AGGREGATE STOCK LIQUIDITY OF BURSA MALAYSIA

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AGGREGATE STOCK LIQUIDITY OF BURSA MALAYSIA

ABSTRACT

Liquidity plays a crucial role in the functioning of secondary stock markets. However, little is known about the liquidity condition and how trading activities of different investor groups affect liquidity in the Malaysian stock exchange. This thesis focuses on three aspects of Malaysian stock market liquidity, namely, aggregate liquidity in the context of foreign equity flows, higher-order statistical moments of liquidity in the context of proprietary day trading, and, the liquidity connectedness of stock, bond, money and foreign exchange markets. First, this thesis examines the impact of gross foreign equity inflows on aggregate liquidity in a Vector Autoregression framework using newly assembled foreign trading data over the period from October 2009 to December 2016. Based on the best performing bid-ask spread proxy for Malaysian stocks – Closing Percent Quoted Spread (*CPQS*), a one-way causality from gross foreign equity inflows to aggregate liquidity is detected. The participation of foreign investors erodes the stock market liquidity. Uncertainties in the U.S. markets negatively affect aggregate liquidity through the flows of foreign institutions, whose positive feedback trading destabilizes the local bourse. Despite the shocks, there is sufficient liquidity provision from local state-backed institutional funds and local proprietary day traders. Second, capitalizing on the availability of trade data of proprietary day traders (PDTs), the liquidity effect of PDTs' trading is empirically assessed in a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) framework using daily data spanning October 2012 to June 2018. Higher PDTs' trade volume promotes aggregate liquidity, and this is attributable to intense competition among informed traders. However, such improved liquidity comes at the expense of higher conditional volatility and conditional skewness of *CPQS*. The former is due to the exchange-imposed immediacy for PDTs to close their open positions, whereas the latter can be attributed to the exclusive intraday short selling rights granted to PDTs. Lastly, this thesis computes both static and time-varying liquidity connectedness indices of four financial asset markets – stock, bond, money and foreign exchange using daily data spanning from July 2005 to December 2018. The analysis reveals that liquidity connectedness is severely underestimated in the static framework. In the time-varying framework, total liquidity connectedness of the four asset markets is significantly responsive to market events. The foreign exchange market emerges as the main transmitter as well as receiver of liquidity spillovers. The liquidity connectedness surges during crisis periods such as the Global Financial Crisis. Spillovers are the strongest for volatility connectedness, followed by return connectedness and lastly, liquidity connectedness.

Keywords: Aggregate liquidity; Foreign equity flows; Proprietary day trading; Liquidity connectedness; Malaysia

KECAIRAN AGREGAT SAHAM DI BURSA MALAYSIA

ABSTRAK

Kecairan memain peranan yang penting dalam kefungsian pasaran saham sekunder. Walau bagaimanapun, sedikit diketahui mengenai keadaan kecairan dan bagaimana aktiviti dagangan kumpulan pelabur yang berbeza mempengaruhi kecairan dalam bursa saham Malaysia. Tesis ini menumpu kepada tiga aspek kecairan pasaran saham Malaysia, iaitu, kecairan saham agregat dalam konteks aliran ekuiti asing, momen statistik kecairan yang lebih tinggi dalam konteks perdagangan peniaga hari proprietari, dan, keterhubungan kecairan pasaran saham, bon, wang dan pertukaran asing. Pertamanya, tesis ini mengkaji kesan aliran masuk ekuiti asing kasar terhadap kecairan agregat dalam kerangka Vektor Autoregresi dengan menggunakan data perdagangan asing yang baru dikumpul untuk tempoh Oktober 2009 hingga Disember 2016. Berdasarkan proksi kecairan yang terbaik untuk saham Malaysia – *Closing Percent Quoted Spread* (*CPQS*), hubungan sebab-akibat sehala dari aliran masuk ekuiti asing kasar ke agregat kecairan telah dikesan. Penyertaan pelabur asing didapati mengikis kecairan pasaran saham. Ketidakpastian dalam pasaran Amerika Syarikat memberi kesan negatif terhadap kecairan agregat melalui aliran ekuiti institusi asing, dimana perdagangan maklum balas positif mereka menjejas kestabilan bursa saham tempatan. Walaupun terdapat kejutan, peruntukan kecairan oleh dana institusi tempatan yang disokong oleh kerajaan dan juga peniaga hari proprietari adalah mencukupi. Kedua, dengan mengambil kesempatan ketersediaan data perdagangan peniaga hari proprietari (PDT), kesan kecairan daripada perdagangan PDT di Malaysia dinilai secara empirik dengan kerangka Heteroskedastisiti Bersyarat Autoregresif Umum (GARCH) menggunakan data harian untuk tempoh Oktober 2012 hingga Jun 2018. Jumlah perdagangan PDT yang lebih tinggi mempromosikan kecairan agregat, dan ini disebabkan oleh persaingan sengit di kalangan pelabur yang bermaklumat. Walau bagaimanapun, kecairan yang dipertingkatkan ini disertai oleh kemeruapan bersyarat dan kecondongan bersyarat untuk *CPQS* yang lebih tinggi. Peningkatan kemeruapan bersyarat adalah disebabkan oleh syarat kesegeraan yang ditetapkan oleh bursa ke atas PDT untuk menutup kedudukan terbuka mereka, manakala peningkatan kecondongan bersyarat dapat dikaitkan dengan pemberian hak eksklusif jualan singkat intra hari kepada PDT. Akhirnya, tesis ini mengira indeks keterhubungan kecairan yang statik dan juga merentas masa untuk empat pasaran aset kewangan, iaitu pasaran saham, bon, wang dan pertukaran asing dengan menggunakan data harian untuk tempoh Julai 2005 hingga Disember 2018. Analisis menunjukkan bahawa keterhubungan kecairan amat dikurang-anggar dalam kerangka statik. Dalam kerangka merentas masa, jumlah keterhubungan kecairan antara keempat-empat pasaran aset didapati peka secara signifikan terhadap peristiwa pasaran. Pasaran pertukaran asing muncul sebagai pelimpah utama dan penerima utama limpahan kecairan di Malaysia. Keterhubungan kecairan meningkat semasa tempoh krisis seperti Krisis Kewangan Global. Limpahan adalah paling kuat untuk keterhubungan kemeruapan, diikuti oleh keterhubungan pulangan dan akhirnya, keterhubungan kecairan.

Kata Kunci: Kecairan agregat; Aliran ekuiti asing; Perdagangan peniaga hari proprietari; Keterhubungan kecairan; Malaysia

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

ADF	: Augmented Dickey-Fuller
AIC	: Akaike Information Criterion
ARCH	: Autoregressive Conditional Heteroskedasticity
BHHH	: Berndt-Hall-Hall-Hausman
BNM	: Bank Negara Malaysia
BoE	: Bank of England
CBOE	: Chicago Board Options Exchange
CBRS	: Capital Market Development Fund – Bursa Research Scheme
CCI	: Consumer Confidence Index
CDS	: Credit Default Swap
CHF	: Swiss Franc
CMP2	: Capital Market Masterplan 2
CPQS	: Closing Percent Quoted Spread
CPQSIM	: Closing Percent Quoted Spread Impact
DJIA	: Dow Jones Industrial Average
DY	: Diebold & Yilmaz
ECB	: European Central Bank
EGARCH	: Exponential GARCH
EGLS	: Estimated Generalized Least-Squares
EPU	: Economic Policy Uncertainty
ETF	: Exchange-Traded Funds
ETP	: Electronic Trading Platform
EUR	: Euro Dollar
EUROSI	: Eurozone Sentix Investor Confidence Index
FBM KLCI	: FTSE Bursa Malaysia Kuala Lumpur Composite Index
FDI	: Foreign Direct Investment
FEVD	: Forecast Error Variance Decomposition
FIFLOW	: Gross Inflows of Foreign Institutions
FRFLOW	: Gross Inflows of Foreign Retail Investors
FTFLOW	: Total Gross Inflows of Foreign Investors
GARCH	: Generalized Autoregressive Conditional Heteroskedasticity
GARCH-M	: GARCH-in-Mean
GBP	: Great Britain Pound
GDP	: Gross Domestic Product
GED	: Generalized Error Distribution
GFC	: Global Financial Crisis
GFEVD	: Generalized Forecast Error Variance Decomposition
GIRs	: Generalized Impulse Response Functions
HAC	: Heteroskedasticity- and Autocorrelation-Consistent
IDSS	: Intraday Short Selling
ILLIQ	: Amihud Illiquidity Ratio
IPO	: Initial Public Offering
IRF	: Impulse Response Function
ISSM	: Institute for the Study of Securities Markets
JPY	: Japanese Yen
KLIBOR	: Kuala Lumpur Interbank Offered Rate
KRW	: Korean Won
LCAPM	: Liquidity-Adjusted Capital Asset Pricing Model
LIBOR	: London Interbank Offered Rate

LINET	: Net Purchase of Local Institutions
LNNET	: Net Purchase of Local Nominees
LPDTNET	: Net Purchase of Local Proprietary Day Traders
LRNET	: Net Purchase of Local Retail Investors
LTNET	: Total Net Purchase of Local Investors
MYR	: Malaysian Ringgit
MSCI	: Morgan Stanley Capital International
NBER	: National Bureau of Economic Research
NDF	: Non-Deliverable Forwards
NYSE	: New York Stock Exchange
OIS	: Overnight Index Swap
OLS	: Ordinary Least Squares
OPR	: Overnight Policy Rate
OTC	: Over-The-Counter
PCA	: Principal Component Analysis
PDTs	: Proprietary Day Traders
PHLS	: Percentage High-Low Spread
PIN	: Probability of Informed Trading
QE	: Quantitative Easing
REER	: Real Effective Exchange Rate
S&P 500	: Standard & Poor's 500
SCM	: Securities Commission Malaysia
SIC	: Schwarz Information Criterion
SOES	: Small Order Execution System
TAQ	: Trades and Quotes
TBill	: Treasury Bill
TCI	: Total Connectedness Index
TPI	: Turnover Price Impact
TRACE	: Trade Reporting and Compliance Engine
TRTH	: Thomson Reuters Tick History
TVP-VAR	: Time-Varying Parameter Vector Autoregressive
TVP-VMA	: Time-Varying Parameter Vector Moving Average
U.K.	: United Kingdom
U.S.	: United States
USD	: U.S. Dollar
VAR	: Vector Autoregression
VIX	: Chicago Board Options Exchange's CBOE Volatility Index
WFE	: World Federation of Exchanges
1MDB	: 1Malaysia Development Berhad

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

During market meltdowns such as the Global Financial Crisis (GFC) in 2007-2008 and the Flash Crash on 6th May 2010 in the United States (U.S.), investors in the financial markets learned the hard way that liquidity is king. Liquidity, defined as the speed and ease of trading an asset without substantial change in price, is central to the well-functioning of economy and financial markets. In the literature, the drying-up of market liquidity during the GFC of 2007-2008 is often cited as one of the reasons responsible for the financial contagion and plunge in asset prices seen during the crisis (Amihud & Mendelson, 2012; Brunnermeier, 2009; Rösch & Kaserer, 2014). When the liquidity crunch hit the U.S. interbank market following the bankruptcy of Lehman Brothers on 15th September 2008, difficulty in obtaining funding had put pressures on investors facing margin calls, leading to the liquidation of assets at fire-sale prices when market liquidity for these assets is low. This in turn created a liquidity spiral as explained in the work of Brunnermeier and Pedersen (2009) which is apparent during the GFC.

Recognizing the importance of liquidity in ensuring proper functioning of the financial markets, deepening market liquidity has been on the top of the list for stock exchange regulators worldwide. This is especially the case for emerging markets which are deemed to have low level of market liquidity that does not commensurate with the growth of their capital markets (Lesmond, 2005). In a report published by the World Federation of Exchanges[1] (WFE) in late 2016, the importance of growing liquidity in emerging markets is highlighted and exchange regulators in emerging markets are

[1] The World Federation of Exchanges (WFE), founded in 1961, is a global industry group for more than 250 exchanges and clearing houses around the world. The WFE is mandated to promote the development of organized and regulated securities markets to meet the needs of the world's capital markets. More information about this organization can be found at https://www.world-exchanges.org/.

encouraged to embark on efforts to further enhance local market liquidity by developing a diverse investor base, increasing the pool of securities and financial products, and creating a conducive market environment for the trading of financial products (Peterhoff, Calvey, Goddard, Cleary, & Alderighi, 2016). In the case of Malaysia, poor liquidity condition in the local stock market had been acknowledged by the Securities Commission Malaysia (SCM) in April 2011, when it presented the Capital Market Masterplan 2 (CMP2), despite numerous liquidity-enhancing measures such as the lot size reduction in early 2003 and the introduction of the Capital Market Development Fund – Bursa Research Scheme (CBRS) in 2005 (for details, see Securities Commission, 2011). Since then, more liquidity-promoting policies have been introduced in the local bourse with the latest being the six-month waiver of trading and clearing fees for new investors, the exemption of stamp duty for small- and mid-capitalization firms and the availability of intraday short selling for all investors announced in 2018.

Notwithstanding the emphasis placed on improving aggregate market liquidity by exchange regulators, the liquidity literature is disproportionately dominated by firm-level studies. Since the seminal paper of Amihud and Mendelson (1986) which establishes stock liquidity as a standard factor in asset pricing as well as a key determinant of cost of capital, scholars have been exploring the role of firm-level liquidity both as a dependent and an independent variables. As a dependent variable, a firm's liquidity is affected by its ownership structure (Becht, 1999; Brockman, Chung, & Yan, 2009; Heflin & Shaw, 2000), analyst coverage (Brennan & Subrahmanyam, 1995; Dang, Doan, Nguyen, Tran, & Vo, 2019; Jiang, Kim, & Zhou, 2011; Roulstone, 2003), corporate governance (Chung, Elder, & Kim, 2010; Foo & Mat Zain, 2010), stock volatility (Chen & Poon, 2008) and internationalization (Levine & Schmukler, 2006). As an independent variable, firm liquidity is found to be an important element in the price discovery process (see the extensive survey papers by Amihud, Mendelson, & Pedersen, 2005; Vayanos & Wang, 2012), firm value (Amihud & Mendelson, 2008; Fang, Noe, & Tice, 2009) and other aspects of corporate finance (see the survey papers of Benson, Faff, & Smith, 2015; Holden, Jacobsen, & Subrahmanyam, 2014).

