Funding Liquidity and Its Risk Premiums

Jaehoon Lee

University of Illinois at Urbana-Champaign

June 7, 2012

Summary

- A model is derived to explain that, during a crisis, large stocks' liquidity is more correlated with stock market returns than small stocks' liquidity.
- The estimated funding liquidity appears correlated
  - positively with aggregate hedge fund leverage ratios, stock market sentiments, and the total number of M&A activities
  - negatively with bond liquidity premiums, Moody's Baa-Aaa corporate bond spreads, and the relative prevalence of liquidity mergers
- The estimated funding liquidity forecasts stock market returns with strong significance

Summary

- A model is derived to explain that, during a crisis, large stocks' liquidity is more correlated with stock market returns than small stocks' liquidity.
- The estimated funding liquidity appears correlated
  - positively with aggregate hedge fund leverage ratios, stock market sentiments, and the total number of M&A activities
  - negatively with bond liquidity premiums, Moody's Baa-Aaa corporate bond spreads, and the relative prevalence of liquidity mergers
- The estimated funding liquidity forecasts stock market returns with strong significance

Summary

- A model is derived to explain that, during a crisis, large stocks' liquidity is more correlated with stock market returns than small stocks' liquidity.
- The estimated funding liquidity appears correlated
  - positively with aggregate hedge fund leverage ratios, stock market sentiments, and the total number of M&A activities
  - negatively with bond liquidity premiums, Moody's Baa-Aaa corporate bond spreads, and the relative prevalence of liquidity mergers
- The estimated funding liquidity forecasts stock market returns with strong significance

Asset and Funding Liquidity

- Asset liquidity: the ease with which an asset is traded (e.g.) bid-ask spreads
- Funding liquidity: the capacity for a trader to raise funds (e.g.) margin requirements
- These two are interconnected, but not identical : Kyle and Xiong (2001), Gromb and Vayanos (2002), Brunnermeier and Pedersen (2009)
- The question is how to estimate funding liquidity?

Previous Literature

Literature for measuring the funding liquidity

- Fontaine and Garcia (2012): difference in yields between on-the-run and off-the-run Treasury bonds
- Hu, Pan, and Wang (2011): price deviations of Treasury bonds
- Adrian and Shin (2009): the ratio of aggregate market-based liabilities to bank-based loans (1990–2008)
- Ang, Gorovyy, and van Inwegen (2011): hedge funds' aggregate leverage ratios (2005–2010)

Anecdote #1

Large (less volatile) stocks are preferred to small (more volatile) stocks during a financial crisis

- Ben-David, Franzoni, and Moussawi (2011, RFS)
  : hedge funds sold more high- than low-volatility stocks, and shifted their portfolio towards larger stocks during the financial crisis.

- Anand, Irvine, Puckett, and Venkataraman (2011)
  : smaller and more volatile stocks experience a more severe liquidity decline during the crisis.

Anecdote #2

Negative stock market returns are followed by a decline in stock liquidity

- Liquidity providers (both speculators and specialists) in aggregate are almost always net long on the stock market (94% of time from 1994 to 2004)
- Negative market returns lower their own capital and make them financially constrained
- Hameed, Kang, and Viswanathan (2010, JF)
- Comerton-Forde, Hendershott, Jones, Moulton, and Seasholes (2010, JF)

Key Intuition

- In good times, large and small stocks' liquidity would be equally correlated with market returns
- In bad times, large stocks' liquidity would be more correlated with market returns than small stocks' liquidity
- Thus, the difference of the two correlations can be used as a proxy of funding liquidity

The Economy

- Two dates : $t = 0, 1$
- Two risky assets
  - They are in fixed supply of one share for each
  - The distribution of terminal payoffs is known ex ante

$$v \sim \mathcal{N}(\, v_0, \, \Omega \,)$$

  - Asset 1 is larger and less volatile than Asset 2

$$v_0^{(1)} > v_0^{(2)} \quad \text{and} \quad \frac{\sigma_1}{v_0^{(1)}} < \frac{\sigma_2}{v_0^{(2)}}$$

- Three market participants : customer, speculator, financier

Agent 1: Customer

At time $t = 0$, a customer

- Holds the total fixed supplies of risky assets : $\mathbf{1}$
- Trades y shares to maximize his CARA utility at $t = 1$

$$\max_{y} E_0 \left[-\exp\left(-\gamma W_1^{(c)} \right) \right]$$

$$\text{s.t.} \quad W_1^{(c)} = p_0^\top \mathbf{1} + (v - p_0)^\top (y + \mathbf{1})$$

