Intermediary Asset Pricing

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Intermediary financing and intermediated asset markets

- Recent events: High spreads in debt markets August 07 to October 08. S&P500 near all time high in August 2008.
- Q4 1998: Similar pattern
- Narrative: intermediaries get in trouble, drive up required risk premium in intermediated asset.

Two distinguishing features of our analysis

(1) Relative to macro literature:

- Model captures non-linearities in crises.
- We solve for a stochastic steady state and study behavior near the tails.
- Much of macro literature (e.g., Kiyotaki and Moore, 1997) log-linearizes around a non-stochastic steady-state.

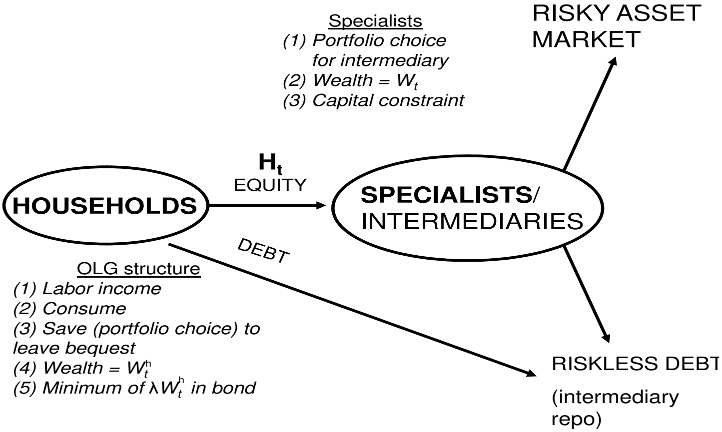
(2) Relative to finance literature:

- We model constraint on raising equity capital.
- Much of literature studies constraint on raising debt.
  - Margin-constraints models (Gromb-Vayanos, Brunnermeier-Pedersen, Adrian-Shin, Geanokoplos-Fostel)

Outline

- The Model;
- Calibration;
- Crisis episode;
    - Crisis risk premia and flight to quality;
    - Crisis recovery;
- Policy experiments.

Model Structure



Model Structure

1. Variant of a two-agent model (i.e. Heaton and Lucas, 1996). Competitive. Continuum of agents.
2. **Households**:
   - Limited participation in risky asset market
3. **Specialists** run intermediaries subject to an intermediation constraint;
   - Household's investment cannot exceed a capacity, which is increasing in intermediary's (specialist's) capital;

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   - Household's investment cannot exceed a capacity, which is increasing in intermediary's (specialist's) capital;
4. **Risky asset** and **riskless asset**:
   - Risky asset is *illiquid* in the sense of market participation; riskless debt is *liquid*.
5. Intermediaries, not households, are marginal in setting the price of the risky asset.

Assets

- Continuous time, infinite horizon.
- Risky asset (unit supply) with dividend

$$\frac{dD_t}{D_t} = g dt + \sigma dZ_t;$$

- Riskless short-term debt in zero net supply;
- Risky asset price P_t and interest rate r_t are determined in equilibrium.

Intermediation

- Long-lived specialists can invest in the risky and riskless assets with no constraints.

$$\int_0^\infty e^{-\rho t} \frac{c_t^{1-\gamma}}{1-\gamma} dt$$

- Households can invest in the risky asset *indirectly* via intermediaries.

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- Households can invest in the risky asset *indirectly* via intermediaries.
- Match one specialist with one household to form “intermediary." Short-term intermediation relation (dt):
    - Specialist contributes all of his wealth w_t, and household chooses contribution $H_t \leq w_t^h$
    - The intermediary then invests in risky/riskless asset markets;
    - Both parties share in the fund's return based on equity contributions.

Intermediary Equity Capital Constraint

- *Intermediation constraint*: households' investment

$$H_t \leq mw_t$$

- Intermediation capacity mw_t is increasing in the specialist's contribution.

