Int. Journal of Economics and Management 10(2): 297 – 319 (2016)

PERTANIKA JOURNALS

IJEM
International Journal of Economics and Management
Journal homepage: http://www.econ.upm.edu.my/ijem

Aggregate Liquidity for Malaysian Stock Market: New Indicators and Time Series Properties

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ABSTRACT

This study constructs two liquidity indicators, "Closing Percent Quoted Spread" and "Closing Percent Quoted Spread Impact", for all publicly listed firms on Bursa Malaysia over the 2000-2014 sample period. The raw firm-level daily liquidity values are averaged across months and then aggregated using equal- and value-weighted schemes to provide two Malaysian monthly aggregate liquidity indicators. Tracking the level of market liquidity over the last 15 years, all indicators consistently show that there is an obvious dry-up in liquidity in year 2008 when the bankruptcy of Lehman Brothers shattered confidence in the financial markets. Unlike the U.S. stock exchanges, there is no conclusive evidence to suggest that liquidity in the Malaysian market has improved over the sample period. However, in the short-term, there is evidence of seasonality in which the market is less liquid at year end as compared to the beginning of the year. Further structural break analysis indicates that the sharp liquidity changes in the Malaysian stock market are mainly driven by reactions to international events. When comparing with other commonly used liquidity proxies, the correlation analysis provides evidence in the Malaysian context that the turnover ratio is a poor indicator of liquidity.

JEL Classification: C10, G12, G20

Keywords: Aggregate liquidity; Malaysian stock market; Seasonality; Structural Break; Trend.

Article history:
Received: 12 May 2016
Accepted: 25 September 2016

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INTRODUCTION

In the academic literature, liquidity is one of the most researched areas simply because it plays a crucial role in ensuring the functioning of financial markets. The extensive surveys conducted by Amihud *et al*. (2006), Vayanos and Wang (2012), Holden *et al*. (2014) and Benson *et al*. (2015) clearly demonstrate the breadth and depth of the stock liquidity literature, covering both theoretical developments and empirical research. To provide valuable input to exchange regulators, standard-setting bodies, market participants and corporations, the huge empirical literature largely explores the determinants and effects of stock liquidity using a large array of liquidity proxies.[1] Despite its richness, the empirical studies are confined to liquidity at the firm level, which might not have direct macro implications. In contrast, aggregate market liquidity has been given relatively less attention by academicians. However, during the recent global financial crisis, financial press across the world has given wide coverage to liquidity at the macro level using terms such as "liquidity crunch", "flight to liquidity", "liquidity floodgates", "liquidity mismatch" or "liquidity drying up".

Research on aggregate market liquidity has its own scholarly merit and should be given greater attention than it presently receives. The earliest macro work on market liquidity can be traced back to the finance-growth literature, with studies exploring the role of stock market liquidity in promoting economic growth (see Levine, 2005 and references cited therein; Smimou and Khallouli, 2015). In recent years, the literature documents further macro implications of market liquidity. First, Næs *et al*. (2011) and Florackis *et al*. (2014) find that stock market liquidity is a better predictor of the real economy than stock prices, as market liquidity generally worsens well ahead of the onset of recessions. Second, moving in tandem with the liberalization of emerging markets, academic journals have published extensively on the growth benefits of financial liberalization (see the survey papers by Eichengreen, 2001; Edison *et al*., 2004; Henry, 2007; Kose *et al*., 2009; Obstfeld, 2009). Departing from the norm, Levine and Zervos (1998), Bekaert *et al*. (2002) and Vagias and van Dijk (2012) explore the effect of such financial reform on stock market liquidity with their analyses showing favourable results. Third, the recent global financial crisis demonstrates the interconnectedness of various asset markets, highlighting the possibility of liquidity spillovers among stock, foreign exchange, bond and money markets. Such interactions have been explored by Chordia *et al*. (2005) and Goyenko and Ukhov (2009) for stock and bond markets, and Nyborg and Östberg (2014) for interbank and stock markets.

For stock exchange regulators, improving the liquidity of their stock markets is one of the key policy objectives. Apart from ensuring the efficient functioning of stock markets, liquidity is a key consideration in stock market investment decisions. As highlighted by Handa and Schwartz (1996: 44): "Investors want three things from the markets: liquidity, liquidity and liquidity." Indeed, several studies find that investors demand higher returns for stocks that are more sensitive to aggregate market liquidity (see Pastor and Stambaugh, 2003; Acharya and

[1] Goyenko *et al*. (2009), Holden *et al*. (2014) and Fong *et al*. (2016) provide an extensive discussion on the existing liquidity measures. In a parallel literature, academic studies find that liquidity affects the pricing of stock returns, capital structure decisions, cost of capital, managerial payout decisions, dividend payout policy, firm value, price efficiency and corporate governance (see references cited in Holden *et al*., 2014; Benson *et al*., 2015; Lim *et al*., 2015). As a dependent variable, the literature reports a set of liquidity determinants which include firm characteristics, corporate governance, financial transparency, financial liberalization and investor types (see references cited in Lim *et al*., 2015).

Pedersen, 2005; Watanabe and Watanabe, 2008). Bazgour *et al*. (2016) examine the impact of aggregate market liquidity on investment decisions, and find evidence consistent with the flight-to-safety and flight-to-liquidity episodes. More specifically, these authors report that investors react more strongly to aggregate liquidity shocks when investing in small illiquid stocks, but their portfolio allocations tend to shift toward large liquid stocks when aggregate liquidity dries up. In a broad cross-country study, Stulz *et al*. (2014) show that equity issuance is significantly and positively related to aggregate market liquidity. Firms across the world are less likely to carry out more initial public offerings (IPOs) and seasoned equity offerings (SEOs) when market liquidity deteriorates.

Despite the obvious needs, there is no concrete effort to construct indicators for assessing the liquidity of the aggregate stock market, which runs contrary to the abundance of stock market indices that are quoted daily in financial press as a performance barometer of the whole market. Stock exchanges around the world publish on their respective websites the official stock market indices, not to mention the burgeoning industry of index providers dominated by MSCI, FTSE Russell and S&P Dow Jones. Surprisingly, it is the World Bank and International Monetary Fund (IMF) that take up this statistical initiative. To assist in policy formulation and reform, these two international organizations have embarked on projects assessing the development or soundness of financial sectors for a large cross-section of countries. For instance, in early 2000s, World Bank started the Financial Sector Development Indicators (FSDI) project to provide assessment of banking sector, bond and stock markets in four dimensions of size, access, efficiency and stability.[2] To measure the efficiency of stock markets, liquidity is selected as one criterion reflected by the proportion of zero return days. The FSDI project aimed to publish the data online in 2006, but it never materializes.[3] IMF, on the other hand, initiated the Financial Soundness Indicators (FSIs) project in response to the financial market crises of the late 1990s. The FSIs project, with its data now publicly available, measures market liquidity using two indicators – the average bid-ask spread in the securities market and the average daily turnover ratio in the securities market.[4]

