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# Financial Intermediaries Leverage and Stock Market Liquidity

# 금융기관의 레버리지 변화가 주식시장 유동성에 미치는 영향

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## Abstract

# Financial Intermediaries Leverage and Stock Market Liquidity

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Consistent with the supply-side hypothesis of liquidity where financial intermediaries' binding funding constraints deteriorates stock market liquidity, I find that the negative change of primary dealers' repo volume and capital ratio deteriorates stock market liquidity. The relationship is stronger for the negative shocks and the volatile stocks. Moreover, since the funding condition affects individual stocks' liquidity simultaneously, it can explain the commonality of liquidity. Although I cannot find evidence for repo volume, capital ratio shocks can explain the commonality of liquidity, whose effect is mainly driven by large negative shocks.

Keywords: liquidity, financial intermediaries, repurchase agreement, leverage

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# 1. Introduction

One of the intermediaries' crucial roles is to provide market liquidity, which allows investors to easily trade stocks, rebalance portfolios, and smooth consumption. For intermediaries to provide liquidity, it is common for them to raise capital from financiers. With loose funding constraint, intermediaries can provide sufficient liquidity. However, when it is difficult to finance their position, intermediaries cannot finance to trade illiquid stocks and the market liquidity declines. In this way, the "supply-side" hypothesis attempts to explain the market liquidity from the perspective of liquidity providers (Gromb & Vayanos 2002; Vayanos 2004; Brunnermeier & Pedersen 2009). Also, funding shock can cause liquidity commonality, since liquidity declines occur at the same time. Using primary dealers' repo volumes and capital ratio, this paper empirically studies the effect of intermediaries' funding constraint on stock market liquidity and liquidity commonality.

With intermediaries' leverage, we can better assess the funding constraint they face. After the financial crisis in 2008, researchers have paid greater attention to intermediaries and their balance sheet data. Adrian and Shin (2010b) analyzes the balance sheet of security brokers and dealers, while He *et al.* (2010) addresses diverse institutions including commercial banks, investment banks and insurance companies. Supported by their empirical analysis, these authors model the relationship between intermediaries' leverage behavior and funding condition (He & Krishnamurthy 2012; Adrian

& Shin 2014). Although many papers document an empirical relationship between intermediaries' funding constraint and stock market liquidity, they use market-wide shocks (Hameed *et al.* 2010; Jensen & Moorman 2010) or inventory data (Coughenour & Saad 2004; Comerton-Forde *et al.* 2010) to assess the funding condition. Their measures may not correctly identify the intermediaries' funding condition because market-wide shock can affect liquidity through investor sentiment and inventory data are small portion of intermediaries' business. Thus, I test the supply-side hypothesis of liquidity and liquidity commonality using the measure from intermediary leverage data.

The literature that links intermediary leverage and their funding constraint can be classified into two models: debt constraint theories and equity constraint theories (He *et al.* 2010; He *et al.* 2017). First, debt constraint theories focus on time varying debt constraint and the debt capacity (Brunnermeier & Pedersen 2009; Adrian & Shin 2010b, 2014). Intermediaries demand funds proportional to their debt capacity and financiers impose stricter debt constraint during the downturn. Thus, when their equity is impaired, intermediaries have smaller debt capacity with harsher funding constraint and eventually reduce their leverage. These literatures argue leverage is procyclical and deleveraging behavior reveals binding funding constraint. Adrian and Shin (2014) present empirical evidence of procyclical leverage using security broker and dealers' book equity and book debts. Second, equity constraint theories emphasize the effective equity capital and bankruptcy risk (He & Krishnamurthy 2012, 2013; Brunnermeier & Sannikov

2014). In their model, intermediaries choose leverage and portfolio depending on their relative equity capital and leverage does not always move with debt capacity. When their equity is impaired, intermediaries reduce debt. However, since fall in equity outweighs the amounts of debt reduction in equilibrium, the leverage increases and it is countercyclical. He *et al.* (2017) documents that while leverage is procyclical for security brokers and dealers' level, it is countercyclical in the bank holdings company level whether book equity or market equity is used to calculate leverage. If the internal capital market within holdings company is an important source of funding, their measure would be more relevant to find out the financial distress of intermediaries. Overall, I use both of their empirical measures to assess intermediaries' funding condition.

To overcome the frequency problem, I use monthly primary dealers' repo volume growth and the HKM factor from He *et al.* (2017). The early literatures emphasize the importance of intermediaries' leverage but its lack of high frequency is a problem. To measure security brokers and dealers leverage growth, I use primary dealers' repo contract volume. Primary dealers are active and important security brokers and dealers in the market and their primary source of funds is the repo market (King 2008; Adrian & Shin 2010a). Thus, I interpret increasing repo volumes to be increasing leverage. Also, I used the HKM capital ratio from He *et al.* (2017), which is calculated by AR(1) shock to primary dealers' capital ratio (inverse of leverage) at the holdings company level. The capital ratio measures the effective equity capital of the financial intermediaries.

Using the CHL illiquidity measure proposed by Abdi and Ranaldo (2017), I found evidence from the panel regression that the HKM factor and repo volume growths affect stock market liquidity. While the HKM factor's impact concentrates on the 2007-2008 financial crisis periods, both the HKM factor and repo volume growth have a significant relationship across markets and sub-periods. Also, since funding condition affects liquidity only when the constraint binds, I further divided the shocks according to its signs and magnitudes. I find that negative shocks have a larger coefficient and significance, where the difference is clear with large negative shocks. Moreover, since volatile stocks are more sensitive to funding conditions, I divide stocks into size and volatility portfolios. I find that volatile stocks are more sensitive to the HKM factor, repo volume growth and their negative shocks. Overall, I find supporting evidence for both debt and equity constraint models that the HKM factor and repo volume growth affects stock market liquidity, which is more pronounced for the negative shocks and volatile stocks.

Furthermore, the HKM factor can partially explain liquidity commonality documented by extensive literature (Chordia *et al.* 2000; Hasbrouck & Seppi 2001). Since negative HKM factor and repo volume growth simultaneously deteriorate individual stocks' liquidity, it can also increase liquidity commonality among individual stocks. While repo volume growth has an insignificant and inconsistent sign with the models, the HKM factor has a significant impact on the liquidity commonality. Also, consistent with liquidity analysis, it is a large negative HKM shock that drives the relationship. Therefore, while I cannot find evidence supoprting debt constraint theories for liquidity commonality, I find supporting evidence of equity constraint theories that the HKM factor can explain the commonality.

The remainder of this paper is organized as follows. Section 2 develops the main hypothesis to be tested and covers relevant papers about financial intermediaries' leverage and the supply-side hypothesis of liquidity. Section 3 describes the data and key variables. The regression specifics and results on the relationship between intermediary leverage shock and market liquidity are reported in section 4. Section 5 presents the empirical results of the effect of HKM factor on the commonality of liquidity. Section 6 concludes the paper.

# 2. Hypothesis

This section develops hypothesis for empirical analysis. Section 2.1 compares debt constraint models and equity constraint models in describing intermediaries leverage behavior. Section 2.2 discuss relevant literatures on the relationship between intermediary funding constraint and market liquidity.

## 2.1 Intermediaries' funding constraint and leverage

Literatures related to intermediary funding constraint and their leverage are broadly distinguished into two classes: debt constraint theories and equity constraint theories (He *et al.* 2010; He *et al.* 2017). Both theories are not mutually exclusive in the sense that they may describe different aspects of complex financial institutions.

First, debt constraint theories focus on the time varying debt constraints (Brunnermeier & Pedersen 2009; Adrian & Shin 2010b, 2014). While intermediaries funding demand is proportional to their debt capacity, debt financing is subject to leverage ratio or haircut constraint set by financiers. Typically, the debt constraint exhibits procyclical behavior, becoming harsher when the market is volatile or bearish. For example, in Brunnermeier and Pedersen (2009), intermediaries use up all their funding capacity to take liquidity premium. When their equity is impaired, intermediaries deleverage because of decreased equity and increasing haircut during downturn. The forced deleveraging is strong that it outweighs the fall in equity value. Thus, leverage is procyclical and intermediaries' deleveraging behavior can be interpreted as their binding funding constraint. Adrian and Shin (2010b) documents empirical evidence that security brokers and dealers exhibit procyclical leverage using book equity and book debt from Flow of Funds data. The procyclical leverage is primarily driven by active management of book debt, supporting the debt constraint model. Moreover, Adrian *et al.* (2014) presents new pricing kernel, security brokers and dealers leverage growth, to proxy risk-appetite of financial intermediaries. With intermediaries as marginal investors, they require larger risk premium for stocks that comove with their leverage growth.