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- Intermediation capacity $m w_t$ is increasing in the specialist's contribution.
- How to interpret m?
  1. Intermediary capital requirement: outside/inside contribution ratio;
     - Officers/directors holdings of financial industry $\approx$ 18% (Holderness, Kroszner, Sheehan 1999).
     - Set $\frac{1}{1+m} = 0.18$ gives $m = 4.55$.
  2. Incentive contract — the performance share of hedge fund managers:
     - Hedge fund manager receives $\frac{1}{1+m}$ of return of fund. The 20 in "2 and 20", gives $m = 4$.
  3. Mutual funds' flow-performance sensitivity. Specialist's w_t tracks his past gains and losses (Shleifer-Vishny, JF)
  4. He-Krishnamurthy, "Model of Capital and Crises" derives this optimal contract and asset market equilibrium.

Equity capital restriction

Sector	Q4 2007	Q1 2009
Hedge fund equity capital	$1,975bn	$1,002bn
Top 19 Commercial bank equity capital	827bn	285 bn
Top 19 Commercial bank debt liabilities	6,360bn	6,845bn
Top 19 Commercial bank leverage	7.7	24

Notes:

- Hedge fund capital: 600 bn due to losses, 400bn due to investor redemptions.
- Commercial bank capital falls mostly due to losses.
- (In fact, capital injection from government of 174bn)
- Commercial bank debt liabilities: 900bn increase in deposits.

Intermediation Constraint: An Example

- $m = 1$. Say $w_t^h = 80$.
- *Unconstrained Region:* $w_t = 100$. Then $H_t = 80$;
  - Fund's total equity 180. Risky asset price $P_t = 180$ (sum of w_t and w_t^h)
  - Fund invests 100% in risky asset. No leverage.

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  - Fund invests 100% in risky asset. No leverage.
- *Constrained Region:* $w_t = 50$. Then $H_t = 50$;
  - Fund's total equity is $50 + 50 = 100$. But $P_t = 130$.
  - In equilibrium, the intermediary borrows 30 from the debt market;
    - Supplied by households: $w_t^h - H_t = 30$.

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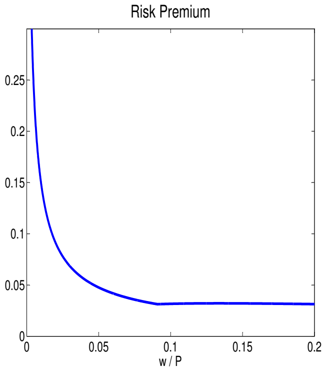
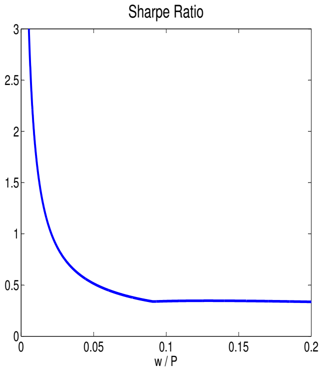
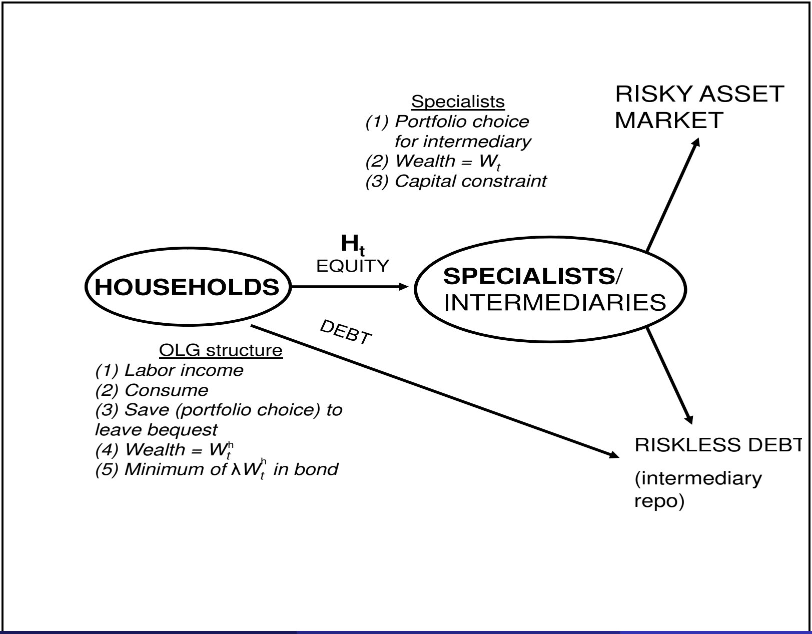
    - Supplied by households: $w_t^h - H_t = 30$.
  - Specialist and household have equal shares in the intermediary;
  - Specialist's leveraged position in risky asset: $\alpha^I = \frac{50+15}{50} = 130\%$.
  - Risk premium has to adjust to make this portfolio choice optimal for the specialist.


