Tracking Illiquidities in Daily and Intradaily Characteristics[1]

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Motivation

- Return volatility and volume evolutions result from information and liquidity shocks.
    - Information generates trades;
    - Liquidity problems modify the way information is incorporated into price change and volume;
    - On the other hand, information shocks are responsible for the presence of liquidity shocks into the market.

- The interaction between information and liquidity problems can explain some well-known stylized facts.
    - $Cov(R_t, R_{t-1})$ [Getmansky et al. (2004)];
    - $Cov(R_t^2, R_{t-1}^2)$ [GARCH and stochastic volatility models];
    - $Cov(R_t^2, V_t) > 0$ [Andersen (1996), Darolles et al. (2013)...].

Motivation

- Two aspects of (il)liquidity:
  - Short-term liquidity frictions, due to temporary order imbalances (in the sense of GM), which are resorbed by the market within the trading day and increase the daily traded volume.
  - Time-persistent illiquidity events due to destabilizing margins and volatility spirals (in the sense of Brunnemeier and Pedersen, 2009), provoking the time-persistence of returns, volatility and volume.
- Why is it important to understand liquidity?
  - Detecting investment opportunities for liquidity traders: mean reversion versus momentum strategies exploiting respectively short-term and time-persistent liquidity issues.
  - Regulators must distinguish between both aspects of liquidity and focus on the second one which is inherent to risk that liquidity may disappear from the market resulting in important loses.

Motivation

Questions

- How to isolate liquidity problem effects on daily volatility and volume?
- How to separate the respective effects of the two aspects of liquidity?
- How to infer their presence from trading characteristics?

Main contributions

- We propose a statistic model in order to simultaneously:
  - account for the impact of liquidity frictions on the daily traded volume;
  - account for the time-persistent pattern of liquidity shocks.
- As compared to previous literature, we exploit both data dimensions, time-series and bivariate distribution, and thus exploit both stylized facts, $Cov(R_t^2, V_t)$ and $Cov(R_t^2, R_{t-1}^2)$, in order to:
  - measure the liquidity part of volume;
  - filter time-varying stock-specific liquidity indicators.

Main results

- Short-term liquidity frictions:
  - impact the traded volume at the intradaily and daily frequencies;
  - affect the stock volatility only at the intradaily frequency.
- The time-persistent liquidity problems:
  - can explain daily volume dynamics;
  - are responsible for stochastic volatility.
- $\Rightarrow$ Filter dynamic and stock-specific liquidity indicator.

Outline

Outline

1. Introduction
2. Our framework
   - The statistic model
   - Literature review
3. The estimation methodology
4. Empirical applications
5. Concluding remarks

A bivariate model with two dynamic latent variables, accounting for information and liquidity problems:

$$\begin{aligned} \Delta P_t &= \mu_p I_t^* + \sigma_p \sqrt{I_t^*} Z_{1t}, \\ V_t &= \mu_v^{at} I_t^* + \mu_v^{la} L_t + \sigma_v \sqrt{I_t^*} Z_{2t}, \end{aligned}$$

- I_t^* represents the information flow process which is supposed to be time-persistent in order to account for the presence of long-lasting liquidity problems.
- L_t is the latent factor allowing to account for the presence of short-term liquidity frictions which increase the daily traded volume. It is supposed to be serially correlated: in fact, liquidity frictions are not isolated events in time but seem to exhibit time-series clustering.

The impact of time-persistent liquidity problems on daily price change

- Let I_t be the iid process of information inflow in the absence of long lasting liquidity problems.
- When liquidity problems persist in time, only part of information hitting the market during the trading day is incorporated in daily price change.
- Let x_t be the proportion of I_t incorporated in day t price change $(0 < x_t < 1)$;
- Let I_t^* denote the information process in the presence of long lasting illiquidity events:

$$\begin{aligned} I_t^* &= x_t I_t \\ I_{t+1}^* &= x_{t+1} I_{t+1} + (1 - x_t) I_t. \end{aligned}$$

