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Illiquidity Premium and Monetary Conditions in Emerging Markets: An Empirical Examination of Taiwan Stock Markets

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ABSTRACT

This study empirically examines the illiquidity premium of Taiwan stock markets and its relationship with monetary policies. We find that commonly used illiquidity measures are generally sensitive and capable of capturing market illiquidity, particularly during the most volatile periods. Evidence shows that unconditional illiquidity is significantly priced across three illiquidity measures during the sample period. Aggregate market illiquidity innovations are noticeably affected by monetary policies. The results of Granger causality tests reveal that expansive monetary policy improves market illiquidity, whereas restrictive policy adversely affects market liquidity.

Keywords: Illiquidity, Illiquidity Premium, Monetary Policy, Asset Pricing, Granger's Causality Tests
JEL Classifications: G11, G12, G15

1. INTRODUCTION

Market illiquidity commonly prevails as a systematic risk and is significantly priced among markets. The illiquidity premium has been extensively investigated for various asset classes by using different methodologies. Amihud and Mendelson (1986) establish that expected asset returns increase assets' trading costs and that the clientele effect exists in the relationship between return and illiquidity costs. Amihud (2002) shows that both cross-sectional and time-series expected stock returns were an increasing function of expected illiquidity for New York Stock Exchange stocks during 1964–1997. Many researchers, such as Chen et al. (2007), Longstaff et al. (2005), and Nashikkar et al. (2011), have reported similar results for bond markets.

Liquidity externality can exert a systematic market-wide effect and dry up market liquidity. Overall market liquidity changes are persistent and can affect aggregate asset prices. This phenomenon is modeled by Acharya and Pedersen (2005) in terms of the liquidity capital asset pricing model (LCAPM). In the LCAPM, assets display higher required returns when their returns have a greater covariance with market-wide illiquidity shocks. Recently, the global financial crisis of 2007–2009 has drawn considerable attention from both academics and practitioners. Brunnermeier and Pedersen (2009) note that liquidity providers and their access to capital can significantly affect market liquidity. Their model shows the interaction and multiplier effect of market and funding liquidity by liquidity spirals.

Several theoretical studies have suggested that market liquidity and the illiquidity premium are strongly connected with funding liquidity. Jensen and Moorman (2010) find that both aggregate fund availability and aggregate market liquidity considerably improve during an expansive monetary policy period. Improvements in liquidity are most noticeable for the most illiquid firms in US markets. Aragon and Strahan (2012) show that stocks held by Lehman-connected funds experienced a greater decline in market liquidity following bankruptcy than did other stocks. Dick-Nielsen et al. (2012) indicate that when a bond underwriter encounters a funding problem, the corresponding bond market liquidity considerably declines thereafter. Furthermore, Glascock and Lu-Andrews (2014) report that funding liquidity in real estate and investment trust markets is strongly influenced by changes in macroeconomic factors. Luis et al. (2015) report an association of monetary loosening with increased market liquidity. An expansionary monetary policy causes a reduction in the liquidity premium, which is particularly high during economic recession periods when investors require a greater compensation for holding illiquid stocks. Therefore, both the monetary policy and systematic market beta play an essential role as the determinants of liquidity commonality.

Jeewon et al. (2017) show that a high illiquidity premium is closely associated with periods of real economic recessions, market declines, and high volatility, which coincide with major events of liquidity dry-up and high liquidity commonality. Jang et al. (2015) investigate how the real economic state and monetary policy affect aggregate market illiquidity and find that the illiquidity premium exhibits strong state-dependent variations. Economic and monetary expansions enhance aggregate market illiquidity, whereas economic recession and monetary stringency deteriorate the whole market illiquidity.

Luis et al. (2018) report that the funding environment (i.e., macroeconomic factors) can significantly affect stock momentum returns. The transition of funding states stimulates the revision of the pricing decision by market investors, which in turns generates time-varying momentum observed in stock markets.

To date, little is known regarding the illiquidity premium and funding conditions in the setting of emerging markets. As a study on a typical developing market, this research draws attention to the relationships among monetary conditions, illiquidity, and asset returns in Taiwan stock markets. Our work is related to those conducted by Jensen and Moorman (2010) and Jang et al. (2015) who report that monetary states serve as the funding condition for determining the time-varying illiquidity premium. However, we analyze the intertemporal illiquidity innovation more on the dynamic scheme by using the impulse response function and Granger's causality tests. We follow the argument made by Brunnermeier and Pedersen (2009) that the connection between monetary conditions and aggregate market innovations is examined through the dynamic scheme in Taiwan stock markets.

2. DATA AND VARIABLES

2.1. Data

Empirical data are obtained from Taiwan Economic News for the period between January 1982 and December 2017 for a total of 432 months. Data include the listing stocks of the Taiwan Stock Exchange (TWSE) and Taipei Exchange (TPEx) and exclude the shares of noncommon stocks, such as TDR, F shares, and full-cash delivery stocks. Among them, the stocks of the TWSE cover the period from January 1982 to December 2017 including a total of 924 firms, and the stocks of the TPEx cover the period from January 1990 to December of 2017 including a total of 746 firms. In particular, the firms of the TPEx are mostly emerging small capital stocks.

