VOLATILITY, LIQUIDITY AND LIQUIDITY RISK

Dan Amiram
Columbia Business School

Balazs Cserna
Goethe University of Frankfurt

Ariel Levy
Ben-Gurion University

August, 2017

Liquidity

Stock liquidity affects a number of capital market outcomes:

- **Expected returns** (e.g., Amihud and Mendelson, 1986 and 2015; Pastor and Stambaugh, 2003; Acharya and Pedersen, 2005).
- **Capital structure** (e.g., Lipson and Mortal, 2009).
- **Dividend policy** (Banerjee et al., 2007).
- **Ownership structure** (e.g., Bhide, 1993).

Determinants of Liquidity

Higher volatility $\Longrightarrow$ Higher liquidity costs

Theoretical works:

1. Stoll (1978a)
2. Amihud and Mendelson (1980)

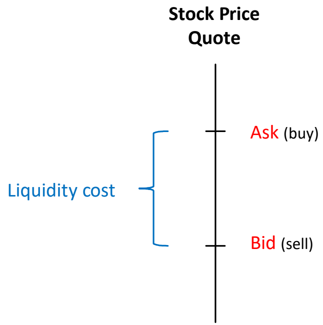
Empirical studies:

1. Stoll (1978b)
2. Amihud and Mendelson (1989)
3. Bao and Pan (2013)

Volatility

Market makers demand compensation for inventory risk

Liquidity



Volatility

But, not all volatilities are made equal....

Volatility: a deeper look

Two return processes ($\frac{dS_t}{S_t}$):

Continuous Returns:

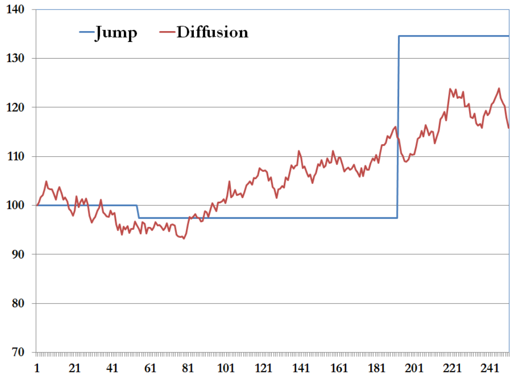
Wiener process: σdW_t

Discrete (Jump) Returns:

Jumps per year $\sim Poisson\left(\lambda\right)$
Log(jump-size) $\sim N\left(\alpha, \gamma^2\right)$

Volatility: a deeper look

Example - Simulation



Diffusion process:

Trend $= 0$

Volatility $= 20\%$

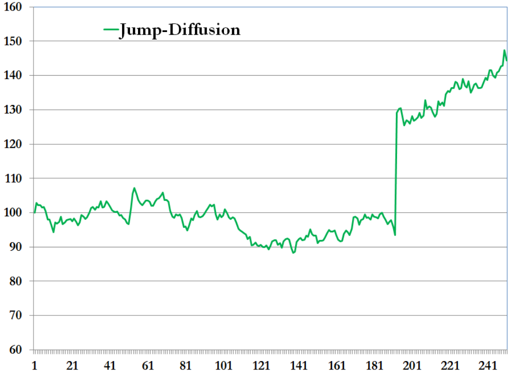
Jump process:

Trend $= 0$

Volatility $= 20\%$ $\lambda = 1$

Volatility: a deeper look

Example - Simulation



Diffusion process:

Trend $= 0$

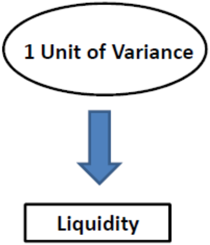
Volatility $= 20\%$

Jump process:

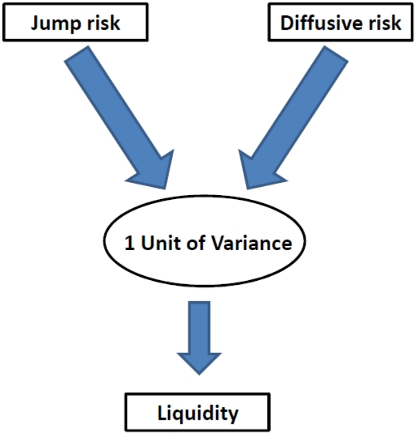
Trend $= 0$

Volatility $= 20\%$ $\lambda = 1$

Volatility: a deeper look



Volatility: a deeper look



Research Question

Do **jump** and **diffusive** risk

have

the same effect on liquidity?