The objective of this paper is to fill in the void of IMF's project in constructing aggregate liquidity indicators for the Malaysian stock market. The FSIs database relies on the voluntary contribution of participating member countries to compile their respective indicators on a continuing basis. Unfortunately, we find that Malaysia does not provide data for the two market liquidity indicators. To achieve our research objective, the first issue to be addressed is which liquidity measures to be used, as Aitken and Comerton-Forde (2003) report a total of 68 different indicators with each focuses only on a certain attribute of liquidity. The standard liquidity measure in most U.S. firm-level studies is the bid-ask spread because researchers can obtain microstructure data from Trades and Quotes (TAQ) database. However, such high frequency microstructure data is difficult to obtain for an emerging market like Malaysia for

[2] For background information, see the slides presented by Stijn Claessens in 2006, the then senior adviser for World Bank, at http://web.worldbank.org/archive/website01049/WEB/IMAGES/DCLAESSE.PDF (retrieved on 1 December, 2015).
[3] Instead, World Bank assembles the Global Financial Development Database (GFDD) with measures of depth, access, efficiency and stability for financial institutions, bond and stock markets (see http://www.worldbank.org/en/publication/gfdr/data/global-financial-development-database, retrieved on 30 March, 2016). However, there is no indicator in GFDD for measuring the liquidity of stock markets.
[4] For the history of Financial Soundness Indicators (FSIs) and the development of its methodology, see https://www.imf.org/external/np/sta/fsi/eng/fsi.htm (retrieved on 30 March, 2016). The FSIs data and metadata are available online at http://fsi.imf.org.

long time horizon. Having said so, it is now possible to construct bid-ask spread using daily data. Corwin and Schultz (2012) propose a simple way to estimate bid-ask spread from daily high and low prices. Chung and Zhang (2014) construct the "Closing Percent Quoted Spread" using only closing bid and ask prices. This represents a major breakthrough for emerging market research because the raw data needed for constructing daily bid-ask spread can be retrieved from Thomson Reuters Datastream. More importantly, their performances as liquidity proxies have been evaluated in a recent liquidity horserace conducted by Fong *et al*. (2016).

Using a relatively new global intraday equity database of Thomson Reuters Tick History (TRTH), Fong *et al*. (2016) compare the daily/monthly liquidity proxies to their corresponding intraday benchmarks for 24,847 firms across 43 stock exchanges around the world.[5] Such liquidity horserace provides useful guides as to which low frequency liquidity proxies are highly correlated with their intraday benchmarks, and thus avoid incurring enormous computational time and high subscription cost for extracting microstructure data. In the context of Malaysia, the authors find that, among the selected 10 percent-cost liquidity proxies, the best-performing monthly measure for Malaysian stocks is the "Closing Percent Quoted Spread" from Chung and Zhang (2014), outperforming its closest competitor by a large margin in the dimensions of average cross-sectional correlation and portfolio time-series correlation. For the shortlisted 13 cost-per-volume proxies, the price impact version of monthly "Closing Percent Quoted Spread" again emerges as the best performer. The "Closing Percent Quoted Spread" maintains its strong performance in both categories at the daily frequency.[6] Despite the excellent performance, "Closing Percent Quoted Spread" and its price impact counterpart have not been widely adopted after its debut in 2014.

Motivated by the above development, this study constructs two order-based liquidity indicators for Malaysian stocks, namely "Closing Percent Quoted Spread" (CPQS) and "Closing Percent Quoted Spread Impact" (CPQS Impact). In this exercise, the two liquidity measures are constructed for all public listed stocks on Bursa Malaysia over a 15-year sample period from 2000 to 2014 at the highest daily frequency, providing the most comprehensive dataset which is fundamental to future Malaysian liquidity research. Firm-level liquidity values are then aggregated using equal- and market value-weighting schemes to track the level of market liquidity representative of Malaysian stock market over time. Given the dominance of firm-level liquidity studies, there is a significant gap in the extant literature where time series properties of stock liquidity have been relatively understudied. Since our aggregate liquidity indicators have never been constructed before for Malaysian market, their time series properties remain

[5] Thomson Reuters starts to offer microsecond tick data in recent years across all asset classes for over 400 exchanges worldwide through its Thomson Reuters Tick History (TRTH) database. Despite this positive development, constructing high-frequency liquidity indicators requires enormous computational time due to the exponential growth of intraday data. For instance, Fong et al. (2016) use 8.5 billion trades and 13.6 billion quotes to compute high-frequency liquidity measures for 24,847 firms traded on 43 stock exchanges around the world. Furthermore, the subscription cost for accessing TRTH is beyond the financial ability of most academic institutions in developing countries.

6 Several remarks are given here on those liquidity proxies commonly used in emerging market research. First, trading volume and stock turnover ratio are widely employed as liquidity proxies in cross-country studies (see, for example, Levine and Zervos, 1998; Levine and Schmukler, 2006, 2007). However, these trade-based measures are in fact capturing trading activity, and thus do not account for transaction costs or the price impact of transactions. Recent empirical evidence in Lesmond (2005) and Barinov (2014) further reaffirms the lack of positive correlation between trading volume and stock liquidity, as these authors find that more frequently traded stocks do not necessarily correspond with higher liquidity. A classic example of liquidity drying up amid very high trading volume is the "Flash Crash" of May 6, 2010. Second, the liquidity proxy of "Zeros" (the proportion of zero return days), advocated for emerging markets by Lesmond (2005) and Bekaert et al. (2007), records the worst performance in the liquidity horserace of Fong et al. (2016) for Malaysian stocks.

to be investigated in this introductory work, which we choose to focus on the monthly interval by averaging the daily measures across months.

The remainder of the paper is structured as follows. Section 2 reviews the related literature and highlights the non-trivial research gaps. Section 3 then outlines the selection, formulas, data and procedure involved in constructing the aggregate liquidity measures. These constructed Malaysian monthly aggregate liquidity indicators are then presented in Section 4 through graphs, descriptive statistics and correlation analysis. A time series analysis is then conducted in Section 5 to detect trend, seasonality and structural break. The final section contains the conclusion.