Risk Premium
0.25
0.2
0.15
0.1
0.05
0
0
0.05
0.1
0.15
0.2
w / P


Sharpe Ratio
3
2.5
2
1.5
1
0.5
0
0
0.05
0.1
0.15
0.2
w / P

Model Structure



Households

- Overlapping generations: Generation t born at t lives until $t + \delta$ ($\delta \rightarrow dt$).
- Born with wealth w_t^h, and receives labor income flow of $l_t = lD_t$.
- Utility:
$$\rho\delta \; ln \; c_t^h + e^{-\rho\delta} E_t[v(w_{t+\delta}^h)].$$
$v(\cdot)$ is bequest function. Assume that $v(w) = ln \; w$.
- $c_t^h = \rho w_t^h$ is optimal consumption policy for log utility.

Investment restriction and heterogeneity:

- λ fraction of households can only invest in bonds.
- $1 - \lambda$ fraction can invest with an intermediary. $\alpha_t^h \in [0, 1]$ is share of wealth given to intermediary

We will calibrate l, and λ.

Specialist Optimization

The specialist chooses his consumption rate c_t, and the holding of the risky asset α_t^I (for the intermediary):

$$\max_{\{c_t,\alpha_t^I\}} E\left[\int_0^\infty e^{-\rho t} u(c_t)\, dt\right] \quad s.t. \quad dw_t = -c_t dt + w_t \widetilde{dR}_t\left(\alpha_t^I\right) \tag{1}$$

Where,

$$\widetilde{dR_t} = \alpha_t^I (dR_t - r_t dt) + r_t dt. \tag{2}$$

An *equilibrium* is a set progressively measurable price processes $\{P_t\}$ and $\{r_t\}$, and decisions $\{c_t, c_t^h, \alpha_t^I, H_t \equiv \alpha_t^h w_t^h\}$ such that,

1. Given the price processes, decisions solve the consumption-savings problems of the households and the specialists;
2. Decisions satisfy the intermediation constraint;
3. The risky asset market clears:

$$\frac{\alpha_t^I(w_t + H_t)}{P_t} = 1;$$

4. The goods market clears:

$$c_t + c_t^h = D_t(1 + l).$$

Solutions

- The wealth distribution matters in our economy.
- State variables: dividend D, and the specialist's wealth w.
  - Scale invariance. One dimensional state variable w/D.
- Specialist is always marginal in this economy (unconstrained portfolio choice problem). We use his Euler equation to derive an ODE.
- Boundary condition as $w \to 0$. Reflecting barrier. Solved on MATLAB.

Solutions Steps

- Specialist is marginal investor. Faces no constraints. Portfolio choice must be an optimal choice for him.
- Thus, his Euler equation is always valid. Household is always constrained.
- Log household means $c_t^h = \rho w_t^h$.
- Goods market clearing then gives $c_t = (1 + l)D_t - c_t^h$.
- Equilibrium specialist consumption into Euler equation $\Rightarrow$ ODE for $F(y)$.
- Close the loop: We can write dynamics of w_t^h as a function of returns (innovations in $F(y)D$), and household portfolio share α_t^h.

Table 1: Intermediation Data[a]

Group	Assets[b]	Debt	Leverage
Commercial banks	11,800	10,401	0.88
S&L and Credit Unions	2,574	2,337	0.91
Property & Casualty Insurance	1,381	832	0.60
Life Insurance	4,950	4,662	0.94
Private Pensions	6,391	0	0.00
State & Local Ret Funds	3,216	0	0.00
Federal Ret Funds	1,197	0	0.00
Mutual Funds (excluding Money Funds)	7,829	0	0.00
Broker/Dealers	2,519	2,418	0.96
Hedge Funds	6,913	4,937	0.71

- Intermediaries account for over 60% of financial wealth.
- Calibration: we try to represent the entire heterogeneous intermediary sector into the intermediaries of our model

Mapping model to reality

Model constrained region:

- Negative shock $\Rightarrow$ households withdraw $\Rightarrow$ identical intermediaries lever up to clear market and earn risk premium

Reality: Leverage and functional heterogeneity

- Funds: Negative asset shock $\Rightarrow$ households withdraw $\Rightarrow$ sell assets/downsize
- Insurance, Small Commercial Banks: Negative asset shock + leverage $\Rightarrow$ bigger shocks $\Rightarrow$ withdrawal, downsize
- Bank traders: If others are downsizing $\Rightarrow$ raise equity or lever up to clear market and earn risk premium

Trading desks

- In the constrained region, in both model and world, a leverage player like a trading desk at a bank is marginal.
  - $m = 4$: Traders in hedge fund get paid 20%, outside investors get 80%. Sharing rule: $\frac{1}{1+m} = 20\%$.
  - $m = 4$: Officers/directors in financial industry hold 18% of equity stake in firms (Holderness, Kroszner and Sheehan (1999))

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- *m* controls how fast leverage rises in constrained region.
- *m* has no effect on unconstrained region ... but clearly institutions carry leverage in unconstrained region;
- Relevant for liquidations, shock transmission, transit from constrained to unconstrained regions.

Intermediary leverage in unconstrained region

- λ fraction of households only demand debt (no intermediary investment)
- Since intermediaries supply debt, λ controls leverage of intermediary in unconstrained region.
- We choose $\lambda = 0.6$ to match unconstrained average leverage of 0.52 – which is the weighted average leverage from Table 1.

Baseline Parameters

Panel A: Intermediation		
m	Intermediation multiplier	4
λ	Debt ratio	0.6
Panel B: Preferences and Cashflows		
g	Dividend growth	1.84%
σ	Dividend volatility	9%
ρ	Time discount rate	5%
γ	RRA of specialist	2
l	Household labor income ratio	1.3

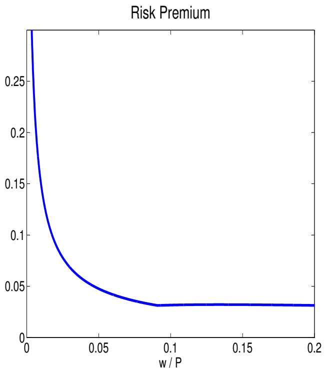
1. g from stock market, not critical
2. $\sigma = 9\%$ is critical. It produces equilibrium return volatility between 9 and 9.5%.
3. Volatility of returns on Agency MBS portfolio from 1976 to 2008 = 8.1%. CMBS portfolio from 1999 to 2008, return volatility = 9.6%.

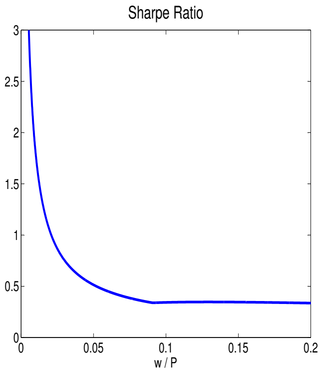
Calibration: Parameters

Baseline Parameters

Panel A: Intermediation		
m	Intermediation Multiplier	$4, 6$
λ	Fraction of Debt Investors	0.5
Panel B: Cashflows and Preferences		
g	Dividend Growth	1.84%
σ	Dividend Volatility	12%
ρ	Time Discount Rate	8%
γ	RRA of Specialists	2
l	Households Labor Income	1

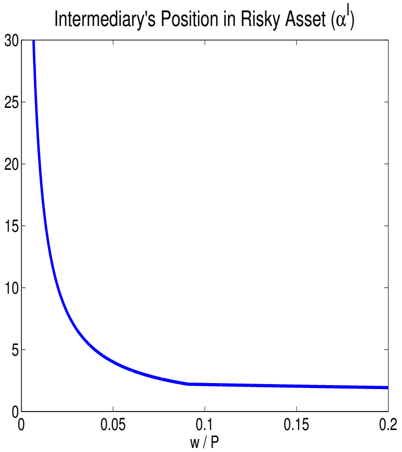
1. ρ to match average riskless interest rate around 0.5%
2. $\gamma = 2$ matches avg. return on agency MBS portfolio of near 3%
3. l chosen to match $E[(CapitalIncome)/(TotalIncome)] = 0.337$ from Parker-Vissing-Jorgensen.