As far as the macro implications of liquidity is concerned, it may be misleading to draw inferences from firm-level liquidity studies. Bond and Lombardi (2005) have empirically proven the inconsistencies of results obtained at different levels of aggregation in the studies of the relationship between uncertainty and investment. Such inconsistencies can arise due to two reasons. The first factor is the dissimilarity between the specifications of micro-econometric and macro-econometric models in which the former tends to be nonlinear. Second, while it is a common practice in panel data analysis to capture unobserved influences by including firm and year dummies, the inclusion of simple time trend in the aggregate model may not be able to control for such unobserved influences as well as its panel counterpart. Apart from that, the set of explanatory variables used to understand the impact of liquidity on macroeconomic variables such as economic growth or business cycle is entirely different from those employed in firm-level studies. While stock returns, return volatility and turnover are frequently included as control variables in firm-level liquidity studies, macroeconomic liquidity studies generally include unemployment rate, real consumption, private investment (Næs, Skjeltorp, & Ødegaard, 2011), term spreads and investor sentiment (Smimou & Khallouli, 2015) in the aggregate model.

Aggregate liquidity began drawing the attention of scholars only in the early 2000s following the discovery of co-movements between an individual stock's liquidity and market-wide liquidity of a stock exchange by Chordia, Roll and Subrahmanyam (2000) and Huberman and Halka (2001) in the U.S. markets. Such phenomena, dubbed the "commonality in liquidity", which is also observed in several other markets in Japan

(Bai & Qin, 2010), Hong Kong (Brockman & Chung, 2006), London (Galariotis & Giouvris, 2007), Taiwan (Lowe, 2014), China (Qian, Tam, & Zhang, 2014) and Germany (Rösch & Kaserer, 2014), underscores the importance of aggregate market liquidity. It also implies the existence of underlying forces driving the co-movements of liquidity of stocks listed on an exchange. The factors identified by previous empirical studies include, among others, institutional ownership (Bai & Qin, 2010; Karolyi, Lee, & van Dijk, 2012), volatility (Chordia et al., 2000; Huberman & Halka, 2001; Karolyi et al., 2012), institutional quality (Karolyi et al., 2012; Moshirian, Qian, Wee, & Zhang, 2017), inclusion in a stock index (Brockman & Chung, 2006), macroeconomic announcement (Brockman, Chung, & Pérignon, 2009) and funding constraints (Qian et al., 2014).

Moving beyond liquidity commonality, there is also an emerging literature associating aggregate liquidity with macroeconomic variables with the former taking the roles of both independent and dependent variables. As an independent variable, scholars mainly focus on its predictive power on the real economy. Most notably, market-wide liquidity has been found to be an important predictor of real economic activity in the developed markets (Apergis, Artikis, & Kyriazis, 2015; Chen, Eaton, & Paye, 2018; Ellington, 2018; Ellington, Florackis, & Milas, 2017; Florackis, Giorgioni, Kostakis, & Milas, 2014; Kim, 2013; Meichle, Ranaldo, & Zanetti, 2011; Næs et al., 2011; Smimou & Khallouli, 2015; Yen & Chou, 2020). As a dependent variable, market liquidity is found to be influenced by the states of monetary and fiscal policies as well as uncertainties arising from economic policies (Chordia, Sarkar, & Subrahmanyam, 2005; Chowdhury, Uddin, & Anderson, 2017; Dash, Maitra, Debata, & Mahakud, 2019; Debata & Mahakud, 2018; Fernández-Amador, Gächter, Larch, & Peter, 2013; Fujimoto, 2004; Goyenko & Ukhov, 2009), financial liberalization (Agudelo, 2010; Bekaert, Harvey, & Lumsdaine, 2002; Lee & Chou, 2018; Levine & Zervos, 1998; Peranginangin, Ali, Brockman, & Zurbruegg, 2016; Vagias & van Dijk, 2012), investor sentiment (Chiu, Chung, Ho, & Wu, 2018; Debata, Dash, & Mahakud, 2018; Kumari, 2019; Liu, 2015) and also politics (Marshall, Nguyen, Nguyen, & Visaltanachoti, 2018).

A noticeable trend in the empirical aggregate liquidity literature is the uneven distribution across the developed and developing markets, with most studies covering the former. This can be attributed to the availability and ease of extracting high-frequency bid and ask prices in the developed stock markets. In the U.S., the Trades and Quotes (TAQ) database which enables scholars to access such high-frequency data has contributed to the stock markets being the most researched in the liquidity literature (see, for instance, Chen et al., 2018; Chordia et al., 2000; Ellington et al., 2017; Fujimoto, 2004; Goyenko & Ukhov, 2009; Hasbrouck & Seppi, 2001; Switzer & Picard, 2016). In this strand of literature, earlier studies like Chordia et al. (2000), Huberman and Halka (2001), Brockman and Chung (2006) and Galariotis and Giouvris (2007) generally employ quoted spread, effective spread, proportional spread, absolute spread and volume depth as their liquidity proxies. Following the introduction of the illiquidity ratio (henceforth referred to as *ILLIQ*) by Amihud (2002), the literature witnesses a boom in liquidity studies adopting the illiquidity ratio as their key liquidity proxy, which requires only daily price and turnover data. Aggregate liquidity studies which employ *ILLIQ* exclusively include Bai and Qin (2010), Ellington et al. (2017), Goyenko and Ukhov (2009), Karolyi et al. (2012), Kim (2013), Liu (2015), Lowe (2014), Meichle et al. (2011), Qian et al. (2014), and Yen and Chou (2020).

Apart from *ILLIQ*, two other low-frequency proxies have also gained popularity in recent studies. The first is the "High-Low" proxy of Corwin and Schultz (2012) which requires only daily high and low prices for its computation. This liquidity proxy has been used by Chen et al. (2018) to examine the ability of liquidity to predict future real economic activity, Dash et al. (2019) and Debata and Mahakud (2018) to investigate the influence of monetary policy on market liquidity, Debata et al. (2018) and Kumari (2019) to explore the relationship between investor sentiment and market liquidity, and also Marshall et al. (2018) in their politics-liquidity study. The second is the turnover price impact (TPI) measure introduced by Florackis, Gregoriou and Kostakis (2011), computed as the ratio of return to turnover. Its adoption can be seen in the works of Ellington (2018) and Florackis et al. (2014) in their exploration of the role of liquidity in forecasting real Gross Domestic Product (GDP) as well as Chowdhury et al. (2017), Debata and Mahakud (2018) and Fernández-Amador et al. (2013) to examine the economic policy and liquidity relationship.

The review of liquidity proxies used in aggregate liquidity studies above reveals that the choice of proxies is not very different from what has been adopted in firm-level liquidity studies. At the firm-level, scholars generally average higher frequency observations, for example daily liquidity proxies, over a month, a quarter or a year to arrive at their monthly, quarterly or yearly liquidity proxies for a firm. To compute market-wide liquidity measure for a stock market, these firm-level observations are further aggregated, using either equal weighting or market value weighting schemes. In the aggregate liquidity literature, almost all studies employ the simple equal weighting method when aggregating firm-level observations. Only a handful of studies adopt the market value weighting scheme, namely Bekaert, Harvey and Lundblad (2007), Chordia et al. (2005), Liu (2015) and Lowe (2014).

1.2 Motivations of the Study

As can be seen in the previous section, the growing body of literature on liquidity primarily focuses on the developed markets, particularly the U.S. given its reputation as the most liquid market in the world and the availability of trade data. Nonetheless, there are huge differences between developed and emerging markets in terms of information efficiency (Lim & Brooks, 2010; Morck, Yeung, & Yu, 2000), the level of liquidity (Lesmond, 2005; Peterhoff et al., 2016), ownership concentration (Carney & Child, 2013; Wang & Shailer, 2013), investor protection (La Porta, Lopez-de-Silanes, Shleifer, & Vishny, 2002), corporate governance (Claessens & Yurtoglu, 2013) and the order-driven nature of most emerging markets as opposed to the quote-driven developed markets. This implies that empirical evidences or policy suggestions derived from liquidity studies in developed markets may not be completely applicable to the emerging markets.

The main factor motivating this thesis to focus solely on the Malaysian stock market is the paucity of knowledge on the aggregate liquidity in the country despite the emphasis placed by stock exchange regulator on improving liquidity and the fact that liquidity is one of the key factors ensuring the smooth functioning of the secondary market. Since the inception of the Kuala Lumpur Stock Exchange in 1976, which was later renamed as Bursa Malaysia in 2004, very few studies have been conducted on the liquidity of Malaysian stocks. Studies on the liquidity of the Malaysian stock market conducted by Abdul Rahim and Mohd Nor (2006), Azevedo, Karim, Gregoriou and Rhodes (2014), Chia, Lim and Goh (2020a, 2020b), Foo and Mat Zain (2010), Hameed and Ting (2000), Liew, Lim and Goh (2016), Lim, Thian and Hooy (2017), Ramlee and Ali (2012), and Sapian, Abdul Rahim and Yong (2013) are among the limited published studies available.

It is worth highlighting that liquidity studies in Malaysia are dominated by firm-level studies with the exception of Liew et al. (2016), who compute the first aggregate liquidity series for the Malaysian stock market and examine its time series properties. In terms of liquidity measurement, the "Closing Percent Quoted Spread" (*CPQS*) by Chung and Zhang (2014), which is found in the horserace of Fong, Holden and Trzcinka (2017) to be the best performer for Malaysian listed stocks, has only been adopted in three out of ten studies, namely Chia et al. (2020a, 2020b) and Liew et al. (2016). The scarceness of aggregate liquidity research deprives Malaysian stock exchange regulator and policymakers of valuable policy inputs on their liquidity boosting strategies. This key research gap, coupled with the finding of the best liquidity measure for Malaysian stocks by the liquidity horserace of Fong et al. (2017), motivate this thesis to shed more lights into the aggregate liquidity of the Malaysian stock market. Besides, this thesis is also motivated by the recent commercialization of historical trade data by the exchange operator, Bursa Malaysia, in which aggregate trade data of different frequencies for both local and foreign investors are made available through its Information Services Division.[2]

The first empirical chapter of this thesis, which aims to investigate the impact of foreign equity flows on aggregate liquidity in the Malaysian stock market, is mainly motivated by the massive withdrawals of foreign funds from the Malaysian stock market seen during monetary policy tightening in the U.S. In December 2015, about a year and a half after the then Federal Reserve Chairman Ben Bernanke signaled the possible reduction in the bond purchase pace of the central bank, emerging markets witnessed massive withdrawals of foreign portfolio investments. Malaysia, being an open emerging market, was not spared from such exodus of foreign investments. During such episode, the local financial press and fund houses frequently claimed that local institutions, who have ample of liquidity, always step in to support the market.[3] Such statement, frequently seen in the news or reports of investment banks, might be misconstrued due to two reasons. First, the term “liquidity” in these news/reports could be referring to the availability of funds held by local institutions, that is, funding liquidity, instead of the ease at which an asset can be bought or sold with minimal price impact. Second, the impression created by

[2] See the list of historical data packages at https://www.bursamalaysia.com/market_information/market_data/historical_data_packages
[3] See https://www.thestar.com.my/business/business-news/2016/03/11/local-capital-market-seen-resilient/, https://www.fundsupermart.com.my/fsmone/article/article-view/6639/-2016-Malaysia-Outlook-Challenging- and https://www.nst.com.my/news/2016/12/194781/20rm7805mln-outflow-market-well-supported-says-mid (retrieved on 31st December 2017).

these news/reports that foreign investors are detrimental to liquidity in the local bourse while local institutions are the suppliers of liquidity has not been vigorously and empirically verified in the limited Malaysian liquidity studies.

Liquidity is also severely understudied in the vast literature examining the costs and benefits of financial liberalization. Often taken for granted during good times, liquidity, or rather the lack thereof, takes center stage during crises as the primary channel through which financial contagion occurs (Brunnermeier & Pedersen, 2009; Calvo, 2012; Longstaff, 2010). One classic example of how evaporation of liquidity in one market could lead to a full-blown financial crisis is the complete dry-up in the U.S. interbank market in August 2007. On the policy side, stock exchange regulators, particularly those in emerging markets, have been working on enhancing market liquidity. Relatively low level of liquidity in these markets remains a major threat to investment return and a barrier to further growth in foreign portfolio investment. In the last decade, ultra-loose monetary policies in developed countries which sent hot money flooding the emerging markets had raised one important policy debate - does the local bourse suffer from liquidity dry-up when foreign funds fled the market in droves? Unfortunately, the literature does not provide useful policy guides as the liquidity effects of foreign portfolio flows have been severely understudied. Even among the pool of limited literature on this aspect, empirical evidence is at best mixed. Cross-country studies generally find liquidity-enhancing effect of foreign participation (Bekaert et al., 2002; Lee & Chung, 2018; Levine & Zervos, 1998; Ng, Wu, Yu, & Zhang, 2016; Vagias & van Dijk, 2012; Wei, 2010), whereas individual-country studies conclude otherwise (Agudelo, 2010; Lim et al., 2017; Peranginangin et al., 2016; Rhee & Wang, 2009; Vo, 2016).

Adding further complication is the ambiguous theoretical predictions on the relationship between foreign trading and liquidity. The asymmetric information model

(Easley & O'Hara, 1987; Glosten & Milgrom, 1985; Kyle, 1985) argues that the privileged access to private firm-specific information gained by informed traders drives a gap in market knowledge between them and the uninformed traders. When these privately informed investors capitalize on such superior information in their trading activity, bid-ask spreads widen and hence liquidity declines due to the increase in adverse selection costs. The opposing effect has been predicted by Admati and Pfleiderer (1988), whose model shows that liquidity is an increasing function of noise trading. Noise traders who are uninformed and do not have exogenous reasons to trade allow specialists to recoup their losses from trades with informed traders. The reduction in adverse selection costs permits specialists to offer lower spreads, hence boosting liquidity in the market. Unfortunately, previous studies are not able to precisely distinguish whether liquidity is driven by informed or noise trading as predicted by the two competing theoretical models due to their use of foreign ownership data that do not capture the dynamics of trading activity. This is because foreign investors who prefer longer investment horizon might resort to buy-and-hold strategy and rarely engage in active trading, and thus the detected causal relationship from foreign ownership to liquidity might operate through other non-trading channels such as information competition (see references cited in Lim et al., 2017) and corporate governance (see Chung et al., 2010; Prommin, Jumreornvong, Jiraporn, & Tong, 2016). Given the inconclusive empirical evidence and ambiguous theoretical predictions, this thesis therefore aims to empirically examine the effect of gross foreign equity flows[4] on the aggregate liquidity of the Malaysian stock market.