REVIEW OF RELATED LITERATURE

The Introduction section highlights three non-trivial research gaps in the extant literature that motivates this study. First, the stock liquidity literature is dominated by firm-level liquidity studies, while relatively less attention is given to aggregate market liquidity. Second, among the limited empirical literature on aggregate market liquidity, the liquidity proxies used have been found to perform poorly in capturing transaction costs or price impact of transactions. This applies to trade-based measures such as trading volume and stock turnover commonly employed in cross-country studies, and the proportion of zero return days advocated for emerging markets by Lesmond (2005) and Bekaert *et al*. (2007). The extensive liquidity horserace conducted by Fong *et al*. (2016) proclaims the "Closing Percent Quoted Spread" and its price impact version as the best liquidity proxies in their respective categories of percent-cost and cost-per-volume, particularly for Malaysian stocks. However, this liquidity measure introduced by Chung and Zhang (2014) is relatively new with very few empirical applications. Third, unlike stock returns and stock volatility, little is known about the time series properties of stock liquidity. The available few studies are largely confined to the U.S. stock exchanges, but their focus is mainly on time trend and seasonality in liquidity (see, for example, Clark *et al*., 1992; Chordia *et al*., 2001, 2005, 2011; Jones, 2002). Only a recent paper by Smimou and Khallouli (2015) explores the possible existence of structural break in aggregate liquidity of selected European stock markets.

This paper also adds to the limited liquidity studies on the Malaysian stock market despite liquidity being an active research area in the finance discipline on the global front. Our literature search only finds a handful of published papers but all of them focus on the liquidity of individual stocks, with half of them using trade-based liquidity proxies. Previous Malaysian studies focus on using liquidity to predict stock returns (Hameed and Ting, 2000; Rahim and Nor, 2006; Ramlee and Ali, 2012), or relating changes in liquidity to corporate governance (Foo and Mat Zain, 2010), underpricing of IPOs (Sapian *et al*., 2013), stock index revisions (Azevedo *et al*., 2014) and corporate ownership (Lim *et al*., 2015). To date, there is not one single study on the aggregate liquidity of Malaysian stock market.

CONSTRUCTING AGGREGATE LIQUIDITY INDICATORS

This section describes the construction of the aggregate liquidity indicators for the Malaysian stock market. It first justifies the selection of "Closing Percent Quoted Spread" proposed by Chung and Zhang (2014) and its price impact version. The formulas, data and procedure for construction of the selected liquidity indicators are provided in the subsequent subsections.

Selection of the Best Liquidity Proxies for Malaysian Stocks

Copious liquidity measures lead to the question of which proxies are the best players in their leagues, and this question has been answered by at least four studies via liquidity horseraces. To assess the efficacy of a daily or monthly liquidity proxy, the standard approach in the literature is to examine its correlation with the intraday benchmarks. Such liquidity horseraces have been conducted using data from the U.S. (Goyenko *et al*., 2009), emerging markets (Lesmond, 2005), frontier markets (Marshall *et al*, 2013) and global stock exchanges (Fong *et al*., 2016). These studies provide useful guides as to which daily or monthly liquidity proxies are highly correlated with their intraday benchmarks, and thus avoid incurring enormous computational time and high subscription cost for extracting microstructure data. In the context of Malaysia, Fong *et al*. (2016) proclaim the "Closing Percent Quoted Spread" and its price impact version as the best liquidity proxies in their respective categories of percent-cost and cost-per-volume, with their results for the top three performers reproduced in Table 1.

Table 1 Performance of Top Three Monthly Liquidity Proxies for Malaysian Stocks

	Average Cross-Sectional Correlation	Portfolio Time-Series Correlation	Average Root Mean Squared Error
Panel A: Percent-Cost Proxies			
CPQS	0.8580	0.9340	0.0133
High-Low	0.5280	0.6450	0.0199
FHT	0.5450	0.7090	0.0132
Panel B: Cost-Per-Volume Proxies			
LOT Mixed Impact	0.6850	–	–
CPQS Impact	0.6850	–	–
FHT Impact	0.6770	–	–

Notes: In Panel A, CPQS refers to the "Closing Percent Quoted Spread" proposed by Chung and Zhang (2014). High-Low, introduced by Corwin and Schultz (2012) is a bid-ask spread estimator derived from daily high and low prices. Fong *et al*. (2016) develop the FHT, a simplified version of the LOT Mixed measure by Lesmond *et al*. (1999) which captures the difference between the percent buying cost and the percent selling cost.
In Panel B, LOT Mixed Impact is the ratio of the LOT Mixed to local currency value of trading volume. CPQS Impact denotes the "Closing Percent Quoted Spread Impact" introduced in Fong *et al*. (2016). FHT Impact is defined as the ratio of FHT to local currency value of trading volume. For the case of Malaysia, Fong *et al*. (2016) only provide the average cross-sectional correlation of monthly cost-per-volume proxies with the intraday benchmark of "lambda".
For average cross-sectional correlation and portfolio time-series correlation, higher readings denote better performance. For average root mean squared error, lower reading is preferred.
Source: Fong *et al*. (2016)

Computation of Liquidity Indicators

The "Closing Percent Quoted Spread" is computed as the daily ratio of the difference of ask and bid prices to the mid-point of these prices. The liquidity for stock *i* on day *t* can be written as:

$$Closing\ Percent\ Quoted\ Spread_{i,t} = \frac{Closing\ Ask_{i,t} - Closing\ Bid_{i,t}}{(Closing\ Ask_{i,t} + Closing\ Bid_{i,t}) / 2} \quad (1)$$

where $Closing\ Ask_{i,t}$ and $Closing\ Bid_{i,t}$ are the closing ask and bid prices of stock *i* on day *t* respectively. A higher value for "Closing Percent Quoted Spread" indicates greater illiquidity because a wider spread implies that it is more difficult to trade the stock due to a bigger imbalance in supply and demand. This may ultimately incur higher trading costs for the investors.

The "Closing Percent Quoted Spread Impact" is the ratio of the "Closing Percent Quoted Spread" scaled by dollar trading volume. The proxy can be expressed as follows:

$$Closing\ \ Percent\ \ Quoted\ \ Spread\ \ Impact_{i,t} = \frac{Closing\ \ Percent\ \ Quoted\ \ Spread_{i,t}}{P_{i,t} \square Volume_{i,t}} \quad (2)$$

where $P_{i,t}$ is the closing price of stock *i* on day *t* and $Volume_{i,t}$ is the number of shares traded for stock *i* on day *t*. Higher values for the "Closing Percent Quoted Spread Impact" signify greater degree of illiquidity as one dollar of trading volume results in a higher closing percent bid-ask spread, and vice versa. Following the convention in the literature, the "Closing Percent Quoted Spread Impact" is multiplied by a factor of 104 to arrive at meaningful readings.

Data and Procedure for Constructing Monthly Aggregate Liquidity Indicators

The data for this study cover all publicly listed firms on Bursa Malaysia over a 15-year sample period from 2000 to 2014. The liquidity indicators are first constructed on a daily basis for each firm based on data sourced solely from Thomson Reuters Datastream. The mean of these daily ratios is computed to obtain the liquidity measure for each month and each individual stock. The daily data required include closing bid price, closing ask price, number of shares traded and closing stock price.