To obtain higher frequency data, I use monthly primary dealers' repo volume growth to measure their leverage growth. Since their primary source of funding is repo market, when repo volume growth is positive (negative), I assume the leverage growth is positive (negative) (King 2008; Adrian & Shin 2010a). Both repo volume growth and net repo volume growth is used in the analysis. This is because the repo volume may double count repo contracts between Primary Dealers (Krishnamurthy *et al.* 2014). The net repo may be relevant for stock market analysis, since net repo may capture the funding that primary dealers use to trade in stock market. However, if reverse repo is lent to hedge funds and they carry out strategies to take liquidity premium, the repo volume may well capture the funding constraint on liquidity provision.

Second, equity constraint theories stress the risk bearing capacity of financial intermediaries (He & Krishnamurthy 2012, 2013; Brunnermeier & Sannikov 2014). In their model, intermediaries endogenously choose portfolios and leverage facing bankruptcy risk. Specifically, they should maintain their wealth positive to have non-negative consumption and choose leverage depending on their relative equity capital rather than debt capacity. When their equity is impaired, this reduces their risk bearing capacity and make them deleverage. However, the leverage increases because the fall in equity value exceeds the amount of deleverage, resulting countercyclical leverage. With enough capital, funding constraint does not bind and risk premium stays low. On the other hand, with insufficient capital, their funding constraint binds and risk premium rises. He *et al.* (2017) presents a new pricing kernel, the market capital ratio (inverse of market leverage) of primary dealers' holdings company which is positively correlated with the relative equity capital of intermediaries and their marginal utility of wealth. Negative shock of the ratio reveals binding funding constraint and intermediaries require higher risk premium for stocks that comove with their market capital ratio. Their factor is priced in diverse asset markets including stocks, bonds, commodity, and options. I used the factor (HKM factor) from their paper to measure financial constraint.

Two theories describe the leverage of financial intermediary in opposite way. Debt constraint theories argue procyclical leverage and equity constraint theories argue counter cyclical leverage (procyclical capital ratio). The two theories are not mutually exclusive because they may describe different sub-sectors of financial intermediaries. During a downturn, hedge funds, more likely to be affected by debt constraint, sell their assets to commercial banks with deposit insurance and their leverage move in opposite direction (He *et al.* 2010; He *et al.* 2017)). Thus, the two models may illustrate debt constrained hedge fund sectors and equity constrained bank sectors.

## 2.2 Intermediaries' funding constraint and market liquidity

Many theoretical papers present models that negative funding shock for intermediaries can deteriorate market liquidity and cause fire-sale, supporting supply-side hypothesis for liquidity (Gromb & Vayanos 2002; Brunnermeier & Pedersen 2009; Gromb & Vayanos 2010). In Brunnermeier and Pedersen (2009), intermediaries provide liquidity and finance their operation by collateralizing their assets on margin. The model shows that the "liquidity spiral" and "feedback loop" may occur in equilibrium. When there is a negative illiquidity shock, financiers perceive it as larger fundamental volatility and require higher margin because they cannot distinguish between fundamental shock and illiquidity shock. Then, with their reduced capital, intermediaries cannot raise capital to trade illiquid assets and the market liquidity declines. Moreover, the paper addresses that the commonality in liquidity may exist because of the feedback relationship. When the funding constraint binds, liquidity for individual assets decline simultaneously, causing commonality of liquidity among stocks. In similar vein, He and Krishnamurthy (2012) also show that when intermediaries' funding constraint binds, the set of buyers of risky asset diminishes and the market dries up.

Empirical evidences support the predictions from the theories. For example, Hameed *et al.* (2010) show that liquidity decline after negative market return, which may cause damage to intermediaries' collateral value. This relationship is more pronounced for negative return and for volatile portfolios. Also, negative market return increases the commonality of liquidity. Jensen and Moorman (2010) shows that expansive monetary policies ease funding conditions for intermediaries and increase market liquidity. Coughenour and Saad (2004) and Comerton-Forde *et al.* (2010) used inventory data to proxy cost of capital and show its effect on market liquidity and commonality. While early literatures use the market wide shocks and inventory data, they may not correctly identify funding conditions. While market wide shocks can influence investor sentiment and have impact on the liquidity from the demand-side, inventory data represent small portion of intermediaries' business. Thus, I analyzed market liquidity with the repo volume growth and the HKM factor which identifies the funding constraint of intermediaries more precisely.

Supported by prior literatures, I test several hypotheses with the repo volume growth and HKM factor. First, I test whether repo volume growth and HKM factor affects stock market illiquidity. When the intermediaries deleverage in repo markets or there is negative shock to capital ratio, these signals binding funding constraint and stock market illiquidity would increase. Moreover, I extend the test in signs, magnitudes and cross-section. Since the funding condition affects liquidity only when the constraint binds, I test whether the effect is more pronounced for the negative and large negative shock. Additionally, since theoretical models predict volatile stocks are more sensitive to funding condition, I form portfolios by sorting stocks by size and volatility and test whether the more volatile stocks are sensitive. Moreover, if individual stocks' liquidity is affected simultaneously by funding constraint, this may explain liquidity commonality among stocks. Thus, I test whether the repo growth and the HKM factor have influence on liquidity commonality.

# 3. Data

The daily and monthly stock return data are retrieved from the Center for Research in Security Prices (CRSP). Delisting returns are adjusted according to Shumway (1997)[1]. The sample includes 238 months from Jan.1998 to Oct.2017 because the repo data starts at Jan.1998 and the HKM capital factor ends at Oct.2017. The sample stocks are restricted to ordinary stocks with share code 10 and 11. I exclude the stock-monthly observation if the start price of the month is not within 2$ and 1000$ to avoid the influence of extreme price levels. Also, the monthly observation should have at least 12 applicable days, which is defined as a day with the closing price, high price, low price, price range, and volume above zero (Abdi & Ranaldo 2017). Additionally, I exclude monthly observation with stock splits and change of primary exchange. Lastly, an individual stock should have at least 36 months data to be included in the sample.

## 3.1. Intermediary funding constraint measure

To encompass both debt constraint and equity constraint model, I use the primary dealers' repo volume growth and HKM factor to measure funding constraint. Consistent with debt constraint model literatures, I use the repo volume growth to proxy for leverage growth of intermediaries. The amount of weekly primary dealers' repo and reverse-repo contract volume are obtained from New York Fed's data, which is released every Wednesday. I

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[1] If a stock is delisted, the return used is either the last return available on CRSP, or the delisting return, if available. If the deletion code is not in 500s and neither the last return nor delisting return is available, then the last return is set to -1.0. If delisting code is in the 500s, the delisting return is assigned to be -30%.

aggregate the repo volumes of overnight contracts and terms agreements collateralized by various assets. Then, I change the weekly data into monthly data by using the last observation within months and calculate their percentage change. The net repo volume is calculated by subtracting reverse repo volume from repo volume and monthly net repo volume growth is calculated with the percentage change.

Consistent with equity constraint model literature, the HKM factor is used from He *et al.* (2017). They match New York Fed primary dealers with publicly traded holding companies and calculate the HKM capital ratio as

$$\eta_t = \frac{\sum_i Market\ \ Equity_{i,t}}{\sum_i (Market\ \ Equity_{i,t} + Book\ \ Debt_{i,t})}$$

where firm $i$ is a primary dealer designee during the period t. Then, they estimate the HKM factor as an innovation $(u_t)$ in the auto-regression $\eta_t = \rho_0 + \rho_1 \eta_{t-1} + u_t$. I use monthly version of the HKM factor with monthly market equity and quarterly book debt from their website[2]. Although there may be measurement error in book debt, market equity played major role as the pricing kernel. Since higher frequency data is valuable, I proceed my analysis with the monthly HKM factor.

## 3.2. Stock market liquidity measure

[2] http://apps.olin.wustl.edu/faculty/manela/data.html

To measure illiquidity, CHL measure, proposed by Abdi and Ranaldo (2017) is used to estimate the bid-ask spread. Their measure provides highest cross-sectional and time-series average correlations with the TAQ effective spread. When the daily TAQ data is unavailable, CHL measure is good alternative to measure the spread. Using close, high, and low prices, the monthly CHL measure for individual stocks is calculated as

$$\hat{s}_{i,monthly} = \frac{1}{N}\sum_{t=1}^{N} \hat{s}_{i,t}\,, \qquad \hat{s}_{i,t} = \sqrt{\max\{4\left(c_{i,t} - x_{i,t}\right)\left(c_{i,t} - x_{i,t+1}\right), 0\}}$$

where $N$ shows the number of days in the month, $c_{i,t}$ is daily close log-price, $x_{i,t}$ is average of daily high and low log-price.

[INSERT TABLE 1 HERE]

Table 1 shows the summary statistics for key variables and control variables. I equal weighted CHL measure to construct aggregate CHL measure. Since the standard deviation of $\mathrm{Std}(R_m)$ and $\Delta\ \mathrm{Std}(R_m)$ are too small, I multiplied 100 to make it comparable when it is used in regression. Although HKM factor and market return shows large positive correlation, the variance inflation factor is approximately 2 and the condition ratio is 5, indicating less concern for multicollinearity. Although repo volume and net repo volume have strong correlation over 0.9, their growth has weaker correlation about 0.4. Overall, the change in aggregate CHL is negatively correlated with HKM factor, repo volume growth, net repo volume growth, and market return and positively correlated with $\Delta$ Std($R_m$).

