New Liquidity Risk in a Multi-period Investment Horizon

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1. Introduction

Liquidity in the stock market means how quickly an investor's position can be liquidated without a change in stock prices. In this study, I analytically derive new illiquidity risks in the context of the changing investment opportunity set of Merton (1973)'s Intertemporal Capital Asset Pricing Model (CAPM), which are distinct from the three illiquidity risks of Acharya and Pedersen (2005). Also, using the multivariate GARCH model and employing equity factors, bond factors, and macroeconomic factors as state variables to estimate the new illiquidity risks, I find that these risks are priced in the cross-section. Based on such findings, I argue that my new illiquidity risks can be added to the asset pricing literature, which can further be used in various related areas, such as fund performance evaluation, portfolio management, etc.

Acharya and Pedersen (2005) develop an equilibrium model that incorporates illiquidity level and three illiquidity risks to the traditional CAPM, assuming a single period. The first illiquidity risk is the commonality in illiquidity, which refers to the comovement of an individual stock's illiquidity and the market illiquidity. Chordia, Roll, and Subrahmanyam (2000), Hasbrouck and Seppi (2001), Huberman and Halka (2001), Karolyi, Lee, and van Dijk (2011), Brockman, Chung and Perignon (2009) further investigate this issues. The second illiquidity risk is the covariance between an individual stock's return and the market illiquidity. Pastor and Stambaugh (2003), Liu (2006), Watanabe and Watanabe (2007), and Korajczyk and Sadka (2008) investigate whether this source of risk is priced. The last illiquidity risk is the covariance between a stock's illiquidity and the market return. Acharya and Pedersen (2005) highlight this as the most important type of illiquidity risk.

In addition to the three illiquidity risks of Acharya and Pedersen (2005), this study analytically derive new sources of illiquidity risk in the context of the changing investment opportunity set of Merton (1973)'s Intertemporal CAPM. To be more specific, I identify the covariance between an individual stock's illiquidity and a state variable as a new source of illiquidity risks. For an empirical test, I select 10 of the variables known to reflect a shift in the investment opportunity set and use them as proxies for state variables. There are three categories of state variable proxies: (1) equity market factors, i.e. SMB, HML, and UMD; (2) bond market factors, i.e. term spread and default spread; and (3) macroeconomic factors, i.e. federal funds rate, unemployment rate, industrial production growth rate, the percent change in the CPI, and the percent change in energy prices. While Acharya and Pedersen's (2005) empirical test is based on the unconditional model, I test the conditional version liquidity-adjusted asset pricing model using the multivariate GARCH model. Among many empirically feasible multivariate GARCH models, I follow Bollerslev's (1990) specification due to the relatively small number of unknown parameters. Finally, I find that among the new sources of illiquidity risks, the covariance between a stock's illiquidity and SMB, default spread, federal funds rate, the percent change in the CPI, and the percent change in energy prices are priced.

The remainder of the study proceeds as follows. In Section 2, I derive the new source of liquidity risk in the context of Merton (1973)'s Intertemporal CAPM. In Section 3, I explain the conditional liquidity risk estimation in the multivariate GARCH framework. In Section 4, I introduce the data and illiquidity measures used in the study. Section 5 presents the empirical results, and Section 6 concludes.

2. New source of liquidity risk in the changing investment opportunities[1]

Acharya and Pedersen (2005) suggest a theoretical model that reveals how asset prices are connected to liquidity risks. They obtain a liquidity-adjusted CAPM based on the standard CAPM. The model shows that illiquidity level and three illiquidity risks, proxied by covariances of an individual stock with the market return and the market illiquidity, affect a stock's expected return, assuming a stochastic illiquidity cost per share and risk averse agents in a single-period investment horizon. In other words, the conditional expected gross return of security *i* in equilibrium is

$$E_t\left(r_{t+1}^i - c_{t+1}^i\right) = r^f + E_t(r_{t+1}^m - c_{t+1}^m - r^f)\frac{cov_t\left(r_{t+1}^i - c_{t+1}^i, r_{t+1}^m - c_{t+1}^m\right)}{var_t(r_{t+1}^m - c_{t+1}^m)} \quad (1)$$

$$= r^f + \gamma_t cov_t\left(r_{t+1}^i - c_{t+1}^i, r_{t+1}^m - c_{t+1}^m\right)$$

where γ_t is the price of covariance risk at time *t* defined as

$$\gamma_t = \frac{E_t(r_{t+1}^m - c_{t+1}^m - r^f)}{var_t(r_{t+1}^m - c_{t+1}^m)} \quad (2)$$

Eq. (1) can be rewritten as

$$E_t\left(r_{t+1}^i\right) = r^f + E_t(c_{t+1}^i) + \gamma_t cov_t\left(r_{t+1}^i, r_{t+1}^m\right) + \gamma_t cov_t\left(c_{t+1}^i, c_{t+1}^m\right)$$

$$-\gamma_t cov_t\left(r_{t+1}^i, c_{t+1}^m\right) - \gamma_t cov_t\left(c_{t+1}^i, r_{t+1}^m\right) \quad (3)$$

where r_{t+1}^i is stock *i*'s return, c_{t+1}^i is stock *i*'s relative illiquidity cost, r_{t+1}^m is market return, and c_{t+1}^m is relative market illiquidity cost. Eq. (3) states that the expected return is the sum of the expected relative illiquidity cost, $E_t(c_{t+1}^i)$, and four covariance risks times the price of risks. Besides the conventional market risk, $cov_t\left(r_{t+1}^i, r_{t+1}^m\right)$, Acharya and Pedersen (2005) develop

[1] The derivation of this section is based on CH 12, 13 of G. Pennacchi's *Theory of Asset Pricing.*

three additional sources of illiquidity risks to which they also give economic meanings. With respect to the commonality in liquidity, $cov_t\left(c_{t+1}^i, c_{t+1}^m\right)$, the authors explain that investors require extra premium for holding a stock that becomes more illiquid in an illiquid market. For a stock with positive $cov_t\left(r_{t+1}^i, c_{t+1}^m\right)$, investors are willing to accept a lower return because it should yield a higher return in an illiquid market. For a stock with positive $cov_t\left(c_{t+1}^i, r_{t+1}^m\right)$, investors are willing to accept a lower return because it has lower trading cost during market downturns.

Extending the findings of Acharya and Pedersen (2005), I consider the liquidity-adjusted CAPM in a multi-period investment horizon with changing investment opportunities. Merton (1973)'s Intertemporal CAPM provides a theoretical framework of this assumption. Following Merton (1973)'s intertemporal CAPM, I assume investors maximize a time-separable expected utility function in a continuous-time environment.

$$J(W, x, t) = \max_{C_s, \{\omega_{i,s}\}, \forall s, i} E_t\left[\int_t^T U(C_s, s)\, ds\right] \tag{4}$$

where C_t is the induvidual's rate of consumption per unit time at time *t*. W is defined as the value of the individual's wealth portfolio. Utility function $U(C_t, t)$ is assumed to be strictly increasing and concave in C_t.