Two filters are introduced to ensure the reliability and consistency of liquidity indicators constructed in this study. First, in order to address the concerns of data entry errors in Thomson Reuters Datastream and the presence of outliers, the estimated daily liquidity values are winsorized at the 1 and 99 percentile levels where values above the 99th percentile are replaced with the 99th percentile value and values below the 1st percentile are replaced with the 1st percentile value. Second, a stock is required to have at least 11 non-zero daily liquidity values in a month to produce a monthly liquidity estimate which is obtained by taking the mean of all daily observations in the month. If a stock does not have sufficient daily observations in a month, reading for that particular month will be treated as missing value. These two filters are imposed in line with the work of Fong *et al*. (2016).

The common practice in aggregating firm-level data to obtain a representative market measure involves assigning weights to individual observations. Two frequently used weighting methods in the finance literature are: (1) equal-weighting which assigns the same weight to each stock in the sample; and (2) market value-weighting where individual stocks are weighted according to their market capitalization, defined as the total market value of outstanding shares. It is worth noting that equally-weighted aggregate liquidity measure tends to be influenced by potentially higher spreads and illiquidity associated with stocks that are not traded frequently. As for value-weighted aggregate liquidity measure, stocks that have higher trading frequency (usually stocks with large market capitalization) will be given more emphasis than stocks that are infrequently traded. This study employs both weighting methods in computing the two monthly aggregate liquidity indicators.

MONTHLY AGGREGATE LIQUIDITY INDICATORS

This section first provides an overview of the raw firm-level liquidity estimates at the daily frequency. Subsequently, the monthly aggregate liquidity indicators for Malaysian stock market are presented along with their descriptive statistics and correlation analysis.

Raw Daily Firm-level Liquidity Estimates

The construction of the two liquidity indicators has to be done at the firm level at the daily frequency. Table 2 provides the total number of listed stocks on Bursa Malaysia for each year from 2000 to 2014 in which Thomson Reuters Datastream has sufficient data points for computing the order-based liquidity indicators. Note that the companies included in the study are those that are on the stock exchange list as at the last trading day of the year. Therefore, these numbers are not representative of the total number of listed companies on Bursa Malaysia throughout their respective years as some stocks might be listed or delisted in a year.

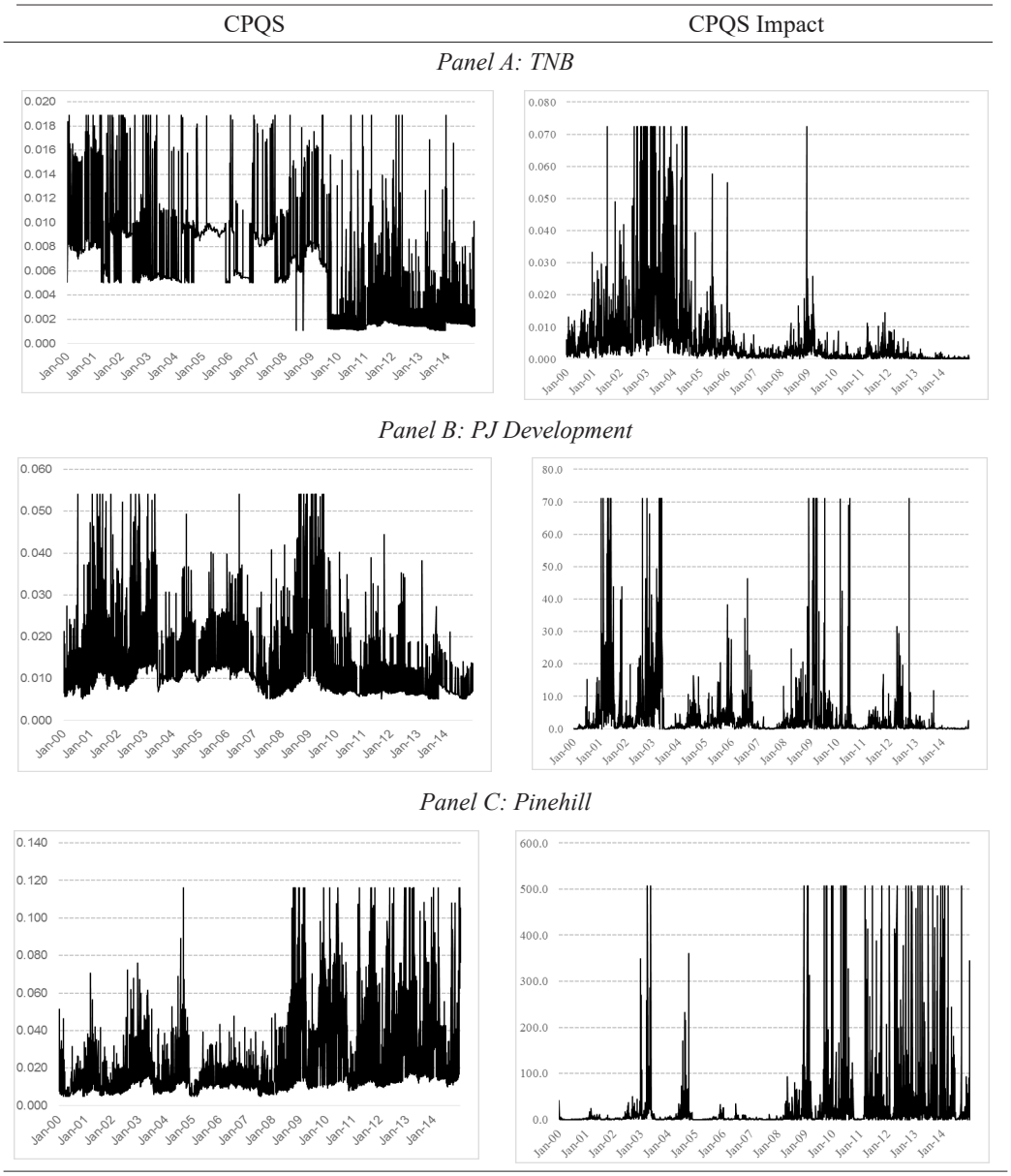
Given that the number of stocks is huge for each year, it is impossible to compare the relative liquidity of each stock cross-sectionally or over time. However, the richness of the constructed daily firm-level liquidity data is useful for future panel analysis on the determinants and effects of liquidity. Nonetheless, to provide a glimpse of the firm-level daily liquidity estimates, this section selects three sample firms drawn from the population of stocks listed on Bursa Malaysia. All public listed stocks that were active as at December 31, 2014 are first sorted based on market capitalization and then divided into three groups. Large-capitalization stocks consist of firms at and above the top 20th percentile, small-capitalization stocks consist of firms at and below the bottom 20th percentile while the remaining firms are classified as middle-capitalization stocks. One firm is drawn randomly from each group. The selected firms are Tenaga Nasional Berhad (hereafter referred to as TNB) from large-cap stocks, PJ Development Holdings Berhad (hereafter referred to as PJ Development) from middle-cap stocks and Pinehill Pacific Berhad (hereafter referred to as Pinehill) from small-cap stocks.