- Therefore,

$$y^* = \frac{1}{\gamma} \Omega^{-1} (v_0 - p_0) - \mathbf{1}$$

Agent 2: Speculator

A speculator

- Trades x shares to maximize his profits

$$\max_x E_0 \left[(v - p_0)^\top x \right] = \max_x (v_0 - p_0)^\top x$$

- Subject to margin constraints

$$|x_1|\, m_1 + |x_2|\, m_2 \leq W_0^{(s)}$$

Agent 3: Financier

A financier

- Determines the margin requirements based on Value-at-Risk (VaR) method

$$\pi = \mathrm{P}\left\{ \left| v^{(j)} - p_0^{(j)} \right| > m_j \right\}$$

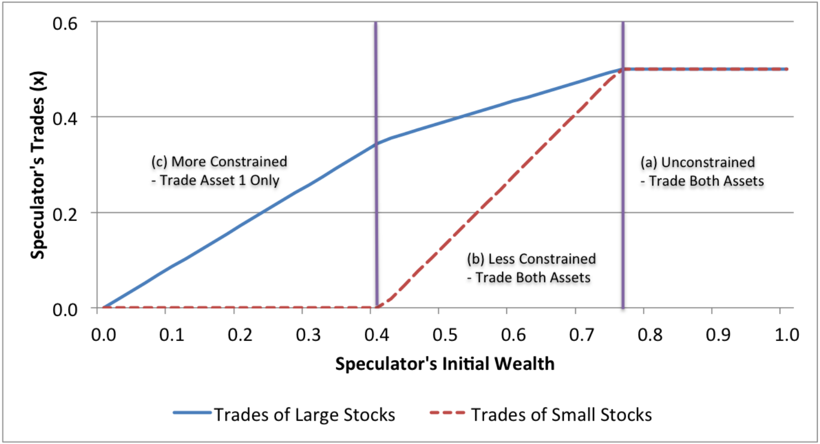
- Believes that the current price is the ex ante expected terminal payoff

$$v \sim \widehat{\mathcal{N}}(\, p_0,\, \Omega\,)$$

- Therefore,

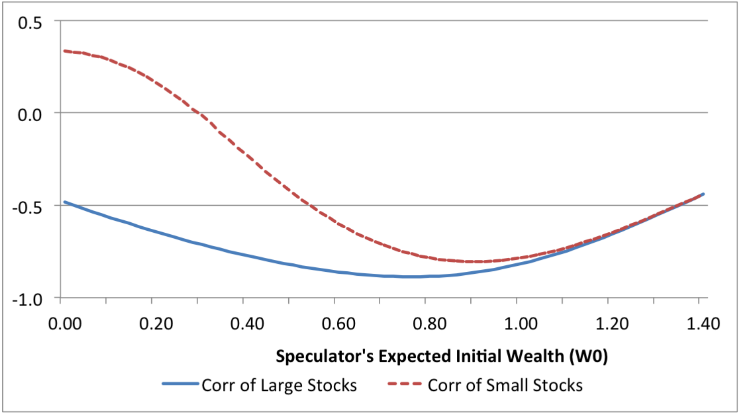
$$m_j = \Phi^{-1}(1-\pi) \cdot \sigma_j$$

Trades over Speculator's Initial Wealth



Simulated Price Impact of a Trade

- Price impact of a trade is defined as $\{p_0|_{\epsilon=0} - p_0|_{\epsilon=\hat{\epsilon}}\} / v_0$ where ϵ denotes an exogenous trade shock
- The speculator's initial wealth is simulated as $W_0^{(s)} + \eta$ where η denotes an exogenous shock to the speculator's capital



How to Estimate Funding Liquidity

- Asset liquidity for large and small stocks using the Amihud (2002) measure

$$illiq_t^{(i)} = \frac{1}{D_t} \sum_{d=1}^{D_t} \frac{|\, r_{i,t,d} \,|}{vol_{i,t,d}}$$

- Rolling correlations between stock market returns and asset liquidity

$$\rho_{\text{small}} = \text{corr}\,(\text{Stock Market Returns, Illiquidity of Small Stocks})$$
$$\rho_{\text{large}} = \text{corr}\,(\text{Stock Market Returns, Illiquidity of Large Stocks})$$