Also, the following constraints are applied in maximizing the objective function.

$$dW = \left[\sum_{i=1}^{n} \omega_i\,(dS_i/S_i - dG_i) + \left(1 - \sum_{i=1}^{n} \omega_i\right) r dt\right] W - C dt \tag{5}$$

$$\frac{dS_i}{S_i} = \mu_i(x, t)dt + \sigma_i(x, t)dz_i \tag{6}$$

$$dG_i = \delta_i(x, t)dt + \lambda_i(x, t)dy_i \tag{7}$$

$$dx = a(x, t)dt + b(x, t)d\zeta \tag{8}$$

Eq. (5) describes the dynamics of wealth: r is the risk-free asset return, and ω_i is the proportion of total wealth allocated to risky asset i. Eq. (6) shows risky asset i's instantaneous return where $S_{i,t}$ is the price of risky asset *i* at time *t*. The return distribution of risky asset *i* depends on state variable x. In this framework, investors face changes in the investment opportunity set. dG_i and dx describe instantaneous changes in relative illiquidity costs of risky asset *i* and a state variable process, respectively. dz_i, dy_i and $d\zeta$ follow a pure Brownian motion process. Therefore, each individual maximizes Eq. (4) subject to Eq. (5), controlling C_s and $\omega_{i,s}$ at time s from *t* to T. After applying Bellman's Principle of Optimality,

$$J(\mathrm{W_t}, x_\mathrm{t}, \mathrm{t}) = \max_{C_s,\{\omega_{i,s}\},\forall s,i} E_t\left[\int_t^{t+\Delta t} U(C_s,s)\,ds + \max_{C_s,\{\omega_{i,s}\},\forall s,i} E_t\left[\int_{t+\Delta t}^{T} U(C_s,s)\,ds\right]\right]$$

$$= \max_{C_s,\{\omega_{i,s}\},\forall s,i} E_t\left[\int_t^{t+\Delta t} U(C_s,s)\,ds + J(W_{t+\Delta t}, x_{t+\Delta t}, t+\Delta t)\right] \quad (9)$$

Taylor series at $\mathrm{W_t}, x_\mathrm{t}$ and t give the following equation,

$$J(\mathrm{W_t}, x_\mathrm{t}, \mathrm{t}) = \max_{C_s,\{\omega_{i,s}\},\forall s,i} E_t[U(C_t)\Delta t + J(W_t, x_t, t) + J_W \Delta W + J_x \Delta x + J_t \Delta t + \tfrac{1}{2} J_{WW}(\Delta W)^2 +$$

$$\tfrac{1}{2} J_{xx}(\Delta x)^2 + \tfrac{1}{2} J_{tt}(\Delta t)^2 + J_{xt}(\Delta x)(\Delta t) + J_{xW}(\Delta x)(\Delta W) + J_{Wt}(\Delta W)(\Delta t) + o(\Delta t)] \quad (10)$$

where Δt is a short interval of time and $o(\Delta t)$ is a higher-order term which is almost zero as $\Delta t \to 0$. Substituting the approximated version of Eq. (8) into Eq. (10), dividing both sides by Δt, and taking the limit as $\Delta t \to 0$ after subtracting $J(\mathrm{W_t}, x_\mathrm{t}, \mathrm{t})$ from both sides, I have

$$0 = \max_{C_s,\{\omega_{i,s}\}} E_t\left[U(C_t) + J_t + \left[\sum_{i=1}^{n} \omega_i\,(\mu_i - \delta_i - r)W + (rW - C)\right] J_W + aJ_x + \tfrac{1}{2}W^2\left[\sum_{i=1}^{n}\sum_{j=1}^{n} \sigma_{ij}\omega_i\omega_j\right] J_{WW}\right.$$

$$\left. + \tfrac{1}{2}W^2\left[\sum_{i=1}^{n}\sum_{j=1}^{n} \lambda_{ij}\omega_i\omega_j\right] J_{WW} - \tfrac{1}{2}W^2\left[\sum_{i=1}^{n}\sum_{j=1}^{n} \psi_{ij}\omega_i\omega_j\right] J_{WW} - \tfrac{1}{2}W^2\left[\sum_{i=1}^{n}\sum_{j=1}^{n} \tau_{ij}\omega_i\omega_j\right] J_{WW}\right.$$

$$+\frac{1}{2}b^2J_{xx} + WJ_{xw}\sum_{i=1}^{n}\varphi_i\omega_i + WJ_{xw}\sum_{i=1}^{n}\pi_i\omega_i\Bigg] \quad (11)$$

Now, I have a first order condition given the concavity of $U(.)$,

$$0 = U_c(C^*, t) - J_w(W, x, t) \quad (12)$$

$$0 = (\mu_i - \delta_i - r)J_W + \left[\sum_{j=1}^{n}\sigma_{ij}\omega_j^* + \sum_{j=1}^{n}\lambda_{ij}\omega_j^* - \sum_{j=1}^{n}\psi_{ij}\omega_j^* - \sum_{j=1}^{n}\tau_{ij}\omega_j^*\right]WJ_{WW} + [\varphi_i - \pi_i]J_{Wx} \quad (13)$$

where $\sigma_{ij}dt = (\sigma_i dz_i)(\sigma_j dz_j)$, $\lambda_{ij}dt = (\lambda_i dy_i)(\lambda_j dy_j)$, $\psi_{ij}dt = (\sigma_i dz_i)(\lambda_j dy_j)$, $\tau_{ij}dt = (\lambda_i dy_i)(\sigma_j dz_j)$, $\varphi_i dt = (\sigma_i dz_i)(bd\zeta)$, and $\pi_i dt = (\lambda_i dy_i)(bd\zeta)$.

Next, I divide Eq. (13) of individual *p*'s optimal choice by J_{WW}^p, with the superscript *p* denoting individual *p* and bold type describe *n* assets vector,

$$\boldsymbol{\mu} - \boldsymbol{\delta} - r\boldsymbol{e} = \gamma\boldsymbol{\sigma B} + \gamma\boldsymbol{\lambda B} - \gamma\boldsymbol{\psi B} - \gamma\boldsymbol{\tau B} + \theta\boldsymbol{\varphi} - \theta\boldsymbol{\pi} \quad (14)$$

where $\gamma \equiv -\sum_p W^p / \sum_p(J_W^p/J_{WW}^p)$, $\boldsymbol{B} \equiv \sum_p \boldsymbol{\omega^p} W^p / \sum_p W^p$, . and $\theta \equiv -\sum_p(J_{Wx}^p/J_{WW}^p) / \sum_p(J_W^p/J_{WW}^p)$. $\boldsymbol{B}$ is the average investment in each asset across investors and the market weight in equilibrium. Hence, *i*th asset is

$$\mu_i - \delta_i - r = \gamma\sigma_{im} + \gamma\lambda_{im} - \gamma\psi_{im} - \gamma\tau_{im} + \theta\varphi_i - \theta\pi_i \quad (15)$$

Eq. (15) is a natural generalization of the Acharya and Pedersen (2005) model with two additional risks with changing investment opportunities dependent on state variable x in a multi-period horizon.

