Asset Betas under Regime-Switching Market Illiquidity and Return Innovations

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Outline

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- The illiquidity cost, C_t^i, is modeled as the per-share cost of selling security i

Definitions

- Asset i (gross) return and relative illiquidity cost:

$$r_t^i = \frac{D_t^i + P_t^i}{P_{t-1}^i} \quad \text{and} \quad c_t^i = \frac{C_t^i}{P_{t-1}^i}$$

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$$r_t^M = \frac{\sum_i S^i (D_t^i + P_t^i)}{\sum_i S^i P_{t-1}^i} \quad \text{and} \quad c_t^M = \frac{\sum_i S^i C_t^i}{\sum_i S^i P_{t-1}^i}$$

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$$\mathbb{E}_t[r^i_{t+1} - c^i_{t+1}] = r^f + \lambda_t \frac{\text{Cov}_t(r^i_{t+1} - c^i_{t+1}, r^M_{t+1} - c^M_{t+1})}{\text{Var}_t(r^M_{t+1} - c^M_{t+1})}$$

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where $\lambda_t = \mathbb{E}_t[r^M_{t+1} - c^M_{t+1} - r^f]$ is the risk premium and r^f is the risk-free rate of return

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$$\begin{aligned}
\mathbb{E}_t[r^i_{t+1}] &= r^f + \mathbb{E}_t[c^i_{t+1}] \\
&\quad + \lambda_t \frac{\mathrm{Cov}_t(r^i_{t+1}, r^M_{t+1})}{\mathrm{Var}_t(r^M_{t+1} - c^M_{t+1})} + \lambda_t \frac{\mathrm{Cov}_t(c^i_{t+1}, c^M_{t+1})}{\mathrm{Var}_t(r^M_{t+1} - c^M_{t+1})} \\
&\quad - \lambda_t \frac{\mathrm{Cov}_t(r^i_{t+1}, c^M_{t+1})}{\mathrm{Var}_t(r^M_{t+1} - c^M_{t+1})} - \lambda_t \frac{\mathrm{Cov}_t(c^i_{t+1}, r^M_{t+1})}{\mathrm{Var}_t(r^M_{t+1} - c^M_{t+1})}.
\end{aligned}$$

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- $\text{Cov}_t(c^i_{t+1}, r^M_{t+1})$: disposition of investors to accept a lower expected return on a security that is liquid in a down market

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$$\beta^{i1} = \frac{\text{Cov}\left(r_t^i, r_t^M - \mathbb{E}_{t-1}[r_t^M]\right)}{\text{Var}\left((r_t^M - \mathbb{E}_{t-1}[r_t^M]) - (c_t^M - \mathbb{E}_{t-1}[c_t^M])\right)}$$

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$$\beta^{i2} = \frac{\text{Cov}\left(c_t^i - \mathbb{E}_{t-1}[c_t^i], c_t^M - \mathbb{E}_{t-1}[c_t^M]\right)}{\text{Var}\left((r_t^M - \mathbb{E}_{t-1}[r_t^M]) - (c_t^M - \mathbb{E}_{t-1}[c_t^M])\right)}$$

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$$\beta^{i3} = \frac{\text{Cov}\left(r_t^i, c_t^M - \mathbb{E}_{t-1}[c_t^M]\right)}{\text{Var}\left((r_t^M - \mathbb{E}_{t-1}[r_t^M]) - (c_t^M - \mathbb{E}_{t-1}[c_t^M])\right)}$$

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$$\beta^{i4} = \frac{\text{Cov}\left(c_t^i - \mathbb{E}_{t-1}[c_t^i], r_t^M - \mathbb{E}_{t-1}[r_t^M]\right)}{\text{Var}\left((r_t^M - \mathbb{E}_{t-1}[r_t^M]) - (c_t^M - \mathbb{E}_{t-1}[c_t^M])\right)}$$

Empirical methodology

Illiquidity measure

For stock i in month t its illiquidity measure is

$$\mathrm{ILLIQ}_{it} = \frac{1}{D_{it}} \sum_{d=1}^{D_{it}} \frac{|r_{itd}|}{\mathrm{VOL}_{itd}},$$

where:

- r_{itd} be the percentage return of stock i on day d of month t
- D_{it} is the number of days for which data is available for stock i in month t
- VOL_{itd} is daily trading volume in PEN
- Used in Amihud (2002) and Acharya and Pedersen (2005)