Table 2 Total Number of Stocks with Sufficient Data Points

Year	Number of Stocks
2000	783
2001	798
2002	848
2003	894
2004	956
2005	1,021
2006	1,035
2007	999
2008	989
2009	970
2010	971
2011	955
2012	934
2013	924
2014	923

Note: Only stocks that have at least 11 non-zero daily liquidity values in a month are included.

Figure 1 provides the graphical plots of the "Closing Percent Quoted Spread" and "Closing Percent Quoted Spread Impact" for these three sample firms. Note that for all graphs, winsorization at the 1 and 99 percentile levels has resulted in the aggregate liquidity measures to fall within a certain range. The graphs generally show that liquidity levels are highly volatile at the daily frequency regardless of the size of the firm. For this reason, the construction of aggregate liquidity indicators at the monthly frequency is necessary to minimize the impact of high-frequency volatility present in daily observations for meaningful understanding of the stock market liquidity.



Notes: CPQS refers to the "Closing Percent Quoted Spread" proposed by Chung and Zhang (2014). CPQS Impact denotes the "Closing Percent Quoted Spread Impact" introduced in Fong *et al*. (2016)

Figure 1: Firm-level Daily Liquidity Estimates for Three Sample Stocks

Monthly Aggregate Market Liquidity Indicators

The construction of the monthly aggregate market liquidity indicators proceeds as follows: (1) From the daily firm-level liquidity estimates, the mean of all daily observations in that month is computed to obtain the firm-level monthly liquidity measures; (2) These monthly liquidity estimates are then aggregated across all stocks using equal- and value-weighting schemes to construct the monthly aggregate liquidity indicators for the Malaysian stock market.

Table 3 presents the descriptive statistics for all the monthly aggregate liquidity indicators. It is observed that the statistics of the equally-weighted "Closing Percent Quoted Spread" (hereafter referred to as $CPQS_{EW}$) have higher values relative to the market value-weighted "Closing Percent Quoted Spread" (hereafter referred to as $CPQS_{VW}$). Over the period from January 2000 to December 2014, $CPQS_{EW}$ averages 0.0499 with a maximum value of 0.1665 whereas $CPQS_{VW}$ registers lower mean and maximum value of 0.0106 and 0.0245, respectively. The measure $CPQS_{EW}$ exhibits a higher dispersion (standard deviation of 0.0282 and coefficient of variation of 56.5%) compared $CPQS_{VW}$ (standard deviation of 0.0038 and coefficient of variation of 35.8%). Interpreting these observations on the percent-cost category is straightforward. It is well documented that small-cap stocks have higher trading costs and illiquidity risk (Amihud, 2002; Pastor and Stambaugh, 2003), mainly due to a higher degree of information asymmetry. In contrast, information on large-cap stocks are more widely available to the public and the interest financial analysts have in them helps to increase dissemination of information.

Table 3 Descriptive Statistics for Monthly Aggregate Liquidity Indicators of Malaysian Stock Market

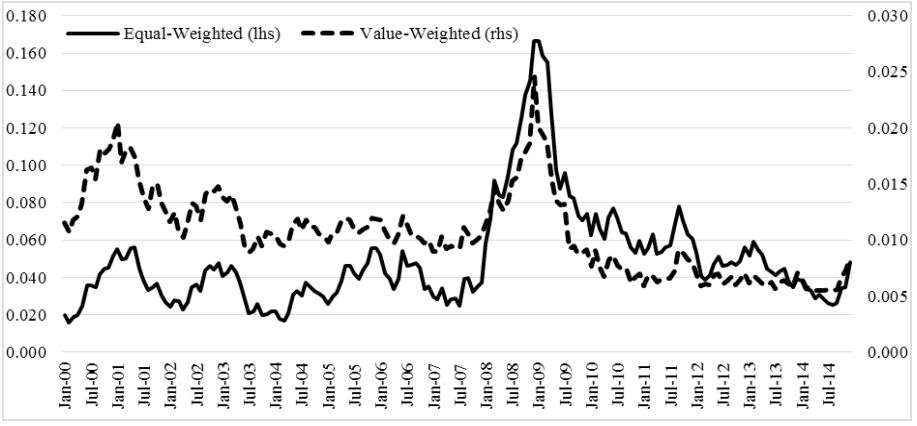
	Minimum	Median	Maximum	Mean	Standard Deviation	Skewness	Kurtosis
Panel A: Equal-Weighted (EW) Scheme							
CPQS	0.0160	0.0433	0.1665	0.0499	0.0282	2.1052	8.1419
CPQS Impact	2.8966	106.3505	376.3798	117.6086	72.8861	0.9972	3.7858
ln(CPQS Impact)	1.3601	4.6761	5.9333	4.5568	0.7411	-1.1573	5.6655
Panel B: Value-Weighted (VW) Scheme							
CPQS	0.0055	0.0104	0.0245	0.0106	0.0038	0.7834	3.3706
CPQS Impact	0.6758	5.6530	16.6383	6.1542	3.3286	0.7032	3.0123
ln(CPQS Impact)	0.5163	1.8951	2.8701	1.8568	0.4828	-0.1923	2.3201

Notes: CPQS refers to the "Closing Percent Quoted Spread" proposed by Chung and Zhang (2014). CPQS Impact denotes the "Closing Percent Quoted Spread Impact" introduced in Fong *et al*. (2016). ln(CPQS Impact) is the natural logarithm of one plus the "Closing Percent Quoted Spread Impact".

In the cost-per-volume category, the range and standard deviation for "Closing Percent Quoted Spread Impact" are very high, especially for equal-weighted scheme. Following the convention in the literature, this indicator is rescaled by taking the natural logarithm of one plus the "Closing Percent Quoted Spread Impact" in order to reduce the impact of large variations on the measure. After the transformation, it is observed that the equally-weighted indicator (hereafter referred to as $\ln(CPQS\ Impact)_{gw}$) is generally higher than its market value-weighted counterpart (hereafter referred to as $\ln(CPQS\ Impact)_{vw}$) in terms of minimum, median, maximum, mean and standard deviation. The indicator $\ln(CPQS\ Impact)_{gw}$ has mean and overall standard deviation of 4.5568 and 0.7411 respectively, while the same statistics for $\ln(CPQS\ Impact)_{vw}$ come in at 1.8568 and 0.4828. This reinforces earlier inference that small-cap stocks are relatively less liquid compared to large-cap Malaysian stocks.