[INSERT FIGURE 1 HERE]

The figure 1A shows the equal-weighted average of individual stock's CHL measure exhibiting large increase in 2008. Though the average measure seems not volatile enough, the individual measure exhibit sufficient change in cross-section and over times-series. Additionally, the figure 1B presents dynamics of the repo, net repo volumes, and capital ratio which all show large decline in 2008. The net repo volumes are consistently smaller than the repo volumes. The capital ratio often falls below 5% which seems to violate regulations to maintain adequate capital ratio. However, the capital ratio used market equity and some firms with B/M ratio less than 1 can explain the phenomena.

# 4. Liquidity and Intermediary leverage

When financial intermediaries' funding constraint binds, they face problem in providing liquidity. I conducted panel regression by regressing market liquidity on lagged funding shock. Specifically, individual stocks' monthly changes of CHL spread are regressed on the lagged HKM factor, repo volume growth, and net repo volume growth. The regression is done with lagged variables because market liquidity can influence funding shock, which may cause reverse relationship and endogeneity problem (Brunnermeier & Pedersen 2009).

A diverse set of variables are included to control other sources of intertemporal variation in liquidity. I included lagged spread of CHL, market return, individual return (Hameed *et al.* 2010), change in fed funds rate (Jensen & Moorman 2010), change in standard deviation of market return and its lagged term, change in standard deviation of individual return and its lagged term (Vayanos 2004), change in individual stock's turnover (Ho & Stoll 1980). Thus, monthly changes in spreads are regressed on monthly variables

$$\begin{aligned}\Delta CHL_{i,t} &= \beta_0 + \beta_1 X_{i,t-1} + c_1 \Delta CHL_{i,t-1} + c_2 R_{m,t-1} + c_3 R_{m,t-1} \\ &\times MarketDown_{m,t-1} + c_4 \Delta Fedfunds_{i,t} + c_5 \Delta std(R_m)_t \\ &+ c_6 \Delta std(R_m)_{t-1} + c_7 \Delta std(R_i)_t + c_8 \Delta std(R_i)_{t-1} + c_9 \Delta Turn(R_i)_{t-1} \\ &+ \varepsilon \end{aligned} \tag{1}$$

where $X_{i,t}$ is the HKM factor, repo or net repo volume growth. I did not use the repo and net repo volume growth at the same time, because they both proxies the book leverage growth of primary dealers.

[INSERT TABLE 2 HERE]

Table 2 presents the main result of the panel regression of change in CHL on lagged HKM factor, repo and net repo volume growth with fixed effect model and t-statistics calculated from doubled clustered standard errors by firm and month. Changes in spreads show mean reverting behavior with negative significant coefficient of lagged term. Consistent with previous literatures, a decrease in turnover, individual return and market return or increase in volatility of market return and individual return predict higher spreads. Moreover, the coefficient of changed in fedfunds rate is positive but insignificant.

More importantly, lagged HKM factor, repo and net repo volume growth on average affect changes in spreads. In details, the coefficients are negative and significant at 5 %, which indicates that negative shock to funding condition predicts higher spreads. Considering their economic significance, 1 standard deviation decrease in the factors predicts on average 0.04 standard deviation increase in change of spreads for all stocks. Although the economic significance seems small, the effect is more pronounced for large negative shocks and volatile portfolios. Also, since the regression predicts changes in spreads for all stocks, the small coefficients are reasonable. Furthermore, when we include HKM factor, the coefficient of market return decreases and becomes insignificant. This implies that HKM factor may captures better information about funding condition.

[INSERT TABLE 3 HERE]

According to Table 3, the results are robust to different markets and periods. Using the same regression in Table 2, the relationship is negative and significant for both NYSE/AMEX and NASDAQ markets. The coefficient of HKM factor is larger in NASDAQ market, suggesting further cross-sectional extension since NASDAQ stocks are more volatile than NYSE/AMXE stocks. Moreover, I divided periods between crisis period and non-crisis period, because the role of intermediary draw attention from recent crisis and the effect may concentrate on those periods. The analysis with sub-periods show interesting results. Although the samples are smaller in crisis periods, HKM factor has large, negative, significant coefficient. On the other hand, the repo volume growth are only significant in non-crisis period and net repo volume growth are significant at both periods with similar magnitude.

## 4.1 Negative shock and magnitude analysis

The models that relate the intermediaries' funding constraint and liquidity pose stronger prediction that the relation should be stronger for negative shocks. When funding constraint is loose, intermediaries can fully manage the liquidity demand and funding constraint does not affect liquidity. Likely, negative shocks and its large magnitudes indicate binding constraint and cause increase in spreads. Accordingly, I modify the equation to allow spreads to react differently to signs and magnitudes of shocks

$$\Delta CHL_{i,t} = \beta_0 + \beta_1 X_{i,t-1} \times D_{postivie,t-1} + \beta_2 X_{i,t-1} \times D_{negative,t-1} + \varepsilon \qquad (2)$$

$$\Delta CHL_{i,t} = \beta_0 + \beta_1 X_{i,t-1} \times D_{small,t-1} + \beta_2 X_{i,t-1} \times D_{Downlarge,t-1} + \beta_3 X_{i,t-1} \times D_{Uplarge,t-1} + control\ \ variables + \varepsilon \qquad (3)$$

where $X_{i,t}$ is the HKM factor, repo or net repo volume growth. $D_{positive,t}$ ($D_{negative,t}$) is a dummy variable equals one when $X_{i,t}$ is positive (negative). $D_{Downlarge,t}$ ($D_{Uplarge,t}$) is a dummy variable equals one when $X_{i,t}$ is smaller (larger) than $\hat{\mu} - 1.5\hat{\sigma}$ ($\hat{\mu} + 1.5\hat{\sigma}$). $D_{small,t}$ is a dummy variable equals one when $X_{i,t}$ falls between $\hat{\mu} - 1.5\hat{\sigma}$ and $\hat{\mu} + 1.5\hat{\sigma}$. The control variables are same as the equation (1).

[INSERT TABLE 4 HERE]

Table 4 presents results of panel regression of change in spreads on intersection of HKM factor, repo and net repo volume growth, and dummy variables. In panel A, the coefficients of positive shocks often lose their significance and are smaller than those of negative shocks. In panel B, despite consistent negative sign, small shocks lose their significance except for the repo volume growth. Large negative shocks have large and significant coefficients and they are larger than those of Table 2. Particularly, the coefficient of the HKM factor almost doubled which is consistent with the prior evidence in crisis period. On the other hand, the repo volume growth does not show similar results. The result could be from its double counting problem or hedge funds' diverse strategies other than liquidity premium strategy. Overall, the evidences support that it is large negative shock that drives the relationship between funding constraint and market liquidity.

## 4.2 Cross-sectional analysis

Brunnermeier and Pedersen (2009) suggest that high volatility stocks require greater use of risk capacity and face greater funding shortage when the constraint binds. Thus, intermediary funding constraint have larger impact on the liquidity of high volatile stocks than that of low volatile stocks.

I extend the analysis by forming portfolios with size and volatility double sorts. To be included, individual stocks should have at least 100 applicable days and positive market capitalization at the end of the year. First, at every year (t), individual stocks are sorted by their previous yearend market size (t-1) based on breakpoints for the bottom 30 percent (Small), middle 40 percent (Medium), and top 30 percent (Large). Then, within each size class, I divide stocks based on previous years' realized return volatility (t-1) based on breakpoints for the bottom 30 percent (Low), middle 40 percent (Medium) and top 30 percent (Large). The portfolios are constructed every year and their monthly variables are calculated by averaging individual stocks' variable with equal weights. To test the differential influence between portfolios, I run seemingly unrelated regression (SUR) with the equation (1) and (3) and test whether the magnitude of coefficient is larger for high volatility stocks.

[INSERT TABLE 5 HERE]

Table 5 presents results of SUR for coefficient of interest. The predicted patterns are mainly observed in large size portfolios which seems consistent with active institution trading for large size stocks. In details, across all size sorts, HKM factor have same pattern that it has small coefficient with low significance in low volatile portfolios, while large coefficient with strong significance in high volatility portfolios. The large negative HKM factor shows similar pattern with coefficient larger than HKM factor. I test whether the coefficient from high and low volatility portfolio is same using Wald statistics. The difference in coefficient of HKM factor is significant across all size sorts, while that of large negative HKM factor is significant for medium and large portfolios. Thus, the evidences suggest that HKM factor has greater influence on volatile portfolios.