One of the liquidity-boosting initiatives introduced by Bursa Malaysia, the Malaysian exchange regulator, is the introduction of proprietary day traders (PDTs) in January 2007. This group of day traders is tasked with the primary responsibilities of

[4] In the terminologies of the capital flows literature, gross inflows refer to the net purchases of domestic assets by foreign investors, whereas gross outflows are the net purchases of foreign assets by domestic investors. Hence, net inflows are computed by subtracting gross outflows from gross inflows. This thesis focuses solely on the gross inflows of foreign investors.

injecting liquidity into the local bourse and reducing imbalances between long-term and short-term investors.[5] To ensure the effectiveness of this policy measure, Bursa Malaysia further granted PDTs the exclusive rights to perform intraday short selling (IDSS), perhaps influenced by conventional wisdom or research-based evidence of short-sellers acting as liquidity providers (see, for example, Charoenrook & Daouk, 2005).[6] However, when such initiative was introduced by Bursa Malaysia, the literature was silent on the liquidity effect of day trading, with Chou, Wang, & Wang (2015) and Chung, Choe, & Kho (2009) remain the only two available studies.[7] In fact, the day trading literature remains scant despite the growing attention on such trading strategy in the investment world, mainly due to difficulty in identifying day traders (Kuo & Lin, 2013) and the lack of data (Chung et al., 2009; Linnainmaa, 2005). Geographically, the limited empirical studies on day trading are confined to financial markets in the U.S. (Battalio, Hatch, & Jennings, 1997; Garvey & Murphy, 2005; Harris & Schultz, 1998; Jordan & Diltz, 2003; Koski, Rice, & Tarhouni, 2004; Lo, Repin, & Steenbarger, 2005; Lundström, 2017), Taiwan (Barber, Lee, Liu, & Odean, 2014; Chen & Tai, 2014; Cheng, Lin, Li, Lai, & Watkins, 2016; Chou et al., 2015; Kuo & Lin, 2013), Finland (Kyröläinen, 2008; Linnainmaa, 2005) and lastly, South Korea (Chung et al., 2009; Park & Park, 2015). Given the lack of emerging market studies on day trading and the limited attention given to the liquidity effect of such trading strategy, Malaysia, which introduces PDTs with the specific purpose of enhancing local market liquidity, might offer a clean test on the capital market effects of day trading.

[5] There are two groups of day traders, namely retail day traders and proprietary day traders (PDTs). Garvey and Murphy (2005) outline the general differences between these two groups of day traders in terms of their capital, transaction costs, licensing requirement, margin requirements and training. In the Malaysian context, PDTs are individuals with dealer's representative license and are hired by participating firms of Bursa Malaysia, usually brokerage firms or investment banks. They trade using the firms' capital and share their profits from trading with the firms. They are subject to strict trading requirements, in which long positions must be closed within two trading days while short positions have to be closed on the same day.

[6] Intraday short selling (IDSS) was banned on 5th September 1997 when the Malaysian stock market suffered from the Asian financial crisis. However, when Bursa Malaysia introduced PDTs in January 2007, the ban was lifted to give PDTs the exclusive rights to conduct IDSS. This exclusivity ended in April 2018 when IDSS was made available to all investors in a bid to further boost liquidity of the Malaysian stock market.

[7] More than half of the studies in the day trading literature focus on the performance and trading strategies of day traders, attributing the profit- or loss-making outcome of day trading to disposition effect (Garvey & Murphy, 2005; Linnainmaa, 2005), the possession of private information or ability to react quickly to new information (Barber et al., 2014; Park & Park, 2015), and other behavioural factors such as overconfidence (Kuo & Lin, 2013) and reaction to end-of-the-day performance (Lo et al., 2005).

Besides, the recent availability of historical trade data by investor types, PDTs' included, has enabled accurate and direct measurement of the trading activities of this group of investors. In the historical data packages provided by the Information Services Division of Bursa Malaysia where real time market information is disseminated through the thirty authorized information vendors that include Bloomberg and Thomson Reuters, the trade value and trade volume of PDTs are available at daily, weekly and monthly frequencies from October 2009 onwards. Relative to existing proxies, the trade value and trade volume of PDTs are appealing as they provide exact measurement of day trading, at least those regulated by the exchange, though miss out on day trading by other investor types. Previous empirical studies instead infer day trading from transactions that fit its definition of performing a round trip trade within a trading day (Barber et al., 2014; Cheng et al., 2016; Chou et al., 2015; Garvey & Murphy, 2005; Kyröläinen, 2008; Linnainmaa, 2005), trades of Nasdaq's Small Order Execution System (SOES) bandits (Battalio et al., 1997; Harris & Schultz, 1998), and message board postings in financial forum (Koski et al., 2004). Capitalizing on the special case of Malaysia in which PDTs are mandated to boost liquidity in the local bourse and the recent availability of daily trading data, the second empirical chapter of this thesis provides a timely evaluation of the liquidity effect of proprietary day trading which might serves as a reference point to other stock exchanges.

On the other hand, the exclusive intraday short selling rights granted to PDTs and their strict trading restrictions to close open positions in very short time frame also underscore the worthiness to examine the impact of their trades on the volatility and skewness of liquidity in the Malaysian stock market. The volatility/variability of liquidity[8] is of particular relevance to PDTs given their immediacy to close open positions

[8] This thesis refrains from using "liquidity risk" to avoid confusion as the term has been widely used in the asset pricing literature, pioneered by the seminal paper of Pástor and Stambaugh (2003) whose "liquidity beta" is defined as the covariance between individual stock returns and market liquidity. Their measure is later adopted in the Liquidity-Adjusted Capital Asset Pricing Model (LCAPM)

as imposed by the exchange regulator. As pointed out by Lang and Maffett (2011), trading flexibility of a PDT would be adversely impacted if the liquidity condition of an asset is highly uncertain. The urgency to close any open positions also means that PDTs would have to accept bid or ask prices that might be far away from the market price, hence generating greater variation in the liquidity of an asset. On the other hand, the exclusive rights granted to PDTs to engage in intraday short selling, at least until April 2018, has put this group of investors under the limelight when abnormal trading activities are observed in the local bourse.[9] Additionally, the study by Brunnermeier and Pedersen (2005) also reports the adverse liquidity impact of short selling. Therefore, it is of interest to this thesis to examine if the trading activities of PDTs, given their trading requirements and rights to short sell, would have impacts on the volatility and skewness of aggregate liquidity in the Malaysian stock market.

The liquidity contagion seen during the 2007-2008 GFC where the evaporation of liquidity in the U.S. interbank market later spread to the corporate debt market and stock market has drawn considerable attention from scholars and policymakers. While scholars explore liquidity spillovers and determine its sources, policymakers are wary of the possibility of a systemic liquidity meltdown in a country's financial markets should an extreme event such as the GFC was to unfold. Despite the importance of understanding liquidity spillovers, studies in this strand of literature are limited (see Banti, 2016; Chatterjee, 2015; Chordia et al., 2005; Goyenko & Ukhov, 2009; Haas & Reynolds, 2017; Jacoby, Jiang, & Theocharides, 2009; Lee & Ryu, 2019; Nyborg & Östberg, 2014; Tang & Yan, 2006; Zafeiridou, 2015), largely due to the challenging nature of measuring liquidity of different assets. The concentration of this strand of literature in the U.S. markets, with the exception of Lee and Ryu (2019) who focus on the Korean market,

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of Acharya and Pedersen (2005), alongside two other liquidity risk measures, namely: (i) the covariance between individual stock liquidity and market liquidity, and (ii) the covariance between individual stock liquidity and market returns.

[9] https://www.thestar.com.my/business/business-news/2014/08/23/dont-be-fooled-by-the-high-trading-volume/ (retrieved on 15th September 2018).

motivates this thesis to explore the extent of liquidity spillovers across different asset classes in the developing economy of Malaysia.

The third empirical chapter of this thesis is also motivated and enabled by the recent works of Karnaukh, Ranaldo and Söderlind (2015) and Mancini, Ranaldo and Wrampelmeyer (2013) which introduce low-frequency liquidity measures for the foreign exchange market. As is the case with the stock markets, the foreign exchange markets in emerging economies are also plagued by the issue of costly subscription to high-frequency intraday data. Karnaukh et al. (2015) further highlight the limited access to very recent data as well as the high computational power needed to handle data of such high frequency. Therefore, the identification of low-frequency foreign exchange liquidity measures which highly mimic their high-frequency counterparts allows scholars to advance their knowledge on foreign exchange liquidity and promote research in this area. In the context of Malaysia, the bond and stock markets of this country have been popular destinations of foreign investments, particularly during periods of expansionary monetary policies in the developed countries, due to the higher returns they offer relative to financial markets in the developed countries. On the flip side, Malaysia is also one of the worst performers when the U.S. began tightening its monetary policy. Given the pivotal role played by the foreign exchange market in the inflows and outflows of foreign investment in this country, this thesis therefore aims to examine the liquidity connectedness among the stock, bond, money and foreign exchange markets in Malaysia.

Lastly, the final motivating factor of the third empirical chapter is the introduction of the straightforward but novel connectedness framework of Diebold and Yilmaz (2009, 2012, 2014), which is later advanced by Antonakakis, Chatziantoniou and Gabauer (2020) to provide a more accurate measurement of dynamic connectedness using a time-varying parameter framework. The Diebold-Yilmaz connectedness framework has already been adopted extensively to examine return and volatility spillovers (Antonakakis & Kizys, 2015; Claeys & Vašíček, 2014; Kang, Maitra, Dash, & Brooks, 2019; Liow, 2015; Tiwari, Cunado, Gupta, & Wohar, 2018), macroeconomic uncertainties spillovers (Tsai, 2017; Yin & Han, 2014) and connectedness among financial institutions (Demirer, Diebold, Liu, & Yilmaz, 2017; Diebold & Yilmaz, 2016), amongst others. However, in the limited liquidity spillovers literature, studies are still largely using Vector Autoregression (VAR) (Banti, 2016; Chatterjee, 2015; Chordia et al., 2005; Goyenko & Ukhov, 2009; Haas & Reynolds, 2017; Jacoby et al., 2009; Nyborg & Östberg, 2014; Zafeiridou, 2015) and linear regression (Lee & Ryu, 2019), both of which are not able to provide a numerical measure of the degree of total liquidity connectedness among the markets in their respective studies. This thesis therefore employs the novel framework of Diebold and Yilmaz (2009, 2012, 2014) and Antonakakis et al. (2020) to advance the liquidity spillovers literature in the context of the Malaysian financial markets.

1.3 Research Questions

The opening of a country's financial markets to foreign investors has been a contentious topic. Advocates of financial liberalization often cite the reduction in cost of capital (Bekaert & Harvey, 2000), the growth in productivity (Kose, Prasad, & Terrones, 2009) and national output (Bekaert, Harvey, & Lundblad, 2005), improvement in market efficiency (Bae, Ozoguz, Tan, & Wirjanto, 2012) as well as better firm performance (Mitton, 2006) to support foreign participation in a country. On the other hand, Rodrik and Subramanian (2009) and Stiglitz (2010) caution against fully liberalizing a country's financial markets, particularly in the emerging markets, citing financial instability. Specifically on the aspect of liquidity, there is no consensus yet on whether foreign participation enhances or worsens liquidity of a local market, with cross-country studies generally supportive of foreign participation due to the positive liquidity impact of their presence (Bekaert et al., 2002; Lee & Chung, 2018; Levine & Zervos, 1998; Ng et al., 2016; Vagias & van Dijk, 2012; Wei, 2010) whereas single-country studies find foreign investors' participation to have a detrimental effect on local market liquidity (Agudelo, 2010; Lim et al., 2017; Peranginangin et al., 2016; Rhee & Wang, 2009; Vo, 2016).

In Malaysia, there is surprisingly little empirical work on foreign investors' half-century participation in the Malaysian stock market despite constant media scrutiny on them. As highlighted in the previous section, the foreign participation-liquidity literature is mainly saturated with evidence from the developed stock markets. Given the differences in institutional and market features between the emerging and developed stock markets, as well as the contradicting findings from cross-country and single-country studies, this thesis thus argues that a study focusing solely on the Malaysian stock market is needed to provide policymakers of valuable inputs on their financial liberalization measures. Therefore, the first research question is formulated as follows:

Research question 1: Does foreign trading affect the aggregate liquidity of the Malaysian stock market?

Policymakers in Malaysia are also intensifying their efforts to enhance the liquidity and vibrancy of the local stock exchange as evidenced by the series of measures announced in February 2018 to encourage greater investor participation in the local bourse.[10] One of the measures introduced some thirteen years ago is the Proprietary Day Traders (PDTs) who are expected to provide liquidity and reduce imbalances between short-term and long-term investors. Nevertheless, scholarly work on this group of investors is limited and hence the effectiveness of PDTs in enhancing local market liquidity remains unknown to policymakers. The day trading-liquidity literature only

[10] Among the initiatives announced are the opening up of intraday short selling to all investors, 3-year stamp duty waiver for the trading of small- and medium-capitalization stocks as well as the cross-border trading between stocks listed on the Malaysian and Singaporean stock exchanges. For news report of these initiatives, see https://themalaysianreserve.com/2018/02/07/capital-market-initiatives-will-boost-liquidity-trades/ (retrieved on 8th August 2018).

started emerging in 2009 with the work of Chung et al. (2009) on the Korean stock exchange followed by Chou et al. (2015) on the Taiwan index futures market.

Apart from looking at only the liquidity impact of day trading at the level, this thesis also examines if trading activities of PDTs in the Malaysian stock exchange have any impact on the volatility and skewness of aggregate liquidity. This is mainly motivated by two factors. First is the exclusivity granted to PDTs in Malaysia to engage in intraday short selling and their strict trading requirements which might have an impact on the volatility and skewness of liquidity in the local bourse. The second motivating factor is the thin literature on liquidity volatility (Akbas, Armstrong, & Petkova, 2011; Barinov, 2015; Blau & Whitby, 2015; Cahan, Cahan, Lee, & Nguyen, 2017; Chordia, Subrahmanyam, & Anshuman, 2001; Lang & Maffett, 2011; Pereira & Zhang, 2010) and liquidity skewness (Hsieh, Li, Mckillop, & Wu, 2018; Roll & Subrahmanyam, 2010; Wei, Hamill, Li, Vigne, & Waterworth, 2018). Since day traders exist in many stock exchanges around the world, the lack of research on the liquidity effect of day trading might reflect the disconnect between academia and exchange regulators. Therefore, these factors lead to the formulation of the second research question as follows:

Research question 2: Is trading activity of proprietary day traders associated with higher-order moments of aggregate liquidity in Malaysia?