A preliminary examination on the movements of these liquidity indicators over time is provided in Figure 2. It is observed that the market value-weighted "Closing Percent Quoted Spread" and "Closing Percent Quoted Spread Impact" are significantly lower than their equally-weighted counterparts. All indicators generally indicate a liquidity dry-up in year 2008 when the bankruptcy of Lehman Brothers shattered confidence in the financial markets. The observation of a highly illiquid market during the global financial crisis is consistent with two previous studies on U.S. market (see Aragon and Strahan, 2012; Anand *et al*., 2013). The post-2008 downward trend seen in "Closing Percent Quoted Spread" and "Closing Percent Quoted Spread Impact" can be explained by a surge in global liquidity following the introduction of the Fed's aggressive bond purchase program known as Quantitative Easing (QE).[7]

Panel A: Closing Percent Quoted Spread



Panel B: Closing Percent Quoted Spread Impact

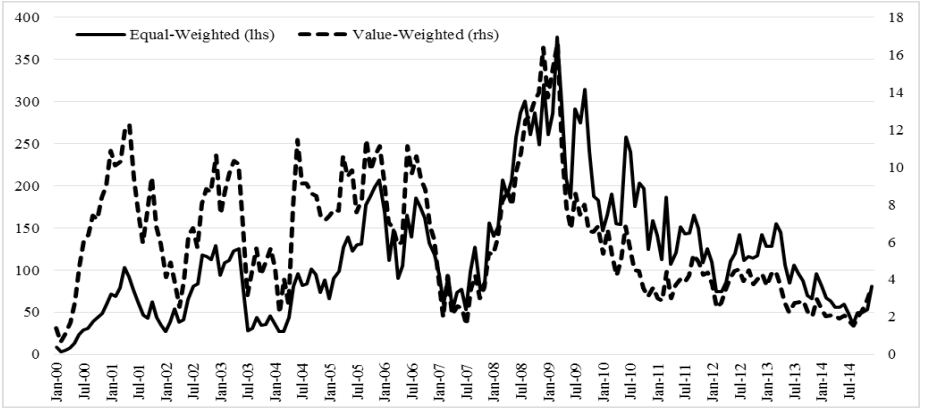


Figure 2 Time Series Plots of Monthly Aggregate Liquidity Indicators for Malaysian Stock Market

[7] There are a total of three rounds of QEs. The first QE was launched in late November 2008, just shortly after the bankruptcy of Lehman Brothers. The second and third QEs were announced in late November 2010 and September 2012, respectively.

Correlation with Other Monthly Liquidity Indicators

For comparison purpose, two commonly used liquidity indicators for the aggregate Malaysian stock market are also constructed. The first one is turnover ratio, defined as the fraction of total value of shares traded to total value of shares outstanding. The popularity of turnover ratio among researchers and regulatory authorities in Malaysia as a liquidity proxy warrants examination on its efficacy in capturing the cost and immediacy of stock trading. The second indicator is the Amihud illiquidity ratio, which is a popular price impact measure in empirical finance research. The popularity of the Amihud illiquidity ratio can be verified from the number of citations it receives since the introduction of the measure in 2002. As at 27 September 2016, the paper by Amihud (2002) has been cited 5,226 times. The Amihud illiquidity ratio is computed as the daily ratio of absolute stock returns to its dollar trading volume, in which higher values of the ratio indicate greater illiquidity because a small trading volume would result in greater price movement, and vice versa.

Table 4 presents two correlation matrices for all three liquidity indicators and the turnover ratio. The first section reports correlations of equally-weighted liquidity proxies whereas the second panel contains correlations of market value-weighted liquidity measures. Liquidity indicators from both the percent-cost and cost-per-volume categories are hypothesized to be positively correlated as smaller "Closing Percent Quoted Spread" is associated with lower price impact for a trade ("Closing Percent Quoted Spread Impact" and Amihud illiquidity ratio). This hypothesis holds for all order-based liquidity indicators in this study. For equally-weighted aggregate liquidity, $CPQS_{EW}$, $\ln(ILLIQ)_{EW}$ and $\ln(CPQS\ Impact)_{EW}$ are positively correlated with correlation coefficients of more than 63.55 per cent. When proxies are market value-weighted, correlations between $CPQS_{VW}$, $\ln(ILLIQ)_{VW}$ and $\ln(CPQS\ Impact)_{VW}$ are stronger with a minimum correlation coefficient of 68.86 per cent. The strongest correlation observed in each of the weighting method is the association between "Closing Percent Quoted Spread Impact" and Amihud illiquidity ratio with correlation of 93.98 per cent for equal-weighting and 91.02 per cent for market value-weighting. This implies that our constructed "Closing Percent Quoted Spread Impact" is a good substitute for the popular Amihud illiquidity ratio in the cost-per-volume category.

The correlation analysis also provides an assessment on the reliability of turnover ratio as a liquidity measure for the Malaysian stock market. When equal-weighting is applied, the turnover is negatively correlated with all the liquidity indicators, suggesting that higher frequency of stock trading corresponds to higher liquidity. Whether this is the case or the results are masked by illiquidity associated with infrequently traded stocks that have larger influence on equal-weighted indicators warrants further investigation. While the equally-weighted liquidity proxies appear to have a reasonable relationship with the turnover ratio, an inspection of the market value-weighted liquidity measures indicates otherwise. In his liquidity study of the emerging markets, Lesmond (2005) notes that one of the most noteworthy findings is the lack of correlation between turnover and the bid-ask spread. Our finding from the use of market value-weights concurs with that of Lesmond's (2005), where the coefficient of correlation between turnover ratio and $CPQS_{VW}$ is not only low, but also positive (8.32 per cent). Further,

the negative relationship between the turnover ratio and each of $\ln(ILLIQ)_{VW}$ and $\ln(CPQS\ Impact)_{VW}$ is weaker at -12.42 per cent and -30.06 per cent, respectively. This inconsistency of relationship between turnover ratio, "Closing Percent Quoted Spread", "Closing Percent Quoted Spread Impact" and Amihud illiquidity ratio highlights that the turnover ratio is a poor measure of liquidity as stressed by scholars such as Aitken and Comerton-Forde (2003), Lesmond (2005) and Barinov (2014).

Table 4 Correlation between Monthly Aggregate Liquidity Indicators of Malaysian Stock Market

	Turnover	CPQS	ln(ILLIQ)	ln(CPQS Impact)
Panel A: Equal-Weighted (EW) Scheme				
Turnover	100.00			
CPQS	-54.66	100.00		
ln(ILLIQ)	-59.45	63.55	100.00	
ln(CPQS Impact)	-65.11	70.41	93.98	100.00
Panel B: Value-Weighted (VW) Scheme				
Turnover	100.00			
CPQS	8.32	100.00		
ln(ILLIQ)	-12.42	71.59	100.00	
ln(CPQS Impact)	-30.06	68.86	91.02	100.00

Notes: Turnover refers to the stock turnover ratio, defined as the fraction of total value of shares traded to total value of shares outstanding. CPQS is the "Closing Percent Quoted Spread" proposed by Chung and Zhang (2014). ln(ILLIQ) is the natural logarithm of one plus the Amihud illiquidity ratio (Amihud, 2002). ln(CPQS Impact) is the natural logarithm of one plus the "Closing Percent Quoted Spread Impact" introduced in Fong *et al*. (2016). All correlation coefficients are expressed in percent (%).