For an empirical test, I use an econometric specification similar to that of Acharya and Pedersen (2005),

$$E_t(r_{t+1}^i - r) = \alpha + \gamma_0 E_t(c_{t+1}^i) + \gamma_1 cov_t(r_{t+1}^i, r_{t+1}^m) +$$

$$\gamma_2 cov_t(c_{t+1}^i, c_{t+1}^m) + \gamma_3 cov_t(r_{t+1}^i, c_{t+1}^m) + \gamma_4 cov_t(c_{t+1}^i, r_{t+1}^m) +$$

$$\theta_1 cov_t\left(r_{t+1}^i, x_{t+1}\right) + \theta_2 cov_t\left(c_{t+1}^i, x_{t+1}\right) \tag{16}$$

where r_{t+1}^i is stock *i*'s return, c_{t+1}^i is stock *i*'s relative illiquidity cost, r_{t+1}^m is market return, and c_{t+1}^m is relative market illiquidity cost. Eq. (16) states that the expected return is the sum of expected relative illiquidity cost, $E_t(c_{t+1}^i)$, and six covariances. In this model, I newly add another illiquidity risk, $cov_t\left(c_{t+1}^i, x_{t+1}\right)$, in addition to (1) the conventional market risk, $cov_t\left(r_{t+1}^i, r_{t+1}^m\right)$, (2) the risk related to state variable x, $cov_t\left(r_{t+1}^i, x_{t+1}\right)$, and (3) the three illiquidity risks of Acharya and Pedersen (2005), $cov_t\left(c_{t+1}^i, c_{t+1}^m\right)$, $cov_t\left(r_{t+1}^i, c_{t+1}^m\right)$, and $cov_t\left(c_{t+1}^i, r_{t+1}^m\right)$. In other words, what is distinct from Acharya and Pedersen's (2005) findings in my model is that a new source illiquidity risk related to changing investment opportunities is added in a multi-period investment horizon.

With respect to the covariance between an individual stock's return and state variables, investors require an additional compensation for a stock that yields a lower return in a bad state. A stock with a higher return in a bad state provides investors with a hedging opportunity for consumption smoothing. On the other hand, investors are willing to accept a lower return for a stock that has a higher return in a bad state. Note that a bad state is defined as a change in *x* such that consumption decreases for a given wealth. Therefore, when $\frac{\partial C_{consumption}}{\partial x} > 0$ and $cov_t\left(r_{t+1}^i, x_{t+1}\right) > 0$, θ_1 should be positive.

Also, with respect to the new illiquidity risk, $cov_t\left(c_{t+1}^i, x_{t+1}\right)$, investors are willing to accept a lower return for a stock that has a lower illiquidity in a bad state. A stock with a lower illiquidity in a bad state provides investors with a hedging opportunity for consumption smoothing, so investors would require a premium for stocks with a higher illiquidity in a bad state. Thus, when the market is in a bad state, i.e. $\frac{\partial C_{onsumption}}{\partial x} > 0$, and $cov_t(c_{t+1}^i, x_{t+1})$>0, θ_2 should be negative.

3. Conditional liquidity risk estimation in the multivariate GARCH framework

For the cross-sectional test of liquidity-adjusted CAPM, Acharya and Pedersen (2005) derive an unconditional version of the LCAPM. In this study, I employ a multivariate generalized autoregressive conditional heteroskedasticity (GARCH) model for the cross-sectional test of Eq. (16), which is a conditional version of the LCAPM. Eq. (17) describes the econometric specification of Eq. (16).

$$E_t(r_{t+1}^i - r^f) = \alpha + \gamma^0 E_t(c_{t+1}^i) + \gamma^1 cov_t(r_{t+1}^i, r_{t+1}^m) + \gamma^2 cov_t(c_{t+1}^i, c_{t+1}^m) + \gamma^3 cov_t(r_{t+1}^i, c_{t+1}^m) + \gamma^4 cov_t(c_{t+1}^i, r_{t+1}^m) + \gamma^5 cov_t(r_{t+1}^i, x_{t+1}) + \gamma^6 cov_t(c_{t+1}^i, x_{t+1}). \tag{17}$$

First, I estimate conditional covariance in the multivariate GARCH framework using Bollerslev's (1990) model.[2] Also, using the estimated conditional covariance, I run the Fama-MacBeth (1972) regression to obtain the coefficients and *t*-values. Note that the expected illiquidity level, $E_t(c_{t+1}^i)$, is estimated as a predicted value from the AR(2) specification.

Bollerslev (1990) introduces a multivariate GARCH model assuming constancy of the conditional correlation as follows. Bollerslev's (1990) constant conditional correlation GARCH decomposes the conditional covariance into the conditional variance and the constant correlation.

[2] For estimation, Kevin Sheppard's UCSD Toolbox is used. (http://www.kevinsheppard.com)

$$\boldsymbol{R_t}|\boldsymbol{F_t} \sim \boldsymbol{N}(\boldsymbol{0}, \boldsymbol{H_t}),$$

$$\boldsymbol{H_t} = \boldsymbol{D_t}\boldsymbol{\rho}\boldsymbol{D_t}, \tag{18}$$

where $\boldsymbol{R_t}$ is $N \times 1$ vector, $\boldsymbol{H_t}$ is the conditional covariance matrix at time *t*, and $\boldsymbol{D_t}$ is a diagonal matrix with the conditional standard deviation, $\sqrt{\sigma_{ii,t}}$, of *i* asset on (*i*,*i*). The conditional variances are specified using a univariate GARCH (1, 1) process,

$$\sigma_{ii,t} = \alpha_0 + \alpha_1 r_{i,t-1}^2 + \alpha_2 \sigma_{ii,t-1} \tag{19}$$

Constant conditional correlation, $\boldsymbol{\rho}$**,** is

$$\boldsymbol{\rho} = (\rho_{ij})_{ij}\ , (\ i = j\ then\ \rho_{ii} = 1) \tag{20}$$

Thus,

$$\boldsymbol{H_t} = (\rho_{ij}\sqrt{\sigma_{ii,t}}\sqrt{\sigma_{jj,t}})_{ij} \tag{21}$$

The conditional covariance matrix is the product of conditional standard deviations and the conditional correlations, so the variation in the conditional covariance is attributable to the conditional variance. The constant correlation assumption allows a simple parameterization in the multivariate GARCH in contrast to other multivariate GARCH models. And it has an advantage that the conditional covariance matrix, $\boldsymbol{H_t}$, is almost surely positive definite for all *t*.

Then, the likelihood function for maximum likelihood estimation for unknown parameter vector, **φ**, is as follows:

$$L_t(\boldsymbol{\varphi}) = -\frac{1}{2} log|\boldsymbol{H_t}| - \frac{1}{2}\boldsymbol{R_t'}\boldsymbol{H_t^{-1}}\boldsymbol{R_t} \tag{22}$$

4. Data and illiquidity measure

My sample covers all NYSE, AMEX, and NASDAQ stocks over the period of January 1965 ~ December 2011 and is constructed at the monthly frequency. The stock data is retrieved from the Center for Research in Security Prices (CRSP) and only common stocks are included (share code: 10, 11). The sample is composed of stocks with at least 36-month data available. Three equity factors (SMB, HML, and UMD) are obtained from Kenneth French's online data library.[3] Term spread, default spread and federal funds rate are obtained from the H.15 database of Board of Governors of the Federal Reserve System. Unemployment rate and energy prices are obtained from the Bureau of Labor Statistics of the U.S. Department of Labor and the World Bank, respectively. The Industrial Production Index and the Consumer Price Index are from the Economic Research Division of the Federal Reserve Bank of St. Louis.