The contagious effects that the drying up of liquidity in the U.S. interbank market had on other asset markets during the GFC have led to the blossoming of literature examining the spillovers of returns and volatility across different stock exchanges (Mensi, Hammoudeh, Nguyen, & Kang, 2016; Sugimoto, Matsuki, & Yoshida, 2014; Yilmaz, 2010), return and volatility spillovers across different asset markets (Antonakakis & Kizys, 2015; Kang et al., 2019; Tiwari et al., 2018) as well as the degree of connectedness among financial institutions (Demirer et al., 2017; Diebold & Yilmaz, 2016). While most of the studies in these strands of literature have adopted the seminal connectedness methodology devised by Diebold and Yilmaz (2009, 2012, 2014), the liquidity spillovers literature has largely lagged behind, inferring spillovers instead from Vector Autoregression (VAR) and Granger causality.

In the case of Malaysia, it was one of the favorite destinations of foreign investments during the period when major central banks were embarking on unprecedented monetary policy easing. When the U.S. Federal Reserve Bank started to tighten its monetary policy on signs that the world's largest economy was improving, Malaysia also witnessed massive withdrawals of foreign funds from the local stock and bond markets. Such volatile and large-scale movements of foreign funds raise the question of whether there are any spillover effects among the liquidity of the various asset markets in Malaysia. Encouraged by the recent discovery of low-frequency liquidity proxies for the foreign exchange market by Karnaukh et al. (2015), this thesis thus formulates the third research question as follows:

Research question 3: Does liquidity spillover across the four main asset markets of stock, bond, money and foreign exchange in Malaysia?

1.4 Research Objectives

The main objective of this thesis is to shed more lights on the aggregate liquidity of the Malaysian stock market. The three specific research objectives of this thesis are as follows:

1. To ascertain the impact of foreign trading on the aggregate liquidity of the Malaysian stock market.

2. To examine the association between proprietary day trading and higher-order moments of aggregate liquidity in Malaysia.

3. To quantify the magnitude of liquidity spillovers across the four main asset markets of stock, bond, money and foreign exchange in Malaysia.

1.5 Significance of the Study

Scholarly works on liquidity are largely centered around developed economies, especially the U.S. given the ease of obtaining intraday bid-ask spreads data from the Trades and Quotes (TAQ) database. With the introduction of low-frequency liquidity measures, liquidity research on emerging markets has also expanded. This thesis, with a focus on the Malaysian stock market, contributes to this growing literature on the liquidity of emerging stock markets. More crucially, it adds to the limited aggregate liquidity studies on the Malaysian stock market. Despite more than four decades since its incorporation, little is known about the aggregate liquidity condition of Bursa Malaysia with firm-level studies dominating the limited Malaysian liquidity literature. The computation of aggregate liquidity proxy for the local stock exchange in this thesis, which aggregates individual *CPQS* readings for all firms listed on the exchange using market capitalization weighting scheme, also adds credence to our findings as the resulting market liquidity indicator is representative of liquidity conditions of the whole market and not only a selected sample of firms in the composite barometer index. Additionally, the selection of liquidity proxy in this thesis is based on its strong correlations with intraday benchmarks in the liquidity horserace by Fong et al. (2017) and hence provides more accurate measurement of local liquidity.

The specific contributions of this thesis to the academic literature can be summarized as follows. On the theoretical front, this thesis contributes to the foreign investors-liquidity literature which largely uses official liberalization dates, stock market openness indicators, investable weight and foreign ownership data as proxies for foreign participation. Given that such measures do not capture the trading dynamics of foreign investors, the liquidity inferences drawn from the theoretical models of asymmetric information (Easley & O'Hara, 1987; Glosten & Milgrom, 1985; Kyle, 1985), noise trading (Admati & Pfleiderer, 1988; Glosten & Milgrom, 1985) and information competition (Spiegel & Subrahmanyam, 1992; Subrahmanyam, 1991), which are based on trading activities of an investor, may be flawed as these measures do not test directly the trading channel. In the extant foreign investor-liquidity literature, only three liquidity papers utilize the actual trade data of foreign purchases and sales, either at the intraday (Peranginangin et al., 2016), daily (Agudelo, 2010) or monthly (Vagias & van Dijk, 2012) intervals.

Second, findings from the first research question in this thesis which looks at the liquidity role of foreign investors in Malaysia provide useful policy guides to policymakers on the liquidity impact of foreign investors' trades. It also helps to answer the question of whether huge outflows of foreign funds pose a risk to the liquidity of the local bourse. While this thesis provides a country-specific study on Malaysia, it could also serve as a reference point for other developing countries experiencing huge foreign portfolio flows. Besides, understanding the liquidity roles of foreign and local investors would aid policymakers in formulating strategies targeted at the types of investors who are identified as liquidity suppliers to further enhance liquidity in the local stock exchange.

Third, the second research question contributes to the limited pool of research on day traders, with focus given largely to their performance and possible market volatility induced by their active trading strategies. At the time of writing, only two studies (Chou et al., 2015; Chung et al., 2009) address the liquidity impact of day trading. Since the introduction of PDTs in January 2007, policymakers in Malaysia have not been given any validation that their objective of enhancing local market liquidity is achieved. Therefore, this thesis addresses the disconnect between academia and exchange regulators in this respect.

Fourth, this thesis also contributes to the empirical literature that uses largely liquidity measures at the level. This pales in comparison to the stock return literature, which registers phenomenal growth in studies exploring return volatility and return skewness. The novelty of this thesis lies in the introduction of conditional skewness to the liquidity skewness literature, vis-à-vis the unconditional skewness measure adopted by Hsieh et al. (2018), Roll and Subrahmanyam (2010) and Wei et al. (2018). Unlike liquidity skewness, there is already a large body of literature on stock return skewness (see literature cited in Albuquerque, 2012), and their return skewness measure has long moved beyond unconditional skewness following the pioneering works of Hansen (1994) and Harvey and Siddique (1999). Furthermore, evidence of increasing right-skewness in the distribution of liquidity in the U.S. and the United Kingdom (U.K.) over time, as demonstrated by Roll and Subrahmanyam (2010) and Hsieh et al. (2018), further emphasizes the need to address time-variation in skewness. On the other hand, understanding the variation in liquidity is equally important from the policy perspective because sudden evaporation of liquidity may lead to market inefficiencies in processes such as price discovery, risk transfer and liquidation of real investments (for details, see Johnson, 2008).

Fifth, this thesis contributes to the limited liquidity spillovers literature which uses largely impulse response functions and Granger causality of VAR models to infer evidence of spillovers. Such models, which could only provide evidence of pairwise liquidity spillovers, are inferior to the Diebold and Yilmaz (2009, 2012, 2014) connectedness methodology which is able to provide an index for total connectedness among a system of units and account for time variation in the connectedness of these units.

Instead of adopting the rolling-window approach of Diebold and Yilmaz (2009, 2012, 2014) to examine liquidity spillovers over time, this thesis instead follows the time-varying parameter VAR framework of Antonakakis et al. (2020). The latter eliminates the shortcomings of the rolling-window approach such as the need to set an arbitrary window size as well as the problem of identifying which data points contribute to the changes observed in the total connectedness index. The third empirical chapter of this thesis is the first to adopt such method to quantify liquidity spillovers across the stock, bond, money and foreign exchange markets in the extant literature. The findings of this chapter would help policymakers to better comprehend liquidity connectedness in the local financial markets and identify the sources of liquidity spillovers such that strategies and policies can be formulated to contain any systemic dry-up of liquidity in the main asset markets of the country.

1.6 Outline of the Study

This thesis is organized into seven chapters. Chapter one provides an overview of key developments in the stock liquidity literature followed by key issues that motivate this thesis. The next sections then outline the research questions and their respective research objectives, and the contributions of this thesis. Chapter two provides an extensive review of the academic literature from which research gaps are identified. Chapter three then discusses existing theories and empirical studies that lead to the three research questions. Also discussed in Chapter three are the empirical model specifications, all variables and their sources as well as the robustness tests. Empirical results for the three research questions are presented in Chapter four to six. Lastly, Chapter seven concludes the thesis by summarizing key findings of the three research questions and provides policy implications as well as recommendations for future research.

CHAPTER 2

LITERATURE REVIEW

As discussed in Chapter 1, this thesis is motivated by the lack of aggregate liquidity studies in Malaysia, which would ultimately lead to the deprivation of valuable policy insights and assessment of the efficacies of liquidity enhancing strategies implemented by policymakers and stock exchange regulators. This chapter thus provides a review of the relevant liquidity literature and discusses developments that motivate the research questions and guide the research design in this thesis. Section 2.1 highlights the importance of aggregate stock liquidity, both as a dependent variable as well as an independent variable in various macroeconomic studies. Section 2.2 then reviews existing liquidity proxies and horseraces that guide the selection of the Closing Percent Quoted Spread (*CPQS*) as the main liquidity proxy of this thesis. Section 2.3 discusses studies that seek to ascertain whether the participation of foreign investors in a local market is desirable or otherwise, highlighting the lack of studies utilizing actual foreign trade data which motivates the first research question. Section 2.4 reviews the limited day trading literature that leads to the formulation of the second research question. The limited liquidity volatility and liquidity skewness literature, discussed in Section 2.5 and Section 2.6 respectively, further motivate the extension of our second research question to explore the association between proprietary day trading and higher-order moments of aggregate liquidity. Section 2.7 explores the various liquidity spillovers literature, of which most include only two asset markets and employ basic Vector Autoregression and Granger causality to infer spillovers. Section 2.8 provides a discussion on the recent advancements in measuring connectedness. Lastly, a summary section is provided at the end of this chapter.

2.1 The Importance of Aggregate Liquidity

The importance of liquidity in a financial market can be seen from its frequent appearance in the headlines of major financial press during the 2007-2008 Global Financial Crisis (GFC). Notwithstanding the fact that liquidity is a well-researched topic in the finance literature, most of the empirical liquidity studies are done at the firm-level, which might not be able to provide useful insights on its macro implications. Research on aggregate market liquidity has its own scholarly merits and should be given greater attention than it presently receives. This section highlights the importance of aggregate liquidity, both as an independent variable and a dependent variable, in various macroeconomic studies as well as the dominance of studies focusing on the developed markets. The latter further underscores the need to expand the aggregate liquidity literature in the emerging markets spectrum.

2.1.1 Real Economic Activity

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). In the U.S., such relationship has been examined by Chen et al. (2018), Ellington et al. (2017), Næs et al. (2011), Switzer and Picard (2016) and Yen and Chou (2020). Empirical evidence from the U.S. market is generally in favor of aggregate stock market liquidity having predictive power on future economic activities of the country. Using quarterly data spanning the period from 1947 to 2008, Næs et al. (2011) find that stock market liquidity, particularly the liquidity of small-capitalization stocks, is a very good leading indicator of the real economy. Ellington et al. (2017) who cover the period from 1970 to 2014 quantify that stock market liquidity is able to explain 17% of the variation in U.S. GDP during the Great Recession. Employing the longest time series data spanning from 1926 to 2015 and a variety of volatility- and break-adjusted liquidity measures, Chen et al. (2018) find that not only is liquidity able to predict stock market returns, it is also able to predict future output growth and unemployment in the U.S. economy. In a recent study by Yen and Chou (2020), the authors provide evidence that illiquidity shocks, stemming from the Amihud (2002) illiquidity ratio (*ILLIQ*), lead to lower industrial production, employment and consumption, resonating the findings of Chen et al. (2018).

In Europe, a number of scholarly works have also been found exploring such relationship and provide further reinforcement on the importance of aggregate liquidity as a predictor of future economic activities. Using both linear and non-linear models covering the sample period from 1989:Q1 to 2012:Q2, Florackis et al. (2014) find that the ability of liquidity in predicting economic growth in the U.K. outperforms the models using term spread, short-term interest rates and real money supply. Their predictions also beat those published by the Bank of England (BoE). These authors further find that the relationship is stronger during periods of highly illiquid market conditions and weak economic growth. Also using U.K. data but with a slightly longer sample period of 1988:Q1 to 2016:Q4, Ellington (2018) improves the earlier work of Ellington et al. (2017) by using theoretically grounded contemporaneous sign restrictions to identify illiquidity shocks and conducting structural inference in a non-linear framework. With liquidity proxied by *ILLIQ* and return to turnover ratio, the author finds that liquidity shocks adversely affect economic growth and inflation in the U.K. economy.

Apergis et al. (2015) find similar results as Næs et al. (2011) in which liquidity, particularly those of small-capitalization firms, explains the state of economy for both the U.K. and Germany during the period from 1994 to 2011. Smimou and Khallouli (2015) consider ten Eurozone countries (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, Spain) and the U.K. over the sample period from January 1990 to June 2010. They find that the improvement in stock market liquidity coincides with better economic growth. In Switzerland, Meichle et al. (2011) discover that stock market liquidity is the main predictor for economic activity for the Swiss economy over the period 1990–2010. Shifting the focus to Asia, Kim (2013) performs a similar analysis for the Korean stock market using quarterly data spanning the period from 1995:Q2 to 2011:Q4. In a Vector Autoregression (VAR) framework, the author finds that liquidity is a good predictor of real GDP growth in the next quarter. Furthermore, the liquidity of small, young, non-dividend paying and financially stressed firms contains more information of future economic downturns, corroborating the findings of Apergis et al. (2015) and Næs et al. (2011).

Nonetheless, not all studies in this strand of literature agree with the studies reviewed above. When analysis is carried out at the cross-country level, the ability of home market liquidity in forecasting macroeconomic variables has diminished. Using *ILLIQ* and "Roll" by Roll (1984) as liquidity proxies, Galariotis and Giouvris (2015) find that macroeconomic variables such as the growth of real GDP, unemployment rate, real consumption and private investments cannot be predicted by previous quarter liquidity proxies for Canada, France, Germany, Italy, Japan, the U.K as well as the U.S. In addition, the superior ability of liquidity of small and volatile firms in predicting economic growth of the U.S. (Apergis et al., 2015; Næs et al., 2011) has also been nullified in the work of Galariotis and Giouvris (2015). Instead, these authors find that global liquidity, measured as the value-weighted aggregate of all sample firms except those belong to the specific country, is statistically significant in Granger causing macroeconomic indicators in all countries except the U.S. The weakness of aggregate liquidity in forecasting future real economic activities in the U.S. is later uncovered in the work of Switzer and Picard (2016), which uses quarterly data from 1947 to 2012.

2.1.2 Commonality in Liquidity

The shift of liquidity studies from the market microstructure perspective to market-wide angle is pioneered by Chordia et al. (2000), Hasbrouck and Seppi (2001) and Huberman and Halka (2001), who find that the liquidity of individual stocks co-moves with market liquidity in the U.S. stock exchanges (termed as "commonality in liquidity"), hence underscore the importance of aggregate market liquidity. However, commonality in liquidity is not idiosyncratic to the U.S. as Bai and Qin (2010), Brockman and Chung (2006), Galariotis and Giouvris (2007), Lowe (2014), Qian et al. (2014) and Rösch and Kaserer (2014) find evidence of liquidity co-movement in the stock exchanges of Japan, Hong Kong, London, Taiwan, China and Germany, respectively. Brockman et al. (2009) further show that commonality spills across national borders using data from 47 stock exchanges spanning both developed and emerging economies.