Market portfolio return and illiquidity

With the selected stocks we form an equally weighted market portfolio, P, for each month t. If r_t^i and w_t^{iP} are the percentage return and the weight P of stock i in month t, then the return, the un-normalized and the normalized illiquidity of P in t are given by

$$\begin{aligned} r_t^P &= \sum_{i \in n_t^P} w_t^{iP} \times r_t^i, \\ \text{ILLIQ}_t^P &= \sum_{i \in n_t^P} w_t^{iP} \times \text{ILLIQ}_{it}, \\ c_t^P &= \sum_{i \in n_t^P} w_t^{iP} \times c_t^i, \end{aligned}$$

Illiquidity measure

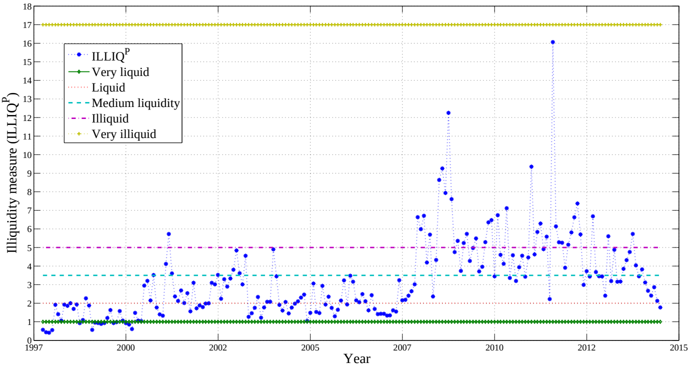

Figure: Monthly evolution of ILLIQ_t^P for the period 10/1997-07/2014 and liquidity states

Illiquidity innovations

Since ILLIQ_{it} does not directly measure the cost of a trade, we relate it to c_t^i using the following

$$c_t^i = \min\left(0.25 + 0.41 \times \text{ILLIQ}_{it} \times \overline{P}_{t-1}, 45.00\right);$$

where

- $\overline{P}_{t-1}$ represents the ratio of the total average trading volume (in millon PEN) of portfolio P during month $t-1$ and its corresponding value when $t = 0$
- Coefficients 0.25 and 0.41 were derived from Table 1 of Chalmers and Kadlec (1998)

Illiquidity measure (selected BVL stocks)

TICKER	Av. $ILLIQ_i$	Liquidity State	Av. c^i	IGBVL at 07/2014
VOLCABC1	0.01	Very liquid	0.26	YES
MINSUR1	0.08	Very liquid	0.31	YES
EDELNOC1	0.93	Very liquid	0.89	YES
CASAGRC1	1.04	Liquid	0.93	YES
MIRL	1.07	Liquid	1.18	YES
TUMANC1	1.85	Liquid	1.64	NO
VP	2.13	Medium liquidity	1.05	NO
RCZ	2.70	Medium liquidity	2.71	NO
LGC	3.20	Medium liquidity	2.79	NO
BACKUYES1	3.72	Illiquid	3.66	NO
IFS	3.84	Illiquid	3.49	YES
BROCALC1	4.67	Illiquid	3.17	NO
MINCORI1	6.80	Very illiquid	6.08	NO
LUISAI1	33.37	Very illiquid	18.85	NO
ANDINBC1	98.13	Very illiquid	40.28	NO

Illiquidity innovations

To compute market illiquidity innovations, $c_t^P - \mathbb{E}_{t-1}[c_t^P]$, we introduce the following

$$\begin{aligned} 0.25 + 0.41\overline{\text{ILLIQ}}_t^P \overline{P}_{t-1} &= \overline{a_0} + \overline{a_1}(0.25 + 0.41\overline{\text{ILLIQ}}_{t-1}^P)\overline{P}_{t-1} \\ &+ \overline{a_2}(0.25 + 0.41\overline{\text{ILLIQ}}_{t-2}^P)\overline{P}_{t-1} + u_t^P, \end{aligned}$$

where $u_t^P \sim \text{iid} \;\; \text{N}(0, \sigma^2)$ and

$$\overline{\text{ILLIQ}}_t^P = \sum_{i \in n_t^P} w_t^{iP} \times \min\left(\text{ILLIQ}_{it}, \frac{45.00 - 0.25}{0.41\overline{P}_{t-1}}\right).$$

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Then, $u_t^P := c_t^P - \mathbb{E}_{t-1}[c_t^P]$ and the same procedure can be applied to $u_t^i := c_t^i - \mathbb{E}_{t-1}[c_t^i]$

