Abstract

What causes deep recessions and slow recovery? I revisit this question and develop a macro-finance model that quantitatively matches the salient empirical features of financial crises such as a large drop in the output, a high risk premium, reduced financial intermediation, and a long duration of economic distress. The model has leveraged intermediaries featuring stochastic productivity and regime-dependent exit rate that governs the transition in and out of crises. A model without these two features suffers from a trade-off between the amplification and persistence of crises. I show that my model resolves this tension and generates realistic crisis dynamics.

Introduction

A Macro-finance model with financial amplification to explain deep and persistent financial crises

1. Two sector model with households, and experts facing a) stochastic productivity and b) regime-dependent exit rate
2. Multi-dimensional model → Active deep learning that encodes economic information as regularizers (Gopalakrishna (2021))

B Quantification of a simpler model: shut-off time variation in productivity and remove exit

1. Trade-off between unconditional risk premium and probability of crisis
2. Trade off between conditional risk premium (amplification) and duration of crisis (persistence)
3. My model resolves these tensions and provides a better match to data

Economic Mechanisms

Setup:

- Two classes of agents: **Households**, and **Experts** (financially constrained, leveraged).
- Normal times: More productive experts sufficiently capitalized, hold all capital

Crisis dynamics:

- **Capital and Productivity shock**: negative shock → ↓ leveraged expert net worth → amplification (large risk premium, GDP falls, investment falters, and return volatility increases)
- **Regime-dependent exit**
  1. Larger exit in crisis pushes economy deeper into recession
  2. only way to come out of crisis is by increased expert productivity. Slow mean reversion in productivity $\implies$ delayed recovery (persistence)

Model

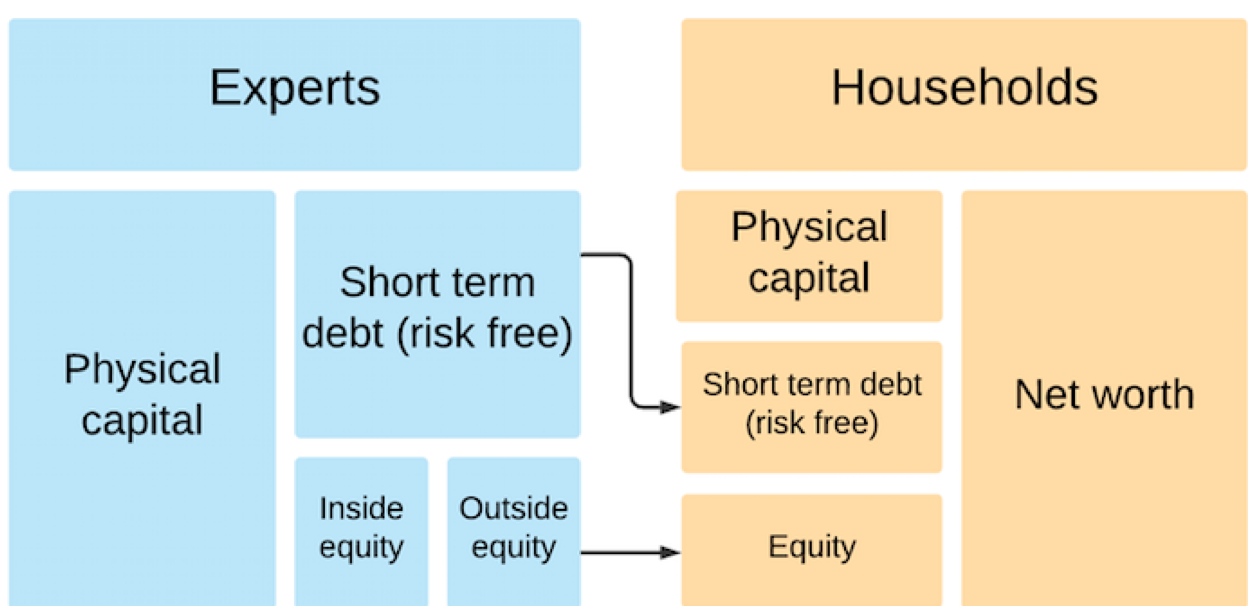

Figure 1: Balance sheet

AK technology $y_{j,t} = a_{j,t}k_t, \quad j \in e, h$

$$\frac{dk_t}{k_t} = (\Phi(\iota_t) - \delta)dt + \sigma dZ_t^k$$

1. Productivity of experts is time-varying and follows the process

$$da_{e,t} = \pi(\hat{a}_e - a_{e,t})dt + \nu(\overline{a}_e - a_{e,t})(a_{e,t} - \underline{a}_e)dZ_t^a$$

with $d\langle Z_t^k, Z_t^a\rangle = \varphi dt > 0$ and $a_h < \underline{a}_e < \hat{a}_e < \overline{a}_e$ → Reflects bank economies of scale