Having established the existence of co-movement with aggregate market liquidity, researchers also work on identifying the factors that drive commonality in liquidity. Empirical evidence shows that stocks or exchanges with greater institutional ownership tend to have higher commonality in liquidity due to herding behavior and their preference for liquid stocks (Bai & Qin, 2010; Chordia et al., 2000; Karolyi et al., 012; Lowe, 2014). Chordia et al. (2000) and Huberman and Halka (2001) show that volatility has a positive influence on liquidity commonality. Karolyi et al. (2012) reveal asymmetric effect of volatility on the co-movement of liquidity as commonality is higher during market declines relative to market increases. Using data from all A-share stocks in the Shanghai and Shenzhen stock exchanges in China over the sample period from 1995 to 2012, Qian et al. (2014) find similar asymmetric effect of market returns on systematic liquidity in that negative market returns lead to higher commonality in liquidity.

Besides, Karolyi et al. (2012) and Moshirian et al. (2017), using a sample of 40 and 39 exchanges respectively over a 15-year sample period, find that liquidity commonality is higher in countries with weak investor protection and exchanges which are less transparent. Other factors that are positively associated with commonality in liquidity include stock index inclusion (Brockman & Chung, 2006) and macroeconomic announcement (Brockman et al., 2009). In terms of funding constraints, while Chordia et al. (2000) and Karolyi et al. (2012) find little evidence that interest rate explains variation in commonality, Qian et al. (2014) use new market entrants as a measure of funding supply and discover that funding constraints do explain commonality of liquidity in the Chinese stock markets. Additionally, the effect of trading regime shift on liquidity commonality turns out to be insignificant as supported by the work of Galariotis and Giouvris (2007).

2.1.3 Asset Pricing

In the liquidity literature, extensive works have been done to establish the relationship between liquidity and stock returns. The earliest work which theoretically establishes such relationship can be traced back to Amihud and Mendelson (1986) which concludes that market-observed expected return is an increasing and concave function of the bid-ask spread. Following the seminal work, research investigating the effect of liquidity on expected stock return has grown exponentially and become one of the richest areas in finance in the last few decades, making it impossible to review all extant studies. Fortunately, a number of survey papers on the importance of liquidity in the price discovery process has been published (see, for example, Amihud *et al.*, 2006; Vayanos and Wang, 2012). One notable feature of this strand of literature is that while firm-level studies are plentiful, only a handful of studies, reviewed below, examine the relationship between liquidity at the aggregate level to market-wide stock return.

In the influential study of Amihud (2002) which introduces the price impact measure of *ILLIQ* that has since been widely adopted in the liquidity literature, the author tests the effect of aggregate liquidity on market excess return both across stocks and over time using U.S. data from 1964 to 1997. The author concludes that expected market illiquidity, obtained from an autoregressive model, predicts future stock excess return, and unexpected market illiquidity is negatively associated with contemporaneous stock prices. Such effect is found to be stronger for small-capitalization firms. In another study, Jones (2002) computes three liquidity measures for stocks listed on the New York Stock Exchange (NYSE) for a century beginning 1900 and finds that quoted bid-ask spreads and turnover predict excess stock returns of up to three years ahead.

In the emerging markets, Jun, Marathe and Shawky (2003) use data from 27 emerging equity markets spanning the period from January 1992 to December 1999. In both cross-section and time-series analyses, the authors discover that stock returns are positively correlated with aggregate market liquidity, measured by turnover ratio, trade value and the volatility-adjusted turnover ratio. These positive associations, however, are at odds with those found in the developed markets. While the authors attribute such inconsistency to emerging markets' lower level of integration with the global economy, such deviation from the findings obtained from other matured markets could also be caused by the choice of trade-based liquidity proxies employed. Trade-based liquidity proxies have been found to be reflecting firm-specific uncertainty (Barinov, 2014) and is not representative of the ease of trading large amount of securities without causing huge change in market price (Aitken & Comerton-Forde, 2003; Lesmond, 2005). This is further proven by Bekaert et al. (2007) when they find that liquidity, measured by the proportion of zero daily returns, is able to predict future returns whereas turnover do not, for a sample of 19 emerging markets over the period from 1987 to 2003.

2.1.4 Economic Policy

The presence of co-movement of liquidity among individual stocks and that of individual stocks to the market indicates that some underlying common factors are driving the systemic component of liquidity. One such factor is economic policy, with empirical evidence concentrated on the monetary aspect (Chordia et al., 2005; Chowdhury et al., 2017; Dash et al., 2019; Debata & Mahakud, 2018; Fernández-Amador et al., 2013; Fujimoto, 2004; Goyenko & Ukhov, 2009) and less so from the fiscal side (Chowdhury et al., 2017).

Unsurprisingly, this strand of literature is dominated by studies on the impact of monetary policy on aggregate liquidity in the U.S. Using monthly data spanning 1965 to 2001, Fujimoto (2004) finds that expansionary monetary policy, proxied by non-borrowed reserves and the federal funds rate, has a positive impact on aggregate liquidity in the U.S. stock markets, proxied by proportional spread, *ILLIQ* and the return reversal measure of Pástor and Stambaugh (2003). The author also finds that the effect of monetary policy on liquidity is stronger when business cycle dynamics in the country are more volatile, corresponding to the period prior to 1984 in the sample. The study by Goyenko and Ukhov (2009), which uses a slightly longer sample from July 1962 to December 2003 and monetary policy proxies identical to that of Fujimoto (2004), finds that while liquidity in the stock market responses directly to changes in monetary policy, the latter also affects stock market liquidity indirectly through the bond market due to the presence of bidirectional causality between liquidity of stock and bond markets. A tightening of monetary policy leads to lower stock and bond market liquidity. Chordia et al. (2005) find only modest predictive power of monetary policy for stock market liquidity when the analysis is performed at a higher frequency using daily data for the period from June 1991 to December 1998. Using net-borrowed reserves and the fed funds rate as proxies for monetary policy, these authors also observe greater predictive power of monetary policy during crisis periods. Their findings are more in line with that of Fujimoto (2004) in which the latter also finds stronger influence of monetary policy on stock market liquidity when business cycle dynamics are more volatile.

Moving on to cross-country studies but still among developed markets, Fernández-Amador et al. (2013) examine the impact of monetary policy on stock market liquidity in the three largest economies in the Eurozone, namely Germany, France and Italy. Using monthly data spanning January 1999 to December 2009 and growth rate of the base money in these countries as the main explanatory variable, these authors find that expansionary monetary policy by the European Central Bank (ECB) results in higher aggregate liquidity in the stock markets of the sample countries. In terms of liquidity measures, this study is by far the most extensive, using seven proxies namely turnover rate, total trade volume, *ILLIQ*, turnover price impact, Roll impact, Roll and relative bid-ask spread. Another notable finding from this study is that the aggregate liquidity of small-capitalization stocks is more responsive to innovations in monetary policy than their large-capitalization counterparts.

Shifting the focus to emerging markets, Chowdhury et al. (2017) examine the effect of both monetary and fiscal policies on the aggregate stock liquidity of eight emerging economies – Bangladesh, India, Indonesia, Malaysia, Pakistan, South Korea, Taiwan and Thailand – using data from 1050 firms over a 16-year period from January 2000 to December 2015. In a VAR framework followed by Granger causality, this study finds unidirectional causality running from short-term interest rate, government expenditure and private borrowing to stock market liquidity, the latter proxied by turnover, trade volume, *ILLIQ* and turnover price impact ratio. On the other hand, money supply growth and public borrowing are found to have bidirectional causality with stock market liquidity in these countries.

The novel study which introduces the measurement of Economic Policy Uncertainty (EPU) by Baker, Bloom and Davis (2016) has facilitated the birth of another strand of literature in the liquidity domain.[11] Instead of looking at monetary policy or fiscal policy, Dash et al. (2019) capitalize on the EPU index to investigate the causal relationship between EPU and stock market liquidity in the G7 countries over the sample period from January 2000 to July 2017. Employing the "High-Low" spread of Corwin and Schultz (2012), trade value and *ILLIQ* as liquidity measures, these authors discover a two-way causality between stock market liquidity and EPU in Canada, Germany, the U.K. and the U.S. Furthermore, the causation running from stock market liquidity to EPU is found to be stronger during times of market turmoil, indicating that liquidity contains important economic information, consistent with the findings of most of the studies reviewed in Section 2.1.1. Using data from an order-driven emerging market – India alone, Debata and Mahakud (2018) shortlist 510 firms from the Stock Exchange of India in an exercise to determine whether there exists any causal relationship between EPU and stock market liquidity. In a VAR framework followed by Granger causality, they find that EPU Granger causes stock market liquidity, the latter proxied by turnover rate, trade value, *ILLIQ*, turnover price impact ratio and the High-Low spread. Similar to Dash et al. (2019), this causal relationship is also found to be stronger during periods of financial turmoil.

2.1.5 Investor Sentiment

The investor sentiment-liquidity literature is one of the nascent areas in the liquidity literature, with the work of Liu (2015) being the first empirical study to examine such relationship despite the existence of theoretical models such as the noise trading model (De Long, Shleifer, Summers, & Waldmann, 1990a), irrational market makers model (Baker & Stein, 2004) and the overconfidence model (Odean, 1998) linking sentiment

[11] These authors measure policy-related economic uncertainties using textual analysis of policy-related news. EPU indices for the global economy as well as selected countries are made publicly available in their website at: https://www.policyuncertainty.com/index.html.

with liquidity. Using the *ILLIQ* as proxy for liquidity and two sentiment indicators, namely the Index of Investor Intelligence (for institutional investors) and the Index of the American Association of Individual Investors (for retail investors), Liu (2015) finds that investor sentiment has a positive causal relationship with market liquidity and market turnover, consistent with predictions of the theories listed above. Market liquidity, however, are not affected by variation in investor sentiment in a regression model where standard deviation of investor sentiment is one of the independent variables.

Focusing solely on exchange-traded funds (ETFs) during the Global Financial Crisis, Chiu et al. (2018) use the same institutional and individual investor sentiment indices as Liu (2015) to examine the impact of investor sentiment on four dimensions of market liquidity – price, quantity, limit order and volume. The novelties of this paper are the use of high-frequency intraday data and the examination of asymmetric effects of positive and negative sentiments on market liquidity. Besides reporting the general findings that positive sentiment increases liquidity through lower proportional quoted spread, greater market depth, more limit buy orders and higher trade volume, the authors also find asymmetric sentiment effects on liquidity in that pessimistic sentiment accelerates the evaporation of liquidity in the market. The authors attribute such effect of pessimism on liquidity to the funding constraints of Brunnermeier and Pedersen (2009) whereby noise traders are forced out of the market by short-sales constraints, therefore lowering market liquidity.

Arguing that developed and emerging markets are inherently different due to the dominance of noise traders and better institutional quality in the former, Kumari (2019) extends the sentiment-liquidity literature by looking at such relationship in an emerging market – India. Using two aggregate sentiment indices with the first being the principal component of ten indirect measures of sentiment proxies and the second being the orthogonalized version of the first aggregate sentiment index, the author probes the effect of investor sentiment on conditional volatility of liquidity in the Indian Stock Exchange besides the usual causal relationship at the level. A bidirectional causal relationship is found between market liquidity and investor sentiment and the latter also explains variation in market liquidity.

Unlike all the studies mentioned above, Debata et al. (2018) consider the liquidity impact of both local and foreign investor sentiments in twelve emerging stock markets over the period from April 2002 to March 2015. Consistent with the literature, positive investor sentiment, both local and foreign, are found to have positive impact on market liquidity, proxied by trade value, *ILLIQ* and High-Low spread, in these markets. However, the major drawback of the above study is that the domestic investor sentiment indices employed, namely the orthogonalized Consumer Confidence Index (CCI), might not capture the true essence of investor sentiment as not all consumers are investing in the stock market and hence it reflects mainly households' future spending and saving behavior. This is as opposed to the investor-centric sentiment indices used to measure foreign investor sentiment, namely Baker and Wurgler's (2006) sentiment index[12] for the U.S. and the Eurozone Sentix Investor Confidence Index (EUROSI) for the European markets, respectively.

2.1.6 Asset Allocation

The study by Xiong, Sullivan and Wang (2013) is one of the pioneers in the literature which explores the relationship between aggregate liquidity and asset allocation in a portfolio. Using data from all stocks listed on the NYSE over the period January 1963 to September 2010 and two liquidity measures – *ILLIQ* and turnover, the authors construct

12 The seminal paper of Baker and Wurgler (2006) introduces a composite index for sentiment based on principal component analysis of six sentiment proxies – closed-end fund discount, share turnover, the number and average first-day returns on Initial Public Offerings (IPOs), the equity share in new issues and dividend premium.

a portfolio in which the equity proportion of a portfolio is overweight (underweight) when illiquidity premium is high (low). When market liquidity is low, greater allocation is given to equities as more market returns in the form of liquidity premium can be extracted by providing liquidity when it is most needed. They find significant enhancement to a portfolio's performance when allocation is determined based on changes in market liquidity conditions. Replicating the above study to examine the practicality of liquidity-driven portfolio allocation in the German stock market, Baitinger, Fieberg, Poddig and Varmaz (2015) find that such strategy works only in an in-sample analysis. In out-of-sample analysis, the positive performance of a liquidity-driven asset allocation strategy vanishes. The authors attribute such outcome to the rigidity of the model proposed by Xiong et al. (2013) and instead specify the equity proportion of a portfolio as a linear function of *ILLIQ*, leading to significant performance improvement of the portfolio.

Focusing on portfolio with short investment horizons, Bazgour, Sougne and Heuchenne (2016) compute optimal conditional portfolio allocation as a function of lagged aggregate liquidity. Consistent with the clientele effect of Amihud and Mendelson (1986), this study finds that aggregate liquidity, proxied by *ILLIQ*, is a decreasing function of investment horizon with its effect seen strongest at daily frequency. Furthermore, not only do portfolios with higher share of small-capitalization stocks react more aggressively to shocks in aggregate liquidity, their allocation in a portfolio also declines as aggregate liquidity deteriorates, in line with the notion of flight-to-quality or flight-to-liquidity. In the presence of short selling, however, worsening aggregate liquidity does not translate to reducing allocation of small-capitalization stocks as investors adopt the long/short strategy.