Market illiquidity innovations

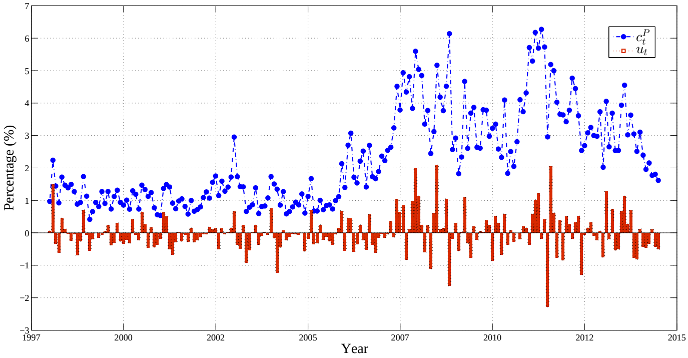

Figure: Monthly evolution of market illiquidity innovations, u_t^P, and market normalized illiquidity, c_t^P, for the period 10/1997-07/2014.

Illiquidity regimes

Considering the following equation

$$\text{ILLIQ}_t^P \overline{P}_{t-1} = a_0 + a_1 \text{ILLIQ}_{t-1}^P \overline{P}_{t-1} + a_2 \text{ILLIQ}_{t-2}^P \overline{P}_{t-1} + \epsilon_t^P,$$

and $\epsilon_t^P \sim \text{iid} \;\; \text{N}(0, \vartheta^2)$.

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and $\epsilon_t^P \sim \text{iid} \;\; \text{N}(0, \vartheta^2)$.

The two-state Markov regime-switching version of the equation above is

$$\text{ILLIQ}_t^P \overline{P}_{t-1} = a_{0,s_t} + a_{1,s_t} \text{ILLIQ}_{t-1}^P \overline{P}_{t-1} + a_{2,s_t} \text{ILLIQ}_{t-2}^P \overline{P}_{t-1} + \tilde{\epsilon}_t^P,$$

where the unobserved variable $s_t \in \{L, H\}$ evolves according to the first order Markov-switching process and $\tilde{\epsilon}_t^P \sim \text{iid} \;\; \text{N}(0, \vartheta_{s_t}^2)$.

Illiquidity regimes: calibration results

Parameter	Coeff.	Std. Error	Robust S.E.	t-value	t-prob
a_0	0.793	0.367	-	2.16	0.032
a_1	0.446	0.095	-	4.70	0.000
a_2	0.446	0.088	-	5.07	0.000
ϑ	3.742	-	-	-	-
$a_{0,H}$	4.486	1.515	1.260	3.56	0.000
$a_{0,L}$	0.524	0.203	0.307	1.70	0.000
$a_{1,H}$	0.403	0.107	0.108	3.74	0.000
$a_{1,L}$	0.558	0.095	0.135	4.14	0.000
$a_{2,H}$	0.245	0.125	0.126	1.94	0.054
$a_{2,L}$	0.238	0.082	0.109	2.19	0.030
ϑ_H	5.701	0.472	1.166	4.89	0.000
ϑ_L	0.958	0.073	0.112	8.52	0.000
p_H	0.982	0.007	0.010	98.40	0.000
p_L	0.993	0.007	0.010	98.40	0.000

Illiquidity regimes: calibration results

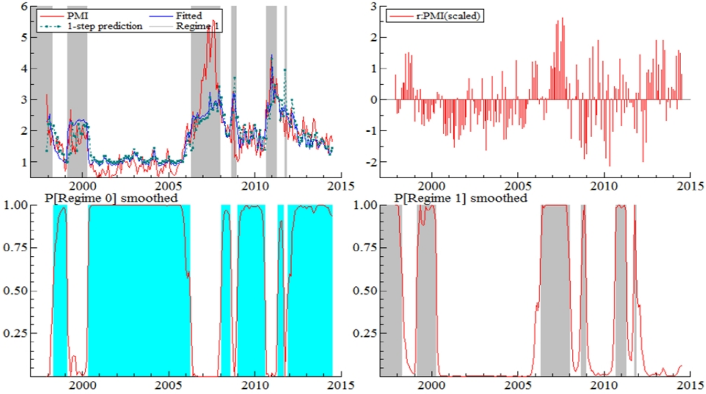

Figure: Transition probabilities for the regime-switching model

Market return innovations

The innovations in the market portfolio return

$$\xi_t^P = r_t^P - \mathbb{E}_{t-1}[r_t^P],$$

are determined using the following an AR(2) model

$$r_t^P = \theta_0 + \theta_1 r_{t-1}^P + \theta_2 r_{t-2}^P + \xi_t^P, \quad \text{with} \quad \xi_t^P \sim \text{iid} \;\; \text{N}(0, \nu^2).$$

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The two-state Markov regime-switching version of the equation above is

$$r_t^P = \theta_{0,v_t} + \theta_{1,\mathrm{R}} r_{t-1}^P + \theta_{2,\mathrm{R}} r_{t-2}^P + \tilde{\xi}_t^P,$$

where $v_t \in \{L^P, H^P\}$ and $\tilde{\xi}_t^P \sim \text{iid} \;\; \mathrm{N}(0, \nu_{v_t}^2)$.