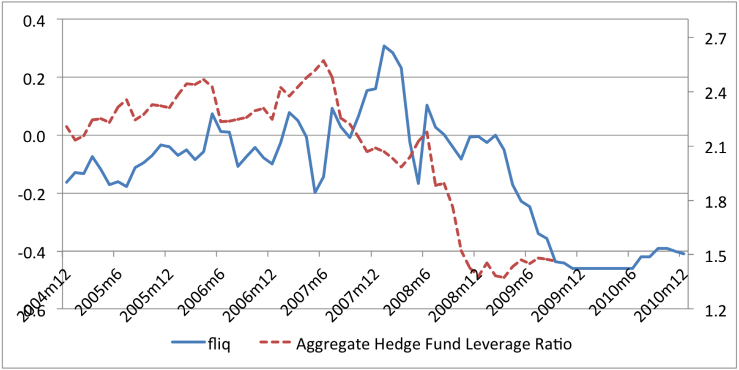
- Funding liquidity as their difference

$$fliq \equiv \rho_{\text{large}} - \rho_{\text{small}}$$

High *fliq* implies low funding liquidity

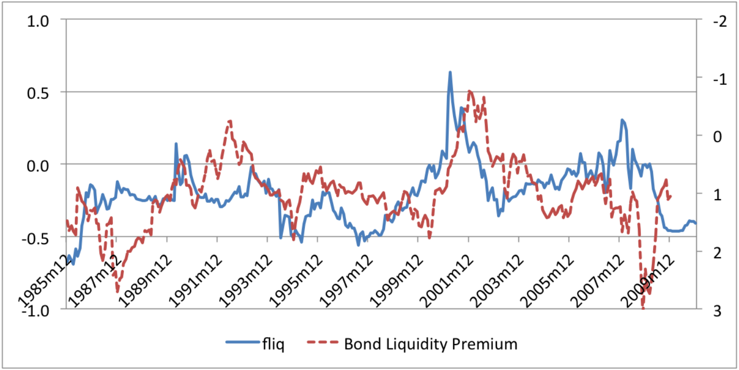
fliq and Aggregate Hedge Fund Leverage Ratio

- Provided by Ang, Gorovyy, and van Inwegen (2011)
- *fliq* is lagging behind the aggregate hedge fund leverage ratio

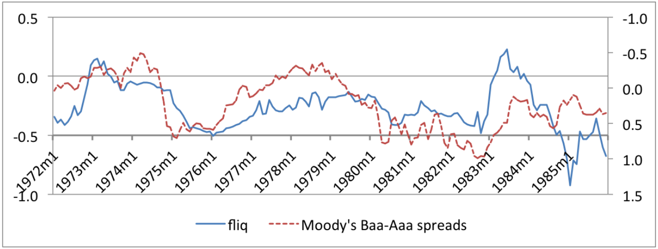


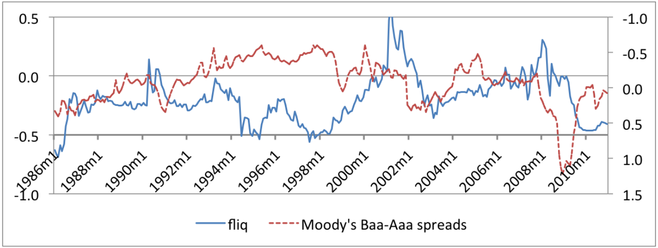
fliq and Bond Liquidity Premium

- Fontaine and Garcia (2012) estimate bond liquidity premiums using the difference of yields between on-the-run and off-the-run bonds



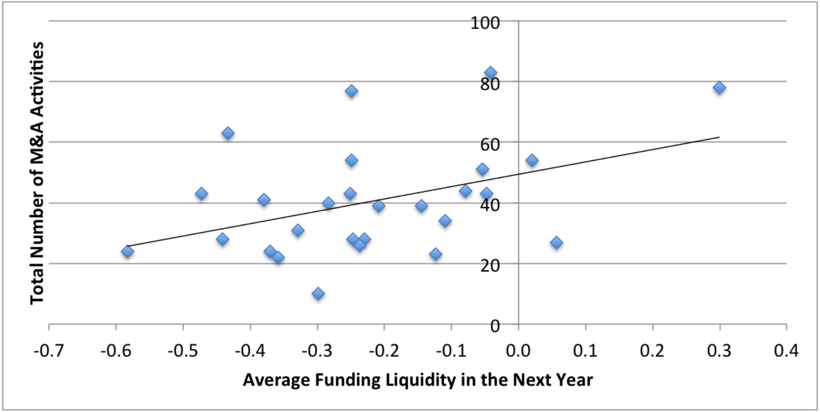
fliq and Moody's Baa-Aaa Spreads





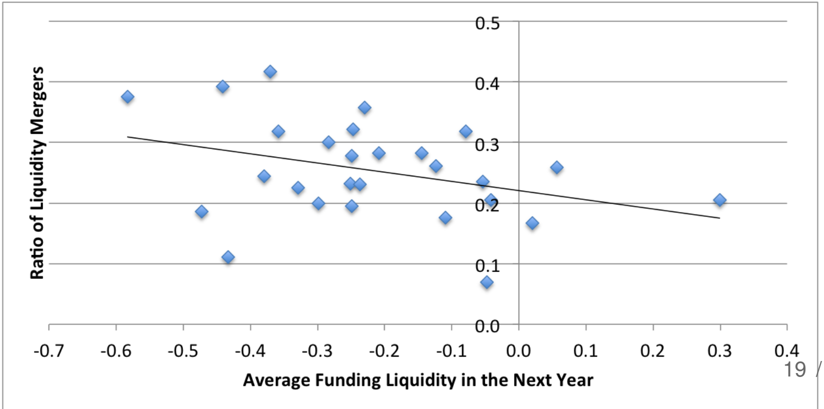
fliq and M&A Activities

- M&As are likely to be made more often when funding liquidity is high



fliq and Liquidity Mergers

- Almeida, Campello, and Hackbarth (2011): liquidity mergers are defined as liquid firms' acquiring financially distressed firms which would be otherwise inefficiently terminated
- Values are created by reallocating liquidity rather than by operational synergies