As a proxy for illiquidity, Amihud's (2002) price impact measure is employed. Goyenko, Holden, and Trzcinka (2009) examine various illiquidity measures to identify high quality proxies, and they find that Amihud's measure performs well in measuring illiquidity. Also, Amihud's illiquidity measure is used in many other studies such as Acharya and Pedersen (2005). Amihud (2002) proposes that price impact proxy of stock *i* in month *t* as,

$$Illiq_{i,t} = monthly\ average(|r_d|/dVol_d), \tag{23}$$

where r_d is daily return and $dVol_d$ means daily volume in dollars. High $Illiq_{i,t}$ means that a stock price reacts highly sensitively to a given change in a dollar volume. Following Pastor and Stambaugh (2003) and Acharya and Pedersen (2005), I scale Amihud's measure by the ratio of the capitalization of the market portfolio at the end of month *t*-1 and of the market portfolio at the end

[3] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

of July 1962. This is not only to make Amihud's measure stationary but also to adjust the time trend due to the amount of change in dollars over time.

5. Empirical results

5.1. Correlations of factors and the estimated covariance risks

<Insert Table 1 here>

Table 1 and Table 2 provide descriptive statistics of the main variables. Table 1 describes the correlations among 10 state variables considered in this study. The table shows that the two bond factors are correlated with four of the macroeconomic variables. That is, the correlations of term spread with unemployment rate, industrial production growth rate, the percent change in the CPI, and the percent change in energy prices stands at 0.518, -0.179, -0.520, and -0.285 at the 1% significance level, respectively. Also, default spread has a correlation coefficient of 0.632, -0.620, 0.265, and -0.149 at the 1% significance level, with the four macroeconomic variables, respectively. Also, these four macroeconomic variables are highly correlated with one another at least at the statistical significance level of 1%, with an exception of the correlation between percent-change industrial production and percent-change energy prices. Thus, it is possible to conjecture that these variables are important candidates for state variables as they capture similar aspects of a shift in the investment opportunity set.

The UMD (Up-Minus-Down) factor, or the momentum factor, is statistically significantly correlated with default spread and other macroeconomic variables. This suggests that the momentum phenomenon is related with macroeconomic aspects as noted by Liu and Zhang (2008) and Chordia and Shivakumar (2002). Thus, the momentum factor can also be a state variable proxy in Merton (1973)'s framework. Although SMB and HML are mainly uncorrelated with other macroeconomic variables, they are still important candidates for state variables because they capture other aspects of a shift in the investment opportunity set. Thus, it is important to investigate the relation between these proxies and consumption in order to check in which way these proxies move when consumption falls. This is an important issue in the subsequent section.

<Insert Table 2 here>

Table 2 displays the correlation coefficients of newly-suggested illiquidity risks with market risk, Acharya and Pedersen's (2005) illiquidity risks, and Merton's (1973) state variable-related risks. Recall from Section 2 that the new illiquidity risks refer to the covariances between an individual stock's illiquidity and the state variables. If the new illiquidity risks are truly distinct from existing risks, such as market risk, Acharya and Pedersen (2005)'s illiquidity risks and Merton's (1973) state variable-related risks, their correlation coefficients should be small in magnitude. Note that the correlation coefficients in Table 2 are mostly below 0.05, with only 9 values scoring higher than 0.3. Therefore, it is possible to say that the new illiquidity risks are legitimate proxies as they are almost uncorrelated with existing risks.

5.2. Relation between consumption and 10 state variable proxies.

<Insert Table 3 here>

With respect to the given state variable proxies, it is still unknown in which direction those proxies move when there is an unfavorable shift in the investment opportunity set. This is an important issue in order to confirm whether the signs on the prices of illiquidity risk are correctly estimated. An unfavorable shift in the investment opportunity set is defined as a change in a state variable that comes with a consumption decrease for a given level of wealth. Thus, to figure out how each state variable is related to the investment opportunity set, I regress the percent change in consumption on each state variable proxy. The results are given in Table 3.

In Table 3, the coefficients on SMB, industrial production growth rate, the percent change in the CPI and the percent change in energy prices are significant at the 1 % significance level and that on default spread is significant at the 5% significance level. Note that the coefficients on SMB and the percent change in industrial production are found with positive signs. Therefore, if SMB and industrial production growth are used as state variables, the coefficients on state variable risks, or $cov_t(r_{t+1}^i, x_{t+1})$, are expected with positive signs as investors require extra premium for stocks with a lower return when the consumption level is low. In contrast to SMB and industrial production growth rate, the coefficients on default spread, the percent change in the CPI, and the percent change in energy prices are negative. Therefore, if those variables used as state variables, the coefficients on $cov_t(r_{t+1}^i, x_{t+1})$ should yield negative signs because investor are willing to accept a lower return for stocks that provide a hedging opportunity for consumption smoothing.

If SMB and industrial production growth rate are used as state variables, the coefficients on the new illiquidity risks, or $cov_t(c_{t+1}^i, x_{t+1})$, should have negative signs because investors are willing to accept a lower return for highly liquid stocks in a bad state. Likewise, if default spread, the percent change in the CPI, and the percent change in energy prices are used as state variable proxies, the coefficients on $cov_t(c_{t+1}^i, x_{t+1})$ should be positive as investors should be compensated for high illiquidity in a bad state. Unless correct signs are found on the coefficients on the risks, a cautious interpretation of results is needed.

5.3. Analysis of new risks measured with equity factors as state variables

<Insert Table 4 here>

Table 4 to Table 6 report time-series averages of coefficients from the cross-sectional regressions and their *t*-values using Fama-MacBeth's (1973) method. Note that the *t*-values are computed using the Newey-West correction of standard errors for heteroscedasticity and autocorrelation. Accordingly, I use the following econometric model

$$E(r_{i,t} - r_f) = \alpha + \gamma_0 E(illiq) + \gamma_{1,t} Cov_{t-1}(r_{i,t}, r_{m,t})$$
$$+\gamma_{2,t} Cov_{t-1}(c_{i,t}, c_{m,t}) + \gamma_{3,t} Cov_{t-1}(r_{i,t}, c_{m,t}) + \gamma_{4,t} Cov_{t-1}(c_{i,t}, r_{m,t})$$
$$+\gamma_{5,t} Cov_{t-1}(r_{i,t}, x_t) + \gamma_{6,t} Cov_{t-1}(c_{i,t}, x_t), \quad (24)$$

where $\gamma_{1,t}$ is price of market risk at time *t*, and $\gamma_{2,t}$, $\gamma_{3,t}$, $\gamma_{4,t}$ and $\gamma_{6,t}$ are the prices of four illiquidity risks, respectively. Net illiquidity risk refers to the aggregated illiquidity risk of Acharya and Pedersen (2005), defined as $Cov_{t-1}(c_{i,t}, c_{m,t}) - Cov_{t-1}(r_{i,t}, c_{m,t}) - Cov_{t-1}(c_{i,t}, r_{m,t})$. Also, $\gamma_{5,t}$ measure the price of Merton's (1973) state variable-related risks. Note that the variable of interest is $\gamma_{6,t}$ because it measures the price of the new illiquidity risk.

