Probability Overweighting or Underweighting? Evidence From Systemically Important Banks

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Summary

- **Capital Asset Pricing Model**: The model combines probability weighting of prospect theory with a consumption-based asset pricing model specifically for regulated banks.
- **Estimating Probability Weighting**: GMM estimates the non-linear probability weighting function to understand banks' probability distortions.
- **Examining Key Drivers**: Investigate factors such as market risk, default probabilities, funding liquidity, investor sentiment, and policy uncertainty that may drive banks' probability distortions.

Motivation

- Probability weighting function in prospect theory: individuals distort objective probabilities of outcomes or lotteries by overweighting small probabilities and underweighting high probabilities.

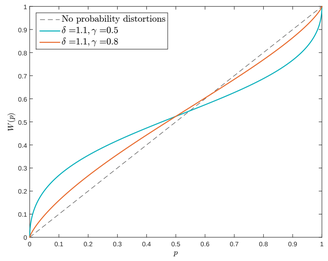


Figure 1: Probability weighting function in prospect theory. The expected utility theory is recovered when banks treat probabilities linearly and $W(p) = p$

- Application to systemic banks: The 2008 financial crisis and the subsequent Capital Purchase Program (CPP) offer a unique opportunity to test the probability weighting function of distressed banks. The CPP injected $250 billion into 707 financial institutions, with $96.6 billion invested in 39 major systemic banks.

Capital Asset Pricing Model

Standard expected utility consumption-portfolio model, with a behavioral one that applies prospect theory to how banks evaluate market losses. Banks choose capital k_t and consumption c_t to maximize expected utility

$$E\left[\int_0^\infty e^{-\rho t}\log c_t dt\right] \tag{1}$$

subject to equity evolution

$$dn_t = Ak_t d_t + d(q_t k_t) - r_t(q_t k_t - n_t)dt - c_t dt \tag{2}$$

and subjective expected loss constraint

$$q_t k_t L_W(\delta,\gamma) \le n_t \tag{3}$$

where $L_W(\delta,\gamma)$ denotes subjective expected market loss on the asset side of the bank balance sheet, which is governed by the probability weighting function.

Estimating probability weighting function

Jointly estimate coefficients δ and γ of the probability weighting function and the Lagrange multiplier λ on expected loss constraint from the asset pricing equation by GMM

$$E\left[\left(\frac{A}{q_t}+\mu_t^q+\sigma\sigma_t^q - r_t - \frac{1}{L_W(\delta,\gamma)}(\sigma+\sigma_t^q)^2 - \lambda q_t L_W(\delta,\gamma)\right)Z_t\right] = 0 \tag{4}$$

where Z_t are instruments (Fama-French factors): market, size, value, profitability, investment, and book-to-market.

Data

- Sample composition: Daily equity data from 39 systemic banks
- Estimation periods:
- Before CPP: January 2, 2007 - June 30, 2008
- During CPP: September 2, 2008 - December 26, 2008
- Before-during CPP: January 2, 2007 - December 26, 2008
- After CPP: January 2, 2010 - December 31, 2015

Variable	Empirical counterpart	Source
$\frac{A}{q_t}+\mu^q$	Returns with dividends	CRSP
σ	S&P volatility	OptionMetrics
r_t	Treasury bill rate	Fama-French
σ_t^q	Idiosyncratic volatility	OptionMetrics
q_t	Equity price	CRSP

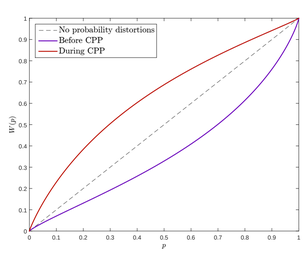
Main results

Dynamic probability weighting

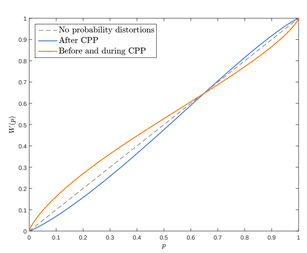
- Pre-2008 financial crisis: Underweighting low- and high-probability losses
- Financial distress and recapitalization: Overweighting low- and high-probability losses
- Combined pre-crisis and crisis periods: Overweighting low- and underweighting high-probability losses (probability weighting as in prospect theory)
- Post-recapitalization: Underweighting small, overweighting highly probable losses

Bank expected loss constraint:

- Binding during recapitalization, relaxed afterward
- Lagrange multiplier: Insignificant pre-crisis, positive during recapitalization (indicating undercapitalization), negative post-recapitalization (indicating risk-seeking preferences)



Before and during CPP

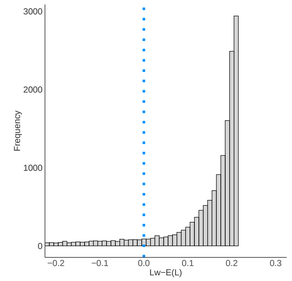


Before-during and after CPP

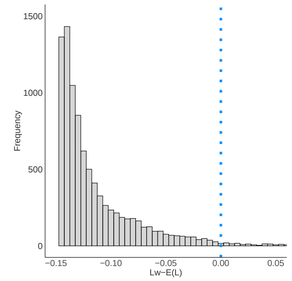
Figure 2: Probability weighting functions for losses based on GMM estimates of δ and γ in equation (4) across four different periods

The wedge between subjective and objective expected losses

The difference between subjective and objective losses (expected losses implied by expected utility) can be attributed to the joint impact of probability weighting and market conditions. Banks overweight losses before and during the CPP and underweight losses post-recapitalization.



Before-during CPP



After CPP

Figure 3: The difference between subjective and objective losses $L_W(\delta,\gamma) - E(L)$. Zero thresholds indicate that subjective expectations of losses match objective losses.

Key drivers of probability weighting

We explore why banks overweight or underweight losses and the economic factors contributing to probability distortions.

Driver	$L_W(\delta,\gamma)-E(L)$ Before and during CPP	$L_W(\delta,\gamma)-E(L)$ After CPP
Risk measures		
Market volatility	0.26^{*}	0.08^{***}
Idiosyncratic volatility	1.45^{***}	0.22^{***}
Beta	0.25^{***}	-0.004^{***}
Max loss	0.061^{***}	0.001
Default probabilities	1.96^{***}	0.1^{***}
Δ Default probabilities	20.92^{**}	6.79^{***}
Investor sentiment		
Max gain	-0.11^{***}	0.02^{***}
Betting against beta	0.03	-0.01^{**}
Performance	0.1^{***}	-0.010^{**}
Illiquidity measures		
TED spread	-0.302^{***}	0.142^{***}
Market illiquidity	-0.045^{***}	-0.005^{***}
Resolution of uncertainty		
Economic Policy Uncertainty	-0.22^{***}	-0.01^{**}
Δ Economic Policy Uncertainty	0.13^{***}	0.006

Table 1. Fixed-effects regression coefficients

The behavioral bias is linked to factors such as funding liquidity, prior gains and losses, market risk, investor sentiment, default probabilities, and policy uncertainty.

Main references

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[3] Amos Tversky and Daniel Kahneman. Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and uncertainty*, 5:297–323, 1992.