2. Experts exit at rate $\tau_t \in \{\tau_{normal}, \tau_{crisis}\}$, with $\tau_{crisis} = \mathbf{9} \times \tau_{normal}$.
→ Reflects bank runs during crises

Experts solve

$$U_{e,t} = \sup_{C_{e,t},K_{e,t},\chi_{e,t}} E_t\left[\int_t^{\tau'} f(C_{e,s}, U_{e,s})ds + U_{h,\tau'}\right]$$

$$\text{s.t.} \quad \frac{dW_{e,t}}{W_{e,t}} = \Big(r_t - \frac{C_{e,t}}{W_{e,t}} + \frac{q_tK_{e,t}}{W_{e,t}}(\mu_{e,t}^R - r_t - (1-\chi_{e,t})\epsilon_{h,t}) - \lambda_d + \frac{\bar{z}}{z_t}\lambda_d - \tau_t\Big)dt + \sigma_{w_{e,t}}\big((\sigma + \sigma_t^{q,k})dZ_t^k + \sigma_t^{q,a}dZ_t^a\big)$$

- Transition time τ' is exponentially distributed with rate $\tau_t \in \{\tau_{normal}, \tau_{crisis}\}$
- $\frac{q_tK_{e,t}}{W_{e,t}}$: fraction of capital invested
- $\chi_{e,t}$: fraction of equity retained in balance sheet
- Preferences follow Duffie-Epstein utility

$$f(c_{j,t}, U_{j,t}) = (1-\gamma)\rho U_{j,t}\left(\log(c_{j,t}) - \frac{1}{1-\gamma}\log\Big((1-\gamma)U_{j,t}\Big)\right)$$

Solution Method

- Two state variables: wealth share of experts z_t (endogenous), productivity of experts $a_{e,t}(exogenous)$
- Solution boils down to solving coupled system of PDEs in J_h and J_e

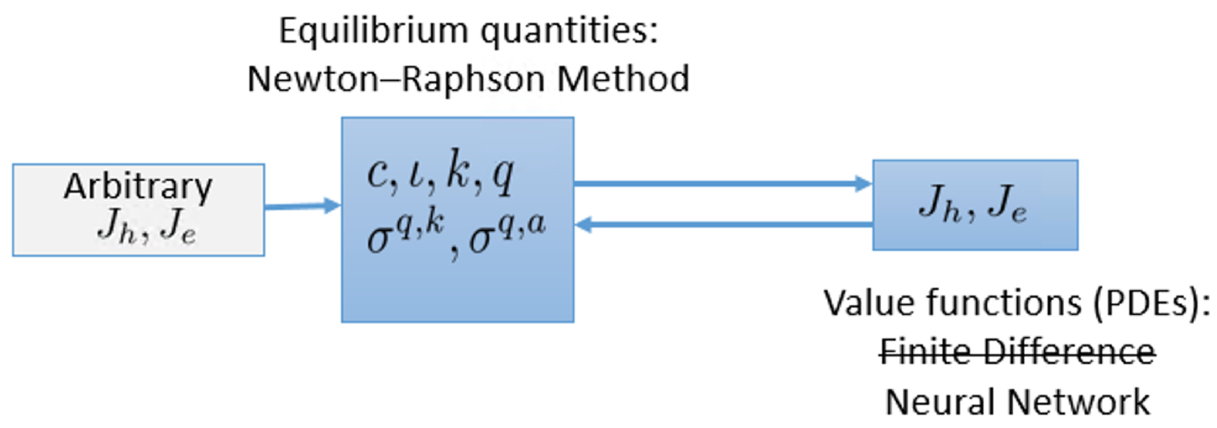

Figure 2: Figure caption

- Neural network approach (ALIENs) developed in Gopalakrishna (2021)

Quantitative Analysis

	Data			Benchmark Model RA=1		Benchmark Model (RA=20)	
	All	Recession	Crisis	All	Crisis	All	Crisis
E(Risk premium)	7.5	16.6	25.0	1.7	13.4	7.3	-
Std(Risk premium)	5.1	6.5	7.4	2.8	1.3	0	-
Probability of Crisis	7			7.8		0	