TIME SERIES PROPERTIES OF MONTHLY AGGREGATE LIQUIDITY INDICATORS

Following the introduction of the new monthly aggregate liquidity indicators of the Malaysian stock market, this section performs the time series analysis that focuses on trend, seasonality and structural break of the constructed indicators.

Trend and Seasonality

Previous studies that examine the existence of trend in stock liquidity generally employ graphs (Chordia *et al*., 2001) or compute the averages over the sample period (Jones, 2002) to discern an increase or a drop in liquidity over time. Apart from these examinations which are mainly observation-based, this study uses linear regression modelling to statistically test for the presence of time trend and seasonality in the Malaysian monthly aggregate liquidity.

The linear regression model can be expressed as:

$$Liq_t = \beta_0 + \beta_1 time_t + \beta_2 Feb_t + \beta_3 Mar_t + \beta_4 Apr_t + \beta_5 May_t + \beta_6 Jun_t + \beta_7 Jul_t + \beta_8 Aug_t + \beta_9 Sep_t + \beta_{10} Oct_t + \beta_{11} Nov_t + \beta_{12} Dec_t + \varepsilon_t \quad (3)$$

where Liq_t denotes the liquidity proxy of interest for month t ; *time* denotes a linear deterministic time trend beginning with 1 (January 2000) and ending with 180 (December 2014); Feb_t , Mar_t to Dec_t are the month dummy variables for February, March to December, respectively. The OLS regression is estimated with the heteroskedasticity- and autocorrelation-consistent (HAC) variance-covariance matrix proposed by Newey and West (1987) and Andrews (1991) to obtain standard errors that are robust to serial correlation and heteroskedasticity problems present in the residuals. The presence of trend can be identified by checking the significance of β_1 while month-of-the-year effect can be examined by checking the significance of β_2 up to β_{12}. Note that dummy for the month of January is excluded to avoid the dummy variable trap and hence coefficients for the month of February to December are benchmarked against the month of January.

It is observed from Table 5 that the time trend for most of the aggregate liquidity indicators are not significant, with the exception of value-weighted "Closing Percent Quoted Spread" which shows an increasing trend in liquidity over the sample period. The difference in statistical significance for time trend in the equal- and market value-weighting classes lead to an inference that trend in liquidity in the Malaysian stock market is mainly driven by large stocks which have higher weighting in the market value-aggregated liquidity indicators. However, when we put the whole results into perspective, there is no conclusive evidence to suggest that liquidity in the Malaysian market has improved over the sample period of 15 years. This is in sharp contrast to the findings reported for the U.S. stock exchanges by Jones (2002) and Chordia *et al*. (2001, 2011). A consensus can be drawn from these studies that liquidity and trading activity in the developed U.S. stock markets have increased substantially in recent decades, which can be attributed to the advent of trading technologies.

Moving on to seasonality in liquidity, our regression analysis shows that month-of-the-year effects are concentrated in the last four months of the year starting from September. Pockets of significantly positive coefficients are found. The highly significance of the December dummy across three out of the four liquidity indicators implies that the market is less liquid at the end of the year as compared to the beginning of the year, probably attributable to greater search friction in the trading of securities given that most market players are away for the year-end holiday. It can also be reckoned that lower liquidity in December is mainly sourced from stocks with larger market capitalization, perhaps due to the low presence of large market players in this season.

Table 5 Trend and Seasonality Regressions for Monthly Aggregate Liquidity Indicators of Malaysian Stock Market

	C	Time	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Panel A: Equal-Weighted (EW) Scheme													
CPQS	0.0374**	0.0001	-0.0004	0.0007	-0.0035	-0.0029	-0.0015	-0.0030	-0.0028	0.0007	-0.0007	-0.0020	0.0022
	(0.0152)	(0.0003)	(0.0020)	(0.0027)	(0.0063)	(0.0114)	(0.0106)	(0.0079)	(0.0093)	(0.0074)	(0.0069)	(0.0056)	(0.0043)
ln(CPQS Impact)	3.9005***	0.0062	-0.1304	0.0653	-0.0123	0.0838	0.1829	0.1279	0.1100	0.2412**	0.1740	0.0583	0.2276**
	(0.5804)	(0.0098)	(0.0951)	(0.1270)	(0.0914)	(0.0898)	(0.0943)	(0.1174)	(0.1336)	(0.1002)	(0.0950)	(0.0625)	(0.1104)
Panel B: Value-Weighted (VW) Scheme													
CPQS	0.0151***	-0.00005***	-0.0002	-0.0001	-0.0005	-0.0003	0.0000	-0.0003	-0.0005	0.0003	0.0002	0.0003	0.0010**
	(0.0014)	(0.00001)	(0.0004)	(0.0004)	(0.0006)	(0.0008)	(0.0008)	(0.0006)	(0.0007)	(0.0006)	(0.0005)	(0.0004)	(0.0005)
ln(CPQS Impact)	2.1103***	-0.0036	-0.0870	0.0263	-0.0571	0.0415	0.1424	0.0608	0.0885	0.2056***	0.1398**	0.1275**	0.2162***
	(0.1756)	(0.0020)	(0.0698)	(0.0608)	(0.0756)	(0.0735)	(0.0796)	(0.0868)	(0.0703)	(0.0633)	(0.0627)	(0.0492)	(0.0420)

Notes: CPQS refers to "Closing Percent Quoted Spread" proposed by Chung and Zhang (2014). ln(CPQS Impact) is the natural logarithm of one plus the "Closing Percent Quoted Spread Impact" introduced in Fong et al. (2016).
Entries in parentheses denote the robust standard error for the coefficient computed using HAC specification.
*** and ** denote statistical significance at the 1% and 5% levels, respectively.

Structural Break Analysis

Over the span of 15 years, countless international as well as domestic events had taken place. Therefore, it is of interest to assess whether these local and international events had caused liquidity in the Malaysian stock market to shift structurally via the examination of structural breaks in the aggregate market liquidity time series. The most prominent structural break test to date is the work of Bai and Perron (1998) which has been cited 3,243 times as at November 30, 2015. This test has been employed by Smimou and Khallouli (2015) who find that the aggregate liquidity for their ten sample European stock markets have been affected by at least one structural break, after which liquidity increases substantially.