2.2. Liquidity Measures

In this study, we use three illiquidity measures that have been widely used in the literature to calculate the illiquidity premium and to examine its relationship with monetary policy. The first measure is the illiquidity measure of Amihud (2002), which is the illiquidity measure available in most markets. The illiquidity of Amihud (ILL-AM) is defined as the average of the daily ratio of the absolute return to the dollar trading value and is defined as follows:

$$ILL-AM_{iM} = \frac{1}{t}\sum_{t}\frac{1,000,000\times\left|return_t\right|}{price_i\times volume_t}, \quad (1)$$

where $ILL\text{-}AM_{iM}$ is the monthly Amihud illiquidity measure accumulated over 1 month and $price_t$, $volume_t$, and $return_t$ are the closing price, daily trading value, and daily return for the i-th firm on day t, respectively.

As stated by Amihud (2002), ILL-AM can easily determine the market price impact described by Kyle (1985). For related empirical works, Acharya and Pedersen (2005) find that securities with high values of ILL-AM tend to have high liquidity betas of liquidity commonality, market return on firm liquidity, and market liquidity on firm return. Simulation results reported by Hasbrouck (2002) reveal that among the most prominent measures of illiquidity, ILL-AM can be considered as the best proxy.

The second measure of illiquidity, Amivest illiquidity (ILL-AV), which is related to ILL-AM, is also designed to gauge the market price impact and is defined as follows:

$$ILL-AV_{iM} = \frac{1}{t}\sum_{t}\frac{0.000001\times price_t\times volume_t}{\left|return_t\right|}, \quad (2)$$

where t is the number of trading days with a nonzero return within the month when the measure is calculated. As evident from the formula, ILL-AV is a reverse version of ILL-AM but excludes zero-return daily data. The design of ILL-AV can slightly strengthen illiquidity during periods of market volatility.

The third illiquidity measure, Liu (2006) illiquidity (ILL-LIU), can directly quantify the degree of market drought of a particular security at a certain period of time. The ILL-LIU is defined as the standardized turnover-adjusted number of zero daily trading volumes over the prior X months and is formulated as follows:

$$ILL-LIU_X = \left[\begin{array}{l} Number\ \ of\ \ zero\ \ daily \\ volumes\ \ in\, prior\ \ x\ \ months + \\ \dfrac{1/(x-month\ \ turnover)}{Deflator} \end{array}\right]\times\frac{21x}{NoTD} \quad (3)$$

$$0 < \frac{1/(x - month \quad turnover)}{Deflator} < 1$$

where *NoTD* is the total number of trading days in the market over the prior X months, *Deflator* is chosen such that all sample stocks satisfy the related inequality, and *x* is set as 1 month in this study.

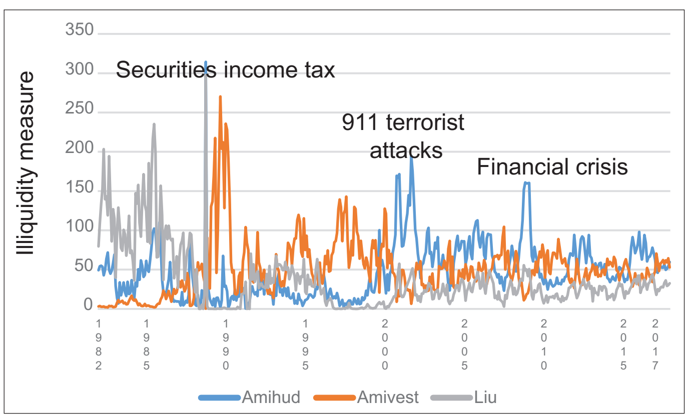
The three aforementioned illiquidity measures are used to present the descriptive statistics of the illiquidity measures of Taiwan stock markets in Figure 1 and Tables 1 and 2.

Figure 1 depicts the market illiquidity of the three measures in Taiwan stock markets for the period between 1982 and 2017. Generally, market illiquidity declined during the sample period due to improvements in the market microstructure (e.g., periods of price limit deregulation and minimum price variation reduction). As shown in the graph, our illiquidity measures perfectly capture critical stock market events that occurred during the sample period, particularly the most volatile market events, such as the announcement of the securities income tax, 911 terrorist attacks, and the financial crisis of 2007-2008.

On September 24, 1988, the announcement that the securities income tax would be reinstated caused the Taiwan stock market to fall on 19 days in a month, with the index falling from 8,900 to 5,700 points. The dramatic shock on illiquidity measures can be seen in Panel A of Table 1, with ILL-AM and ILL-LIU increasing from 19 to 314.4 and from 18.65 to 297.88, respectively, and ILL-AV declining from 34.4 to 0.36.

Panel B of Table 1 shows the illiquidity changes caused by the terrorist attacks of September 11, 2001 in the United States, with ILL-AM and ILL-LIU increasing from 1131.64 to 194.85 and from 39.78 to 46.70, respectively, and ILL-AV declining from 24.03 to 6.53.

Figure 1: Illiquidity in Taiwan stock markets (1982-2017)



Panel C of Table 1 shows the illiquidity changes caused during the subprime crisis of 2007–2008, with ILL-AM and ILL-LIU increasing from 90.12 to 151.57 and from 38.21 to 55.58, respectively, and ILL-AV declining from 37.82 to 10.89. These financial crises are clearly marked in Figure 1.