In Table 4, equity factors, such as SMB, HML, and UMD, are used as x_t. In Panel A, Acharya and Pedersen's (2005) three illiquidity risks, denoted as illiquidity risk 1 to 3, are used for a conditional-version test of Acharya and Pedersen's (2005) empirical findings. It is worthwhile to note that the conditional version of Acharya and Pedersen's (2005) empirical test also yields significant coefficients on the existing illiquidity risks. The coefficients on illiquidity risk 1 to 3 are mostly statistically significant. Except for illiquidity risk 1, or commonality in illiquidity risk, with illiquidity level included in the specification, the gamma coefficients on illiquidity risks are significant at least at the 5% level. In both specifications, market risk is priced with high *t*-values, 2.31 and 2.45. Also, in both specifications, the price of illiquidity level is highly significant as found in Amihud and Mendelson (1986), Brennan and Subrahmanyam (1996), and Amihud (2002).

More importantly, Panel B, Panel C, and Panel D present the empirical tests of whether the new illiquidity risks, or the covariances between stock *i*'s illiquidity and state variable SMB, HML, and UMD, are priced, respectively. Panel E displays the empirical specifications that include the illiquidity risks measured with all three equity factors. In Panel B, the prices of the newly added risks are consistent with the previous conjectures. As stated in the previous section, the coefficient on the state variable risk, or $cov_t\left(r_{t+1}^i, x_{SMB,t+1}\right)$, should have a positive sign, while that on the new illiquidity risk, or $cov_t\left(c_{t+1}^i, x_{SMB,t+1}\right)$, should yield a negative sign. In the specification without illiquidity level, the new illiquidity risk has a significantly negative price of -0.026 (*t*-value=-3.38). In Panel E, the coefficient on the new illiquidity risk measured with SMB, or $cov_t\left(c_{t+1}^i, x_{SMB,t+1}\right)$, is again significant, scoring -0.0205 (*t*-value=-2.3).

5.4. Analysis in bond factors as state variables

<Insert Table 5 here>

The previous section shows that the new illiquidity risk measured with SMB is priced in the cross section of stock returns. In addition, Table 5 shows whether new illiquidity risks measured with state variables as bond market factors are priced. The state variables, or x_t in Eq. (24), used to estimate the new illiquidity risks are term spread and default spread. Also supporting the results from Table 4, market risk, illiquidity risk 1, illiquidity risk 2 and illiquidity risk 3 are all significantly priced.

More importantly, the new illiquidity risk measured with default spread, or $cov_t\left(c_{t+1}^i, x_{default\ spread,t+1}\right)$, is priced with the magnitude of 0.1194 (*t*-value=2.96) or 0.101 (*t*-value=2.67), depending on specifications. The state variable risk measured with term spread, or $cov_t\left(r_{t+1}^i, x_{term\ spread,t+1}\right)$, is also highly significant with the magnitude of -23.931 (*t*-value=-2.64) or -25.406 (*t*-value=-2.77), depending on specifications. However, there should be a more cautious interpretation with respect to $cov_t\left(r_{t+1}^i, x_{term\ spread,t+1}\right)$ as the relation between consumption and term spread is found to be insignificant in Table 3.

In sum, it is legitimate to conclude that the new illiquidity risk estimated with default spread, $cov_t\left(c_{t+1}^i, x_{default\ spread,t+1}\right)$, is priced in the cross section of stock returns.

5.5. Analysis in macroeconomic variables as state variables

<Insert Table 6 here>

Table 6 shows whether the new illiquidity risks measured with macroeconomic variables, such as federal funds rate, unemployment rate, industrial production growth rate, the percent change in the CPI, and the percent change in energy prices, are priced in the cross section of stock returns. Note that each state variable represents an economic situation affecting the consumption level. Throughout specifications, illiquidity level and market risk are strongly significant as in the previous sections, but in some specifications illiquidity risks of Acharya and Pedersen (2005) lose statistical significance.

Table 6 also shows that the new illiquidity risks measured with the percent change in the CPI and the percent change in energy prices are significantly priced, at least at the 10% level. While the coefficient on $cov_t(c_{t+1}^i, x_{feds,t+1})$ is significantly positive, it should also be noted that in Table 3 federal funds rate is found with a marginally insignificantly negative correlation with consumption. Therefore, it may be premature to conclude that the new illiquidity risk measured with federal funds rate is priced in the stock market. Likewise, although the risks from the shift in the investment opportunity set using unemployment rate and industrial production growth rate, $cov_t(r_{t+1}^i, x_{unemp,t+1})$ and $cov_t(r_{t+1}^i, x_{indus,t+1})$, are significant, they also need a cautious interpretation given the signs on the relation between consumption and unemployment rate and industrial production growth.

In short, among the new liquidity risks estimated with various macroeconomic variables, those measured with the percent change in the CPI and the percent change in energy prices are significantly priced in the stock market.

6. Conclusion

In this study, I analytically derive a new source of illiquidity risk, which is the covariance between a stock's illiquidity and a state variable in the framework of Merton (1973)'s intertemporal CAPM, which reflect a shift in the investment opportunity set. With respect to illiquidity level and three illiquidity risks of Acharya and Pedersen (2005), this study supports the previous literature and finds empirical evidence that all of their illiquidity risks are priced even in the conditional version of the LCAPM. More importantly, I also find that estimates of the new illiquidity risks, i.e., the covariance between a stock's illiquidity and SMB, default spread, federal funds rate, the percent change in the CPI, and the percent change in energy prices, are priced in the cross section of stock returns. All of these state variables are known to capture a shift in the investment opportunity set. Thus, the contribution of this study is twofold. First, this study augments the findings of Acharya and Pedersen (2005) by showing that the existing illiquidity risks and liquidity level are priced in the conditional version of the LCAPM using the multivariate GARCH model. Second, this study finds a new source of illiquidity risk and proves that it is priced.