Moreover, Repo and net repo volume growth have similar pattern with HKM factor except their weak significance in small size portfolios. Interestingly, while large negative repo shock was not significant in table 5, its effect is large and significant for high volatility portfolios. With the significant difference of coefficient for both repo volume growth and its large negative shock, the evidence supports that the impact is more pronounced for volatile stocks. In contrast, large negative shock of net repo has significant impact for medium and large stocks, but the difference in coefficient is insignificant.

Overall, the evidences suggest that individual stock market liquidity is negatively influenced by HKM factor, repo and net repo volume growth. When it is hard for financial intermediaries to fund their position, they reduce liquidity provision and market liquidity declines. Consistent with prior literatures, this impact is more pronounced for the negative shocks and volatile stocks.

# 5. Liquidity Commonality and Intermediary leverage

Brunnermeier and Pedersen (2009) suggest that when the funding constraint binds, all stocks' liquidity declines at the same time. Thus, funding condition of intermediary may explain the commonality in liquidity documented by extensive literatures (Chordia *et al.* 2000; Hasbrouck & Seppi 2001). Although Karolyi *et al.* (2012) do not find supporting evidence that intermediaries' funding condition affects liquidity commonality in international markets, I believe using HKM factor, repo and net repo growth can presents supportive evidence.

I calculate the liquidity commonality using $R^2_{liq}$ measure from Hameed *et al.* (2010); Karolyi *et al.* (2012). To filter out day-of-the-week effects documented by Chordia *et al.* (2005), I first run the following filtering regression for each stock *i* based on observations on day *d* within each month *t*: $CHL_{i,t,d} = \beta_0 CHL_{i,d,t-1} + \sum_{\tau=1}^{5} \beta_{i,t,\tau} D_\tau + \varepsilon_{i,t,d}$, where $D_\tau$ ($\tau$=1,…,5) denote day-of-the-week dummies. With lagged CHL as regressor, $\varepsilon$ can successfully capture the liquidity shock on day *d* in month *t*. I used the residuals to obtain measures of commonality in liquidity ($R^2_{liq}$) for each stock by taking the $R^2$ from the commonality regression, based on daily observation with a month: $\hat{\varepsilon}_{i,t,d} = \beta_0 + \sum_{j=-1}^{1} \beta_{i,t,j} \hat{\varepsilon}_{m,t,d} + u_{i,t,d}$, where $\hat{\varepsilon}_{m,t,d}$ denotes the aggregate market liquidity shock, calculated as the market-value (previous yearend) weighted-average of the residuals for all individual stocks. In line with Chordia *et al.* (2011), I include one-day leading and lagging aggregate market liquidity shock as regressor for possible lead and lag relationship. Then, monthly liquidity commonality ($R^2_{liq}$) is obtained as equal-weighted average of $R^2$ from the commonality regression for every stocks. Following Morck *et al.* (2000), since $R^2_{liq}$ always fall within the interval [0,1], I used the logistic transformation of the measure $\left(\mathrm{LIQCOM} = \ln\left[\frac{R^2_{liq}}{1-R^2_{liq}}\right]\right)$ to be used as a dependent variable.

[INSERT FIGURE 2 HERE]

To assess funding condition's impact on liquidity commonality, I regressed LIQCOM on the HKM factor, repo, and net repo volume growth with control variables as the equation (4). To control other factors that may affect commonality, I included equal-weighted CHL, market return, large positive market return, large negative market return ((Hameed *et al.* 2010), change in fedfunds rate (Jensen & Moorman 2010), standard deviation of market return, treasury bill rate, default spread, and market turnover (Karolyi *et al.* 2012).

$$\begin{aligned}\mathrm{LIQCOM}_t = \;& \beta_0 + \beta_1 X_{i,t} + c_1 CHL_{i,t} + c_2 R_{m,t} + c_3 R_{m,t} \times LargeDown_{m,t} \\ & + c_4 R_{m,t} \times LargeUp_{m,t} + c_5 \Delta Fedfunds_{i,t} + c_6 std(R_m)_t \\ & + c_7 TreasuryBill_t + c_8 DefaultSpread_t \\ & + c_9 MarketTurn_t + \varepsilon \qquad (4)\end{aligned}$$

[INSERT TABLE 6 HERE]

Table 6 presents time-series regression results from the equation (4) with t-statistics calculated from Newey-west statistics with 4 lags. Consistent with previous literature, market return shows negative coefficient and change in fedfunds, market volatility, and market turnover shows positive coefficient. However, only market turnover and market return shows significance. I believe the difference comes from different sample period and composition of stocks, since my sample include NASDAQ and AMEX stocks with recent periods. Moreover, the treasury bill rate shows significant negative coefficient, which contradicts argument that increase in treasury bill rate weakens funding condition and increase liquidity commonality. This evidence is consistent with Karolyi, Lee, and Dijk (2012) that weakens supply-side hypothesis.

More importantly, HKM factor has significant influence on liquidity commonality. Among the variables of interests, only HKM factor shows significance, supporting equity constraint theories. Also, market return lose its significance when we include HKM factor in the section. This strengthen argument that HKM factor captures funding constraint better than market wide shocks. To gauge its economic significance, 1 standard deviation decrease in HKM factor cause 0.2 standard deviation increase in liquidity commonality. Overall, although no significant effect is observed for repo and net repo volume growth, the evidences supports supply-side hypothesis that liquidity commonality could be partially explained by intermediaries' funding constraint.

## 5.1 Sign and magnitude analysis

If the influence of funding constraint on market liquidity is largely derived from large negative shock, liquidity commonality would be also derived by large negative shock. Also, the repo and net repo volume growth could have impact for large negative shock. Accordingly, I used dummy variables defined in section 4.2 to capture differential relationship for different magnitude. Specifically, I run time-series regression as:

$$\begin{aligned} \mathrm{LIQCOM}_t = \; & \beta_0 + \beta_1 X_{i,t} + \beta_2 X_{i,t} \times D_{Downlarge,t} + \beta_3 X_{i,t} \times D_{Uplarge,t} \\ & + contol \;\; varaibles + \varepsilon \qquad (4) \end{aligned}$$

where $X_{i,t}$ is HKM factor, repo or net repo volume growth and dummy variables are same as the equation (2)

[INSERT TABLE 7 HERE]

Table 7 show result of the time-series regression for the coefficient of interest from the equation (6). Large negative shock of the HKM factor has large and significant coefficient, almost twice the magnitude of other shocks. Thus, liquidity commonality increases when there is large negative shock to the HKM factor. However, even if repo and net repo volume growth have been divided according to its magnitude, they do not show any significant coefficient. Thus, similar to table 6, I found that the large negative HKM factor increases liquidity commonality but could not find evidence that repo and net repo volume growth affects the commonality.

Overall, I found evidence supporting supply-side hypothesis of liquidity commonality that binding funding constraint increases the commonality. While the results do not support debt constraint theories, the HKM factor has significant influence on the liquidity commonality consistent with equity constraint theories and the relationship is driven by large negative shock.

# 6. Conclusion

Liquidity is important for well-functioning markets and it is important to know what drives the movement of liquidity. According to supply-side theories(Brunnermeier & Pedersen 2009), with binding funding constraint, financial intermediaries cannot fully finance their position to provide liquidity and the market liquidity declines. This paper empirically test their hypothesis using HKM factor and primary dealers' repo volume growth. The measures are used based on recent literatures studying the intermediaries funding constraint and leverage(He & Krishnamurthy 2012; Adrian & Shin

2014).

This paper documents that the HKM factor and repo volume growth affect individual stocks' liquidity. Consistent with supply-side hypothesis, the effect is driven by the large negative shock and stronger for high volatility firms. Also, if the stocks liquidity declines at the same time, this may create the liquidity commonality and intermediary funding shock can explain the movement of commonality. I find that the HKM factor has significant influence on liquidity commonality, which is more pronounced for large negative shocks. Overall, I find evidence that supports the supply-side hypothesis of liquidity.