Table 2 lists the descriptive statistics and correlations among the illiquidity measures of Taiwan stock markets between 1982 and 2017, including the means and standard deviations of ILL-AM, ILL-AV, and ILL-LIU (1.6 and 1.22, 50.50 and 37.12, and 0.37 and 0.41, respectively). Among them, ILL-AV exhibits more precision in terms of a smaller standard deviation compared with ILL-LIU. The Amihud illiquidity measure and Amivest liquidity ratio are derived from a reciprocal relation; thus, the pooled correlation coefficient for the two measures is −0.38. Differences in these two measures are derived from different states in which the measures are undefined. The correlations reported in Table 2 are, in all respects, consistent with the expectations. These correlations indicate that ILL-LIU is related to both ILL-AM and ILL-AV (P = 0.25 and −0.55, respectively). These correlations support the uniqueness of Liu. Liu is designed to indicate a different dimension of liquidity, which links to market depth, whereas ILL-AM and ILL-AV serve as proxies for the price impact dimension.

2.3. Illiquidity Premium

The illiquidity premium of Amihud (2014) is defined as the differential return between the portfolios of stocks that are most illiquid and most liquid. The illiquidity premium is constructed using two steps. In the first step, stocks are sorted into quintile portfolios by ascending order of illiquidity calculated in the previous month; that is, $t - 1$. To prevent the confounding effect between stock risk and illiquidity, within each illiquidity portfolio, stocks are further divided into tercile portfolios based on the standard deviation of each stock in the descending order and thus form 3 × 5 portfolios. The illiquidity premium is the weighted average of the three most illiquid portfolios and the corresponding three most liquid portfolios.

2.4. Monetary Policy Measures

We use two alternative measures to identify shifts in monetary policies in Taiwan's stock market between 1982 and 2017. The first measure is based on changes in the Central Bank's rediscount

Table 1: Illiquidity measurement of financial crisis events in Taiwan securities market

Panel A (Securities income tax)				Panel B (911 Terrorism attack)				Panel C (Subprime crisis)			
Date	Amihud	Amivest	Liu	Date	Amihud	Amivest	Liu	Date	Amihud	Amivest	Liu
198807	23.54	57.31	5.37	200106	121.19	25.306	31.00	200806	64.00	40.29	26.38
198808	14.34	42.22	0.06	200107	144.66	23.10	35.39	200807	83.26	29.94	35.79
198809	19.00	34.40	18.65	200108	131.64	24.03	39.78	200808	90.12	37.82	38.21
198810	314.40	0.36	297.88	200109	194.85	6.53	46.70	200809	112.63	22.25	35.83
198811	18.73	90.97	3.44	200110	175.41	16.00	51.64	200810	151.57	10.89	55.58
198812	24.18	38.80	0.10	200111	138.85	33.64	39.25	200811	160.98	13.67	48.93
199901	12.81	25.89	0.10	200112	101.04	42.08	17.36	200812	159.68	18.62	50.32

Panel A: The announcement of the securities income tax, Panel B: 911 terrorist attacks; Panel C: Subprime crisis of 2007-2008 rate, which has been widely used to identify adjustments in the short-term market. The second measure is based on changes in the overnight rate of interest in the financial industry and has been previously used to identify fundamental shifts in the overall monetary policy of Taiwan's Central Bank.

The rediscount rate of Taiwan's Central Bank has long been considered an indicator of monetary policy in Taiwan. Thornton (1998) suggests that the market's reaction to discount rate changes is purely an announcement effect. The announcement effect appears to vary with both the nature and extent of information that the announcement of a discount rate change is believed to contain. This supports the use of the rediscount rate as a dominant variable for explaining variations in several measures of economic activity. The authors suggest that the sensitivity of the rediscount rate to shocks in the supply of bank reserves makes it a good indicator of monetary policy actions. In addition, the rediscount rate has been used frequently as a monetary policy proxy in the empirical analyses of stock returns.

Because the focus of this study is to identify shifts in the policy of Taiwan's Central Bank, both monetary policy variables are measured as binary variables. Furthermore, measures are employed both individually and in concert with one another. Patelis (1997) argues that shifts in the rediscount rate of monetary policy should affect the market differently depending on whether Taiwan's Central Bank is maintaining an expansive or a restrictive policy for the overnight rate.

Table 3 lists the relative frequencies of rediscount and overnight rate policies during the sample period from 1982 to 2017. As indicated in Panel A of Table 3, expansion and restriction policies of rediscount and overnight rates were implemented for 262 and 199 and 232 and 169 months, respectively, within the 431 months of the sample period. Among them, the state of expansion/expansion occurred for 167 months and the state of restriction/restriction occurred for 104 months. Generally, the figure shows that the monetary authority adopted a more expansive policy during the sample period, whereas policy in the market was relatively strict.

Numerous observations can be made based on the off-diagonal of Table 3, which indicates the nonsimultaneous reinforcement in terms of months spent in both policies and the uniqueness of the two indicators of monetary policy shifts. Specifically, more than ⅓ of the time, the discount rate change is not reinforced by the policy strictness indicated by the overnight rate change. The same situation can also be observed in the figures of the overnight rate. The classification of monetary moods provides empirical data to investigate the relationship between the monetary policy and market illiquidity of Taiwan stock markets, the results of which are detailed in the next section.

3. EMPIRICAL RESULTS AND ANALYSIS

This study empirically examines the illiquidity premium of Taiwan stock markets and its relationship with monetary policy. In the first part of the results, we illustrate the unconditional illiquidity premium between the most illiquid stocks and the most liquid stocks in the market. This study then investigates the relationship between the aggregate market illiquidity innovation and monetary policy. In particular, a dynamic analysis of the aggregate illiquidity innovation in terms of monetary conditions is performed using the impulse response function and Granger's causality tests.