Theoretical Motivation

Volatility **increases** inventory risk (Stoll, 1978; Amihud and Mendelson, 1980):

- **Limited stopping rules**
  Longstaff (1995, 2014), Garleanu et al. (2009).

- **Limited hedging possibilities**
  Garleanu et al. (2009), Jameson and Wilhelm (1992), Gromb and Vayanos (2002), Chen et al. (2014).

Second Reseach Question

Do **jump** and **diffusive** differential effects

carry over to

liquidity risk?

Research Approach

1. Fit log-normal jump-diffusion process to stock returns.
2. Obtain estimates for jump and diffusive components.
3. Test relative effects:
    - Univariate analysis.
    - Fama-MacBeth regressions.
4. Robustness: information asymmetry, turnover, reverse causality, crash risk.
5. Volatility components and liquidity risk.

Methodology

Methodology

Merton (1976), the return of stock price S_t follows:

$$\frac{dS_t}{S_t} = (\mu - \lambda \cdot \kappa)\, dt + \sigma \cdot dW_t + dJ_t$$

Two independent sources of uncertainty:

1. W_t - standard Brownian motion
2. J_t - compound jumps

Estimation

Using MLE we estimate a vector of parameters,

$$\theta_i^t = \left(\mu_i^t, \sigma_i^t, \lambda_i^t, \alpha_i^t, \gamma_i^t\right)$$

for each firm i and year t.

Data

A. Downloaded from CRSP US daily stock data for 2002-2012 on:

1. Prices
2. Volume
3. Shares outstanding
4. Market capitalization

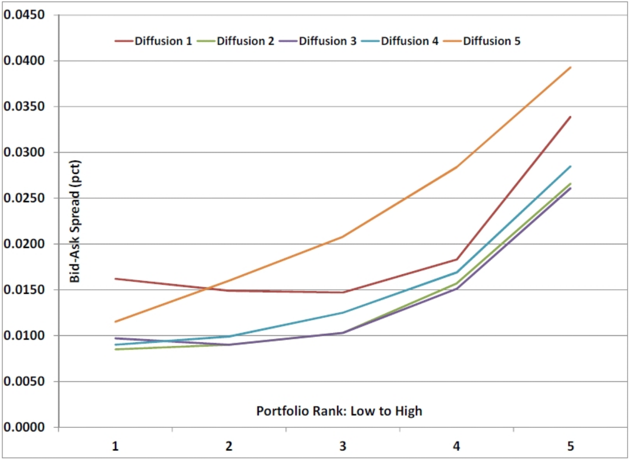
B. Downloaded TAQ intraday bid/ask quotes.