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Table 1 Correlations among state variables

This table describes Pearson correlation coefficients among state variables. *SMB* (Small-Minus-Big) is the difference between the return on the portfolio of small stocks and the return on the portfolio of big stocks. *HML* (High-Minus-Low) is the difference between the return on the portfolio of high book-to-market and the return on the portfolio of low book-to-market. *UMD* (Up-Minus-Down) is the difference between the return on the portfolio of high past (t-2 ~ t-12) return stocks and the return on the portfolio of low past (t-2 ~ t-12) return stocks. The above three equity factors are obtained from Kenneth French's online data library. *term* refers to term spread, which is the difference between the 1-year Treasury bond yield and the 10-year Treasury bond yield. *Def* stands for default spread, or the difference between the yield on the Baa-rated and the Aaa-rated corporate bonds according to Moody's. *FED* is the federal funds rate. The three variables are obtained from H.15 database of Board of Governors of the Federal Reserve System. *unem* is the seasonally adjusted unemployment rate from the Bureau of Labor Statistics of the U.S. Department of Labor. *Indus* and *CPI* are the percent change in the seasonally adjusted Industrial Production Index and that in the seasonally adjusted Consumer Price Index from the Economic Research Division of Federal Reserve Bank of St. Louis, respectively. *energy* is the percent change in the Energy Price Index from the World Bank. The sample period is from January 1965 to December 2011. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	smb	hml	umd	term	def	FED	unem	indus	CPI	energy
smb	1.000	-0.232 ***	-0.001	0.073 *	0.052	-0.075 *	0.053	-0.083 **	0.014	0.032
hml	-0.232 ***	1.000	-0.160 ***	0.002	-0.046	0.055	0.011	0.053	0.021	0.023
umd	-0.001	-0.160 ***	1.000	-0.075 *	-0.135 ***	0.064	-0.087 **	0.106 **	0.071 *	0.093 **
term	0.073 *	0.002	-0.075 *	1.000	0.168 ***	-0.681 ***	0.518 ***	-0.179 ***	-0.520 ***	-0.285 ***
def	0.052	-0.046	-0.135 ***	0.168 ***	1.000	0.251 ***	0.632 ***	-0.620 ***	0.265 ***	-0.149 ***
FED	-0.075 *	0.055	0.064	-0.681 ***	0.251 ***	1.000	0.018	0.019	0.723 ***	0.187 ***
unem	0.053	0.011	-0.087 **	0.518 ***	0.632 ***	0.018	1.000	-0.353 ***	0.108 ***	-0.135 ***
indus	-0.083 **	0.053	0.106 **	-0.179 ***	-0.620 ***	0.019	-0.353 ***	1.000	-0.155 ***	0.024
CPI	0.014	0.021	0.071 *	-0.520 ***	0.265 ***	0.723 ***	0.108 ***	-0.155 ***	1.000	0.472 ***
energy	0.032	0.023	0.093 **	-0.285 ***	-0.149 ***	0.187 ***	-0.135 ***	0.024	0.472 ***	1.000

Table 2 Correlations of new illiquidity risks with existing risks

This table describes the Pearson correlation coefficients of new illiquidity risks with market risk, Acharya and Pedersen's (2005) illiquidity risks, and Merton's (1973) state variable risks. Market risk is the conditional covariance, or $Cov_{t-1}(r_{i,t}, r_{m,t})$, where $r_{i,t}$ and $r_{m,t}$ are stock *i*'s return and value weighted market return, respectively. Illiq Risk 1, 2, and 3 refer to the illiquidity risks of Acharya and Pedersen (2005). Illiq Risk 1 is the commonality in illiquidity, or $Cov_{t-1}(c_{i,t}, c_{m,t})$, where $c_{i,t}$ and $c_{m,t}$ are stock i's illiquidity and market illiquidity, respectively. Market illiquidity is the equally weighted average illiquidity of all stocks. Illiq risk 2 and 3 are $Cov_{t-1}(r_{i,t}, c_{m,t})$, $Cov_{t-1}(c_{i,t}, r_{m,t})$, respectively. SV Risks, or state variable risks, refer to $Cov_{t-1}(r_{i,t}, x_t)$, where *x* indicates 10 state variables, and measure risks from an unfavorable shift in the investment opportunity set in Merton (1973). New illiquidity risks are measured as $Cov_{t-1}(c_{i,t}, x_t)$. 10 state variables are described in Table 1. Illiquidity is defined as Amihud's (2002) illiquidity measure (=monthly average of $(|r_d|/dVol_d)$, where r_d is daily return and $dVol_d$ means daily volume in dollars). All covariance measures are estimated using Bollerslev (1990)'s multivariate GARCH model specification. All variables are required to have at least 36-month observations.

	Market Risk	Illiq Risk 1	Illiq Risk 2	Illiq Risk 3	SV Risk (SMB)	SV Risk (HML)	SV Risk (UMD)	SV Risk (term)	SV Risk (def)	SV Risk (FED)	SV Risk (unem)	SV Risk (indus)	SV Risk (CPI)	SV Risk (energy)
New Illiq Risk (SMB)	0.00	-0.07	0.00	0.44	-0.01	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
New Illiq Risk (HML)	0.01	-0.11	0.01	0.46	0.00	-0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01
New Illiq Risk (UMD)	0.01	-0.27	0.02	-0.30	0.00	-0.01	0.01	0.00	0.01	0.00	0.00	-0.01	-0.01	-0.01
New Illiq Risk (term)	-0.02	0.44	-0.02	-0.22	-0.01	0.02	-0.01	0.01	-0.01	0.00	0.00	0.02	0.01	0.01
New Illiq Risk (def)	-0.02	0.35	-0.03	-0.71	-0.01	0.02	-0.01	0.00	-0.02	0.00	0.00	0.01	0.00	0.00
New Illiq Risk (FED)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	-0.01	0.00	0.00
New Illiq Risk (unem)	0.00	0.01	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	-0.04	0.00	0.00	0.00
New Illiq Risk (indus)	0.02	-0.40	0.03	0.36	0.01	-0.03	0.02	0.00	0.02	0.00	0.00	-0.02	-0.01	0.00
New Illiq Risk (CPI)	0.03	-0.32	0.02	-0.01	0.02	-0.02	0.01	0.01	0.01	0.00	0.00	-0.02	-0.01	-0.01
New Illiq Risk (energy)	0.00	-0.02	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
# of stocks	8950	8950	8950	8950	8950	8950	8950	8950	8950	8950	8950	8950	8950	8950
Avg Length	130	130	130	130	130	130	130	130	130	130	130	130	130	130

Table 3 Coefficients of consumption on state variables

This table describes the coefficients and *t*-values from regressing percent change in real personal consumption expenditures on each state variable from Table 1. The data on consumption is retrieved from the Bureau of Economic Analysis. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Intercept	smb	hml	umd	term	def	FED	unem	indus	CPI	energy
0.2574 ***	3.3240 ***									
11.56	*4.79*									
0.2688 ***		-0.5800								
11.79		*-0.76*								
0.2706 ***			-0.5445							
11.81			*-1.05*							
0.2445 ***				2.2594						
8.37				*1.2*						
0.3824 ***					-10.9065 **					
6.83					*-2.26*					
0.3200 ***						-0.8969				
7.25						*-1.4*				
0.2831 ***							-0.2710			
3.32							*-0.2*			
0.2245 ***								1.5782 ***		
8.78								*3.43*		
0.3770 ***									-2.5407 ***	
9.3									*-3.27*	
0.2887 ***										-0.1400 ***
12.2										*-2.97*