3.1. Unconditional Illiquidity Premium

Starting with the market illiquidity premium without considering monetary conditions, we provide basic figures in this study that can be used for comparison with the literature. The market illiquidity premium is calculated as equal-weighed monthly returns between the most illiquid stock portfolio and the most liquid stock portfolio among quintile portfolios. As shown in Table 4, the monthly unconditional premium is tested using the Newey–West *t* statistics with the bandwidth parameter being equal to 1 plus the number of autocorrelated lags that persist in significance at the 5% level.

As evident in Table 4, the equal-weighed unconditional returns of quintile portfolios consistently increase with illiquidity across the three illiquidity measures. These results are consistent with the literature, and as predicted in the models of Amihud and Mendelson (1986) and Acharya and Pedersen (2005), returns increase with stock illiquidity. Different from the other two measures, the Amivest liquidity ratio is a reverse version of Amihud illiquidity, and portfolios are sorted by the descending order of illiquidity. The unconditional illiquidity premium, which is measured by the spread generated from the monthly returns of the most illiquid portfolio and the most liquid portfolio, shows significance across the three illiquidity measures. The premium ranges from approximately 116 basis points of the Amihud measure to 63 basis points of the Liu measure, as illustrated in Table. These figures are comparable to the illiquidity premium

Table 2: Descriptive statistics of liquidity measures: 1982-2017

Liquidity measure	Correlation			Mean	Std. dev.
	Amihud	Amivest	Liu		
Amihud illiquidity measure	1.00			1.60	1.22
Amivest liquidity ratio	−0.38	1.00	−1.00	50.50	37.12
Liu liquidity measure	0.25	−0.55		0.37	0.41

Table 3: Time spent in monetary policies

Monetary state measure	Number of months in alternative monetary state		
	Expansive	Restrictive	All
Panel A: Months across monetary conditions: measures separated			
Rediscount rate	262	169	431
Overnight rate	232	199	431
Overnight rate	**Number of months in alternative monetary state**		
	Rediscount rate		
	Expansive	**Restrictive**	**All**
Panel B: Months across monetary conditions: Measures intersected			
Expansive	167	65	232
Restrictive	95	104	199
All	262	169	431

reported in the literature; for example, Jensen and Moorman (2010), Jang et al. (2015), and Acharya and Pedersen (2005) report a spread of 91, 102, and 110 basis points, respectively, which can be separately attributed to the three illiquidity-related betas.

3.2. Aggregate Illiquidity and Monetary Conditions

The empirical results of the unconditional illiquidity premium of Taiwan stock markets during the period 1952-2017 are generally consistent with the literature. This study ascertains whether the illiquidity premium is systematically connected with the funding conditions theoretically suggested by Acharya and Pedersen (2005) and Brunnermeier and Pedersen (2009). Previous studies, such as those conducted by Chordia et al. (2005) and Jensen and Moorman (2010), have provided sufficient evidence for the link between monetary conditions and aggregate illiquidity. This study adopts the monetary policy of Taiwan's Central Bank as the funding condition and empirically examines the impact of changes in aggregate and market illiquidity on different funding states.

First, the market-wide illiquidity of the three illiquidity measures serves as the aggregate market illiquidity, as suggested by Pastor and Stambaugh (2003). Aggregate illiquidity innovations are formed through an AR(1) scheme as follows:

$$AILLIQ_t = \acute{a} + \beta AILLIQ_{t-1} + \lambda\left(\frac{m_{t-1}}{m_1}\right) AILLIQ_{t-1} + \varepsilon_t, \quad (4)$$

where $ALLIQ_{t1}$ is the aggregate market illiquidity in month $t-1$, $\Delta ALLIQ_{t-1}$ is the change in aggregate market illiquidity in month $t-1$, and m_{t-1} is the total market value at the beginning of month $t-1$ for all firms with an observation for illiquidity measure in month t.

The fitted regression residual $\hat{\varepsilon}_t$ is the aggregate illiquidity innovation that provides a dynamic measure of $\hat{\varepsilon}_t$ market liquidity conditions. That is, a positive (negative) value of indicates that the market encounters a more illiquid (liquid) funding condition from 1 month to the next month.

Before discussing the dynamic impact of monetary conditions on aggregate illiquidity innovations, in Table 5, we report empirical results for the calculation of aggregate illiquidity innovations. As evident from the figures, $\Delta ALLIQ$ exhibits a significant AR(1) effect and exerts a significantly negative impact in 1 month across the three illiquidity measures. The market value-adjusted $ALLIQ_{t-1}$ amplifies the change in aggregate market illiquidity, as suggested theoretically, and this result is consistent across the three illiquidity measures. Overall, the fitted value of $\hat{\varepsilon}_t$ of the three illiquidity measures sufficiently captures the average aggregate illiquidity innovation of Taiwan stock markets.

The empirical results of the average aggregate illiquidity innovation across monetary conditions are listed in Table 6. The monthly aggregate illiquidity innovation $\hat{\varepsilon}_t$ is matched with expansive or restrictive monetary conditions based on the change in monetary conditions in the previous month $t-1$. For the entire sample period, the average value of $\hat{\varepsilon}_t$ is −0.000 and is not significantly different from zero. These statistics indicate that the initial differentiation and measurement of the innovation successfully eliminate the trend of increasing aggregate illiquidity. The influence of the monetary policy (Table 6) on market illiquidity is observed from two aspects.