2.1.7 Politics

Having seen empirical evidence that the U.S. economy grows faster and the U.S stock markets record higher excess return during the reign of Democratic presidents (Blinder & Watson, 2016; Santa-Clara & Valkanov, 2003), Marshall et al. (2018) extend the literature to examine if market liquidity is also higher under Democratic presidencies. Using a battery of liquidity indicators – High-Low spread, *ILLIQ*, *CPQS*, the Pástor and Stambaugh (2003) measure, the Gibbs measure and the share turnover measure, it is found that market liquidity is indeed higher in times of Democratic presidents. Apart from the business cycle channel inferred from the findings of Blinder and Watson (2016) and Næs et al. (2011), this study also presents evidence that politics and liquidity in the U.S. markets are connected through the information asymmetry, volatility and economic policy uncertainty channels. These three channels are found to be lower during the reign of Democratic presidents, leading to higher market liquidity as per the theoretical model of Glosten and Milgrom (1985) and the empirical findings of Chordia et al. (2005) and Dash et al. (2019).

2.2 Measurements of Stock Liquidity

Liquidity is a multifaceted concept and there is no consensus hitherto as to which measure performs best in capturing all aspects of liquidity. The availability of daily data from Refinitiv (formerly Thomson Reuters) Datastream has made liquidity studies in emerging markets possible, as scholars can now construct low-frequency liquidity proxies which are empirically proven to have high correlations with their high-frequency intraday benchmarks. This section aims to determine the best liquidity proxy that is most representative of the liquidity conditions in the Malaysian stock market. Liquidity proxies can be broadly divided into trade-based, which is reviewed in the first subsection, and order-based, reviewed in the second subsection. The burgeoning literature which introduces copious low-frequency liquidity proxies has then led to the need to perform horseraces to determine their effectiveness in capturing the essence of liquidity in a stock market. The third subsection reports such horseraces. The last subsection discusses the best liquidity proxies suggested by the liquidity horserace of Fong et al. (2017) for the Malaysian stock market – the "Closing Percent Quoted Spread" (*CPQS*) proposed by Chung and Zhang (2014).

2.2.1 Trade-based Liquidity Proxies

Trade-based liquidity measures are widely used in the liquidity literature mainly because of the simplicity of their computations using readily available data. Common trade-based proxies include trade value, trade volume, number of trades and turnover ratio (trading volume over shares outstanding). Looking back at the literature reviewed in Section 2.1, it is not difficult for one to notice that most of the studies employ at least one, if not all, trade-based proxy as measure of liquidity in their studies. To name a few, Apergis et al. (2015) use a mixture of trade- and order-based liquidity proxies, namely the *ILLIQ*, the relative spread, turnover and trade volume to examine if aggregate liquidity is a good predictor of future economic activities. Jun et al. (2003), on the other hand, use exclusively trade-based liquidity measures of turnover, trade value and volatility-adjusted turnover ratio to study if aggregate liquidity is a priced factor in the emerging markets and find results that are at odds with those obtained from the developed markets.

Specifically in Malaysia, Hameed and Ting (2000) investigate the nexus between the predictability of short-term (weekly) return and trading volume using a contrarian investment portfolio of securities traded on Bursa Malaysia. Abdul Rahim and Mohd Nor (2006) employ the turnover ratio as a liquidity measure in evaluating the forecasting accuracy of two liquidity-based three-factor Fama-French models. Using trade volume as one of the liquidity proxies, Foo and Mat Zain (2010) find that independent and diligent directors contribute to higher stock liquidity over a sample of 481 Malaysian firms.

Ramlee and Ali (2012) study the relationship between Initial Public Offering (IPO) long-term return and liquidity with government ownership as the moderating variable using monthly turnover ratio as their main liquidity proxy. Another IPO-related liquidity study is done by Sapian et al. (2013) using a mixture of trade-based (trading volume, dollar volume and share turnover) and order-based (*ILLIQ*) liquidity proxies.

Despite the convenience of these trade-based liquidity indicators, studies like Aitken and Comerton-Forde (2003) and Lesmond (2005) have found that these measures are not good proxies for liquidity as they do not capture the ease and cost of trading. The Flash Crash of 6th May 2010 is a classic example of how liquidity in the market is low even when there are high level of trading activities. During times of financial turmoil, the notion of flight-to-quality/liquidity, margin calls or funding constraints would often see investors rushing to dispose risky assets, one of it being stocks. At the same time, a drop in investor sentiment during these times also means that investors are reluctant to provide liquidity to distressed sellers (Chiu et al., 2018; Liu, 2015). Barinov (2014) further proves that turnover is not related to liquidity but is rather a measure of firm-specific uncertainty.

2.2.2 Order-based Liquidity Proxies

As technological advancement transforms the way trade is carried out, details of trade such as bid price, ask price, high price and low price become more accessible to researchers and thus facilitate the derivation of order-based liquidity measures to more accurately reflect the cost and immediacy of trading. Specifically in the U.S., such stock transaction data are available since 1983 from the Trades and Quotes (TAQ) database. However, these data are still not available in many developing countries, partly explaining the continual adoption and popularity of trade-based liquidity measures in some studies (for details, see Benson et al., 2015; Goyenko, Holden, & Trzcinka, 2009; Holden et al., 2014). The commonly accepted order-based liquidity proxies include bid-ask spread, both quoted and effective as well as quoted depth. Order-based liquidity measures are further grouped into two categories namely high-frequency which uses intraday data and low-frequency which uses daily or monthly data in their computations. In the high-frequency universe, Chordia, Roll, & Subrahmanyam (2001) study the time series variation in market liquidity and trading activity in the U.S. using aggregate market spreads, depths and trading activity computed from intraday data sourced from the Institute for the Study of Securities Markets (ISSM) and TAQ covering the period from 1988 to 1992.

According to Fong et al. (2017), global intraday data are growing exponentially, keeping pace with the growth rate of computer power hence it will remain challenging to utilize high-frequency liquidity proxies for the foreseeable future. Therefore, an alternative to such high-frequency measures is to use low-frequency proxies that can be computed from daily data. Fong et al. (2017) estimate that computational savings of using low-frequency proxies will continue to grow in the years to come given the exponential growth in intraday data relative to linear growth in daily data. Low-frequency liquidity proxies are further categorized into two groups, namely percent-cost which represents the transaction costs required to execute a small trade, and cost-per-volume that measures the marginal transaction costs per currency unit of volume (Fong et al., 2017). Liquidity indicators that fall under the percent-cost category include "Roll" developed by Roll (1984), "LOT Mixed" and "Zeros" by Lesmond, Ogden, & Trzcinka (1999), "Effective Tick" jointly introduced by Goyenko et al. (2009) and Holden (2009), "High-Low" from Corwin and Schultz (2012) and "Closing Percent Quoted Spread" (*CPQS*) from Chung and Zhang (2014). On the other hand, cost-per-volume liquidity proxies include, among others, Amihud illiquidity ratio (*ILLIQ*) by Amihud (2002), "Pástor and Stambaugh" from Pástor and Stambaugh (2003) and "Amivest" from Goyenko et al. (2009). The use of order-based liquidity proxies has gained popularity among researchers since the early

2000s and given the vast literature in the field of liquidity, it is next to impossible to list all previous works that utilize such proxies.

In recent years, liquidity studies in Malaysia have also started to adopt some of the low-frequency liquidity proxies. Apart from using trade-based liquidity proxy like relative volume, Foo and Mat Zain (2010) also employ relative quoted depth and the proportion of zero returns by Lesmond et al. (1999) to examine the relationship between board independence and firm liquidity. Sapian et al. (2013), on the other hand, use *ILLIQ* as one of their liquidity measures in understanding the aftermarket liquidity effect of IPO underpricing. In their examination of liquidity as a channel through which inclusion or exclusion from the FTSE Bursa Malaysia Kuala Lumpur Composite Index (FBM KLCI) affects a firm's stock price and trade volume, Azevedo et al. (2014) use *ILLIQ* and the return to turnover ratio of Florackis et al. (2011) as their liquidity proxies. Lim et al. (2017) use *ILLIQ* to study the association between corporate ownership of various investor groups and firm-level liquidity. In the first aggregate liquidity study for the Malaysian stock market, Liew et al. (2016) construct and examine the time series properties of two aggregate liquidity proxies – *CPQS* and the impact version of *CPQS*, which are empirically proven to be the best performing among all the low-frequency liquidity proxies by Fong et al. (2017). Heeding the findings of Fong et al. (2017), the *CPQS* is also used as the main liquidity proxy to examine the non-linear relationships between stock liquidity and firm value (Chia et al., 2020a) as well as between the number of shareholders and stock liquidity (Chia et al., 2020b).

2.2.3 Liquidity Horseraces

Copious liquidity measures lead to the question of which proxies are the best players in their leagues and at least five literature have attempted to answer this question via liquidity horseraces. Lesmond (2005) computes five liquidity measures namely turnover, Amivest, *ILLIQ*, LOT (Lesmond et al., 1999) and Roll (Roll, 1984) estimate of effective spread for 31 emerging stock markets, Malaysia included. The author uses the quarterly quoted bid-ask spread plus commission cost as a benchmark for liquidity and he finds that LOT and Roll best capture cross-country differences in liquidity with correlations of over 80% and 49%, respectively. As for within-country variations, the LOT and *ILLIQ* dominate Roll and turnover. More significantly, Lesmond (2005) finds that turnover has no correlation with any of the other three measures, casting significant doubt on its vast application as a prominent liquidity measure in the emerging markets.

Holden (2009) introduces two low-frequency spread measures namely "Holden" and "Holden 2". The first measure captures the price clustering and serial correlation attributes of daily data whereas the second measure reflects an additional attribute which is the no-trade quoted spread using high/ask and low/bid prices. The author further introduces two other multi-factor models, namely "Multi-Factor1" and "Multi-Factor2", which are linear combinations of simpler one-attribute or two-attribute liquidity proxies. A horserace is then performed using all the four new measures and other existing low-frequency proxies (Hasbrouck-Gibbs, LOT Mixed, LOT Y-Split, Pástor and Stambaugh, Roll and Zeros) on two high-frequency benchmarks (percent effective spread and percent quoted spread) for U.S. stocks spanning the period from 1993 to 2005. Evaluating the performance of each indicator based on individual firm correlation, portfolio correlation and tracking error, Holden (2009) finds that his new Multi-Factor2, which combines liquidity proxies with serial correlation and no-trade quoted spread attributes, is the top performer followed by Holden2.

Focusing specifically on the U.S. stock markets, Goyenko et al. (2009) construct 24 low-frequency liquidity proxies consisting of twelve percent-cost measures and twelve cost-per-volume indicators. Benchmarks used by the authors are percent effective spread and percent realized spread to gauge the performance of low-frequency percent-cost proxies, whereas the slope of the price function, "lambda", and percent price impact are used to assess low-frequency cost-per-volume liquidity measures. Time-series correlation, cross-sectional correlation and prediction error are the main performance indicators for these proxies. The extensive results obtained by Goyenko et al. (2009) further add to the evidence that low-frequency liquidity measures are good proxies of transaction costs. In the percent-cost category, the authors find that Effective Tick, Holden and LOT Y-Split dominate the remaining nine proxies, whereas *ILLIQ* proved to be the best and most consistent among the cost-per-volume measures.

In the frontier markets, Marshall, Nguyen and Visaltanachoti (2013) construct five low-frequency percent cost measures (Roll, Hasbrouck-Gibbs, Zeros and "Zeros2" by Lesmond et al., 1999 and "FHT" introduced by Fong et al., 2017) and eight price impact proxies (*ILLIQ,* Amivest, Pástor and Stambaugh and price impact version of the five percent-cost measures). Using correlation analysis and root mean squared errors as performance evaluation gauges, the authors find that the *ILLIQ* and Hasbrouck-Gibbs measures have the largest average correlation across the 19 frontier markets as well as the greatest number of countries in which the correlations are statistically significant with the high-frequency effective spread and quoted spread benchmarks. The Zeros2, however, is the worst performing among the percent-cost measures with no correlation with either of the high-frequency spread benchmarks.

Using a relatively new global intraday equity dataset, Thomson Reuters Tick History (TRTH), Fong et al. (2017) compare the monthly and daily low-frequency liquidity proxies to their corresponding high-frequency liquidity benchmarks for 24,240 firms across 42 exchanges around the world. Similar to Goyenko et al. (2009), the authors evaluate the performance of these liquidity proxies based on cross-sectional correlation and prediction accuracy. The only difference here is that Fong et al. (2017) compare portfolio correlation whereas Goyenko et al. (2009) assess time-series correlation. Benchmarks employed in their study include percent effective spread, percent quoted spread, percent realized spread and percent price impact. Results of the horserace conducted by Fong et al. (2017) show that the Closing Percent Quoted Spread (Chung & Zhang, 2014) is the best percent-cost proxy for global research given its high correlations with all the intraday benchmarks. Meanwhile, High-Low (Corwin and Schultz, 2012) performs best in capturing the level of percent realized spread and percent price impact. In terms of cost-per-volume, the authors identify that the daily version of *ILLIQ* (Amihud, 2002) is the top performer.

With emphasis on discovering the best low-frequency liquidity measures during extremely illiquid periods, Będowska-Sójka and Echaust (2020) perform a horserace using three percent-cost liquidity proxies computed for 141 stocks listed in the Warsaw Stock Exchange over the 11-year period from 2006 to 2016. The three low-frequency percent-cost liquidity proxies, namely High-Low, *CPQS* and the High-Low Range[13] introduced in Będowska-Sójka (2019), are compared against four high-frequency benchmarks – percent effective spread, percent price impact, percent quoted spread and percent realized spread. Unlike the horseraces reviewed thus far which estimate only linear dependencies of low-frequency liquidity proxies with their high-frequency benchmarks, Będowska-Sójka and Echaust (2020) focus on extreme values and also estimate tail dependence coefficients of these two sets of liquidity proxies. The authors conclude that not only is the *CPQS* the best performing liquidity proxy during stable periods for the Warsaw Stock Exchange, it is also the best in measuring liquidity during extreme illiquid situations.

[13] The High-Low Range measure is calculated as the ratio of twice the difference between daily high and low prices to their average.

The extensive survey papers by Amihud et al. (2005) and Díaz and Escribano (2020) stress that no single liquidity measure is able to capture all dimensions of liquidity. The former further stresses that the empirically-derived measure is a noisy estimate of the true parameter in which such noise element in these measurements is further exacerbated with the use of low-frequency data. However, given the data limitations facing researchers especially those studying liquidity in the emerging markets where high-frequency data are not available for long time horizon, the solution is to rely on the extensive results of the horseraces in determining which measures are most appropriate for their empirical studies.