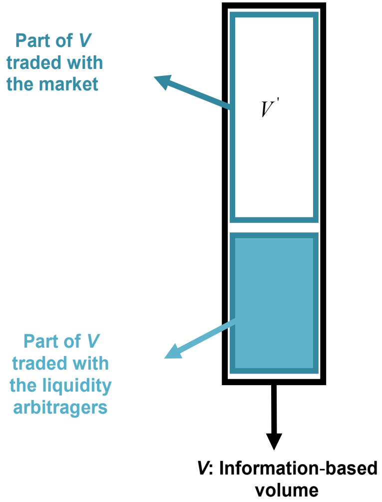
The impact of liquidity frictions on daily traded volume

- Liquidity is determined by the demand and supply of immediacy;
- A GM-process contains only 3 dates: dates 1 and 2 are trading dates, date 3 is used as terminal condition with $\tilde{P}_3$ being the liquidation value;
- Only 2 market participants: J active traders (AT) and M market makers acting as liquidity arbitragers (LA).
- Trade asynchronization at date 1 $\Rightarrow$ Liquidity frictions at date 1 $\Rightarrow$ a temporary order imbalance z:

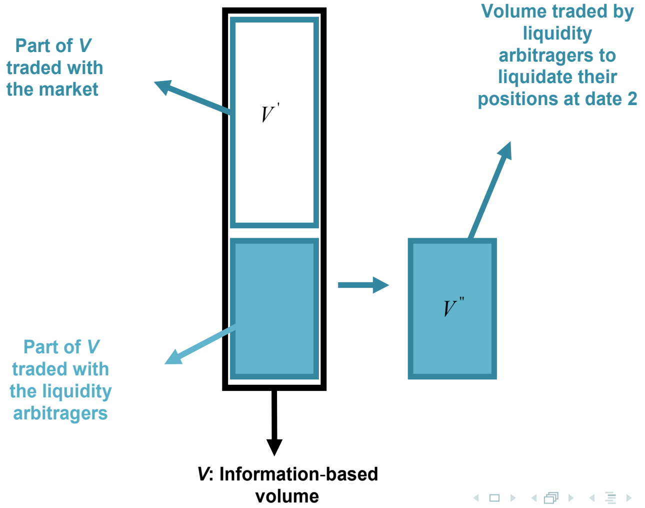
$$z = \sum_{j=1}^{J_1} z_j \neq 0, \quad J_1 < J. \tag{1}$$

- The market makers provide liquidity when needed (date 1) and liquidate their positions at date 2 as other active traders arrive with opposite order imbalances.
- $\Rightarrow$ This increases the total traded volume.

The impact of liquidity frictions on daily traded volume



The impact of liquidity frictions on daily traded volume



Distinguishing the effects of both aspects of liquidity

- In the presence of long-term liquidity problems and short-term liquidity frictions, we have:

$$\begin{aligned} \Delta P_t &= x_t \Delta P'_{1,1} + (1 - x_{t-1}) \Delta P'_{t-1} \\ \Delta P_{t+1} &= x_{t+1} \Delta P'_{t+1} + (1 - x_t) \Delta P'_t . \end{aligned}$$

$$\begin{aligned} V_t &= [x_t V'_t + (1 - x_{t-1}) V'_{t-1}] + V''_t , \\ V_{t+1} &= [x_{t+1} V'_{t+1} + (1 - x_t) V'_t] + V''_{t+1} . \end{aligned}$$

- The triangular structure of our model allows us to distinguish between the two effects of liquidity on the dynamics of the daily traded volume.

- Our bivariate model combines stochastic volatility and states-space formulations for price change and volume respectively;
- $\Rightarrow$ Triangular structure allowing us to:
  - distinguish between both aspects of liquidity;
  - separate information from liquidity shock impacts on daily traded volume
- Model implications: it explains the dynamics of daily trading characteristics:

$$\begin{aligned}
Cov(\Delta P_t, \Delta P_{t+1}) &= x_t(1-x_t)Var(\Delta P_t^{'}) \\
Cov(\Delta P_t^2, \Delta P_{t+1}^2) &= x_t^2(1-x_t)^2 Var((\Delta P_t^{'})^2) \\
Cov(V_t, V_{t+1} \mid I_t^*) &= x_t(1-x_t)Var(V_t^{'}) + Cov(V_t^{''}, V_{t+1}^{''}).
\end{aligned}$$

Outline

Empirical research: positive volatility-volume relationship

- Clark (1976), Epps and Epps (1976), Copeland (1976-77), Tauchen and Pitts (1983), Harris (1983-86).