First, the policy effect is examined for each single monetary policy, namely expansive and restrictive, for two monetary indicators, namely the rediscount rate and overnight rate, respectively. The expansive state of the overnight rate exhibits a negative impact on the aggregate illiquidity innovation, which means that market liquidity improves when the Central Bank adopts a liquid policy, even though its significance is mixed among the three illiquidity measures. The effect is the most significant for ILL-AV, with a significant estimated coefficient of 2.7 (t value = 3.34), and the effect is the least significant for ILL-AH (t value = −1.05). By contrast, the restrictive policy of the overnight rate shows a considerable adverse impact on market liquidity, and this impact is significant for Amihud and Amivest measures. For example, the significant positive estimated coefficients of ILL-AH and ILL-LIU are both 0.08 (t value = 3.03), and that of ILL-AV is −4.18 (t value = −2.30).

For the second monetary policy; that is, the rediscount rate, the expansive mood reduces illiquidity innovations and improves market liquidity, even when the impact is not statistically significant for the three illiquidity measures. For a restrictive rediscount rate, the influence is mixed among the three illiquidity measures. Specifically, the restrictive monetary condition deteriorates market liquidity significantly in ILL-AH, which significantly increases

Table 4: Monthly unconditional illiquidity premium

Liquidity measure	Mean monthly portfolio return (in percent)					
	Liquidity portfolio					
	1	2	3	4	5	5-1
Amihud illiquidity measure (*ILL-AH*)	1.15	1.26	1.43	1.78	2.31	1.16 t=4.07
Amivest liquidity ratio (*ILL-AV*)	2.32	1.75	1.47	1.23	1.15	−1.17 t = −4.03
Liu liquidity measure (*ILL-LIU*)	1.32	1.48	1.65	1.77	1.95	0.63 t=2.21

Portfolios are sorted by ascending order of illiquidity measures. Monthly portfolio returns are equal-weighted stock returns in quintile portfolios, which are formed monthly at the end of each month. Market illiquidity is calculated by the returns of the long–short portfolio of five long portfolios and one short portfolio. The Newey–West t statistic is reported with the bandwidth parameter equal to one plus the number of autocorrelated lags that persist in significance at the 5% level. Values are calculated for the period from January 1982 to December 2017

Table 5: Aggregate illiquidity innovations

	Amihud	Amivest	Liu
α	−0.27 (0.05) t=−5.57	−7.66 (2.33) t=−3.28	−0.07 (0.02) t=−2.77
β	−0.55 (0.05) t=−11.56	−0.27 (0.06) t=−4.19	−0.44 (0.12) t=−3.75
λ	0.33 (0.04) t=7.65	0.15 (0.05) t=3.01	0.16 (0.07) t=2.66
ε	−1.03E-16 (0.03) t=−3.21E-15	−3.68E-15 (0.94) t=−3.91E-15	−5.20E-17 (0.01) t=−5.00E-15
Adj.R^2	0.2441	0.0948	0.1742

Standard deviations are adjusted using the Newey–West heteroskedasticity and autocorrelation consistent estimator the aggregate innovation; however, it exhibits little effect on both ILL-AV and ILL-LIU. Second, the influence of monetary policy is tested under the periods of matched policy; that is, the condition of expansive–expansive and restrictive–restrictive simultaneously. For the expansive–expansive policy, market liquidity is generally shown to be improving, particularly for ILL-AH and ILL-AV, even when no significance is observed for ILL-LIU.

When the market is in the restrictive–restrictive condition, figures consistently display poor market illiquidity across the three illiquidity measures. Overall, our results indicate that the restrictive–restrictive condition exerts a stronger effect on market illiquidity than the expansive–expansive condition. Thus, the influence of monetary policy on the aggregate illiquidity innovation drawn from the empirical results of this study is generally in agreement with those reported by Jensen and Moorman (2010) and Jang et al. (2015).

3.3 Dynamic Analysis of Monetary Conditions and Market Illiquidity

This study finally examines the dynamic impact of monetary conditions on aggregate illiquidity innovations in Taiwan stock markets by using the impulse response function and Granger's causality tests.

The dynamic structure is specified as the following vector autoregression (VAR) model:

$$Y_t = \delta + \sum_{j=1}^{k} \varphi_j Y_{t-j} + \mu_t , \quad (5)$$

where Y is a vector consisting of two variables: the aggregate illiquidity innovation $\hat{\varepsilon}_t$ and a dummy variable that measures monetary conditions. When examining the aggregate illiquidity innovation response to an expansive (restrictive) impulse, the monetary policy is a dummy variable that is one in month t when monetary conditions are expansive (restrictive) and zero when conditions are restrictive (expansive). When considering monetary measures in a matched policy, monetary conditions are one in month t if the conditions are met by two monetary proxies and zero otherwise. The lag length is chosen according to the Akaike information criterion.

We present results from a VAR with the endogenous variables 1E, 1R, 2E, 2R, EE, and RR. The VAR is estimated with two lags and a constant term and uses 322 observations. Empirical results from the VAR estimation are reported in Table 7 in the context of ILL-AH, and similar results are also obtained for ILL-AV and ILL-LIU, which are not presented here. As indicated in Table 7, expansive and restrictive policies exert negative and positive effects on aggregate market illiquidity innovations, respectively. Overall, expansive policy negatively affects illiquidity innovations, indicating improving market illiquidity. By contrast, restrictive policy generally causes positive aggregate market innovations, indicating significantly deteriorating market illiquidity. Matched expansive–expansive and restrictive–restrictive policies exhibit results similar to those of the individual policies (Panel B of Table 7).