2.2.4 The Best Liquidity Measures for the Malaysian Stock Market

In the process of selecting the best-performing liquidity proxies for the Malaysian stock market, this thesis turns to the liquidity horseraces reviewed in the previous section for guidance. Of all the liquidity horseraces that have been conducted thus far, only Lesmond (2005) and Fong et al. (2017) include Malaysia as one of the countries in their samples. Of these two studies, the latter is chosen to be the reference point of this thesis due to its extensive coverage, both in terms of the number of exchanges that they include (42 exchanges globally) as well as the number of low-frequency liquidity proxies that they have selected to be tested (23 monthly liquidity proxies and six daily liquidity proxies). Another advantage of referring to the horserace by Fong et al. (2017) is its recency, which means the performance of new innovations in low-frequency liquidity proxies such as the *CPQS* by Chung and Zhang (2014) and the High-Low by Corwin and Schultz (2012) are also examined.

In the case of Malaysia, Fong et al. (2017) use a total of 189 million trades and 90 million quotes for 960 stocks listed on the stock exchange over a 12-year period to examine the performance of 29 low-frequency liquidity proxies. As previewed in the earlier section, the *CPQS* by Chung and Zhang (2014) emerges as the best-performing liquidity proxy for the Malaysian stock market at both monthly and daily frequencies. At the monthly frequency, the *CPQS* is cross-sectionally better than FHT by a margin of 57.4%. In the portfolio time-series dimension, *CPQS* is 27.6% better than Effective Tick. Lastly, in the individual stock time-series dimension, *CPQS* outperforms High-Low by a huge margin of 105.1%. Therefore, the *CPQS* is selected as the main liquidity measure for the Malaysian stock market in this thesis.

2.3 Foreign Investors and Stock Market Liquidity

This section summarizes the literature focusing on the effect of foreign investor participation on stock market liquidity, an area which has been severely understudied. The first subsection reports literature using *de facto* or *de jure* measures of financial liberalization to proxy foreign participation in a stock market. Subsection 2.3.2 reviews literature employing foreign ownership data as a measure of foreign participation. The following subsection then provides an overview of literature studying the liquidity impact of foreign investors' participation using foreign trade data. A brief review of the literature on the destabilizing impact of foreign investors on local stock market is also included in the final subsection. This section aims to highlight the lack of studies using actual foreign trade data to examine the relationship between foreign participation and local market liquidity. Using actual foreign trade data is superior to foreign ownership as it allows precise distinction of whether liquidity is driven by informed or noise trading as predicted by the two competing theoretical channels of asymmetric information (Easley & O'Hara, 1987; Glosten & Milgrom, 1985; Kyle, 1985) and noise trading (Admati & Pfleiderer, 1988), respectively.

2.3.1 *De Facto* and *De Jure* Measures of Financial Liberalization

Financial liberalization, defined as the removal of barriers on the free exchange of capital between nations, can be measured by either *de facto* or *de jure* indicators. The former is usually quantified by stocks or flows of international capital as a percentage of GDP whereas the latter is a formal account of the legal status of the financial liberalization process. Studies in this strand of literature are commonly done at the cross-country level as financial liberalization is a macroeconomic policy that affects all firms in a stock exchange.

Using *de jure* financial liberalization measure - the actual dates of major policy changes involving portfolio flows, Levine and Zervos (1998) study the impact of financial openness on stock market size, liquidity, volatility and integration in 16 emerging market economies. With turnover ratio as a proxy for stock market liquidity, the authors show evidence that financial liberalization is associated with greater stock market liquidity. With a larger sample size of 20 emerging markets but using similar stock market liquidity measure as the previous authors, the findings of Bekaert et al. (2002) show that capital market liberalization contributes to greater liquidity in the stock markets of emerging economies. Unlike Levine and Zervos (1998), the financial liberalization variable in the study of Bekaert et al. (2002) is endogenously determined by examining the structural break dates of multiple time series that are potentially affected by the opening of a country's financial markets. Such endogenously determined dates are found to be later than the official dates when liberalization is announced. It is also worth noting that both studies employ trade-based liquidity measures that are proven by Aitken and Comerton-Forde (2003) and Barinov (2014) to be poor liquidity indicators.

More recently, Lee and Chou (2018) employ four *de facto* measures of financial openness, namely foreign assets to GDP, foreign liabilities to GDP, sum of foreign assets and liabilities to GDP and foreign direct investment (FDI) to examine the effect of financial liberalization on stock market liquidity in 11 countries over a 16-year period from 2001 to 2016. In a panel regression with *ILLIQ* and trade volume as measures of market liquidity, the authors find that financial liberalization is associated with lower *ILLIQ* and higher trade volume, indicating a positive effect of financial openness on stock market liquidity. In the additional analysis where the authors split the sample into developed and emerging markets, it is found that such effect is strongest in the latter because emerging markets were mostly closed to foreign investors in the late 1980s.

2.3.2 Foreign Ownership

Apart from using macro financial openness measures, foreign investors' presence in a local market can also be inferred from their ownership in local firms. In general, cross-country studies of the foreign ownership-liquidity relationship are in favor of foreign participation in a local stock market as their presence is found to be positively associated with local market liquidity. Wei (2010) uses foreign institutional stock holding data of 40 countries, of which 20 are developed countries and the remaining 20 are emerging markets, to examine the effect of foreign institutional ownership on stock liquidity, proxied by the *ILLIQ*. The author finds that a one standard deviation increase in foreign institutional ownership lowers the *ILLIQ* by 4% and 7% in developed and emerging markets, respectively. Such positive impact is attributed to increased competition by foreign investors in incorporating information through their trades as well as their noise trading when they trade for portfolio rebalancing and risk-sharing purposes.

In another cross-country study with a sample of 27,828 firms from 39 countries, Ng et al. (2016) test whether foreign direct ownership and foreign portfolio ownership affect stock liquidity differently. They discover that foreign direct ownership has a negative association with stock liquidity whereas portfolio ownership is positively associated with stock liquidity. Similar to Wei (2010), the increase in liquidity associated with higher foreign portfolio ownership is rationalized by increased competition among this group of investors which reduces asymmetric information. Using foreign ownership data from 20 emerging markets, Malaysia included, Lee and Chung (2018) find that higher foreign ownership is associated with lower bid-ask spread but higher price impact measure of *ILLIQ*. The authors explain the negative association between foreign ownership and bid-ask spread using the competition model of Subrahmanyam (1991) and Spiegel and Subrahmanyam (1992) whereas the greater price impact is due to higher adverse selection costs given that foreign institutional investors are perceived as better informed.

In single-country studies, however, evidence has been mixed on whether foreign ownership is beneficial to the liquidity of domestic firms. Prommin et al. (2016) on the Stock Exchange of Thailand from 2006 to 2009 and Vo (2016) on the Ho Chi Minh City Stock Exchange from 2006 to 2012 both unveil negative effect of foreign ownership on the liquidity of the respective stock markets. In terms of the measurements of liquidity, Prommin et al. (2016) compute three liquidity proxies namely *ILLIQ*, turnover and liquidity ratio which is calculated as the inverse of *ILLIQ*. The study by Vo (2016) only uses turnover ratio, which again, is not an effective measure of stock liquidity.

In the Indonesian stock market, however, contradicting evidence on the liquidity effect of foreign ownership has been reported. Over the sample period of January 2002 to August 2007, Rhee and Wang (2009) find evidence that foreign holdings negatively affect future liquidity in the Indonesian stock market with 2%, 3% and 4% increases in bid-ask spread, depth and price sensitivity, respectively when there is a 10% increase in foreign institutional ownership. On the other hand, Agudelo (2010), also using data from the Indonesian stock market, shows that the ownership of local shares by foreign investors improves liquidity as their holdings signal greater transparency and monitoring of local stocks.

Apart from the Indonesian stock market, positive liquidity impact from foreign ownership is also found in the Korean and Chinese stock markets. Employing both the High-Low spread and *ILLIQ*, Lee and Ryu (2019) find that both the transaction cost and price impact decrease with higher foreign ownership, indicating lower adverse selection costs and higher trading activities in the Korean stock market as a result of foreign investors' participation. Their finding is consistent with the work of Ding, Nilsson and Suardi (2017) which reports a positive association between foreign institutional ownership and liquidity of stocks listed on the Chinese A-share market, the latter proxied by quoted spread and order book depth. The presence of this group of investors is claimed to have stimulated greater trading activities in the stock market, hence lowering real friction cost. For Bursa Malaysia, Lim et al. (2017) report the existence of a threshold level in foreign shareholdings, which reflects the interactions of competing liquidity channels of information asymmetry, competition among informed traders and the level of trading activity.

2.3.3 Foreign Portfolio Flows / Trade

Financial markets around the world are becoming more integrated due to capital market liberalization. Parallel to this development, the impacts of international capital flows on domestic financial markets have also started to receive growing attention among researchers. Studies on the effects of foreign equity flows on the domestic stock markets are largely confine to stock market returns (Adaoglu & Turan Katircioglu, 2013; Dahlquist & Robertsson, 2004; Froot, O'Connell, & Seasholes, 2001; Griffin, Nardari, & Stulz, 2004; Richards, 2005), volatility (Alemanni & Ornelas, 2008; Pavabutr & Yan, 2007; Umutlu, Akdeniz, & Altay-Salih, 2013; Umutlu & Shackleton, 2015; Wang, 2007), efficiency (Eom, 2015) and liquidity (Agudelo, 2010; Jorgensen & Priestley, 2012; Peranginangin et al., 2016; Prasanna & Bansal, 2014; Vagias & van Dijk, 2012).

In the foreign portfolio flows-liquidity literature, the cross-country study by Vagias and van Dijk (2012) is the only one reporting a positive liquidity impact. This study considers 46 countries, including both developed and emerging markets, from six regions over the sample period from 1995-2008. Using *ILLIQ* as stock liquidity measure and net foreign portfolio flows, calculated as gross purchases of local equities minus gross sales of local equities, these authors find that foreign investors are liquidity providers in developed America, Europe, Asia/Pacific and emerging Asia.

On the contrary, single-country studies are mainly against the idea of opening up a country's financial markets as results from these studies generally show a reduction in local stock market liquidity in the presence of foreign investors. Two studies have been conducted on the Indonesian stock market by Agudelo (2010) and Peranginangin et al. (2016) using actual foreign trade data. Agudelo (2010) examines the effects of both, foreign trade and foreign ownership on the liquidity of the Indonesian stock market over the period from April 2004 to March 2006. In his study, liquidity is measured using proportional spread. The author finds that foreign trade has a negative but short-lived impact on local market liquidity as they demand liquidity more aggressively vis-à-vis their local counterparts. They are also found to be more information efficient, a finding that is supported by Peranginangin et al. (2016) who study the channel through which foreign trades affect co-movement of liquidity in the Indonesian stock market.

Specifically in Malaysia, only one study is found investigating the impacts of foreign investment flow on the local stock market, mainly due to constraints on the availability of trading data at the disaggregated level. Sapian and Auzairy (2015) study the short-term relationship between foreign equity flows, both retail and institution, and stock market returns using a Vector Autoregressive (VAR) framework. The authors find that there is a bidirectional causality between domestic stock market returns and fund flows of foreign retail investors. In the case of foreign institutional investors, causality runs from domestic stock returns to fund flows.

2.3.4 Destabilization of Stock Market

Several prominent economists such as Rodrik and Subramanian (2009) and Stiglitz (2010) argue that unfettered capital mobility is detrimental to financial stability, especially in the developing economies. In the extant literature, the topic of whether foreign investors destabilize the capital markets has been examined in different contexts through stock volatility (Han, Zheng, Li, & Yin, 2015; Vo, 2015), stock returns (Choe, Kho, & Stulz, 1999) and trading behavior (Bowe & Domuta, 2004; Kim & Wei, 2002; Schuppli & Bohl, 2010). Geographically, the studies mentioned above mainly cover the emerging markets of China (Han et al., 2015; Schuppli & Bohl, 2010), Vietnam (Vo, 2015), Korea (Choe et al., 1999; Kim & Wei, 2002) as well as Indonesia (Bowe & Domuta, 2004).

Most of the studies do not find evidence that foreign investors destabilize the local stock market with the exception of Kim and Wei (2002). These authors show that foreign investors residing outside of Korea are more likely to engage in herding and positive feedback trading behaviors. Such behaviors are often cited in the literature as one of the causes explaining the destabilizing effect of investors (Lakonishok, Shleifer, & Vishny, 1992; Schuppli & Bohl, 2010) based on the theoretical framework proposed by De Long, Shleifer, Summers, & Waldmann (1990b).

To the best of my knowledge, the work by Vagias and van Dijk (2012) is the first to examine the destabilizing effect of foreign investors from the liquidity perspective. These authors define liquidity crisis periods as the bottom 30% of the time-series distribution of market liquidity and estimate panel models for all six regions by interacting the liquidity crisis dummy with lagged flows, lagged liquidity, market returns, U.S. market returns and U.S. market liquidity which are the independent variables in the model. Focusing on the response of liquidity to foreign flows during crisis periods by examining the coefficients of the flow and crisis period interaction term, the authors find that all the coefficients are not significant. Therefore, they conclude that foreign investors do not destabilize local equity market through an adverse impact on liquidity.

2.4 Day Trading and Stock Market Liquidity

This section provides a review of the day trading literature which is rather limited in the extant literature. Performance of day traders is the focus in this strand of literature given that making profits within a short trading window is the main incentive these investors engage in such trading strategy. Another area that researchers pay attention to is the volatility impact of day traders' trading activities due to their extremely active trading strategy. Liquidity, the focus of this thesis, remains a relatively understudied area in the day trading literature with only two studies examining the liquidity impact of day trading.

2.4.1 Performance/Profitability of Day Traders

Existing literature on the profitability of day traders are mixed. Using data from two U.S. brokerage firms over the sample period from November 1993 to March 1994, Harris and Schultz (1998) find that day traders, proxied by Small Order Execution System (SOES) bandits, trade on information and are able to earn small profits. Also in the U.S., Garvey and Murphy (2005) examine the performance of a small sample of 15 proprietary day traders for three months in 2000. The authors find that proprietary day traders are better-informed and earn profit by acting quickly when a short-run trend is spotted, especially when volume and price volatility are higher, a finding that is supported by the study done by Lundström (2017). Apart from volatility, another factor that is found to affect trading performance is emotional reactivity. Lo et al. (2005), through an experiment involving 80 volunteers who participated in a 5-week online training program offered by a renowned professional futures trader, discover that day traders whose emotional reactions to monetary gains and losses are more intense exhibit significantly worse trading performance.