Real GDP Growth Forecast by Funding Liquidity

dep var: real GDP growth rate

Horizon (h)	1 qtr	2 qtr	3 qtr	4 qtr	5 qtr	6 qtr	7 qtr
Panel A. Regression on *fliq* $\equiv \rho_{\text{large}} - \rho_{\text{small}}$							
fliq	-0.996***	-1.270***	-1.160***	-1.183***	-0.992***	-0.876***	-0.645*
	(-2.975)	(-3.828)	(-3.518)	(-3.582)	(-2.967)	(-2.611)	(-1.933)
obs	234	233	232	231	230	229	228
R^2	0.037	0.060	0.051	0.053	0.037	0.029	0.016
Panel B. Regression on *fliq* and Yield Curve Slope							
fliq	-0.940***	-1.197***	-1.104***	-1.134***	-0.954***	-0.854**	-0.625*
	(-2.845)	(-3.712)	(-3.419)	(-3.516)	(-2.913)	(-2.566)	(-1.882)
slope	0.221***	0.297***	0.262***	0.270***	0.259***	0.173**	0.151*
	(2.833)	(3.912)	(3.439)	(3.527)	(3.320)	(2.168)	(1.886)
obs	234	233	232	231	230	229	228
R^2	0.069	0.118	0.098	0.102	0.082	0.049	0.032

In-Sample Predictability Test

Dependent Variable
: Stock market excess returns in the next month

	(1)	(2)	(3)	(4)	(5)	(6)
ρ_{small}	3.268***		0.837		2.062**	
	(3.720)		(0.892)		(2.419)	
ρ_{large}	-2.431***			0.837		-0.492
	(-2.874)			(0.892)		(-0.568)
$\rho_{large} - \rho_{small}$		-2.931***	-2.431***	-3.268***		
		(-3.926)	(-2.874)	(-3.720)		
$\log(CAPE)$	-0.469	-0.419	-0.469	-0.469	-0.695*	-0.634
	(-1.145)	(-1.073)	(-1.145)	(-1.145)	(-1.662)	(-1.447)
obs	779	779	779	779	779	779
R^2	0.020	0.019	0.020	0.020	0.013	0.004

Horse Race Tests

Dependent variable: stock market excess returns in the next month

	(1)	(2)	(3)	(4)	(5)
$\rho_{\text{large}} - \rho_{\text{small}}$	-2.931*** (-3.926)	-2.782*** (-2.911)	-3.077*** (-2.997)	-2.598*** (-3.344)	-2.638*** (-3.172)
$\log(CAPE)$	-0.419 (-1.073)	-1.611* (-1.829)	-0.741 (-1.457)	-0.805* (-1.878)	-0.311 (-0.652)
variance premium		28.826*** (4.915)			
market return variance			-0.014*** (-2.744)		
average stock variance			0.005*** (3.689)		
riskfree interest rate				-1.862** (-2.561)	
small-stock value spreads					-1.088 (-0.796)
obs	779	251	450	779	672
R^2	0.019	0.077	0.035	0.029	0.017

Reference: Goyal and Santa-Clara (2003), Ang and Bekaert (2007), Campbell and Vuolteenaho (2004)

Horse Race Tests (cont.)

Dependent variable: stock market excess returns in the next month

	(6)	(7)	(8)	(9)	(10)
$\rho_{\text{large}} - \rho_{\text{small}}$	-3.067*** (-4.140)	-3.134*** (-3.701)	-8.250*** (-3.453)	-8.417*** (-2.875)	-7.415*** (-3.050)
log($CAPE$)	-0.255 (-0.584)		-1.283 (-0.961)	0.323 (0.243)	0.308 (0.232)
Moody's Baa-Aaa spreads	0.345 (0.662)				
net payout yields		0.628 (0.874)			
consumption-wealth ratio (cay)			101.247*** (3.050)		95.377*** (2.682)
average correlation				23.328*** (3.821)	22.507*** (3.591)
obs	779	708	234	176	176
R^2	0.020	0.022	0.090	0.095	0.132

Reference: Chen, Roll, and Ross (1986), Boudoukh, Michaely, Richardson, and Roberts (2007), Lettau and Ludvigson (2001), Pollet and Wilson (2010)

Out-of-Sample Predictability Test

- Three steps of out-of-sample test

$$exr_s = \hat{\beta}_0 + \hat{\beta}^\top X_{s-1} + \epsilon_s, \quad s = 1, \cdots, t$$

$$\hat{\epsilon}_{t+1} = exr_{t+1} - \left(\hat{\beta}_0 + \hat{\beta}^\top X_t\right)$$

$$\text{RMSE} = \sqrt{\frac{1}{T - t_0} \sum_{t=t_0+1}^{T} \hat{\epsilon}_t^{\,2}}$$