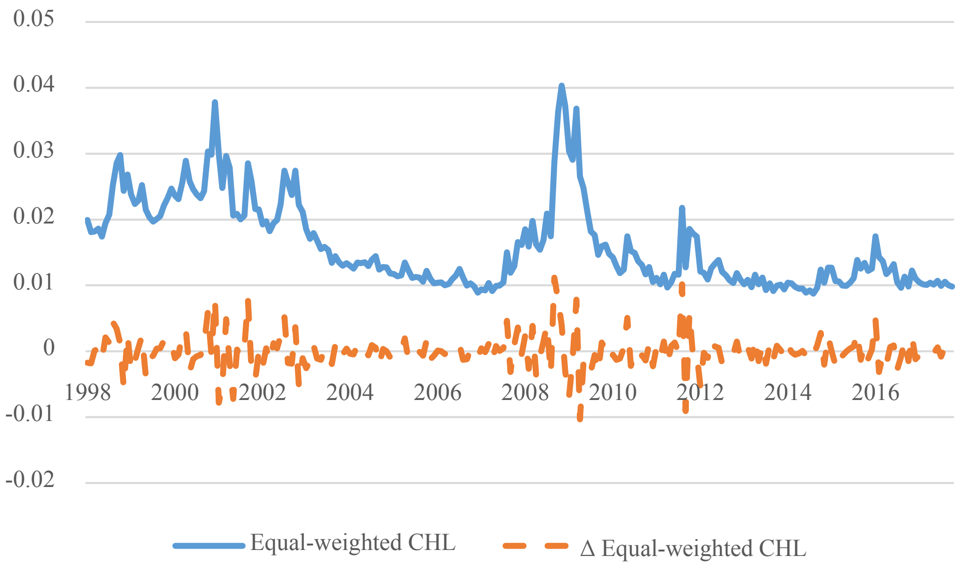


**Figure 1A. Equal-weighted CHL and Change in CHL**

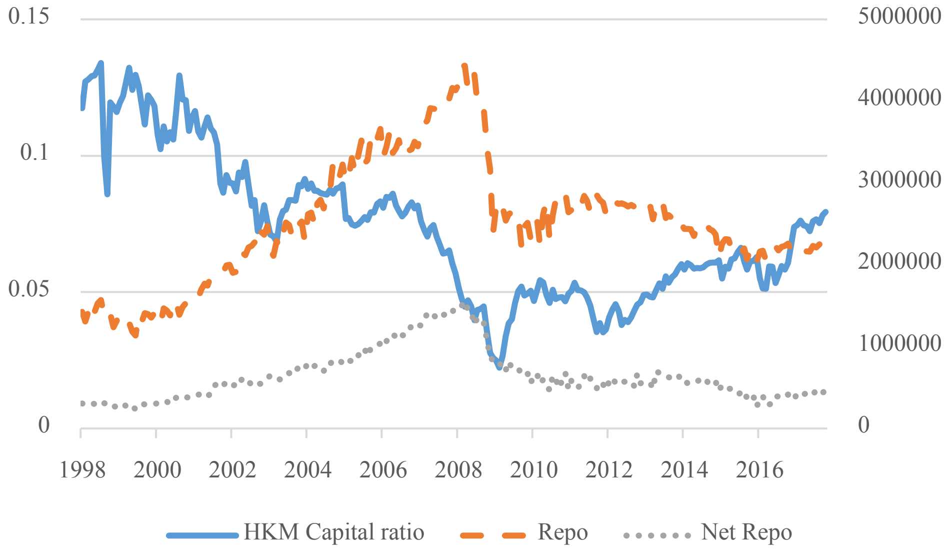


**Figure 1B. HKM capital ratio, Repo, and Net Repo volumes**

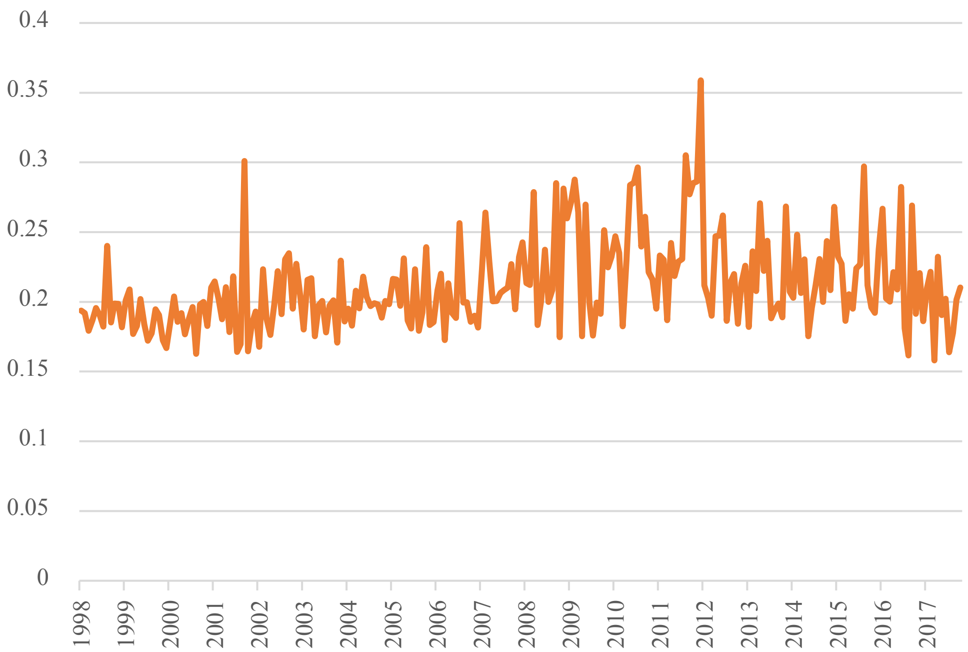


**Figure 2. Liquidity Commonality**

**Table 1. Summary Statistics**

This table reports descriptive statistics of equal-weighted CHL, HKM capital ratio and factor, primary dealers' repo and volume growth, primary dealers' net repo and volume growth, monthly market return, fedfunds rate and its change, and monthly standard deviation of daily market return and its change over the period 1998:01 – 2017:10. Equal-weighted CHL is obtained as the average of individual stocks' CHL from Abdi and Ranaldo (2017). HKM capital ratio is the market-weighted average of capital ratio of primary dealers' holdings company and its factor is AR(1) shock defined as He, Kelly, and Manela (2017). Repo and net repo is primary dealers' amount of contracts reported to New York Fed. Market return is obtained from Kenneth' data library and Fed funds rate is collected from St. Louis Fed. Monthly standard deviation of market return is calculated with daily market return within given month.

| Panel A. Mean, Variance, Quartile, and observation | | | | | |
|---|---|---|---|---|---|
| | Mean | Std | Q1 | Q3 | N |
| Aggregate CHL | 1.601% | 0.661% | 1.079% | 2.004% | 238 |
| Δ Aggregate CHL | -0.005% | 0.265% | -0.120% | 0.086% | 238 |
| HKM Capital ratio | 7.327 % | 2.637% | 5.120% | 8.760% | 238 |
| HKM factor | 0.211% | 6.952% | -3.388% | 3.990% | 238 |
| Repo | 2,517,044 | 745,154 | 2,126,447 | 2,792,879 | 238 |
| Δ Repo | 0.017% | 5.977% | -2.420% | 3.192% | 237 |
| Net Repo | 654,281 | 318,792 | 427,264 | 762,869 | 238 |
| Δ Net Repo | -0.354% | 10.532% | -4.607% | 5.396% | 237 |
| $R_m$ | 0.697% | 4.468% | -1.750% | 3.920% | 238 |
| Fedfunds | 2.108% | 2.179% | 0.160% | 4.590% | 238 |
| Δfedfunds | -0.018% | 0.167% | -0.020% | 0.020% | 238 |
| Std($R_m$) | 0.015% | 0.025% | 0.004% | 0.015% | 238 |
| Δ Std($R_m$) | 0.000% | 0.018% | -0.005% | 0.004% | 238 |

Panel B. Correlation Matrix

| | Aggregate CHL | ΔAggregate CHL | HKM Capital Ratio | HKM factor | Repo volume growth | Δ Repo | Net Repo volume growth | Δ Net Repo | $R_m$ | Fedfunds | Δ Fedfunds | Std($R_m$) | Δ Std($R_m$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aggregate CHL | 1 | | | | | | | | | | | | |
| ΔAggregate CHL | 0.20 | 1 | | | | | | | | | | | |
| Capital Ratio | -0.01 | 0.32 | 1 | | | | | | | | | | |
| HKM factor | -0.24 | -0.11 | 0.14 | 1 | | | | | | | | | |
| Repo | 0.08 | -0.41 | -0.57 | -0.14 | 1 | | | | | | | | |
| Repo volume growth | 0.09 | -0.08 | 0.11 | 0.02 | 0.07 | 1 | | | | | | | |
| Net Repo | 0.08 | -0.2 | -0.33 | -0.14 | 0.92 | 0.03 | 1 | | | | | | |
| Net Repo volume growth | 0.02 | -0.05 | 0.12 | 0.04 | 0.02 | 0.44 | 0.09 | 1 | | | | | |
| $R_m$ | -0.27 | -0.21 | 0.06 | 0.70 | -0.08 | -0.02 | -0.09 | 0.00 | 1 | | | | |
| Fedfunds | 0.07 | 0.38 | 0.76 | -0.03 | -0.14 | 0.08 | 0.14 | 0.12 | -0.06 | 1 | | | |
| Δ Fedfunds | 0.001 | -0.399 | 0.061 | 0.11 | -0.06 | 0.08 | -0.14 | 0.10 | 0.10 | -0.023 | 1 | | |
| Std($R_m$) | 0.39 | 0.68 | -0.19 | -0.33 | 0.027 | -0.20 | 0.06 | -0.19 | -0.38 | -0.02 | -0.43 | 1 | |
| Δ Std($R_m$) | 0.73 | 0.09 | 0.02 | -0.21 | 0.08 | 0.12 | 0.07 | -0.01 | -0.32 | 0.04 | -0.06 | 0.37 | 1 |