Theoretical explanation comes from microstructure models: Information $\Rightarrow$ positive volatility-volume relation.

- Kyle(1986), Glosten and Milgrom (1985), Easley and O'Hara (1987), Easley et al.(1996).

Mixture of Distribution Hypothesis (MDH) explores the microstructure framework:

- Tauchen and Pitts (1983), Harris (1983-86), Richardson and Smith (1994), Andersen (1996).

The standard MDH model of Tauchen and Pitts (1983)

- Information is responsible for return and volume evolutions;
- Static framework.
- The market is perfectly liquid.

$$\Delta P_t = \sum_{i=1}^{I_t} \Delta P_i, \qquad \Delta P_i \sim N(0, \sigma_p^2) \qquad \Leftrightarrow \quad \Delta P_t = \sigma_p \sqrt{I_t} Z_{1t}$$

$$V_t = \sum_{i=1}^{I_t} V_i, \qquad V_i \sim N(\mu_v, \sigma_v^2) \qquad \Leftrightarrow \quad V_t = \mu_v I_t + \sigma_v \sqrt{I_t} Z_{2t}$$

where Z_{1t} and Z_{2t} are i.i.d. standard normals and independent of I_t.

- The volatility and volume are positively correlated:

$$Cov(\Delta P_t^2, V_t) \quad = \quad \sigma_p^2 \mu_v Var[I_t] > 0$$

Richardson and Smith (1994) model specification

- Include a mean parameter in the price change equation;
- Static framework.
- The market is perfectly liquid.

$$\Delta P_t = \mu_p I_t + \sigma_p \sqrt{I_t} Z_{1t} \tag{2}$$

$$V_t = \mu_v I_t + \sigma_v \sqrt{I_t} Z_{2t} \tag{3}$$

Our contribution in the literature

- Our model can be considered as a statistic extension of Richardson and Smith (1994) model toward two directions:
    - Measuring the liquidity part of volume by adding a second latent variable in the volume equation based on GM definition of liquidity;
    - Extending the return equation in order to capture the time-persistence pattern of liquidity by proposing a liquidity-based interpretation of stochastic volatility.

Step 1: Stochastic volatility formulation for ΔP_t equation

$$\Delta P_t = \mu_p I_t^* + \sigma_p \sqrt{I_t^*} Z_{1t}, \qquad (4)$$

$$\ln I_t^* = \beta \ln I_{t-1}^* + \eta_t. \qquad (5)$$

- Long-lasting liquidity problem interpretation of stochastic volatility effect;
- Markov regime switching techniques to estimate (4)-(5) and filter I_t^* [Hwang, Satchell and Pereira (2007)].
- The standard SV model yields extremely high levels of persistence; Allowing for regime switching in the level of volatility reduces the considerably reduces the persistence parameters.

Step 2: State space formulation for V_t equation

$$
\begin{aligned}
V_t &= \mu_v^{at} I_t^* + \mu_v^{la} L_t + \sigma_v \sqrt{I_t^*} Z_{2t}, && (6)\\
L_t &= a L_{t-1} + \omega_t. && (7)
\end{aligned}
$$

- I_t^* is replaced by the one filtered in step 1;
- Kalman filter algorithm to estimate (6)-(7) and filter L_t.
- This specification nests that of Hamilton with iid L_t as a special case.

The data

- Individual stocks belonging to FTSE100;
- Daily return and turnover time series.

Some empirical results

Long lasting illiquidity events and momentum strategies

- Parameters of interest: μ_p and β;
- Implications for momentum trading strategies;
- (μ_p, β) versus sample serial correlation coefficients;

Short-term liquidity frictions and high frequency liquidity arbitrage

- Parameters of interest: μ_v^{la} and a;
- Implications for intraday liquidity arbitrage strategies;
- Immediacy cost.