- Models to Compare

$$\text{Model 1}: \quad exr_t = \mu + \epsilon_t$$

$$\text{Model 2A}: \quad exr_t = \mu + \beta_1 \rho_{\text{large},t-1} + \beta_2 \rho_{\text{small},t-1} + \epsilon_t$$

$$\text{Model 2B}: \quad exr_t = \mu + \beta \left(\rho_{\text{large},t-1} - \rho_{\text{small},t-1}\right) + \epsilon_t$$

Out-of-Sample Predictability Test

- Model 1 : constant risk premium
- Model 2 : time-varying risk premium

# in-sample	# predictions	RMSE1	RMSE2	R^2	ENC-T	ENC-REG	ENC-NEW
			Panel A. Prediction with ρ_{large} and ρ_{small}				
∼ Dec 2005	Jan 2006 ∼	5.431	5.348	0.030	1.30*	1.36*	1.60**
∼ Dec 2001	Jan 2002 ∼	4.807	4.729	0.032	1.71**	1.94**	2.87**
∼ Jul 1995	Aug 1995 ∼	4.873	4.812	0.025	1.81**	2.15**	4.51**
∼ Feb 1984	Mar 1984 ∼	4.625	4.595	0.013	1.87**	2.13**	5.68**
∼ Mar 1975	Apr 1975 ∼	4.579	4.559	0.008	1.93**	2.12**	6.40**
∼ Sep 1970	Oct 1970 ∼	4.664	4.634	0.013	2.27**	2.55**	8.06**
∼ Apr 1966	May 1967 ∼	4.649	4.622	0.011	2.27**	2.56**	8.17**
			Panel B. Prediction with $\rho_{\text{large}} - \rho_{\text{small}}$				
∼ Dec 2005	Jan 2006 ∼	5.431	5.347	0.030	1.58**	1.40*	1.48**
∼ Dec 2001	Jan 2002 ∼	4.807	4.729	0.032	2.04**	1.97**	2.73**
∼ Jul 1995	Aug 1995 ∼	4.873	4.812	0.025	1.91**	2.17**	4.48**
∼ Feb 1984	Mar 1984 ∼	4.625	4.593	0.014	2.01**	2.18**	5.81**
∼ Mar 1975	Apr 1975 ∼	4.579	4.557	0.010	2.09**	2.19**	6.66**
∼ Sep 1970	Oct 1970 ∼	4.664	4.630	0.015	2.51**	2.71**	8.60**
∼ Apr 1966	May 1967 ∼	4.649	4.618	0.013	2.50**	2.71**	8.73**

Predictability for Subsamples

sample periods	All 1928 ∼ 2010	Pre-WW2 1928 ∼ 1945	Post-WW2 1946 ∼ 2010	Bretten Woods 1946 ∼ 1970	Pre-Volcker 1971 ∼ 1985	Post-Volcker 1986 ∼ 2010
Panel A. Regression on Two Rolling Correlations						
ρ_{small}	2.691**	2.532	3.268***	2.562*	4.329***	4.598***
	(2.415)	(0.686)	(3.720)	(1.686)	(2.991)	(3.304)
ρ_{large}	-1.181	-3.011	-2.431***	-2.172	-1.980	-1.519
	(-1.024)	(-0.667)	(-2.874)	(-1.345)	(-1.038)	(-1.274)
$\log(CAPE)$	-1.366**	-6.283***	-0.469	-1.875**	-2.174	-1.701**
	(-2.441)	(-2.752)	(-1.145)	(-2.450)	(-1.587)	(-2.378)
obs	984	205	779	300	180	299
R^2	0.018	0.053	0.020	0.024	0.046	0.034
Panel B. Regression on the Difference of Two Rolling Correlations						
$\rho_{\text{large}} - \rho_{\text{small}}$	-2.042*	-2.610	-2.931***	-2.423*	-3.639***	-3.193***
	(-1.918)	(-0.708)	(-3.926)	(-1.688)	(-2.841)	(-3.019)
$\log(CAPE)$	-1.348**	-6.184***	-0.419	-1.807**	-2.269	-0.943
	(-2.387)	(-2.944)	(-1.073)	(-2.501)	(-1.608)	(-1.392)
obs	984	205	779	300	180	299
R^2	0.016	0.053	0.019	0.023	0.041	0.026