Table 4 Cross-sectional regression using equity factors as state variables

This table reports coefficients and *t*-value from the following Fama-MacBeth (1973) regression,

$$E(r_{i,t}-r_f)=\alpha+\gamma_0 E(illiq)+\gamma_1 Cov_{t-1}(r_{i,t},r_{m,t})+\gamma_2 Cov_{t-1}(c_{i,t},c_{m,t})+\gamma_3 Cov_{t-1}(r_{i,t},c_{m,t})+\gamma_4 Cov_{t-1}(c_{i,t},r_{m,t})+\gamma_5 Cov_{t-1}(r_{i,t},x_t)+\gamma_6 Cov_{t-1}(c_{i,t},x_t)$$

where $r_{i,t}$ is the individual stock returns, $r_{f,t}$ is the one-month treasury bill return, $E(illiq)$ is the AR(2) predictive value of stock i's illiquidity, and $Cov_{t-1}(r_{i,t},r_{m,t})$ is the market risk. $Cov_{t-1}(c_{i,t},c_{m,t})$, $Cov_{t-1}(r_{i,t},c_{m,t})$ and $Cov_{t-1}(c_{i,t},r_{m,t})$ are illiquidity risk 1, 2, and 3, respectively. Net Illiquidity Risk is the sum of three illiquidity risks, or $Cov_{t-1}(c_{i,t},c_{m,t})-Cov_{t-1}(r_{i,t},c_{m,t})-Cov_{t-1}(c_{i,t},r_{m,t})$. $Cov_{t-1}(r_{i,t},x_t)$, or state variable risk (SV Risk), refers to the risk from an unfavorable shift in the investment opportunity set in Merton (1973) and $Cov_{t-1}(c_{i,t},x_t)$, or the new illiquidity risk, uses SMB, HML, or UMD as state variable *x*. The coefficients are the average of parameter estimates of the cross-sectional regression in each month and *t*-values are computed using the Newey-West correction of standard errors for heteroscedasticity and autocorrelation. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Intercept	E(Illiq)	Market Risk	Illiq Risk 1	Illiq Risk 2	Illiq Risk 3	Net Illiq Risk	SV Risk (SMB)	SV Risk (HML)	SV Risk (UMD)	New Illiq Risk (SMB)	New Illiq Risk (HML)	New Illiq Risk (UMD)
Panel A. Acharya and Pedersen's (2005) Illiquidity Risks												
0.0031 **		1.9709 **	0.0006 ***	-0.0315 **	-0.0317 ***							
2.06		*2.31*	*4.53*	*-2.08*	*-4.42*							
0.0025 *	0.0004 ***	2.1026 **	0.0002	-0.0294 **	-0.0246 ***							
1.66	*3.5*	*2.45*	*1.42*	*-1.98*	*-3.56*							
Panel B. Acharya and Pedersen's (2005) Illiquidity Risks and New Risks measured with SMB												
0.003 **		1.6072 **	0.0006 ***	-0.0282 **	-0.0297 ***		1.0427			-0.0034		
1.98		*2.08*	*4.4*	*-2.14*	*-3.41*		*0.91*			*-0.37*		
0.0023	0.0004 ***	1.8477 **	0.0002 *	-0.0278 **	-0.0257 ***		0.7554			0.0043		
1.56	*3.68*	*2.39*	*1.83*	*-2.12*	*-3.01*		*0.66*			*0.38*		
0.0031 **		1.705 **				0.0006 ***	1.4515			-0.026 ***		
2.04		*2.27*				*4.58*	*1.28*			*-3.38*		
0.0024	0.0004 ***	1.9504 ***				0.0002 *	1.1486			-0.0137		
1.6	*3.98*	*2.6*				*1.76*	*1.02*			*-1.5*		
Panel C. Acharya and Pedersen's (2005) Illiquidity Risks and New Risks measured with HML												
0.0034 **		1.9205 **	0.0006 ***	-0.0295 *	-0.0307 ***			-0.5506			0.0376 **	
2.56		*2.52*	*4.19*	*-1.94*	*-4.67*			*-0.41*			*2.52*	
0.0027 **	0.0004 ***	2.0775 ***	0.0002	-0.027 *	-0.0246 ***			-0.5185			0.0279 **	
2.09	*3.58*	*2.71*	*1.51*	*-1.83*	*-3.78*			*-0.38*			*2.05*	
0.0034 **		2.247 ***				0.0008 ***		-0.5201			0.0561 ***	
2.54		*2.8*				*4.55*		*-0.38*			*3.19*	
0.0027 **	0.0005 ***	2.3614 ***				0.0003 **		-0.5265			0.0341 **	
2.02	*4.45*	*2.94*				*2.11*		*-0.39*			*2.31*	
Panel D. Acharya and Pedersen's (2005) Illiquidity Risks and New Risks measured with UMD												
0.0033 **		2 **	0.0006 ***	-0.0251 *	-0.0318 ***				0.9267			-0.0001
2.29		*2.3*	*4.45*	*-1.7*	*-4.75*				*1.2*			*-0.01*
0.0026 *	0.0004 ***	2.1348 **	0.0002 **	-0.0228	-0.0236 ***				0.9476			0.0042
1.86	*3.66*	*2.44*	*1.97*	*-1.59*	*-3.54*				*1.22*			*0.47*
0.0033 **		2.2707 **				0.0008 ***			1.0551			0.0013
2.3		*2.58*				*4.41*			*1.38*			*0.13*
0.0026 *	0.0005 ***	2.3654 ***				0.0003 ***			1.0479			0.0079
1.8	*4.68*	*2.69*				*2.62*			*1.37*			*0.88*
Panel E. Acharya and Pedersen's (2005) Illiquidity Risks and New Risks measured with SMB, HML, and UMD												
0.0032 **		1.8209 **	0.0007 ***	-0.0252 *	-0.0233 ***		0.5812	-0.1581	0.5685	-0.0111	0.0495 ***	0.0041
2.45		*2.42*	*4.24*	*-1.79*	*-2.9*		*0.5*	*-0.11*	*0.75*	*-1.18*	*3.16*	*0.43*
0.0026 **	0.0004 ***	2.0449 ***	0.0003 ***	-0.0249 *	-0.021 **		0.3076	-0.1657	0.5453	-0.0025	0.0413 ***	0.0073
2	*3.55*	*2.74*	*2.59*	*-1.76*	*-2.54*		*0.26*	*-0.12*	*0.72*	*-0.23*	*2.8*	*0.76*
0.0032 **		1.854 **				0.0007 ***	0.9706	-0.2492	0.6736	-0.03 ***	0.0557 ***	0.0093
2.51		*2.55*				*4.38*	*0.84*	*-0.18*	*0.91*	*-3.85*	*3.46*	*0.97*
0.0026 **	0.0003 ***	2.0718 ***				0.0004 ***	0.6819	-0.2824	0.6316	-0.0205 **	0.0454 ***	0.0116
2.05	*3.67*	*2.86*				*2.91*	*0.6*	*-0.2*	*0.85*	*-2.3*	*2.98*	*1.22*