Filtering dynamic liquidity indicators

Illiquidity events and momentum strategies (1)

Panel A: $\widehat{\rho}_{(R_t,R_{t-1})} = 0$ and $\widehat{\rho}_{(R_t^2,R_{t-1}^2)} > 0$

ID	μ_p	μ_0	μ_1	β	$\sigma_{\eta,0}$	$\sigma_{\eta,1}$	σ_ϕ
PSN	0,0004**	-12,14**	-8,84**	0,15**	2,3598**	1,4004**	-0,0003
RR	0,0012**	-14,65**	-9,43**	0,92**	0,4737*	0,1620	1,4554**
SGE	0,0002	-12,76**	-9,20**	0,83**	0,4106	0,4140**	1,1200**
SGRO	0,0001	-11,83**	-9,28**	0,17**	2,4783**	1,2646**	-0,0001
XTA	0,0003	-12,92**	-8,58**	0,04	3,3120**	1,6084	-0,0001

Panel B: $\widehat{\rho}_{(R_t,R_{t-1})} = 0$ and $\widehat{\rho}_{(R_t^2,R_{t-1}^2)} = 0$

ID	μ_p	μ_0	μ_1	β	$\sigma_{\eta,0}$	$\sigma_{\eta,1}$	σ_ϕ
CNA	0,0008**	-17,35**	-9,65**	0,90**	0,3679	-0,1756**	-1,5422**
ITV	0,0006**	-13,75**	-9,22**	0,12**	-1,5672**	1,3934**	0,0060
IVZ	0,0002	-9,13**	-14,84**	0,06	1,6622**	4,0987**	0,0004
RDSB	0,0002	-9,75**	-13,23**	0,06	-1,4248**	2,9780**	0,2681

Illiquidity events and momentum strategies (2)

- The empirical first-order serial correlation of returns is not a sufficient criteria to select stocks to be included in momentum strategies;
- The tests of significance of the sample autocorrelation coefficients are not appropriate since they don't account for volatility clustering.
- A stock may have sample autocorrelations not significantly different from zero when performing classical test statistics and still be affected by long-term liquidity problems whose presence can be empirically inferred using our model.
- In particular, according to our framework, the long-lasting liquidity problems result in μ_p and β parameters statistically positive.
- For example, according to the serial correlation criteria, only stocks 6, 18 and 19 should be included in the momentum strategies; our approach allows us to select somme additional stocks (59, 68, 20 and 41).

Liquidity frictions and high frequency liquidity arbitrage (1)

ID	μ_v^{at}	μ_v^{la}	σ_v	a	σ_w
PSN	0,0005	0,0016**	0,0026**	0,97**	0,81**
RR	0,0085	0,0022**	0,0041**	0,90**	0,66
SGE	0,0030	0,0038	0,0031**	0,97**	0,15
SGRO	0,0001	0,0060**	0,0020**	0,94**	0,15**
XTA	0.0013	0,0662	0,0098**	0,95**	0,02
CNA	0,0064	0,0014	0,0029**	0,70**	1,71
ITV	0,0009	0,0039**	0,0040*	0,93**	0,96
IVZ	0,0003	0,0038	0,0016**	0,90**	1,29
RDSB	0,0001	0,0014*	0,0003**	0,90**	0,33

Liquidity frictions and high frequency liquidity arbitrage (2)

- Once I_t^* filtered, we can filter L_t conditional on I_t^* using the volume equation.
- The parameters of interest here is μ_v^{la} which allows us to identify stocks that are subject to short-term liquidity frictions.
- These stocks represent liquidity arbitrage opportunities at the intradaily frequency.
- These investment opportunities are a source of trade for liquidity arbitragers who enter the market to provide the missing liquidity and liquidate their positions in order to cash the liquidity premium.

Subperiod analysis (1)

January 2005 - June 2007

ID	μ_p	μ_0	μ_1	β	$\sigma_{\eta,0}$	$\sigma_{\eta,1}$	σ_ϕ
ABF	0,0004**	-16,46**	-10,49**	0,75**	0,0001	0,4692**	1,5767**
ATST	0,0052**	-10,95**	-8,36**	0,90**	0,2603**	0,0000	2,0937**
ANTO	0,0002	-11,03**	-8,32**	0,05	2,7315**	1,3141**	0,0002
BG	0,0013**	-14,07**	-9,18**	0,91**	0,3175	0,1992**	1,3930**
BLND	0,0010**	-11,38**	-8,77**	0,24**	1,8722**	0,4584	0,9803**