Market return regimes: calibration results

Parameter	Coeff.	Std. Error	Robust S.E.	t-value	t-prob
θ_0	0.017	0.008	-	2.14	0.035
θ_1	0.182	0.070	-	2.60	0.010
θ_2	0.270	0.068	-	4.00	0.000
ν	0.061	-	-	-	-
$\theta_{0,H}$	0.009	0.009	0.009	1.00	0.317
$\theta_{0,L}$	0.008	0.004	0.005	1.84	0.067
$\theta_{1,R}$	0.241	0.072	0.080	3.02	0.003
$\theta_{2,R}$	0.244	0.070	0.071	3.47	0.001
ν_H	0.078	0.007	0.007	11.1	0.000
ν_L	0.041	0.004	0.004	9.71	0.000
p_{H^P}	0.972	0.023	0.021	47.2	0.000
p_{L^P}	0.980	0.023	0.021	47.2	0.000

Market return regimes: calibration results

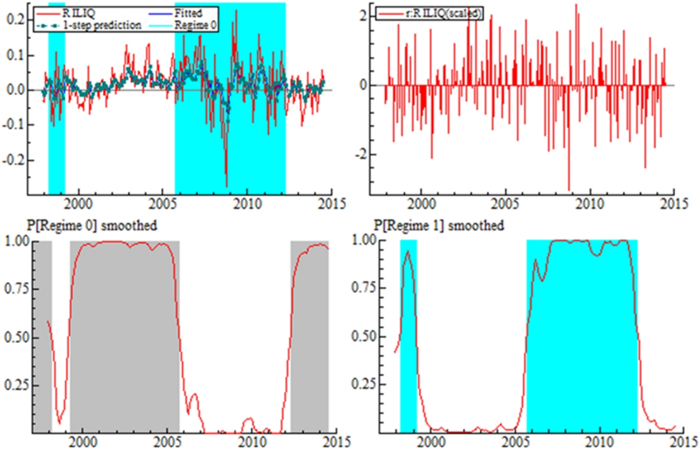
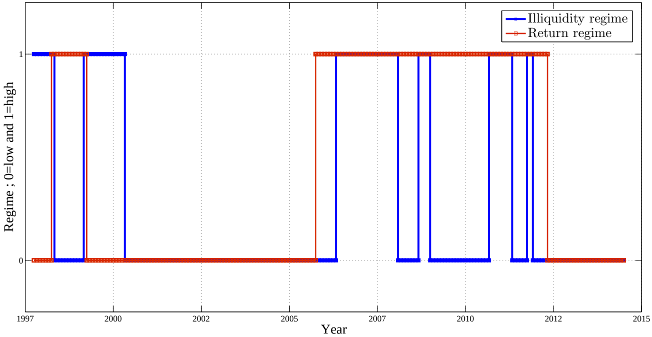


Figure: Transition probabilities for the regime-switching model

Illiquidity and market return regimes: comparison



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Beta estimation

Asset i betas can be expressed as

$$\beta^{i1} = \frac{\text{Cov}\left(r_t^i, \xi_t^P\right)}{\text{Var}\left(\xi_t^P - u_t^P\right)}, \quad \beta^{i2} = \frac{\text{Cov}\left(u_t^i, u_t^P\right)}{\text{Var}\left(\xi_t^P - u_t^P\right)},$$

$$\beta^{i3} = \frac{\text{Cov}\left(r_t^i, u_t^P\right)}{\text{Var}\left(\xi_t^P - u_t^P\right)}, \quad \beta^{i4} = \frac{\text{Cov}\left(u_t^i, \xi_t^P\right)}{\text{Var}\left(\xi_t^P - u_t^P\right)}.$$

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where u_t^P is the innovation in normalized market illiquidity, ξ_t^P is the innovation in market portfolio return, and u_t^i is the innovation in normalized illiquidity for asset i.