The effect of the dynamic impact of monetary conditions on aggregate illiquidity innovations is drawn from the impulse response function and Granger causality tests. Figure 2 shows the response of aggregate illiquidity innovations ($\hat{\varepsilon}_t$) to an impulse in monetary conditions and serves to illustrate and expound on the results presented in Table 7. This study defines 1E as the expansion policy of the first monetary measure (discount rate) when 1E is the exogenous variable of VAR; other monetary policy is defined in the same manner. The impulse response function enables examination of the temporal relationship between policy shifts and aggregate illiquidity innovations.

The figure shows the orthogonalized impulse response functions of aggregate illiquidity innovations to a one-standard-deviation shock in the economic state. The dotted lines indicate plus and minus two standard-error bands. Each subplot represents the responses of aggregate illiquidity innovations to a particular monetary policy for each monetary tool. For example, Response of Residue_Amihud to _1E depicts the response of aggregate illiquidity innovations to an expansive overnight rate policy during the sample period from 1982 to 2017. As evident from Figure 1, an expansive policy shock generally causes a decrease in aggregate market illiquidity, whereas a restitive policy causes stringency in market illiquidity. The results of the impulse function are in agreement with findings reported by Fujimoto (2004), Chordia et al. (2005), Jensen and Moorman (2010), and Jang et al. (2015), in that a relaxed monetary policy

Table 6: Aggregate illiquidity innovations and monetary conditions

Panel: Taiwan monetary policy	A: Amihud illiquidity (ILL-AH) Aggregate illiquidity innovation			B: Amivest liquidity (ILL-AV) Aggregate illiquidity innovation			C: Liu liquidity ratio (ILL-LIU) Aggregate illiquidity innovation		
	Rediscount rate			Rediscount rate			Rediscount rate		
Overnight Rate	Expansive	Restrictive	All	Expansive	Restrictive	All	Expansive	Restrictive	All
Expansive	−0.13	0.08	−0.05	2.47	3.11	2.70	−0.02	−0.04	−0.03
	0.07	0.05	0.05	0.98	1.29	0.81	0.02	0.03	0.02
	(−1.92)	(1.50)	(−1.05)	(2.52)	(2.41)	(3.34)	(−0.94)	(−1.34)	(−1.62)
Restrictive	0.11	0.06	0.08	−6.45	−2.76	−4.18	0.04	0.04	0.04
	0.05	0.03	0.03	3.35	1.80	1.81	0.01	0.01	1.81
	(2.13)	(1.89)	(3.03)	(−1.93)	(−1.53)	(−2.30)	(4.86)	(4.70)	(0.01)
All	−0.06	0.07	−1.03E-16	−0.03	0.03	−3.68E-15	5.92E-04	−6.94E-04	−5.20E-17
	0.05	0.03	0.03	1.20	1.22	0.94	0.01	0.02	0.01
	(−1.17)	(2.26)	(−3.21E-15)	(−0.02)	(0.02)	(−3.91E-15)	(0.05)	(−0.04)	(−5.00E-15)

The figures in parentheses are the Newey–West t statistics reported with the bandwidth parameter equal to one plus the number of autocorrelated lags that persist in significance at the 5% level. Values are calculated for the period from January 1982 to December 2017 is associated with improved market liquidity, whereas a tighter monetary policy corresponds with diminished aggregate liquidity.

Figure 2 presents the aggregate illiquidity impulse response functions. Finally, we perform two-way and pairwise Granger causality tests between the endogenous variables of the VAR (Table 8). For the null hypothesis that variable monetary policy does not Granger-cause market illiquidity innovations, we test whether the lag coefficients of monetary dummy variables are jointly zero when the aggregate illiquidity innovation is the dependent variable in the VAR. This study also tests the reverse causality; that is, whether the aggregate illiquidity innovation can Granger-cause monetary conditions. Table 8 shows the two-way causation between monetary policies and aggregate illiquidity innovations throughout the three illiquidity measures in Taiwan stock markets during 1982–2017.

The results of the Granger test reveal a strong causation effect of monetary policy on market illiquidity, and little evidence can be obtained for the reverse direction of the causality. The results are generally robust across the three illiquidity measures. Furthermore, the causality effects are persistent with regard to expansive or restrictive policy for the overnight and rediscount rates during the entire sample period. Overall, the results in Table 8 indicate