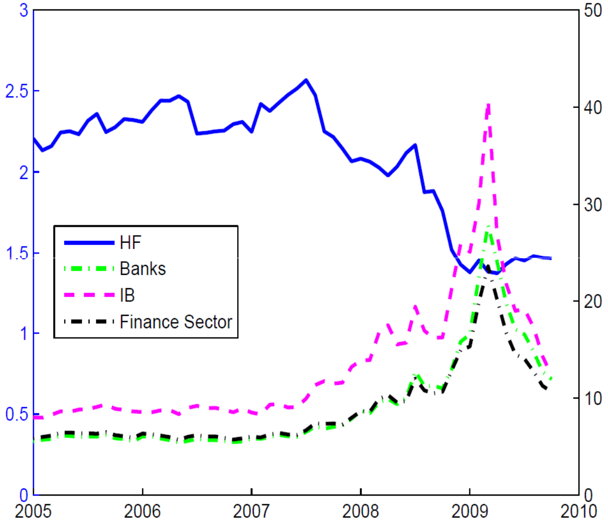


Constraint binds when $mw_t < (1-\lambda)w_t^h$

Portfolio Share



Leveraging: Ang, Gorovyy, Van-Inwegen (2010)



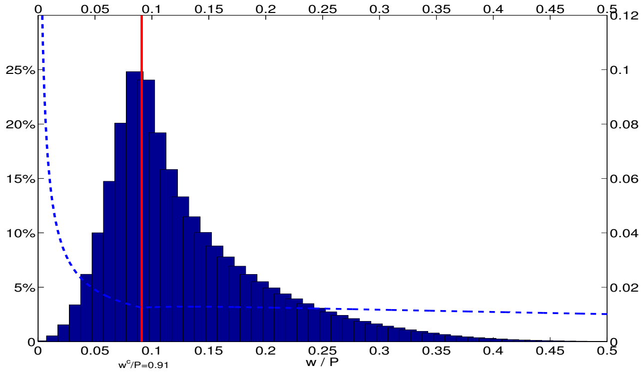
Commercial Bank Leverage

	Q1 2009
Total Assets	7608
Total Liabilities	6845
Equity Capital	763
Preferred Stock (including TARP) raised in 2008	233
"True" Capital	530
Leverage at 763 of Equity Capital	10.0
Leverage in Q4 2007	10.4
Leverage at 530 of Equity Capital	14.4
Leverage if true Assets are lower by 150	19.6
Leverage if true Assets are lower by 300	31.8

- IMF loss estimates as of Oct 2008: >$1.5tn (banks say $500bn)
- Level 3 assets (a subset of securities carried at fair value): $225bn

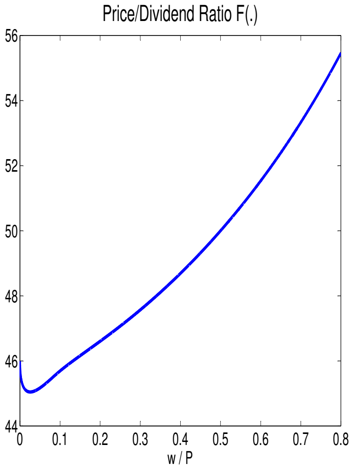
4

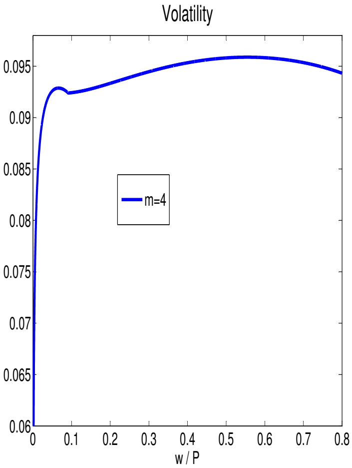
Steady state distribution



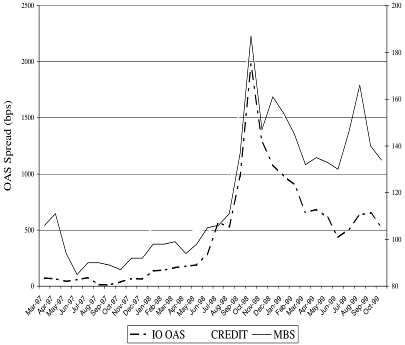
	Measures at Different RP		
Risk Premium π	3%	6%	12%
Prob% (RP$>\pi$)	93.9	1.58	0.08
Leverage Ratio (D/E) at π	0.8	4.6	13.3
Interest Rate% at π	0.96	-1.77	-8.05