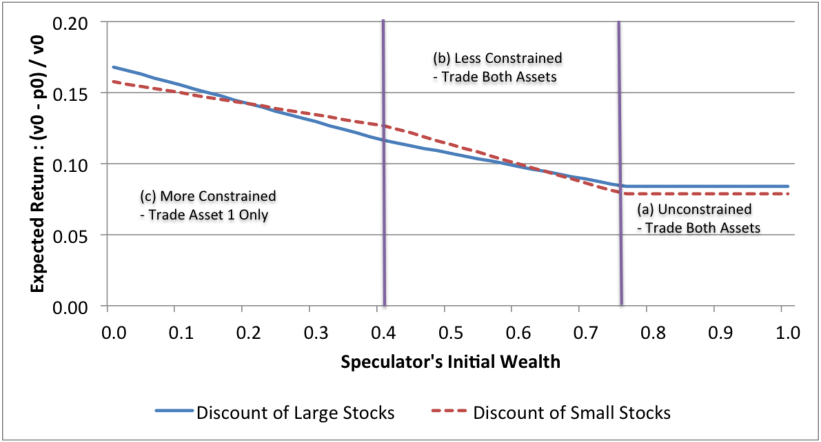
Summary

- A model is derived to explain why speculators first withdraw from small stocks and then from large stocks during a liquidity crisis
- The estimated funding liquidity appears correlated
  - positively to aggregate hedge fund leverage ratios, stock market sentiments, and the total number of M&A activities
  - negatively to bond liquidity premiums, Moody's Baa-Aaa corporate bond spreads, and the relative prevalence of liquidity mergers
- The estimated funding liquidity forecasts stock market returns with strong significance

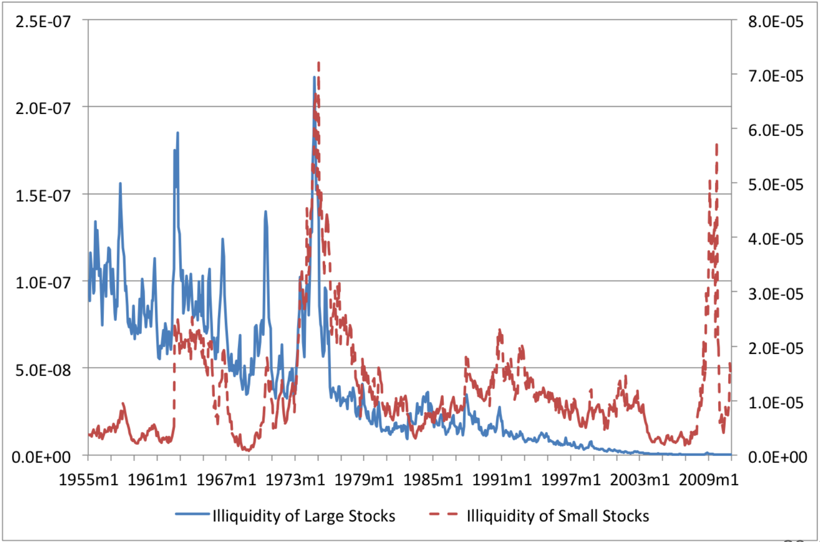
BACK-UP SLIDES

BACK-UP SLIDES

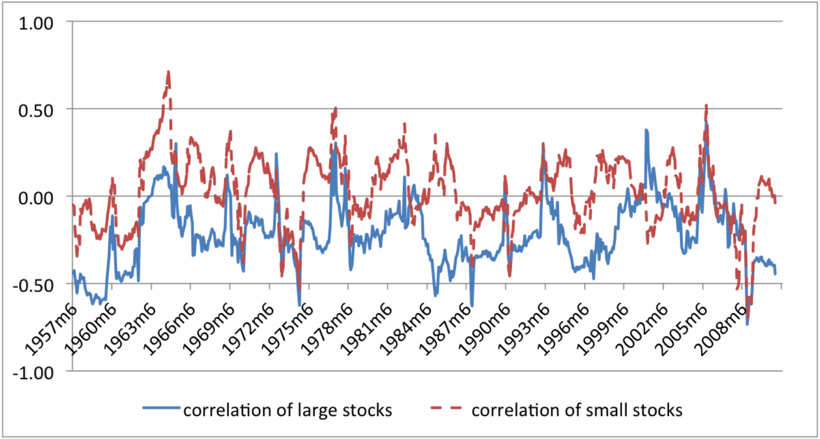
Expected Returns over Speculator's Initial Wealth