Table 7: Amihud_VAR

Panel A	1E[a]	Residue_Amihud	1R[a]	Residue_Amihud	2E[a]	Residue_Amihud
MP (−1)	0.9848[b]	−0.2100	0.9848	0.2100	0.1030	−0.1809
	(0.0501)[c]	(0.1967)	(0.0501)	(0.1967)	(0.0501)	(0.0732)
	[19.6613][d]	[−1.0679]	[19.6613]	[1.0679]	[2.0574]	[−2.4705]
MP (−2)	−0.0114	0.0102	−0.0114	−0.0102	0.0894	0.1201
	(0.0702)	(0.2755)	(0.0702)	(0.2755)	(0.0504)	(0.0737)
	[−0.1621]	[0.0370]	[−0.1621]	[−0.0370]	[1.7744]	[1.6299]
MP (−3)	−0.0099	0.1330	−0.0099	−0.1330	0.1007	−0.1117
	(0.0702)	(0.2755)	(0.0702)	(0.2755)	(0.0509)	(0.0744)
	[−0.1418]	[0.4827]	[−0.1418]	[−0.4827]	[1.9782]	[−1.5017]
Residue_Amihud (−1)	−0.0084	−0.0373	0.0084	−0.0373	0.0385	−0.0261
	(0.0127)	(0.0500)	(0.0127)	(0.0500)	(0.0342)	(0.0501)
	[−0.6629]	[−0.7452]	[0.6629]	[−0.7452]	[1.1241]	[−0.5210]
Residue_Amihud (−2)	0.0078	−0.0647	−0.0078	−0.0647	−0.0612	−0.0565
	(0.0128)	(0.0501)	(0.0128)	(0.0501)	(0.0343)	(0.0501)
	[0.6097]	[−1.2925]	[−0.6097]	[−1.2925]	[−1.7864]	[−1.1269]
Residue_Amihud (−3)	0.0045	0.0478	−0.0045	0.0478	0.0128	0.0152
	(0.0127)	(0.0500)	(0.0127)	(0.0500)	(0.0344)	(0.0502)
	[0.3540]	[0.9560]	[−0.3540]	[0.9560]	[0.3725]	[0.3018]
Adj. R-squared	0.8710	−0.0201	0.8710	−0.0201	0.1210	0.0049
Sum sq. resids	12.4097	191.3099	12.4097	191.3099	87.3101	186.6188
S.E. equation	0.1764	0.6924	0.1764	0.6924	0.4678	0.6839
F-statistic	142.4147	0.5869	142.4147	0.5869	3.8848	1.1031
Log likelihood	143.6183	−430.8185	143.6183	−430.8185	−266.0886	−425.6049
Panel B	**2R[a]**	**Residue_Amihud**	**EE[a]**	**Residue_Amihud**	**RR[a]**	**Residue_Amihud**
MP[a] (−1)	0.1030	0.1809	0.2209	−0.2340	0.3509	0.1258
	(0.0501)	(0.0732)	(0.0505)	(0.0847)	(0.0498)	(0.1071)
	[2.0574]	[2.4705]	[4.3736]	[−2.7642]	[7.0419]	[1.1745]
MP[a] (−2)	0.0894	−0.1201	0.2217	0.1211	0.1204	−0.0924
	(0.0504)	(0.0737)	(0.0519)	(0.0870)	(0.0526)	(0.1131)
	[1.7744]	[−1.6299]	[4.2719]	[1.3918]	[2.2900]	[−0.8169]
MP[a] (−3)	0.1007	0.1117	0.1249	−0.1211	0.1946	0.0413
	(0.0509)	(0.0744)	(0.0536)	(0.0898)	(0.0526)	(0.1130)
	[1.9782]	[1.5017]	[2.3332]	[−1.3493]	[3.7011]	[0.3653]
Residue_Amihud (−1)	−0.0385	−0.0261	0.0310	−0.0357	0.0160	−0.0338
	(0.0342)	(0.0501)	(0.0300)	(0.0503)	(0.0232)	(0.0499)
	[−1.1241]	[−0.5210]	[1.0314]	[−0.7090]	[0.6876]	[−0.6764]
Residue_Amihud (−2)	0.0612	−0.0565	−0.0563	−0.0592	0.0085	−0.0634
	(0.0343)	(0.0501)	(0.0300)	(0.0504)	(0.0232)	(0.0499)
	[1.7864]	[−1.1269]	[−1.8731]	[−1.1746]	[0.3669]	[−1.2699]
Residue_Amihud (−3)	−0.0128	0.0152	0.0006	0.0050	−0.0027	0.0525
	(0.0344)	(0.0502)	(0.0302)	(0.0506)	(0.0231)	(0.0497)
	[−0.3725]	[0.3018]	[0.0212]	[0.0983]	[−0.1166]	[1.0568]
Adj. R-squared	0.1210	0.0049	0.3027	0.0096	0.4460	−0.0172
Sum sq. resids	87.3101	186.6188	66.0805	185.7448	41.2787	190.7634
S.E. equation	0.4678	0.6839	0.4070	0.6823	0.3216	0.6915
F-statistic	3.8848	1.1031	10.0938	1.2022	17.8671	0.6458
Log likelihood	−266.0886	−425.6049	−207.5840	−424.6192	−108.7736	−430.2178

The parentheses indicate the estimated standard error, and the square brackets stand for the t value. 1E and 1R stand for expansive and restrictive conditions for the overnight rate, respectively. 2E and 2R stand for expansive and restrictive conditions for the rediscount rate, respectively. EE and RR stand for matched expansive and restrictive conditions, respectively. MP stands for the corresponding monetary policy in the VAR model