Results A: Univariate Analysis

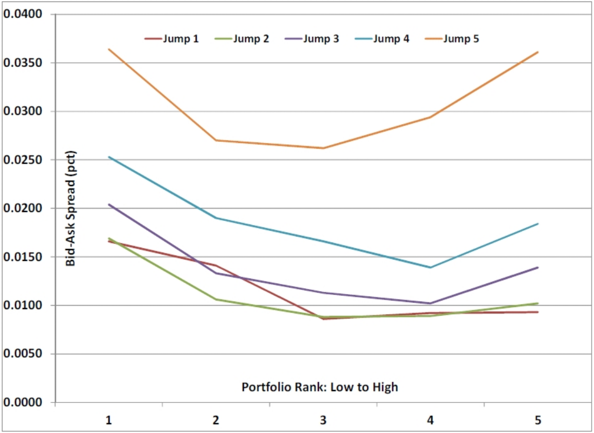
Sorted Portfolios - Table 2

Portfolio	Low	2	3	4	High
Panel A: Controlling for Diffusion					
Low Jump	.0162	.0085	.0097	.0090	.0115
2	.0149	.0090	.0090	.0099	.0160
3	.0147	.0103	.0103	.0125	.0208
4	.0183	.0157	.0151	.0169	.0284
High Jump	.0339	.0266	.0261	.0285	.0393
High-Low	*.0176*	*.0181*	*.0164*	*.0194*	*.0278*
t-stat	*18.94*	*22.90*	*20.86*	24.80	*27.57*
Panel B: Controlling for Jumps					
Low Diffusive	.0166	.0169	.0204	.0253	.0364
2	.0141	.0106	.0133	.0190	.0270
3	.0086	.0088	.0113	.0166	.0262
4	.0092	.0089	.0102	.0139	.0294
High Diffusive	.0093	.0102	.0139	.0184	.0361
High-Low	*-.0073*	*-.0067*	*-.0065*	*-.0068*	*-.0003*
t-stat	*-13.10*	*-10.95*	*-8.42*	*-7.76*	*-0.20*

Sorted Portfolios - Table 1B



Sorted Portfolios - Figure 1A



Results B: Fama-MacBeth Regressions

Model A: Total Variance

$$Liq_{i,t+1} = \beta_0 + \beta_{1,t} V_{i,t} + \sum_{j=1}^{J} \beta_{1+j,t} Control^{j}_{i,t} + \varepsilon_{i,t}$$

Model A: Total Variance

$$Liq_{i,t+1} = \beta_0 + \beta_{1,t} V_{i,t} + \sum_{j=1}^{J} \beta_{1+j,t} Control^j_{i,t} + \varepsilon_{i,t}$$

Model B: Volatility Components

$$Liq_{i,t+1} = \beta_0 + \beta_{1,t} V^d_{i,t} + \beta_{2,t} V^j_{i,t} + \sum_{j=1}^{J} \beta_{2+j,t} Control^j_{i,t} + \varepsilon_{i,t}$$

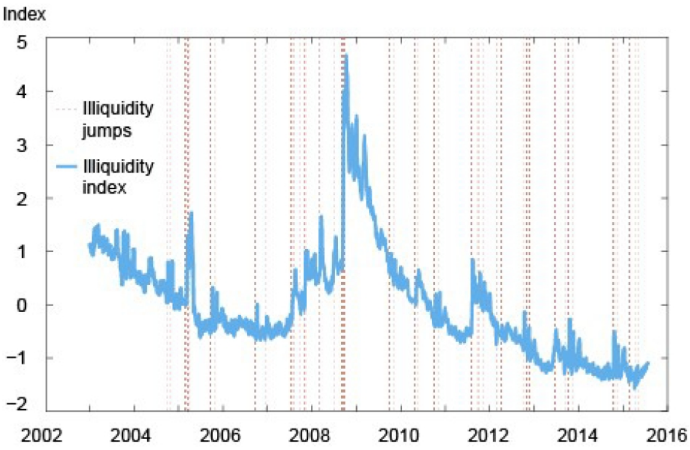
Regression Analysis - Table 5

Variable	*Total Volatility*	*Volatility Components*
Diffusive-var	-	0.0225
	-	*(0.04)*
Jump-var	-	5.1547***
	-	*(8.30)*
Total-var	3.4452***	-
	(6.02)	-
ln(size)	-0.0076***	-0.0075***
	(-11.93)	*(-11.55)*
Turnover	-0.0015***	-0.0015***
	(-5.50)	(-5.44)
Constant	0.1145***	0.1136***
	(12.90)	*(12.57)*
Average-$\overline{R}^2$	50%	50%
Observations	44,171	44,171

Liquidity Risk

Liquidity Risk

Liquidity levels vary over time:



Sources: Financial Industry Regulatory Authority; authors' calculations.