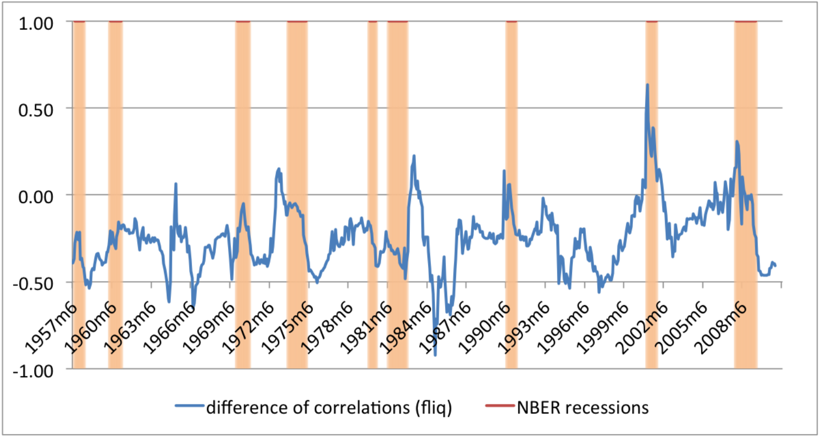
Small- and Large-Stock Illiquidity



Rolling Correlations of Market Returns with Small- and Large-Stock Illiquidity

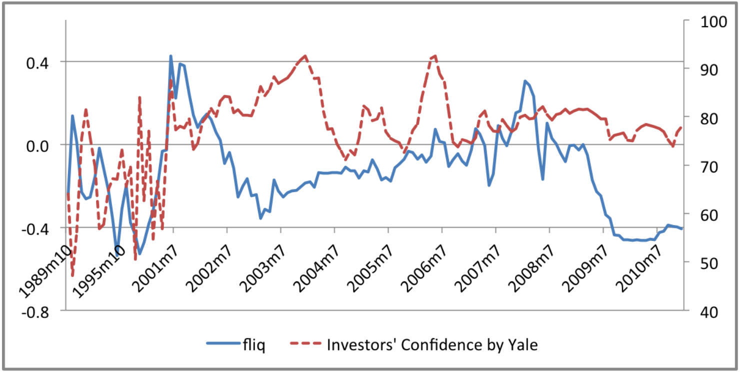


Difference of the Two Rolling Correlations



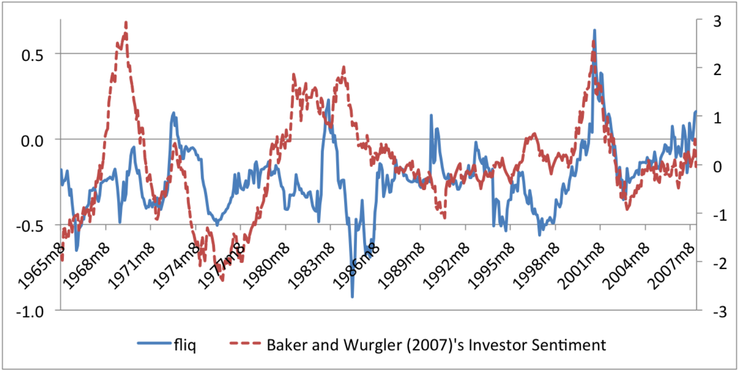
Stock Market Confidence Index

- Survey by the Yale School of Management



Baker and Wurgler (2007)'s Sentiment Index

- Baker and Wurgler (2007)'s sentiment index is estimated as the first principal component of the following six variables: closed-end fund discount, detrended log turnover, number of IPOs, first-day return on IPOs, dividend premium, and equity share in new issues.



Trading Strategies

- The portfolio consists of two assets
  : riskfree assets and stock market mutual funds
- Estimate the percentile of $\Delta\rho_t$ from its previous history

$$x_t = p\left(\Delta\rho \leq \Delta\rho_t \,|\, \rho_1, \cdots, \rho_{t-1}\right)$$
$$= \frac{1}{t-1}\sum_{s=1}^{t-1} \mathcal{I}\left\{\Delta\rho_s \leq \Delta\rho_t\right\}$$

- Use the percentile to decide the weight of stocks

$$\theta_t = \bar{\theta} - x_t\left(\bar{\theta} - \underline{\theta}\right) \in \left[\underline{\theta}, \bar{\theta}\right]$$

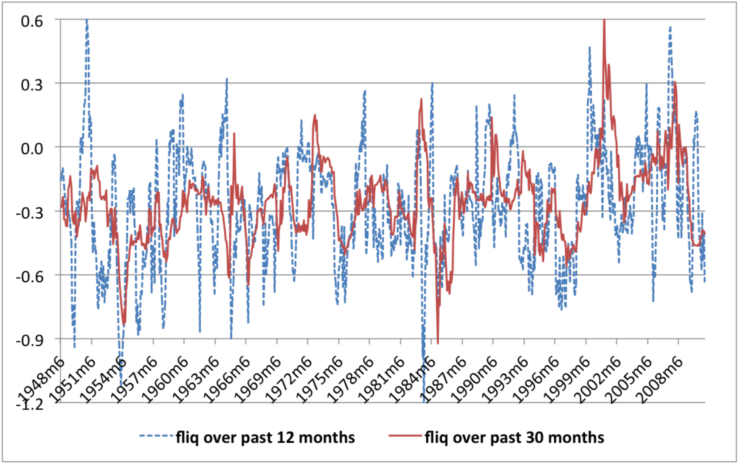
- Portfolio return is given by

$$R_{p,t+1} = \theta_t\left(R_{m,t+1} - R_{f,t}\right) + R_{f,t}$$

Trading Strategies: Sharpe Ratio

	Stocks Only $\theta = 1$	Riskfree Only $\theta = 0$	Strategy 1 $\theta \in [0, 1]$	Strategy 2 $\theta \in [0, 2]$	Strategy 3 $\theta \in [-1, 2]$
Panel A. Portfolio Holding Returns ($R_{p,t+1}$)					
average	0.908	0.452	0.856	1.259	1.206
stdev	4.685	0.253	2.272	4.545	4.431
Panel B. Portfolio Excess Returns ($R_{p,t+1} - R_{f,t}$)					
average	0.456	0	0.404	0.807	0.754
stdev	4.696	0	2.279	4.559	4.437
Sharpe Ratio	0.097	.	0.177	0.177	0.170