Table 5 Cross-sectional regression using bond factors as state variables

This table reports coefficients and t-value from the following Fama-MacBeth (1973) regression,

$$E(r_{i,t} - r_f) = \alpha + \gamma_0 E(illiq) + \gamma_1 Cov_{t-1}(r_{i,t}, r_{m,t}) + \gamma_2 Cov_{t-1}(c_{i,t}, c_{m,t}) + \gamma_3 Cov_{t-1}(r_{i,t}, c_{m,t}) + \gamma_4 Cov_{t-1}(c_{i,t}, r_{m,t}) + \gamma_5 Cov_{t-1}(r_{i,t}, x_t) + \gamma_6 Cov_{t-1}(c_{i,t}, x_t)$$

where $r_{i,t}$ is the individual stock returns, $r_{f,t}$ is the one-month treasury bill return, $E(illiq)$ is the AR(2) predictive value of stock i's illiquidity, and $Cov_{t-1}(r_{i,t}, r_{m,t})$ is the market risk. $Cov_{t-1}(c_{i,t}, c_{m,t})$, $Cov_{t-1}(r_{i,t}, c_{m,t})$ and $Cov_{t-1}(c_{i,t}, r_{m,t})$ are illiquidity risk 1, 2, and 3, respectively. Net Illiquidity Risk is the sum of three illiquidity risks, or $Cov_{t-1}(c_{i,t}, c_{m,t}) - Cov_{t-1}(r_{i,t}, c_{m,t}) - Cov_{t-1}(c_{i,t}, r_{m,t})$. $Cov_{t-1}(r_{i,t}, x_t)$, or state variable risk (SV Risk), refers to the risk from an unfavorable shift in the investment opportunity set in Merton (1973) and $Cov_{t-1}(c_{i,t}, x_t)$, or the new illiquidity risk, uses term spread and default spread as state variable x. The coefficients are the average of parameter estimates of the cross-sectional regression in each month and t-values are computed using the Newey-West correction of standard errors for heteroscedasticity and autocorrelation. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Intercept	E(Illiq)	Market Risk	Illiq Risk1	Illiq Risk2	Illiq Risk3	Net illiq Risk	SV Risk	New Illiq Risk
Panel A : term spread								
0.0025 *	0.0004 ***	2.2982 ***	0.0003 **	-0.0268 *	-0.0249 ***		-23.931 ***	0.075 *
1.75	*3.83*	*2.71*	*2.02*	*-1.88*	*-3.43*		*-2.64*	*1.77*
0.0025 *	0.0006 ***	2.6112 ***				0.0003 **	-25.406 ***	0.0192
1.7	*4.69*	*2.97*				*2.22*	*-2.77*	*0.43*
Panel B : default spread								
0.0024	0.0003 ***	2.1296 **	0.0002 **	-0.0254 *	-0.0309 ***		-2.6238	0.1194 ***
1.65	*3.04*	*2.47*	*1.99*	*-1.75*	*-3.91*		*-0.7*	*2.96*
0.0024	0.0005 ***	2.4318 ***				0.0003 **	-2.9553	0.101 ***
1.57	*4.56*	*2.74*				*2.22*	*-0.78*	*2.67*

Table 6 Cross-sectional regression using macroeconomic variables as state variable

This table reports coefficients and t-value from the following Fama-MacBeth (1973) regression,

$$E(r_{i,t} - r_f) = \alpha + \gamma_0 E(illiq) + \gamma_1 Cov_{t-1}(r_{i,t}, r_{m,t}) + \gamma_2 Cov_{t-1}(c_{i,t}, c_{m,t}) + \gamma_3 Cov_{t-1}(r_{i,t}, c_{m,t}) + \gamma_4 Cov_{t-1}(c_{i,t}, r_{m,t}) + \gamma_5 Cov_{t-1}(r_{i,t}, x_t) + \gamma_6 Cov_{t-1}(c_{i,t}, x_t)$$

where $r_{i,t}$ is the individual stock returns, $r_{f,t}$ is the one-month treasury bill return, $E(illiq)$ is the AR(2) predictive value of stock i's illiquidity, and $Cov_{t-1}(r_{i,t}, r_{m,t})$ is the market risk. $Cov_{t-1}(c_{i,t}, c_{m,t})$, $Cov_{t-1}(r_{i,t}, c_{m,t})$ and $Cov_{t-1}(c_{i,t}, r_{m,t})$ are illiquidity risk 1, 2, and 3, respectively. Net Illiquidity Risk is the sum of three illiquidity risks, or $Cov_{t-1}(c_{i,t}, c_{m,t}) - Cov_{t-1}(r_{i,t}, c_{m,t}) - Cov_{t-1}(c_{i,t}, r_{m,t})$. $Cov_{t-1}(r_{i,t}, x_t)$, or state variable risk (SV Risk), refers to the risk from an unfavorable shift in the investment opportunity set in Merton (1973) and $Cov_{t-1}(c_{i,t}, x_t)$, or the new illiquidity risk, uses federal funds rate, unemployment rate, industrial production growth rate, the percent change of CPI and the percent change of energy prices as state variable x. The coefficients are the average of parameter estimates of the cross-sectional regression in each month and t-values are computed using the Newey-West correction of standard errors for heteroscedasticity and autocorrelation. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Intercept	E(Illiq)	Market Risk	Illiq Risk1	Illiq Risk2	Illiq Risk3	Net Illiq Risk	SV Risk	New Illiq Risk
				Panel A : feds fund rate				
0.0025 *	0.0004 ***	2.1679 **	0.0002 *	-0.0285 *	-0.0184 ***		-5.6161 *	0.0122 ***
1.74	*3.59*	*2.53*	*1.89*	*-1.87*	*-2.87*		*-1.95*	*3.3*
0.0024 *	0.0005 ***	2.4544 ***				0.0003 **	-5.9907 **	0.013 ***
1.67	*4.28*	*2.79*				*2.19*	*-2.09*	*3.36*
				Panel B : unemployment rate				
0.0025 *	0.0002 **	1.9853 **	0.0002	-0.0286 *	-0.032 ***		0.8283 **	0.0123 ***
1.69	*2.19*	*2.32*	*1.33*	*-1.91*	*-4.35*		*2.24*	*3.15*
0.0024	0.0005 ***	2.323 ***				0.0002	0.7944 **	0.0066 **
1.61	*3.85*	*2.62*				*1.64*	*2.2*	*2.04*
				Panel C : industrial production growth rate				
0.0021	0.0004 ***	2.1661 **	0.0002	-0.0245 *	-0.0197 ***		-5.3979 **	0.0071
1.49	*3.51*	*2.58*	*1.42*	*-1.65*	*-2.96*		*-2.4*	*0.9*
0.0021	0.0006 ***	2.4239 ***				0.0002 *	-5.4489 **	0.008
1.43	*4.33*	*2.78*				*1.76*	*-2.42*	*1.03*
				Panel D : CPI				
0.0025 *	0.0004 ***	2.1794 **	0.0001	-0.0328 **	-0.0223 ***		-3.1455	0.0158 ***
1.7	*3.18*	*2.57*	*1.09*	*-2.04*	*-3.4*		*-1.43*	*2.89*
0.0023	0.0005 ***	2.5375 ***				0.0002	-3.4008	0.017 ***
1.59	*4.15*	*2.9*				*1.25*	*-1.55*	*3.15*
				Panel E : Energy price				
0.0037 **	0.0003 ***	1.8963 **	0.0003 ***	-0.0095	-0.0174 ***		-0.2059	0.0022 *
2.47	*3.88*	*2.26*	*2.69*	*-0.93*	*-4.34*		*-0.68*	*1.74*
0.0037 **	0.0004 ***	1.9897 **				0.0003 ***	-0.1916	0.0031 **
2.43	*4.5*	*2.33*				*3.11*	*-0.64*	*2.23*