Table 1: Empirical vs Model moments

- Trade-off 1: **Risk premium and Prob. of crisis**
- Trade-off 2: **Conditional Risk premium and Duration. of crisis**

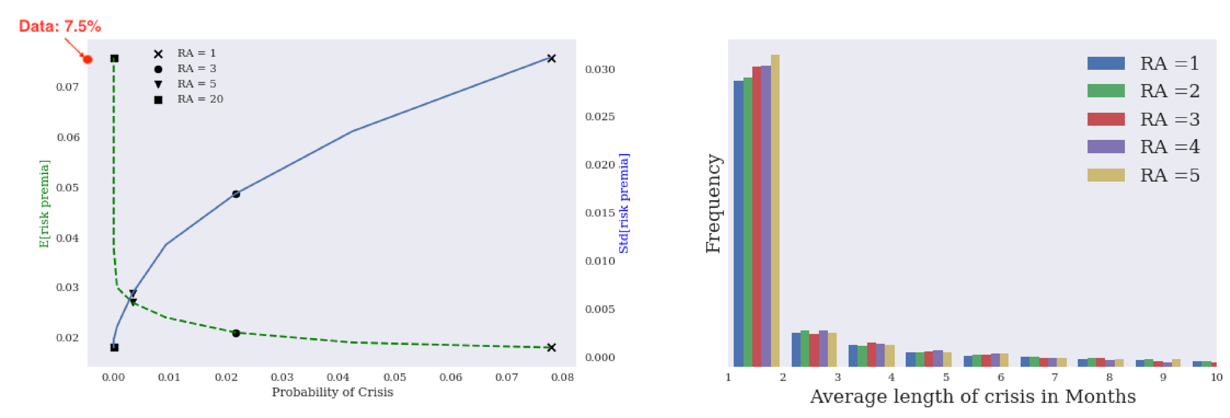

Figure 3: Trade-offs in benchmark model

- **Benchmark**: Only one shock: i.i.d Brownian.
  1. In steady state, capital shock to risk averse experts is not enough to generate sufficient crises periods (trade-off 1)
  2. Once in crisis, amplification happens but experts repair their balance sheet faster $\implies$ quick recovery (trade-off 2)
- **My model**: Two correlated Brownian shocks plus higher exit in crisis.
  1. In steady state, capital shock to risk averse experts also lowers productivity and generates crisis (trade-off 1)
  2. Once in crisis, amplification happens but experts exit economy at higher rate
  3. Productivity shoots up slowly $\implies$ sluggish recovery (trade-off 2)

	My model			Benchmark model		
	All	Crisis	Normal	All	Crisis	Normal
E[leverage]	2.80	4.79	2.62	3.23	5.50	3.10
E[inv. rate]	7.70%	2.80%	8.20%	6.00%	5.00%	6.00%
E[risk free rate]	0.90%	-7.20%	1.70%	4.80%	0.00%	5.00%
E[risk premia]	6.70%	17.50%	5.70%	1.70%	13.40%	1.00%
E[GDP growth rate]	1.20%	-8.00%	1.90%	2.30%	-7.90%	2.70%
Std[inv. rate]	3.18%	1.31%	2.91%	0.36%	1.09%	0.11%
Std[risk premia]	5.35%	1.57%	4.45%	2.82%	1.31%	0.18%
Std[risk free rate]	3.98%	1.64%	3.21%	1.19%	0.42%	0.28%
Corr(leverage,shock)	-0.25	-0.17	-0.30	-0.28	-0.05	-0.25
Probability of crisis	7.0%			7.80%		
Duration of crisis (months)	18.5			6		

Table 2: Comparison of moments

Conclusions

- Wealth share of intermediaries alone cannot jointly match asset pricing, output, and crisis moments
  1. Trade-off between unconditional risk premium and probability of crisis
  2. Trade-off between conditional risk premium (amplification) and duration of crisis (persistence)
- A model of stochastic productivity and regime-dependent exit generates realistic crisis dynamics, and a better match to data
- Active machine learning opens new avenues for future research
  1. 'Brunnermeier-Sannikov meets Bansal-Yaron' economy (Gopalakrishna (2021))
  2. Heterogeneous intermediaries
  3. Main street vs Wall street disconnect, good booms vs bad booms
  4. Sunspot equilibria
  5. ....and more