Figure 2: Amihud aggregate illiquidity impulse response functions

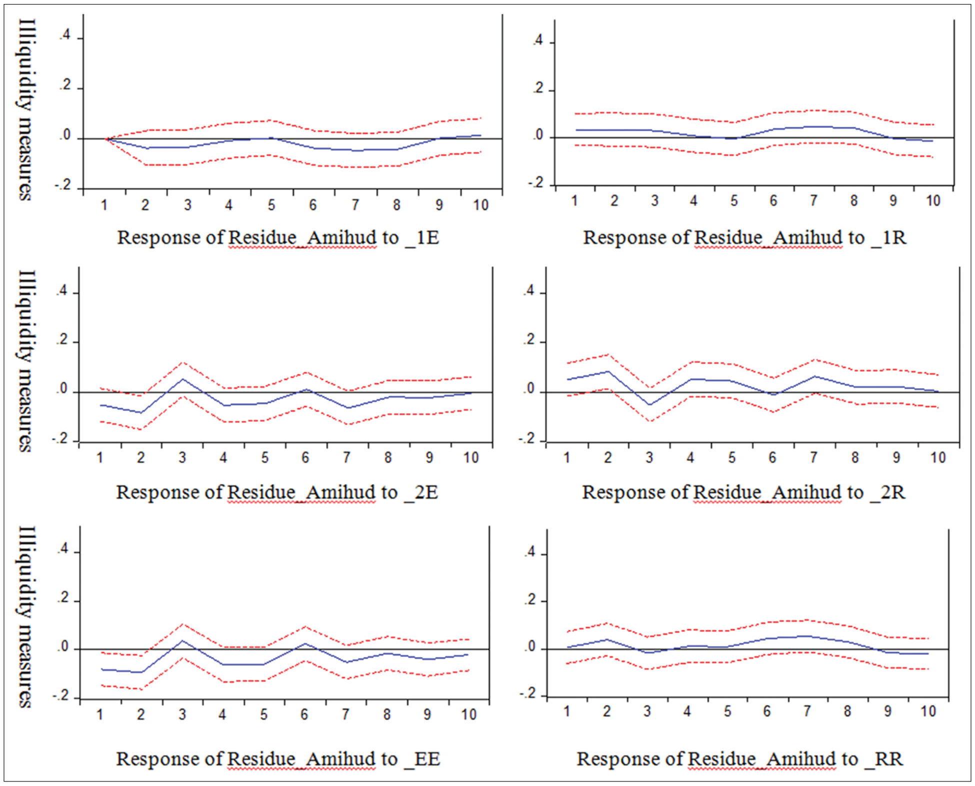


Table 8: Pairwise granger causality tests

Panel A						
	1E	Residue	1R	Residue	2E	Residue
Residue_Amihud	2.8178[a] (0.0940)*	1.0562[b] (0.3047)	2.8178 (0.0940)*	1.0562 (0.3047)	2.5431 (0.0278)*	1.4186 (0.2163)
Residue_Amivest	7.4212[c] (0.0007)*	4.5355[d] (0.0112)	3.1947 (0.0026)*	2.4143 (0.0197)	0.9724 (0.3790)	0.4639 (0.6292)
Residue_Liu	5.8875[e] (0.0030)*	0.0918[f] (0.9123)	5.8875 (0.0030)*	0.0918 (0.9123)	0.7846 (0.4570)	2.0896 (0.1250)
Panel B						
	2R	Residue	EE	Residue	RR	Residue
Residue_Amihud	2.5431 (0.0278)*	1.4186 (0.2163)	3.3900 (0.0052)*	1.7525 (0.1215)	1.1178 (0.3281)	0.2142 (0.8073)
Residue_Amivest	0.9724 (0.3790)	0.4638 (0.6292)	4.8224 (0.0085)*	0.3661 (0.6937)	7.3995 (0.0007)*	0.8734 (0.4183)
Residue_Liu	0.7846 (0.4570)	2.0896 (0.1250)	1.5097 (0.1517)	1.5152 (0.1498)	3.0707 (0.0474)*	0.5573 (0.5732)

Null hypothesis, 1E does not Granger-cause Residue_Amihud; the null hypotheses of other monetary policies are defined in the same manner. The Chi-square statistics associated with this test are reported. The parentheses indicate the p value for each test. *indicates significance at the 10% level

that monetary policy has an expected influence on stock market liquidity, whereas aggregate market illiquidity innovations do not ‘‘lead’’ to observable monetary policy shifts in markets.

4. CONCLUSIONS AND SUGGESTIONS

Several theoretical studies have suggested that market liquidity and the illiquidity premium are strongly connected with funding conditions. Therefore, the relationship between market illiquidity pricing and funding states has been studied in most developed markets. However, little is known regarding the illiquidity premium and funding conditions in emerging markets. Using Taiwan, a typical developing market, as an example, this study investigated whether the illiquidity premium is systematically linked to monetary conditions in Taiwan stock markets. The main empirical evidence suggests that the illiquidity premium is significantly priced in the range of 116 to 63 basis points by the three illiquidity measures. Overall market liquidity is considerably influenced by expansive monetary funding conditions. In particular, expansive overnight and rediscount rate policy negatively affects aggregate illiquidity innovations and improves market liquidity. By contrast, restrictive policy adversely affects aggregate market liquidity. In addition, the results of Granger causality tests reveal that the lead-lag relationship can explain how monetary policy leads to market illiquidity change, but little evidence is obtained for the reverse causality.

Our empirical evidence suggests that the commonly used illiquidity measures are generally sensitive and capable of capturing market illiquidity, particularly in the most volatile periods, as shown in Taiwan stock markets. The illiquidity premium is essential for asset pricing in emerging markets as well as in developed markets. A significant connection between aggregate market liquidity and monetary funding conditions occurs in both emerging and developed markets, indicating that conditional illiquidity asset pricing prevails in markets globally.

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