Second Reseach Question

Do **jump** and **diffusive** differential effects

carry over to

liquidity risk?

Theoretical Motivation

Three channels for liquidity risk (Acharya & Pederson, 2005):

- Sensitivity of stock liquidity to market liquidity,

$$\beta_{i,t}^{1L} = cov\left(L_t^i, L_t^M\right)$$

- Sensitivity of stock return to market's liquidity,

$$\beta_{i,t}^{2L} = cov\left(r_t^i, L_t^M\right)$$

- Sensitivity of stock liquidity to market return,

$$\beta_{i,t}^{3L} = cov\left(L_t^i, r_t^M\right)$$

Theoretical Motivation

Three channels for liquidity risk (Acharya & Pederson, 2005):

- Sensitivity of stock liquidity to market liquidity,

$$\beta_{i,t}^{1L} = cov\left(L_t^i, L_t^M\right)$$

- Sensitivity of stock return to market's liquidity,

$$\beta_{i,t}^{2L} = cov\left(r_t^i, L_t^M\right)$$

- Sensitivity of stock liquidity to market return,

$$\beta_{i,t}^{3L} = cov\left(L_t^i, r_t^M\right)$$

Theoretical Motivation

Three channels for liquidity risk (Acharya & Pederson, 2005):

- Sensitivity of stock liquidity to market liquidity,

$$\beta_{i,t}^{1L} = cov\left(L_t^i, L_t^M\right)$$

- Sensitivity of stock return to market's liquidity,

$$\beta_{i,t}^{2L} = cov\left(r_t^i, L_t^M\right)$$

- Sensitivity of stock liquidity to market return,

$$\beta_{i,t}^{3L} = cov\left(L_t^i, r_t^M\right)$$

Volatility Components and Liquidity Risk

Then, for each $\beta^L_{i,t}$ we test,

$$\beta^L_{i,t} = \alpha + \gamma_1 V^d_{i,t} + \gamma_2 V^j_{i,t} + \gamma_3 \ln(size) + \varepsilon_{i,t} \ .$$

Volatility Components and Liquidity Risk

	$\beta^{1L} = Cov\left(L^i, L^M\right)$	$\beta^{2L} = Cov\left(R^i, L^M\right)$	$\beta^{3L} = Cov\left(L^i, R^M\right)$
Duffusive Var	-26.546***	-537.760***	-0.262
	(-4.65)	*(-5.11)*	*(-0.22)*
Jump Var	61.460***	93.824***	5.914***
	(9.13)	*(2.27)*	*(7.74)*
ln(size)	-0.090***	-0.063***	-0.005***
	(-14.32)	*(-7.11)*	*(-6.18)*
Constant	1.564***	1.305***	0.080***
	(14.05)	*(10.81)*	*(6.60)*

Conclusions

1. The structure of volatility matters for liquidity: Jump volatility is the main driver.
2. The differential effects carry over to liquidity risk and premium.
3. Implication: jumps are associated with the information environment.
4. Information: not only private information, but the way information is released.

Thank you!

Robustness: Reverse Causality - Table 6

Jump	**Low**	**2**	**3**	**4**	**High**	*High-Low*	*t*-stat
Low Turnover	.0354	.0384	.0389	.0424	.0479	*.0125*	*10.73*
2	.0174	.0201	.0213	.0227	.0248	*.0074*	*10.08*
3	.0083	.0103	.0107	.0126	.0151	*.0068*	*13.19*
4	.0050	.0058	.0059	.0071	.0088	*.0038*	*10.76*
High Turnover	.0040	.0044	.0044	.0052	.0066	*.0026*	*8.26*

The Process

$$\frac{dS_t}{S_t} = (\mu - \lambda \cdot E(Z-1))\,dt + \sigma dW_t + (Z-1)\,dN_t,$$

where Z is the log-normal jump amplitude with $\ln Z \backsim N(\alpha;\gamma^2)$ such that,