Beta estimation: numerical results ($\times 100$)

Stock	Regime	β^1	β^2	β^3	β^4	Net beta
VOLCABC1	Full sample	141.44	0.00	-4.27	-0.01	145.72
(Very liquid)	Low mkt illiquidity	157.36	0.00	-2.98	-0.01	160.35
$c^i = 0.26\%$	High mkt illiquidity	123.25	0.00	-5.90	-0.01	129.16
	Low mkt return	167.14	0.00	-1.05	-0.01	168.20
	High mkt return	136.57	0.00	-4.95	-0.01	141.53
FERREYC1	Full sample	59.13	-0.01	-2.71	0.08	61.75
(Very liquid)	Low mkt illiquidity	48.99	0.00	-2.37	0.06	51.30
$c^i = 0.34\%$	High mkt illiquidity	76.29	-0.02	-3.62	0.12	79.76
	Low mkt return	34.21	-0.01	-0.92	0.39	34.73
	High mkt return	66.45	-0.01	-3.31	-0.01	69.76
ALICORP	Full sample	49.89	0.15	-1.59	-0.03	51.66
(Very liquid)	Low mkt illiquidity	37.71	0.17	-0.45	0.09	38.24
$c^i = 0.52\%$	High mkt illiquidity	69.04	0.09	-3.22	-0.16	72.51
	Low mkt return	65.57	0.18	2.49	-0.40	63.66
	High mkt return	44.98	0.14	-2.97	0.08	48.01

Beta estimation: numerical results ($\times$100)

Stock	Regime	β^1	β^2	β^3	β^4	Net beta
TELEFBC1	Full sample	74.70	0.19	-3.14	-1.04	79.07
(Liquid)	Low mkt illiquidity	69.37	0.24	-3.75	-1.54	74.91
$c^i = 1.25\%$	High mkt illiquidity	83.19	0.06	-2.34	-0.24	85.83
	Low mkt return	112.06	0.14	-4.08	-0.13	116.40
	High mkt return	64.34	0.17	-2.87	-1.25	68.63
BACKUSI1	Full sample	28.65	2.32	-1.05	-14.68	46.70
(Illiquid)	Low mkt illiquidity	29.97	1.44	-0.02	-7.91	39.34
$c^i = 3.66\%$	High mkt illiquidity	25.96	3.45	-2.50	-25.51	57.41
	Low mkt return	46.08	0.97	-0.98	0.64	47.39
	High mkt return	23.55	2.45	-1.10	-19.33	46.43
BROCALC1	Full sample	148.45	0.38	-3.73	-9.22	161.79
(Illiquid)	Low mkt illiquidity	146.15	0.95	-1.10	-15.65	163.84
$c^i = 3.17\%$	High mkt illiquidity	151.75	-0.34	-7.19	0.53	158.07
	Low mkt return	180.29	-0.12	5.10	-17.55	192.61
	High mkt return	140.44	0.46	-6.01	-7.08	153.99

Beta estimation: numerical results ($\times 100$)

Stock	Regime	β^1	β^2	β^3	β^4	Net beta
BAP	Full sample	70.98	0.69	-2.10	2.98	70.79
(Very illiquid)	Low mkt illiquidity	69.77	1.41	-1.53	1.58	71.12
$c^i = 4.44\%$	High mkt illiquidity	73.41	-0.25	-3.08	4.64	71.60
	Low mkt return	68.93	3.90	-0.42	-3.12	76.37
	High mkt return	71.39	-0.45	-2.76	4.83	68.87
SCCO	Full sample	88.46	0.33	-2.26	-2.02	93.08
(Very illiquid)	Low mkt illiquidity	85.38	0.73	-1.33	-5.50	92.95
$c^i = 4.61\%$	High mkt illiquidity	93.94	-0.31	-4.02	3.77	93.88
	Low mkt return	90.98	2.05	0.88	-2.65	94.80
	High mkt return	87.71	-0.17	-3.19	-1.84	92.57
SCOTIAC1	Full sample	107.30	2.59	-4.72	-7.98	122.60
(Very illiquid)	Low mkt illiquidity	111.50	3.74	-2.69	-7.71	125.65
$c^i = 4.88\%$	High mkt illiquidity	100.99	0.91	-8.45	-8.41	118.76
	Low mkt return	107.30	2.59	-4.72	-7.98	122.60
	High mkt return	108.01	1.38	-6.71	-9.79	125.88

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- To do: work with portfolios instead of individual assets, compute the liquidity-adjusted market risk premium, and compare with other emerging markets

Thank you