## Table 2. Spreads and Intermediary Leverage

This table reports result of panel regression of changes of CHL on HKM factor, repo volume growth, net repo volume growth and other control variables using the following specifications:

$$\Delta CHL_{i,t} = \beta_0 + \beta_1 X_{i,t-1} + c_1 \Delta CHL_{i,t-1} + c_2 R_{m,t-1} + c_3 R_{m,t-1} \times MarketDown_{m,t-1} + c_4 \Delta Fedfunds_{i,t} + c_5 \Delta std(R_m)_t + c_6 \Delta std(R_m)_{t-1} + c_7 \Delta std(R_i)_t + c_8 \Delta std(R_i)_{t-1} + c_9 \Delta Turn(R_i)_{t-1} + \varepsilon$$

where $X_{i,t}$ is HKM factor, repo or net repo volume growth and the numbers in the parenthesis are t-statistics calculated with two-way clustered standard errors by firm and month.

| | $\Delta$ CHL$_t$ | | | | |
|---|---|---|---|---|---|
| Constant | 0.000*** | 0.000*** | 0.000*** | 0.000*** | 0.000*** |
| | (-3.56) | (-3.09) | (-3.01) | (-3.35) | (-3.28) |
| $HKM\ factor_{t-1}$ | -0.004*** | | | -0.004*** | -0.004*** |
| | (-3.66) | | | (-3.54) | (-3.6) |
| Repo volume growth$_{t-1}$ | | -0.003** | | -0.002** | |
| | | (-2.25) | | (-2.21) | |
| Net Repo volume growth$_{t-1}$ | | | -0.002*** | | -0.002*** |
| | | | (-2.88) | | (-2.65) |
| $\Delta$ CHL$_{t-1}$ | -0.458*** | -0.457*** | -0.457*** | -0.457*** | -0.457*** |
| | (-58.94) | (-58.27) | (-58.14) | (-58.75) | (-58.6) |
| $R_{m,t-1}$ | -0.001 | -0.006** | -0.006* | -0.002 | -0.002 |
| | (-0.27) | (-2.01) | (-1.93) | (-0.48) | (-0.54) |
| $R_{m,t-1} \times Down_{m,t-1}$ | -0.007 | -0.005 | -0.005 | -0.005 | -0.005 |
| | (-1.25) | (-1.01) | (-0.89) | (-1.05) | (-0.93) |
| $\Delta$ Fedfunds$_t$ | 0.071 | 0.064 | 0.067 | 0.069 | 0.073 |
| | (1.44) | (1.22) | (1.29) | (1.39) | (1.45) |
| $\Delta$ Std$(R_m)_t$ | 0.048*** | 0.047*** | 0.047*** | 0.049*** | 0.049*** |
| | (5.37) | (4.68) | (4.84) | (5.3) | (5.44) |
| $\Delta$ Std$(R_m)_{t-1}$ | 0.007 | 0.007 | 0.006 | 0.007 | 0.007 |
| | (0.77) | (0.83) | (0.73) | (0.91) | (0.81) |
| $R_{i,t-1}$ | 0.001*** | 0.001*** | 0.001*** | 0.001*** | 0.001*** |
| | (4.14) | (4.21) | (4.31) | (4.29) | (4.4) |
| $R_{i,t-1} \times Down_{i,t-1}$ | -0.007*** | -0.007*** | -0.007*** | -0.007*** | -0.007*** |
| | (-9.94) | (-9.91) | (-9.89) | (-10.09) | (-10.06) |
| $\Delta$ Std$(R_i)_t$ | 0.184*** | 0.184*** | 0.184*** | 0.183*** | 0.183*** |
| | (39.7) | (39.11) | (39.21) | (39.41) | (39.49) |
| $\Delta$ Std$(R_i)_{t-1}$ | 0.091*** | 0.091*** | 0.092*** | 0.091*** | 0.091*** |
| | (33.24) | (32.13) | (32.08) | (33.09) | (33.02) |
| $\Delta$ Turn$_{i,t-1}$ | 0.000** | 0.000** | 0.000** | 0.000** | 0.000** |
| | (-2.2) | (-2.12) | (-2.2) | (-2.18) | (-2.26) |
| Firm fixed effect | Yes | Yes | Yes | Yes | Yes |
| Time fixed effect | Yes | Yes | Yes | Yes | Yes |
| Two-way clustered standard error | Yes | Yes | Yes | Yes | Yes |
| Adj. R square | 0.398 | 0.398 | 0.398 | 0.399 | 0.399 |
| # of firms | 8808 | 8808 | 8808 | 8808 | 8808 |
| # of observation | 839,588 | 839,588 | 839,588 | 839,588 | 839,588 |

## Table 3. Spreads and Intermediary Leverage: Different Markets and Period

This table reports the coefficient of interest from the panel regression of changes of CHL on HKM factor, repo, net repo volume growth and other control variables using the same specification of table 2 across different markets and sub-periods. Panel A includes stocks listed in NYSE and AMEX market, while panel B includes stocks listed in NASDAQ market. Panel C includes crisis periods (2007:01-2009:12), while panel D includes periods except crisis periods. The numbers in the parenthesis are t-statistics calculated with two-way clustered standard errors by firm and month.

| | $\Delta$ $\mathrm{CHL}_t$ | | | | |
|---|---|---|---|---|---|
| A. NYSE/AMEX | | | | | |
| $HKM\ factor_{t-1}$ | -0.003** | | | -0.003** | -0.003** |
| | (-2.43) | | | (-2.26) | (-2.26) |
| Repo volume growth $_{t-1}$ | | -0.003** | | -0.003** | |
| | | (-2.42) | | (-2.37) | |
| Net Repo volume $\mathrm{growth}_{t-1}$ | | | -0.002*** | | -0.002*** |
| | | | (-3.31) | | (-3.11) |
| B. NASDAQ | | | | | |
| $HKM\ factor_{t-1}$ | -0.005*** | | | -0.005*** | -0.005*** |
| | (-3.61) | | | (-3.60) | (-3.62) |
| Repo volume $\mathrm{growth}_{t-1}$ | | -0.002* | | -0.002* | -0.002** |
| | | (-1.91) | | (-1.88) | (-2.17) |
| Net Repo volume $\mathrm{growth}_{t-1}$ | | | -0.002** | | |
| | | | (-2.38) | | |
| C. Crisis period (2007 ~ 2009) | | | | | |
| $HKM\ factor_{t-1}$ | -0.007*** | | | -0.008*** | -0.007*** |
| | (-3.04) | | | (-3.28) | (-3.06) |
| Repo volume $\mathrm{growth}_{t-1}$ | | -0.003 | | -0.004* | |
| | | (-1.41) | | (-1.7) | |
| Net Repo volume $\mathrm{growth}_{t-1}$ | | | -0.002** | | -0.002** |
| | | | (-2.46) | | (-2.23) |
| D. Non-crisis period | | | | | |
| $HKM\ factor_{t-1}$ | -0.002 | | | -0.001 | -0.001 |
| | (-1.45) | | | (-1.23) | (-1.37) |
| Repo volume $\mathrm{growth}_{t-1}$ | | -0.002*** | | -0.002** | |
| | | (-2.60) | | (-2.42) | |
| Net Repo volume $\mathrm{growth}_{t-1}$ | | | -0.002** | | -0.002* |
| | | | (-2.00) | | (-1.90) |

**Table 4. Spreads and Intermediary leverage: Sign and Magnitude effect**

This table reports result of panel regression of changes of CHL on HKM factor, repo volume growth, net repo volume growth, intersection with their magnitude dummies and other control variables using the following specifications:

$$\Delta CHL_{i,t} = \beta_0 + \beta_1 X_{i,t-1} \times D_{small,t-1} + \beta_2 X_{i,t-1} \times D_{Downlarge,t-1} + \beta_3 X_{i,t-1} \times D_{Uplarge,t-1} + control\ \ variables + \varepsilon$$

where $X_{i,t}$ is HKM factor, repo volume growth or net repo volume growth. $D_{positive,t}$ ($D_{negative,t}$) is a dummy variable equals one when $X_{i,t}$ is positive (negative).$D_{Downlarge,t}$ ($D_{Uplarge,t}$) is a dummy variable equals one when $X_{i,t}$ is smaller (larger) than $\hat{\mu} - 1.5\hat{\sigma}$ ($\hat{\mu} + 1.5\hat{\sigma}$). $D_{small,t}$is a dummy variable equals one when $X_{i,t}$ is between $\hat{\mu} - 1.5\hat{\sigma}$ and $\hat{\mu} + 1.5\hat{\sigma}$. The numbers in the parenthesis are t-statistics calculated with two-way clustered standard errors by firm and month.