Other Measures





Crisis Spreads



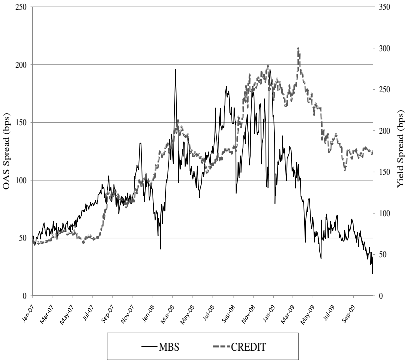


Table 3: Crisis Recovery

Fix a state (y, D) corresponding to an instantaneous risk premium of 12% (“Transit from"). Simulating the model from that initial condition, we compute and report the first passage time that the state hits the risk premium corresponding to that in the “Transit to" column. Time is reported in years.

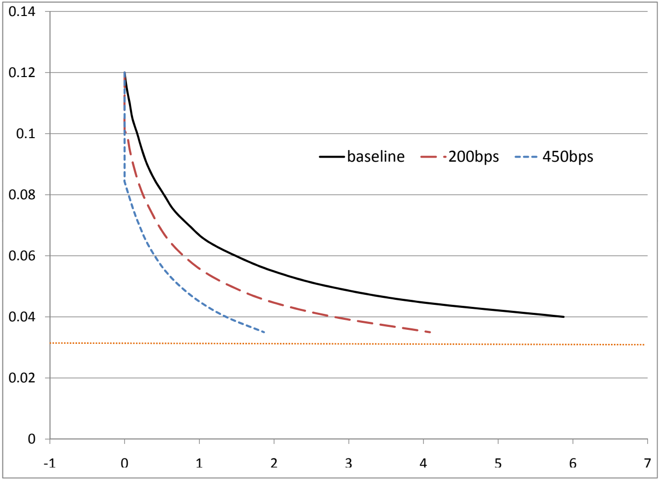
	$m = 4$	
	Transit from 12	Increment
To		
10	0.17	0.17
7.5	0.66	0.49
6	1.49	0.83
5	2.72	1.24
4	5.88	3.15
3.5	9.84	3.97

Policy Experiments

1. Borrowing subsidy
2. Distressed asset purchase
3. Equity injection

Subsidized Loan

Suppose we are currently in the extreme crisis state with risk premium of 12%. The government offers a loan subsidy to intermediaries on all of their borrowings, of size Δr. Households are taxed.



Distressed Asset Purchase

Table 6: Asset Purchase

s is share of risky asset that government purchases. The first row of the table reports the instantaneous jump downwards in the risk premium when the government begins its purchase.

Transit to	$s = 0$	$s = 0.04$	$s = 0.08$	$s = 0.12$
		11.63%	11.18%	10.77%
10	0.17	0.17	0.14	0.10
7.50	0.66	0.68	0.63	0.58
6	1.49	1.47	1.44	1.40
5	2.72	2.70	2.64	2.56
4	5.88	5.87	5.81	5.63

Note: 4% of \$15tn = \$600bn. Fed + Treasury purchased around \$1.8tn of assets,

Equity Injection

Table 7: Equity Injection

Government purchases common equity capital of \$38 bn, \$48 bn and \$58 bn, which is reversed in roughly one year. The first row of the table reports the instantaneous jump downwards in the risk premium when the government injects the equity capital.

Transit to	Baseline	\$38*bn*	\$48*bn*	\$58*bn*
		9.12%	8.67%	8.28%
7.50	1.09	0.39	0.31	0.23
6	1.49	1.14	1.05	0.96
5	2.72	2.33	2.20	2.10
4	5.88	5.13	5.06	4.98

Note: Purchase common equity in our experiment; government purchased preferred equity. We translate that the effective amount of common purchased was \$48bn.

Conclusion

- Model is canonical and fairly tractable.
- Equity pricing literature tells us that low probability bad states have disproportionate effect on average pricing. Needs further exploration.