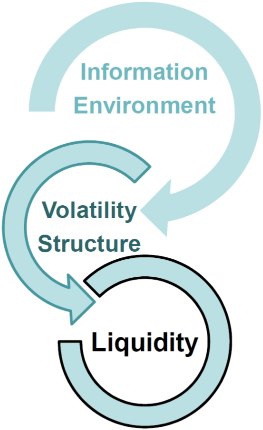
$$E(Z-1) = \exp(\alpha + \frac{\gamma^2}{2}) - 1.$$

Jumps and Information

The firm's information environment determines its volatility structure (e.g., Maheu and McCurdy, 2004):

1. Smooth/continuous information flows - **diffusion**.
2. Bulky/discontinuous information arrivalls - **jumps**.

Jumps and Information



Jumps and Information

Various factors affect the information environment, e.g.:

1. Disclosure regulation.
2. Voluntary disclosure policy.
3. Level of analysts coverage.

Jumps and Information

Information proxy	Coefficient	Info Asymmetry (B/A spread)	Firm & Year fixed effects	N
Panel A				
Number of analysts	-0.042	-	Yes	55,558
	(-20.23)	-		
Management forecast (*Yes/No*)	–0.178	-	Yes	55,558
	(-9.50)	-		
Number of management forecasts	-0.023	-	Yes	55,558
	(-8.98)	-		
Drop in analyst coverage due to closure of brokerage house	0.039	-	Yes	55,558
	(3.93)	-		
Panel B				
Number of analysts	-0.029	17.03	Yes	55,558
	(-14.18)	*(51.48)*		
Management forecast (*Yes/No*)	–0.181	17.62	Yes	55,558
	(-9.94)	*(53.65)*		
Number of management forecasts	-0.023	17.63	Yes	55,558
	(-9.53)	*(53.67)*		
Drop in analyst coverage due to closure of brokerage house	0.063	17.68	Yes	55,558
	(5.35)	*(53.75)*		

Information and Liquidity

Not a new topic...

(e.g., Glosten and Milgrom, 1985; Kelly and Ljungqvist, 2002; Balakrishnan, et al. 2014)

Previous studies:

1. Information asymmetry
2. Total volatility

Our work:

1. No private information
2. Structure of volatility

Methodology

The return variance is,

$$Var\left(\frac{S_t}{S_0}\right) = Var\left(\sigma W_t\right) + Var\left(J_t\right)$$

and denote,

$$\begin{aligned} V^d &\equiv Var\left(\sigma W_t\right) \\ V^j &\equiv Var\left(J_t\right) \end{aligned}$$

Controlling for Information Asymmetry - Table 4

Probability of Informed Trade - Brown & Hillegeist (2007)

PIN Rank	All	Low	2	3	4	High
Jump var	4.367***	6.646***	3.386***	2.323***	3.044***	6.303***
	(5.91)	*(4.16)*	*(4.42)*	*(5.58)*	*(7.11)*	*(5.96)*
Diffusive var	-0.748	0.593	-1.005	-0.635	-1.286***	3.867
	(-0.80)	*(0.58)*	*(-1.22)*	*(-0.69)*	*(-2.42)*	*(1.71)*
ln(size)	-0.007***	-0.007***	-0.005***	-0.004***	-0.004***	-0.010***
	(-10.91)	*(-12.65)*	*(-12.75)*	*(-10.06)*	*(-13.79)*	*(-8.58)*
PIN	0.023***	-	-	-	-	-
	(10.35)	-	-	-	-	-
Constant	0.092***	0.112***	0.075***	0.071***	0.070***	0.149***
	(10.65)	*(12.23)*	*(12.73)*	*(10.43)*	*(14.41)*	*(8.93)*
Average-$\overline{R}^2$	0.52	0.52	0.47	0.45	0.46	0.49
Observations	38,355	7,675	7,672	7,670	7,672	7,666