| | $\Delta$ $\mathrm{CHL}_t$ | | | | |
|---|---|---|---|---|---|
| Panel A. Positive and negative shocks | | | | | |
| $HKM\ factor_{t-1} \times Positive_{HKM,t-1}$ | -0.0035*** | | | -0.0036*** | -0.0031*** |
| | (-3.06) | | | (-3.08) | (-2.58) |
| $HKM\ factor_{t-1} \times Negative_{HKM,t-1}$ | -0.0053* | | | -0.0049* | -0.0057** |
| | (-1.88) | | | (-1.72) | (-2.15) |
| Repo volume $\mathrm{growth}_{t-1}$ $\times Positive_{Repo,t-1}$ | | -0.0014 | | -0.0019 | |
| | | (-0.69) | | (-0.99) | |
| Repo volume $\mathrm{growth}_{t-1}$ $\times Negative_{Repo,t-1}$ | | -0.0033* | | -0.0027 | |
| | | (-1.94) | | (-1.55) | |
| Net Repo volume $\mathrm{growth}_{t-1}$ $\times Positive_{Net\ Repo,t-1}$ | | | -0.0012 | | -0.0012 |
| | | | (-1.20) | | (-1.10) |
| Net Repo volume $\mathrm{growth}_{t-1}$ $\times Negative_{Net\ Repo,t-1}$ | | | -0.0025** | | -0.0025** |
| | | | (-2.14) | | (-1.98) |
| Panel B. Downlarge, small, and Uplarge shocks | | | | | |
| $HKM\ factor_{t-1} \times Small_{HKM,t-1}$ | -0.003 | | | -0.003 | -0.003 |
| | (-1.59) | | | (-1.6) | (-1.59) |
| $HKM\ factor_{t-1} \times Downlarge_{HKM,t-1}$ | -0.007** | | | -0.007** | -0.007** |
| | (-2.25) | | | (-2.2) | (-2.54) |
| $HKM\ factor_{t-1} \times Uplarge_{HKM,t-1}$ | -0.004*** | | | -0.004*** | -0.003*** |
| | (-3.21) | | | (-2.95) | (-2.84) |
| Repo volume $\mathrm{growth}_{t-1}$ $\times Small_{Repo,t-1}$ | | -0.003* | | -0.003* | |
| | | (-1.78) | | (-1.92) | |
| Repo volume $\mathrm{growth}_{t-1}$ $\times Downlarge_{Repo,t-1}$ | | -0.003* | | -0.002 | |
| | | (-1.79) | | (-1.47) | |
| Repo volume $\mathrm{growth}_{t-1}$ $\times Uplarge_{Repo,t-1}$ | | 0 | | 0 | |
| | | (-0.1) | | (-0.2) | |

| | | | | | |
|---|---|---|---|---|---|
| Net Repo volume growth$_{t-1}$ $\times Small_{Net\ Repo,t-1}$ | | | 0 | | 0 |
| | | | (-0.28) | | (-0.15) |
| Net Repo volume growth$_{t-1}$ $\times Downlarge_{Net\ Repo,t-1}$ | | | -0.004*** | | -0.003** |
| | | | (-2.65) | | (-2.48) |
| Net Repo volume growth$_{t-1}$ $\times Uplarge_{Net\ Repo,t-1}$ | | | -0.002*** | | -0.003** |
| | | | (-2.68) | | (-2.45) |
| Controls | Yes | Yes | Yes | Yes | Yes |
| Firm fixed effect | Yes | Yes | Yes | Yes | Yes |
| Time fixed effect | Yes | Yes | Yes | Yes | Yes |
| Two-way clustered standard error | Yes | Yes | Yes | Yes | Yes |
| # of firms | 9389 | 9389 | 9389 | 9389 | 9389 |
| # of observation | 839,916 | 839,916 | 839,916 | 839,916 | 839,916 |

## Table 5. Spread and Financial Intermediary: Cross-sectional Estimates.

This table reports the coefficient of interest from seemingly unrelated regression (SUR) of changes of CHL on HKM factor, repo volume growth, net repo volume growth and other control variables using the following two specifications:

$$\Delta CHL_{i,t} = \beta_0 + \beta_1 X_{i,t-1} + control\ \ variables + \varepsilon$$

$$\Delta CHL_{i,t} = \beta_0 + \beta_1 X_{i,t-1} \times D_{small,t-1} + \beta_2 X_{i,t-1} \times D_{Downlarge,t-1} + \beta_3 X_{i,t-1} \times D_{Uplarge,t-1} + control\ \ variables + \varepsilon$$

where $X_{i,t}$ is HKM factor, repo volume growth or net repo volume growth and dummy variables are defined as the same as table 4. Individual stocks are divided into size and volatility double sort portfolios depending on their previous yearend market capitalization and standard deviation of daily return. The last column of each size portfolios test whether the coefficient is different using Wald statistics.

| | $\Delta$ CHL$_t$ | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Small Size | | | | Medium Size | | | | Large Size | | | |
| | High volatility | Medium volatility | Low volatility | High – low | High volatility | Medium volatility | Low volatility | High – low | High volatility | Medium volatility | Low volatility | High – low |
| $HKM\ \ factor_{t-1}$ | -0.0069*** | -0.0038** | -0.0019 | -0.005** | -0.007*** | -0.0049*** | -0.0018 | -0.0052*** | -0.007*** | -0.0032** | -0.0019* | -0.051*** |
| | (-2.75) | (-2.18) | (-1.54) | | (-3.5) | (-3.35) | (-1.39) | | (-3.73) | (-2.5) | (-1.96) | |
| Repo volume growth$_{t-1}$ | -0.0038* | -0.0019 | 0.0006 | -0.0044** | -0.0053*** | -0.0036*** | -0.0021** | -0.0032** | -0.0051*** | -0.0021** | -0.0016* | -0.0039*** |
| | (-1.85) | (-1.28) | (0.56) | | (-3.13) | (-2.96) | (-1.93) | | (-3.34) | (-2.01) | (-1.92) | |
| Adj. R square | 0.624 | | | | | | | | | | | |
| # of observation | 2,133 | | | | | | | | | | | |
| $HKM\ \ factor_{t-1}$ | -0.0069*** | -0.0037** | -0.0018 | -0.0051** | -0.0069*** | -0.0047*** | -0.0017 | -0.0052*** | -0.0069*** | -0.0032** | -0.0019* | -0.005*** |
| | (-2.76) | (-2.15) | (-1.49) | | (-3.48) | (-3.35) | (-1.31) | | (-3.69) | (-2.51) | (-1.91) | |
| Net Repo volume growth$_{t-1}$ | -0.0012 | -0.0014* | -0.0005 | -0.0007 | -0.0032*** | -0.003*** | -0.0024*** | -0.0080 | -0.0034*** | -0.0024*** | -0.0015*** | -0.0019*** |
| | (-1.05) | (-1.7) | (-0.95) | | (-3.39) | (-4.44) | (-4.05) | | (-3.81) | (-4.11) | (-3.2) | |
| Adj. R square | 0.627 | | | | | | | | | | | |
| # of observation | 2,133 | | | | | | | | | | | |
| $HKM\ \ factor_{t-1} \times Downlarge_{HKM,t-1}$ | -0.0088** | -0.0082*** | -0.0047** | -0.0041 | -0.0083** | -0.0068*** | -0.0035 | -0.0048* | -0.0098*** | -0.0053** | -0.0032* | -0.0066*** |
| | (-2.09) | (-2.69) | (-2.1) | | (-2.44) | (-2.67) | (-1.54) | | (-3.09) | (-2.31) | (-1.87) | |
| Repo volume growth$_{t-1}$ $\times Downlarge_{Repo,t-1}$ | -0.0088** | 0.0024 | 0.0051*** | -0.0139*** | -0.0061** | -0.0026 | -0.0003 | -0.0058*** | -0.0062** | -0.0021 | -0.0002 | -0.0060*** |
| | (-2.09) | (1.06) | (3.17) | | (-2.26) | (-1.33) | (-0.15) | | (-2.52) | (-1.24) | (-0.13) | |
| Adj. R square | 0.634 | | | | | | | | | | | |
| # of observation | 2,133 | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $HKM\ factor_{t-1}$ $\times Downlarge_{HKM,t-1}$ | -0.0089** | -0.0077** | -0.004* | -0.0049 | -0.0084** | -0.0067*** | -0.0032 | -0.0052* | -0.0102*** | -0.0054** | -0.0031* | -0.0071*** |
| | (-2.10) | (-2.47) | (-1.78) | | (-2.49) | (-2.75) | (-1.44) | | (-3.22) | (-2.42) | (-1.84) | |
| Net Repo volume growth$_{t-1}$ $\times Downlarge_{Net\ Repo,t-1}$ | -0.0031 | -0.0027** | -0.0012 | -0.0019 | -0.0053*** | -0.0046*** | -0.0043*** | -0.0010 | -0.0042*** | -0.0035*** | -0.0026*** | -0.0016 |
| | (-1.61) | (-2.00) | (-1.35) | | (-3.48) | (-4.21) | (-4.49) | | (-2.95) | (-3.65) | (-3.46) | |
| Adj. R square | 0.638 | | | | | | | | | | | |
| # of observation | 2,133 | | | | | | | | | | | |