Perron (2006) and Bai and Perron (2006) recommend that a double maximum test is first performed to ascertain if any break is at all present in the time series because this is arguably the most useful test in determining if structural changes are present. If the result of the double maximum test is in favor of structural changes, the number of breaks can then be decided based on the test of versus globally determined breaks available in EViews. These two tests are chosen as they are similarly obtained from a global minimization of the sum of squared residuals.

The structural break test of Bai and Perron (1998) begins with the estimation of the following model specification using least squares:

$$Liq_t = \alpha_0 + u_t \quad (4)$$

where Liq_t is the liquidity indicator at time t, α_0 is the intercept and μ_t is the error term.

Results of the two structural break tests are presented in Table 6. The second and third columns display results of the double maximum test while the fourth and fifth columns show the number of breaks as well as the break months obtained by performing the Bai and Perron (1998) $l + 1$ versus l breaks via global minimization of the sum of squared residuals. The double maximum test which serves as a preliminary test to detect the presence of structural break(s) in a series shows that all liquidity indicators aggregated by market value have at least one break. On the other hand, results of the double maximum test performed on equally-weighted liquidity measures are less consistent with only In($CPQS\ Impact)_{EW}$ exhibiting evidence of structural breaks.

For series that indicate the presence of breaks in the double maximum test, the Bai-Perron test of l+1 versus l globally determined breaks is then performed to obtain the number of breaks and the break months. Series that are subject to one structural break include In($CPQS\ Impact)_{VW}$, $CPQS_{VW}$ and In($CPQS\ Impact)_{VW}$. Structural breaks in liquidity time series could be explained by a sudden evaporation of liquidity which results in a sharp increase in the series, or a sudden boost of liquidity in the stock market which results in a sharp decline in the series. These evaporation and enhancement of liquidity are usually associated with market events that affect the participation and confidence of investors in the stock market. The mapping of major events identified by Bursa Malaysia and Securities Commission Malaysia to the break months in the last column of Table 6 shows that the sharp liquidity changes in the Malaysian stock market are mainly driven by reactions to international events, particularly those in the U.S., rather than local events.

Table 6 Structural Break Tests Results for Monthly Aggregate Liquidity Indicators of Malaysian Stock Market

	Double Maximum Test		Bai-Perron Tests of l+1 vs. l Globally Determined Breaks		
	UD_{max} Number of Breaks	WD_{max} Number of Breaks	Number of Breaks	Break Dates	Event
			Panel A: Equal-Weighted (EW) Scheme		
CPQS	0	0	0	–	
ln(CPQS Impact)	2	5	1	2005/04	General loss in investor risk appetite due to growing concerns over excessive hedge fund losses in the US and prospects of monetary policy tightening by the Fed.
			Panel B: Value-Weighted (VW) Scheme		
CPQS	4	4	1	2009/08	Better-than-expected US corporate earnings results coupled with upbeat second quarter growth numbers in major economies boosted sentiment in share markets worldwide.
ln(CPQS Impact)	1	1	1	2010/08	The Fed resumed its first round of quantitative easing after halting it in June 2010; Malaysia's second quarter GDP increased by 8.9% and BNM announced further liberalization of foreign exchange administration rules.

Notes: CPQS refers to "Closing Percent Quoted Spread" proposed by Chung and Zhang (2014). ln(CPQS Impact) is the natural logarithm of one plus the "Closing Percent Quoted Spread Impact" introduced in Fong *et al*. (2016).
UD denotes the equally-weighted *F*-statistics in the double maximum test while WD denotes the *F*-statistics in the double maximum test whose weights depend on the degree of freedom and the significance level of the test.
Break months supplied in the table in the format of yyyy/mm.

CONCLUSION

This study is motivated by the dearth of research on the liquidity of Malaysian stocks and the recent discovery of liquidity proxies that perform remarkably well in capturing transaction cost and price impact. As exchange regulators in Malaysia strive to enhance trading environment in the local bourse and improve liquidity condition, an accurate liquidity measure is imperative to successful implementation and evaluation of various liquidity-enhancing initiatives. Unfortunately, trading volume and turnover ratio which are often used as proxies for liquidity have been found through our correlation analysis to be inappropriate for measuring liquidity of Malaysian stocks, reaffirming the criticism of Aitken and Comerton-Forde (2003), Lesmond (2005) and Barinov (2014). Therefore, proper use of liquidity measures, namely the "Closing Percent Quoted Spread" and "Closing Percent Quoted Spread impact" is recommended for both research and policy formulation.

The main contribution of this study is the construction of the above two order-based monthly liquidity indicators for the aggregate Malaysian stock market using data for all public listed stocks on Bursa Malaysia. It is observed that the market value-weighted "Closing Percent Quoted Spread" and "Closing Percent Quoted Spread Impact" are significantly lower than their equally-weighted counterparts, suggesting that large-cap stocks are generally more liquid than small-cap stocks. All indicators consistently show that there is an obvious dry-up in liquidity in year 2008 when the bankruptcy of Lehman Brothers shattered confidence in the financial markets. Unlike the U.S. stock exchanges where trading costs have decreased substantially in recent decades due to the enhancement in trading technologies (see Jones, 2002; Chordia *et al*., 2001, 2011), there is no conclusive evidence to suggest that liquidity in the Malaysian market has improved over the sample period of 15 years. However, in the short-term, there is evidence of declining liquidity in the last quarter of each year, particularly in the month of December. Additionally, structural break analysis indicates that liquidity in the Malaysian stock market is most affected by international events that shake the financial markets, especially those stemming from the U.S. which has the largest and most sophisticated financial market. As such, investors investing in Bursa Malaysia not only have to be alert about domestic news that affects specific companies or industries but also keep themselves abreast of the development on the international front to better manage liquidity of their portfolios.

The newly constructed aggregate order-based liquidity indicators in this study has made it possible to amplify its usage in future research. The suitability of the aggregate monthly liquidity indicator as a predictor of business cycle can be tested given that Næs *et al*. (2011) find empirical evidence that stock market liquidity is a better predictor of the real economy than stock prices because liquidity generally worsens ahead of the onset of recessions. Apart from that, the liquidity impact of the recent withdrawal of foreign investors from the local stock market, which sent the FTSE Bursa Malaysian KLCI Index nose-diving, can also be studied using the aggregate liquidity indicator. This recommendation is motivated by the finding of Vagias and Van Dijk (2012) that international capital flows to the Asia Pacific region are positively associated with liquidity of the local stock markets. Lastly, the work of Nyborg and Östberg (2014) suggests that aggregate liquidity measures can be used to study the connection between liquidity in the stock market and interbank markets.

ACKNOWLEDGEMENT

This paper is extracted from the first author's research project for Master of Economics at the Faculty of Economics and Administration, University of Malaya. The second author acknowledges financial funding from the Fundamental Research Grant Scheme (Grant No: FP020-2014B) provided by the Malaysian Ministry of Higher Education.

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