Different Rolling Window Horizons: Estimation



Different Rolling Window Horizons: Predictability

horizon	12 months	18 months	24 months	30 months	36 months	42 months
Panel A. Regression on Two Rolling Correlations						
ρ_{small}	1.301**	1.516**	2.653***	3.385***	3.483***	4.029***
	(2.389)	(1.991)	(3.158)	(3.811)	(3.246)	(3.575)
ρ_{large}	-0.083	0.083	-1.962**	-2.606***	-2.836***	-3.401***
	(-0.115)	(0.089)	(-2.344)	(-3.107)	(-3.141)	(-3.803)
$\log(CAPE)$	-0.656	-0.691	-0.500	-0.455	-0.527	-0.551
	(-1.515)	(-1.588)	(-1.184)	(-1.087)	(-1.299)	(-1.356)
obs	768	762	756	750	744	738
R^2	0.011	0.011	0.017	0.022	0.022	0.025
Panel B. Regression on the Difference of Two Rolling Correlations						
$\rho_{\text{large}} - \rho_{\text{small}}$	-0.830	-0.948	-2.397***	-3.071***	-3.188***	-3.715***
	(-1.552)	(-1.314)	(-3.385)	(-4.124)	(-3.659)	(-4.261)
$\log(CAPE)$	-0.614	-0.618	-0.463	-0.415	-0.500	-0.530
	(-1.431)	(-1.469)	(-1.135)	(-1.033)	(-1.279)	(-1.338)
obs	768	762	756	750	744	738
R^2	0.007	0.007	0.016	0.021	0.021	0.025

Reference

Adrian, Tobias, and Hyun Song Shin, 2009, Money, Liquidity, and Monetary Policy, *American Economic Review* 99, 600–605.

Almeida, Heitor, Murillo Campello, and Dirk Hackbarth, 2011, Liquidity mergers, *Journal of Financial Economics* 102, 558–526.

Amihud, Yakov, 2002, Illiquidity and stock returns: cross-section and time-series effects, *Journal of Financial Markets* 5, 31–56.

Anand, Amber, Paul J. Irvine, Andy Puckett, and Kumar Venkataraman, 2011, Market Crashes and Institutional Trading, *working paper*.

Ang, Andrew, and Geert Bekaert, 2007, Stock Return Predictability: Is it There?, *Review of Financial Studies* 20, 651–707.

Ang, Andrew, Sergiy Gorovyy, and Gregory B. van Inwegen, 2011, Hedge fund leverage, *Journal of Financial Economics* 102, 102–126.

Baker, Malcolm, and Jeffrey Wurgler, 2007, Investor Sentiment in the Stock Market, *The Journal of Economic Perspectives* 21, 129–151.

Ben-David, Itzhak, Francesco Franzoni, and Rabih Moussawi, 2011, Hedge Fund Stock Trading in the Financial Crisis of 2007-2009, *Review of Financial Studies* 25, 1–54.

Boudoukh, Jacob, Roni Michaely, Matthew Richardson, and Michael R. Roberts, 2007, On the Importance of Measuring Payout Yield: Implications for Empirical Asset Pricing, *The Journal of Finance* 62, 877–915.

Brunnermeier, Markus K., and Lasse Heje Pedersen, 2009, Market Liquidity and Funding Liquidity, *Review of Financial Studies* 22, 2201–2238.

Campbell, John Y., and Tuomo Vuolteenaho, 2004, Bad Beta, Good Beta, *The American Economic Review* 94, 1249–1275.

Chen, Nai-Fu, Richard Roll, and Stephen A. Ross, 1986, Economic Forces and the Stock Market, *The Journal of Business* 59, 383–403.

Comerton-Forde, Carole, Terrence Hendershott, Charles M. Jones, Pamela C. Moulton, and Mark S. Seasholes, 2010, Time Variation in Liquidity : The Role of Market-Maker Inventories and Revenues, *The Journal of Finance* 65, 295–331.

Fontaine, Jean-Sébastien, and René Garcia, 2012, Bond Liquidity Premia, *Review of Financial Studies* 25, 1207–1254.

Goyal, Amit, and Pedro Santa-Clara, 2003, Idiosyncratic Risk Matters!, *The Journal of Finance* 58, 975–1008.

Gromb, Denis, and Dimitri Vayanos, 2002, Equilibrium and welfare in markets with financially constrained arbitrageurs, *Journal of Financial Economics* 66, 361–407.