July 2007 - May 2009

ID	μ_p	μ_0	μ_1	β	$\sigma_{\eta,0}$	$\sigma_{\eta,1}$	σ_ϕ
ABF	0,0004	-12,33**	-8,77**	-0,16	1,9633**	0,0004	1,5765**
ATST	0,0003**	-10,68**	-8,83**	0,99**	4,3015**	0,2347**	1,8850**
ANTO	0,0006**	-6,90**	-10,75**	0,98**	0,1332**	0,0004	1,4705**
BG	0,0003**	-12,33**	-7,99**	0,98**	0,5118**	0,0000	1,3410**
BLND	0,0009**	-33,80**	-8,03**	0,88**	0,8095**	0,4062**	1,9187**

Subperiod analysis (2)

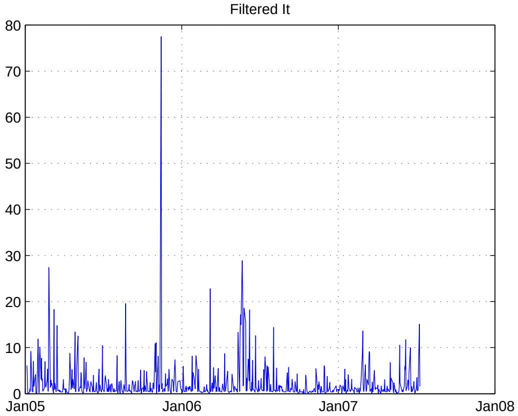
January 2005 - June 2007

ID	μ_v^{at}	μ_v^{la}	σ_v	a	σ_w
ABF	0,0022**	0,0043**	0,0014**	0,90**	0,1203**
ATST	0,0044**	0,0046	0,0060**	0,98**	0,2987**
ANTO	0,0005**	0,0155**	0,0050**	0,91**	0,6301**
BG	0,0040**	0,0056**	0,0198**	0,89**	0,1200**
BLND	0,0001**	0,0165**	0,0014**	0,87	1,3009**

July 2007 - May 2009

ID	μ_v^{at}	μ_v^{la}	σ_v	a	σ_w
ABF	0,0002**	0,0036**	0,0010**	0,99**	0,2078**
ATST	0,0009**	0,0028**	0,0001	0,49	1,0500
ANTO	0,0041**	0,0037**	0,0002	0,96**	0,2078**
BG	0,0014**	0,0072**	0,0006**	0,90**	0,1801**
BLND	0,0038**	0,0085**	0,0043*	0,98**	0,1962**

Persimmon Plc (stock 59)



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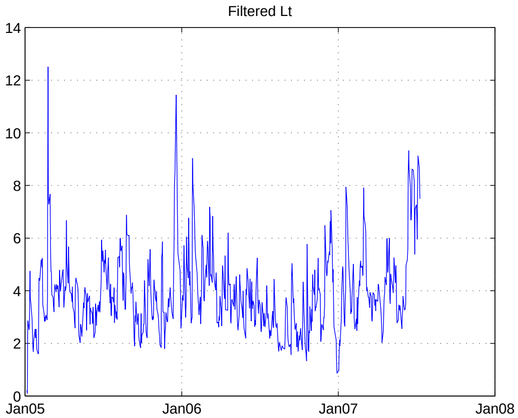

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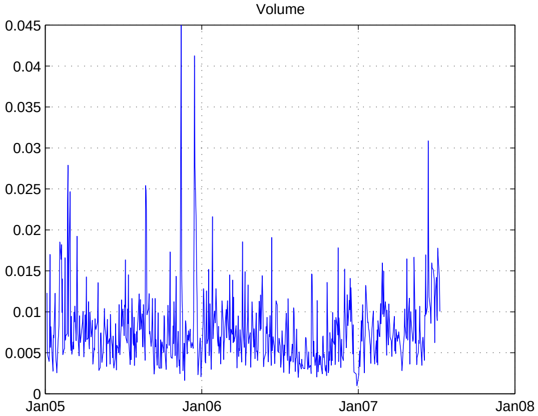

Paper Contributions:

- Short-term liquidity frictions and long lasting illiquidity events have not the same impact on daily returns and volume;
- Decomposing the daily traded volume into two components due to information and liquidity.
- Extracting dynamic stock-specific liquidity indicators.

Further research

- Confront our liquidity indicators to liquidity microstructure measures;
- Empirical tests of the validity of our liquidity measure;
- Build up market liquidity indicators;
- Cross-sectional factor analysis to capture the essence of commonalities in liquidity shocks.