## Table 6. Liquidity Commonality and Intermediary leverage

The table reports time-series regression of liquidity commonality on HKM factor, repo volume growth, net repo volume growth, and other control variables using following specification:

$$\begin{aligned}\mathrm{LIQCOM}_t = \ & \beta_0 + \beta_1 X_{i,t} + c_1 CHL_{i,t} + c_2 R_{m,t} + c_3 R_{m,t} \times LargeDown_{m,t} + c_4 R_{m,t} \\ & \times LargeUp_{m,t} + c_5 \Delta Fedfunds_{i,t} + c_6 std(R_m)_t + c_7 TreasuryBill_t \\ & + c_8 DefaultSpread_t + c_9 MarketTurn_t + \varepsilon\end{aligned}$$

where $X_{i,t}$ is HKM factor, repo volume growth or net repo volume growth. Following Hameed, Kang, and Viswanahthan(2010) and Karolyi, Lee, Dijk (2012), $\mathrm{LIQCOM}_t$ is the logistic transformation of $R^2_{liq}$, which is the equal weighted average of $R^2$ from regression:

$$\hat{\varepsilon}_{i,t,d} = \beta_0 + \sum_{j=-1}^{1} \beta_{i,t,j} \hat{\varepsilon}_{m,t,d} + u_{i,t,d}$$

where $\hat{\varepsilon}_{i,t,d}$ is individual stocks' daily liquidity shock and $\hat{\varepsilon}_{m,t,d}$ is market's daily liquidity shock. The numbers in the parenthesis are t-statistics calculated from Newey-west standard errors with 4 lags.

| | $LIQCOM_t$ | | | | |
|---|---|---|---|---|---|
| Intercept | -1.454*** | -1.44*** | -1.441*** | -1.443*** | -1.442*** |
| | (-13.07) | (-12.56) | (-12.6) | (-13.06) | (-12.94) |
| $HKM\ factor_t$ | -0.625** | | | -0.639** | -0.64** |
| | (-2.14) | | | (-2.24) | (-2.34) |
| Repo volume $\mathrm{growth}_t$ | | 0.223 | | 0.323 | 0.559 |
| | | (1.08) | | (1.14) | (1.11) |
| Net Repo volume $\mathrm{growth}_t$ | | | 0.124 | | |
| | | | (1.06) | | |
| $R_{m,t}$ | -0.395 | -0.994*** | -0.976*** | -0.241 | -0.289 |
| | (-0.99) | (-2.9) | (-2.78) | (-0.55) | (-0.71) |
| $R_{m,t} \times DownLarge_{m,t}$ | -0.143 | -0.14 | -0.225 | -0.301 | -0.082 |
| | (-0.22) | (-0.2) | (-0.32) | (-0.45) | (-0.12) |
| $R_{m,t} \times UpLarge_{m,t}$ | 0.387 | 0.331 | 0.337 | 0.258 | 0.247 |
| | (0.44) | (0.36) | (0.36) | (0.3) | (0.28) |
| $\Delta$ $\mathrm{Fedfunds}_t$ | 12.246 | 11.075 | 10.971 | 11.973 | 12.252 |
| | (1.36) | (1.27) | (1.24) | (1.33) | (1.38) |
| $\mathrm{Std}(R_m)_t$ | 120.544 | 172.442 | 169.383 | 155.317 | 161.584 |
| | (0.55) | (0.77) | (0.75) | (0.71) | (0.74) |
| $Aggregate$ $\mathrm{CHL}_t$ | 1.321 | -0.008 | 0.029 | 0.632 | 0.568 |
| | (0.25) | (0) | (0.01) | (0.12) | (0.1) |
| Treasury Bill $\mathrm{rate}_t$ | -3.574*** | -3.465*** | -3.504*** | -3.658*** | -3.558*** |
| | (-3.4) | (-3.24) | (-3.26) | (-3.47) | (-3.47) |
| Default $\mathrm{Spread}_t$ | 4.727 | 4.333 | 4.021 | 5.015 | 5.786 |
| | (1.02) | (0.87) | (0.8) | (1.1) | (1.24) |
| Market $\mathrm{Turn}_t$ | 0.022** | 0.022** | 0.023** | 0.021** | 0.02** |
| | (2.29) | (2.39) | (2.43) | (2.19) | (2.09) |
| Adj. R square | 0.283 | 0.265 | 0.265 | 0.273 | 0.274 |
| # of observation | 238 | 238 | 238 | 238 | 238 |

## Table 7. Liquidity Commonality and Financial Intermediary leverage: Magnitude effect

The table reports the coefficients of interest from the time-series regression of liquidity commonality on HKM factor, repo volume growth, net repo volume growth, and other control variables using following specification:

$$\mathrm{LIQCOM}_t = \beta_0 + \beta_1 X_{i,t} + \beta_2 X_{i,t} \times D_{Downlarge,t} + \beta_3 X_{i,t} \times D_{Uplarge,t} + contol\ \ varaibles + \varepsilon$$

where $X_{i,t}$ is HKM factor, repo volume growth or net repo volume growth and dummy variables are defined as the same as table 4. $\mathrm{LIQCOM}_t$ and control variables are same as table 6. The numbers in the parenthesis are t-statistics calculated from Newey-west standard errors with 4 lags.

| | $LIQCOM_t$ | | | | |
|---|---|---|---|---|---|
| $HKM\ \ factor_t \times Small_{HKM,t}$ | -0.576 | | | -0.601 | -0.605 |
| | (-1.63) | | | (-1.62) | (-1.74) |
| $HKM\ \ factor_t \times Downlarge_{HKM,t}$ | -1.071** | | | -1.095** | -0.98** |
| | (-2.21) | | | (-2.28) | (-2.02) |
| $HKM\ \ factor_t \times Uplarge_{HKM,t}$ | -0.426 | | | -0.432 | -0.443 |
| | (-1.12) | | | (-1.11) | (-1.13) |
| $\text{Repo volume growth}_t \times Small_{Repo,t}$ | | 0.217 | | 0.172 | |
| | | (0.63) | | (0.51) | |
| $\text{Repo volume growth}_t \times Downlarge_{Repo,t}$ | | 0.202 | | 0.309 | |
| | | (0.57) | | (0.82) | |
| $\text{Repo volume growth}_t \times Uplarge_{Repo,t}$ | | 0.28 | | 0.254 | |
| | | (0.48) | | (0.42) | |
| $\text{Net Repo volume growth}_t \times Small_{Net\ \ Repo,t}$ | | | -0.057 | | -0.058 |
| | | | (-0.26) | | (-0.27) |
| $\text{Net Repo volume growth}_t \times Downlarge_{Net\ \ Repo,t}$ | | | 0.069 | | 0.09 |
| | | | (0.38) | | (0.48) |
| $\text{Net Repo volume growth}_t \times Uplarge_{Net\ \ Repo,t}$ | | | 0.453 | | 0.408 |
| | | | (1.33) | | (1.17) |
| Controls | Yes | Yes | Yes | Yes | Yes |
| Adj. R square | 0.281 | 0.259 | 0.267 | 0.273 | 0.278 |
| # of observation | 238 | 238 | 238 | 238 | 238 |

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국문 초록

# 금융기관의 레버리지 변화가 주식시장 유동성에 미치는 영향

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배규호

본 연구는 미국의 금융기관 레버리지 변화를 이용하여, 금융기관들이 자금조달에 어려움을 겪는 경우 주식시장의 유동성이 하락하는 관계를 분석하였다. 국채전문딜러(Primary dealer)들의 환매조건부매매 규모와 자본 비율은 시장의 유동성과 양의 관계를 나타났다. 이러한 관계는 주식수익율의 변동성이 큰 주식일수록 크게 나타나며, 환매조건부매매 규모와 자본 비율이 감소할 때 더 강하게 나타난다. 또한, 금융기관들의 재무적 제약은 주식들의 유동성에 동시적으로 영향을 주기 때문에 유동성 동행화 현상을 초래할 수 있다. 비록 환매조건부매매 규모에서는 관계를 발견되지 않았지만, 국채전문딜러의 자본 비율의 변화는 유동성 동행화 현상과 음의 관계를 갖고있다. 이러한 관계는 큰 음의 충격이 가해졌을 때 강하게 나타난다.

주요어: 시장 유동성, 금융기관, 환매조건부매매, 레버리지

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