On the losing end, Cheng et al. (2016) assess the profitability of day traders in the Taiwan futures market over the sample period from 1st January 2004 to 30th December 2004. The authors find that only high-frequency retail day traders, defined as those who trade at least 90 days over the sample year, are profitable while other day traders experience losses. Also in the Taiwan futures market, the study by Kuo and Lin (2013) which uses data of 3,470 individual day traders over October 2007 to September 2008 shows that day traders in their sample incur significant losses on average. Defining day trading as the purchase and sale of the same stock by the same investor on the same day, Barber et al. (2014) show that less than 1% of the day trader population in the Taiwan Stock Exchange is able to predictably and reliably earn positive abnormal returns net of fees. Jordan and Diltz (2003) use data from seven branch offices of a national securities firm specializing in day trading and find evidence that twice as many day traders lose money as make money, with their losses mainly attributable to high transaction costs.

2.4.2 Day Traders and Volatility

Empirical evidence generally shows that day traders do not pose significant threat to the stock market in terms of inducing greater market volatility. Using data from the U.S. stock market over the period from 1st June 1995 to 26th July 1995, Battalio et al. (1997) find evidence of two-way causality between stock price volatility and SOES trades, but this effect is only harmful in the short-tun (1 minute) as SOES bandits are found to lower volatility in the long-run (2-5 minutes). Similar findings are also reported by Chung et al.

(2009) who examine the causal relationship between day trading and volatility in the Korean Stock Exchange.

In another study by Chou et al. (2015) which uses day trading data from the Taiwan Index Futures Market, day traders are found to cause temporary price volatility. Nevertheless, the authors do not find evidence that their trades destabilize the Taiwan Index Futures Market, a conclusion that is consistent with the work of Koski et al. (2004) which examines whether day traders destabilize the U.S. stock market. The only study which contradicts the general finding that day traders are not detrimental to the volatility of a stock market is the work by Kyröläinen (2008). Focusing on the ten most heavily traded stocks in Helsinki Stock Exchange, the author finds a strong time-series relationship between the number of day trades and intraday volatility.

2.4.3 Day Traders and Liquidity

Scholarly works on the relationship between day trading and liquidity are scarce with only two studies found to address this research area. Using data from 540 stocks on the Korean Stock Exchange, the study by Chung et al. (2009) is the first to examine the impact of day trading on liquidity, alongside with volatility, in the day trading literature. Employing bivariate VAR to model minute-by-minute trade data, the authors detect a negative bidirectional causal relationship between past day trading activity and bid-ask spread, indicating an enhancement in market liquidity from day traders' participation. Using percentage effective spread and percentage realized spread as their liquidity proxies, Chou et al. (2015) find that an increase in day trading volume is associated with reduction in bid-ask spread. The authors posit that greater trading volume provides opportunities for traders to offset undesirable positions, therefore leading to reduction in price risk and hence lowering the bid-ask spread.

2.4.4 Characteristics of Day Traders

Analyzing the trading characteristics of day traders in the Helsinki Stock Exchange, Linnainmaa (2005) finds that Finnish day traders tend to concentrate their trading near the opening and closing of the market. The author associates the inability of Finnish day traders to earn profit to the disposition effect where they are reluctant to realize losses. Finnish day traders are also found to be attracted to stocks that have excess returns during the previous trading sessions, stocks that they have traded before and stocks that are more liquid. In the only study that looks at foreign day traders, Park and Park (2015) find that foreign day traders in the Korean Stock Exchange are likely to be better informed than their domestic counterparts, even on extremely short-term investment horizon. This group of day traders also considers currency movements in their decisions on overnight positions to benefit from the appreciation of the Korean Won (KRW).

2.5 Liquidity Volatility

This section provides a review of scholarly works on liquidity volatility measured as variation or changes in liquidity covering areas such as stock returns, corporate governance and media content.

2.5.1 Liquidity Volatility and Stock Returns

The work by Chordia et al. (2001) is the first to examine the relationship between volatility of liquidity and expected stock returns. However, the authors use trading activity, which has been criticized by Aitken and Comerton-Forde (2003) and Barinov (2014) as not representative of liquidity, as their liquidity proxy. Against the intuition that the second moment of liquidity should be positively related to expected stock returns, the authors document a puzzling negative and strong relationship between stock returns and the variability of liquidity. Pereira and Zhang (2010) explain the puzzling negative relationship by contending that greater liquidity volatility allows investors to time their trades better, leading to price premiums and the subsequent underperformance of such stocks.

Also motivated by this puzzling relationship, Barinov (2015) analyzes the relationship between liquidity volatility and expected stock returns using variability in trading activity as well as variability of six liquidity measures (Effective Tick, Gibbs spread estimator, *ILLIQ*, Roll's (1984) measure, Zeros and effective bid-ask spread). The author argues that higher turnover variability is positively related to idiosyncratic risk, and higher idiosyncratic risk translates into lower aggregate volatility risk. The positive relationship between turnover variability and expected stock returns can then be explained by investors requiring less risk premium for stocks with lower aggregate volatility risk. On liquidity variability, the author finds muted relationship between liquidity variability and expected stock returns. Another study that provides support to this negative relationship is the work by Blau and Whitby (2015) which uses standard deviation of bid-ask spread as their key variable.

The only study which contradicts the findings of the above papers is the work by Akbas et al. (2011). Using *ILLIQ* and the coefficient of variation of the illiquidity ratio as a measure for volatility of liquidity, Akbas et al. (2011) document a positive relationship between expected return and the volatility of liquidity in the U.S. markets. The authors posit that this relationship is driven by higher risk premium required by risk averse investors to hold stocks which have greater variation in liquidity.

2.5.2 Liquidity Volatility and Corporate Governance

Measuring the volatility of a firm's liquidity as the monthly standard deviation of the daily Amihud's (2002) illiquidity ratio, Lang and Maffett (2011) examine the relationship between liquidity volatility and corporate governance using a sample of 507,822 firms from 37 countries over the sample period from 1997 to 2008. The authors document a strong negative relationship between transparency and liquidity volatility where firms that are transparent are less sensitive to liquidity shocks in general.

2.5.3 Liquidity Volatility and Media Content

In examining how media content in news stories affect liquidity volatility, Cahan et al. (2017) use a firm-specific measure of liquidity volatility derived from a principal component analysis (PCA) of three measures, namely the standard deviation of Amihud's (2002) illiquidity ratio, the skewness of Amihud's (2002) illiquidity ratio as well as the idiosyncratic liquidity volatility measure of Akbas et al. (2011). Using 150,655 firm-month observations and news items over 2003-2011, the authors find that news items provide information to investors and lead to lower liquidity volatility for a firm.

2.6 Liquidity Skewness

Liquidity skewness, despite being introduced some ten years ago in the seminal paper of Roll and Subrahmanyam (2010), has drawn surprisingly little attention until the recent works by Hsieh et al. (2018) and Wei et al. (2018). Using data from the U.S. and the U.K. respectively, Roll and Subrahmanyam (2010) and Hsieh et al. (2018) both find evidence that while liquidity has improved, its distribution has also become increasingly right-skewed. These authors attribute the increase in right-skewness to fiercer competition among market makers, drawing their inability to cross-subsidize freely across periods of high and low information asymmetry.[14] Wei et al. (2018), who examine liquidity skewness in the European sovereign bond market over the sample period June 2005 to December 2011, interpret increasingly right-skewed liquidity distribution as evidence of illiquidity during volatile periods. The novelty of this thesis lies in the introduction of

[14] According to the theoretical model of Glosten and Milgrom (1985), such competition, which lowers market makers' ability to cross-subsidize, leads to a clustering of low bid-ask spreads during periods of low information asymmetry and more observations of large bid-ask spreads during periods of high information asymmetry.

conditional skewness to the liquidity skewness literature, vis-à-vis the unconditional skewness measure adopted by the above-cited three papers.

2.7 Liquidity Spillovers

Studies on liquidity spillovers across different asset markets remain relatively scarce but are slowly gaining traction with the introduction of more computational-friendly liquidity proxies for different asset markets. A search in the existing literature reveals that most studies on cross-market liquidity dynamics are done mainly on the developed markets of U.S., U.K. and Eurozone, underscoring the gap in cross-market liquidity dynamics in emerging markets. In terms of the types of asset market, most studies focus on liquidity spillovers between two different markets and only two study are found looking at liquidity spillovers among four asset markets.

2.7.1 Stock and Bond Markets

Only two studies are found to examine the cross-market liquidity linkages between stock and bond markets at the aggregate level. The first is the pioneering work by Chordia et al. (2005) which combines stock and bond market liquidity under the rationale that there are strong volatility linkages between the two markets and that liquidity in these markets may interact via trading activity, i.e. changes in asset allocation between both markets. Using data from the U.S. over the sample period from 17th June 1991 to 31st December 1998, the authors find that liquidity in both the stock and U.S. Treasury bond markets are driven by common factors namely returns, return volatility and trading activity proxied by order imbalances. Besides establishing that liquidity shocks in both markets are positively and significantly correlated, the authors also find a link between macro and financial market liquidity. Using fund flows and net borrowed reserves, a monetary policy variable, the authors reveal that these macro variables are able to forecast both stock and bond market liquidity.

Arguing that Chordia et al. (2005) mainly provide evidence of co-movement of liquidity in the stock and Treasury bond markets rather than evidence of causation, Goyenko and Ukhov (2009) adopt a longer sample period from July 1962 to December 2003 and discover a two-way Granger causality between illiquidity of the U.S. equity and Treasury bond markets. They also find that Treasury bond illiquidity acts as a channel through which monetary policy shocks in the U.S. are transmitted into the equity market. In terms of measurements of liquidity, these authors measure Treasury market liquidity and stock market liquidity using the relative quoted spreads and *ILLIQ*, respectively. In a Vector Autoregression (VAR) model, the authors analyze the liquidity dynamics between the two markets, controlling for returns and return volatility of both markets.

2.7.2 Stock and Interbank Markets

Using the spread between the London Interbank Offered Rate (LIBOR) and Overnight Index Swap (OIS) as a measure of interbank liquidity and Amihud's (2002) *ILLIQ* to measure stock liquidity, Nyborg and Östberg (2014) find that tightness in the interbank market is connected to liquidity in the stock market over the sample period from 2001 to 2008, as banks engage in liquidity pull-back (selling of financial assets by banks or levered investors) when liquidity in the interbank market is low. Additionally, the authors find that such selling pressure in the stock market as a result of tight interbank market is more prevalent among stocks that are more liquid. Their findings are robust to the use of TED spread, the difference between the three-month LIBOR and Treasury bill rate of same maturity, as a proxy for interbank liquidity.

2.7.3 Stock and Foreign Exchange Markets

This strand of literature is mainly made possible by the introduction of low-frequency foreign exchange liquidity measures by Karnaukh et al. (2015) which built on the recent work of Mancini et al. (2013). Mancini et al. (2013) are the first to systematically measure the liquidity of foreign exchange markets. Karnaukh et al. (2015) significantly expand the avenue for research with the introduction of low-frequency foreign exchange liquidity measures that require only readily available daily data in the computation.

The work by Banti (2016) is the first to investigate the dynamic relationship between stock and foreign exchange market liquidity. In particular, the author pays greater attention to such relationship in the U.S. during periods of market turbulence, i.e. dot-com bubble (2000-2001), the Global Financial Crisis (2007-2009) as well as the European sovereign debt crisis (2010-2014). Over the sample period from 1999 to 2014 and using Vector Autoregression (VAR) analysis, Banti (2016) finds that the liquidity of small-capitalization stocks is more strongly related to foreign exchange liquidity relative to the liquidity of stocks with larger market capitalization. More specifically, the relationship between liquidity of small stocks and currencies hinges on the latter's role in the carry trade, a trading strategy that involves borrowing low-yield currencies (also known as funding currencies) to invest in high-yield currencies (investment currencies). Banti's (2016) finding that investment currencies have a stronger relationship with the liquidity of small stocks is consistent with the finding of Brunnermeier, Nagel and Pedersen (2008) which shows that investment currencies are sensitive to the risk of funding-constrained traders suddenly unwinding their carry trade positions, a trait that small-capitalization stocks share.

Though not looking at the liquidity spillovers between stock and foreign exchange markets directly, the study by Lee and Ryu (2019), which examines how liquidity in the foreign exchange market affects the relationship between foreign ownership and stock liquidity in the Korean stock market, provides evidence of an indirect relationship between foreign exchange liquidity and stock market liquidity through the trading of foreign investors. These authors find that when liquidity in the foreign exchange market falls, shareholding of foreign investors is also lower due to higher transaction costs in the foreign exchange market. Therefore, given the positive association detected between foreign ownership and stock liquidity, such a fall in ownership level by foreign investors, originated from the drop in foreign exchange market liquidity, has a negative impact on the liquidity of the traded stock.

2.7.4 Asset Market Liquidity and Bank Liquidity

With banks functioning as the creators of macro liquidity, defined as the overall supply of money in an economy, Chatterjee (2015) seeks to answer the question of whether higher asset market liquidity leads to greater bank liquidity creation in the U.S. using quarterly data over the sample period from 1984 to 2010. The author uses stock market liquidity as well as bond market liquidity as proxies for asset market liquidity. Three liquidity indicators namely the *ILLIQ*, Roll and the relative bid-ask spread are computed for the stock market whereas liquidity in the Treasury bond market is measured using daily quoted bid-ask spreads of Treasury bills and Treasury bonds of different maturities. Bank liquidity creation is measured by both on- and off-balance sheet bank output. Using two-stage least squares and VAR, the author finds that asset market liquidity explains liquidity creation in large banks (total assets exceeding USD3.0 billion) with the predictive power of stock market liquidity outperforming that of Treasury bond market liquidity. Liquidity creation in small banks (total assets less than USD3.0 billion), on the other hand, cannot be predicted by asset market liquidity.

2.7.5 Credit Default Swap and Other Asset Markets

The liquidity spillovers between stock and Credit Default Swap (CDS) are first examined by Tang and Yan (2006) in a framework which includes bond, stock, option and CDS markets. Using five liquidity measures for CDS market namely total number of quotes and trades per month, monthly average of daily percentage bid-ask spread, order imbalance, total number of contracts outstanding and probability of informed trading (PIN), the authors find that stock liquidity (measured by *ILLIQ*), option liquidity (measured by bid-ask spread, trading volume and total number of contracts outstanding) as well as corporate bond liquidity (measured by age, maturity and issue size) predict CDS liquidity. More specifically, corporate bonds with larger issue size and longer maturity have lower CDS spreads while stock illiquidity has a positive and significant effect on CDS spreads. As for options, higher trading volume or narrower bid-ask spread is associated with lower CDS spreads whereas open interest, proxied by total number of contracts outstanding has a significant positive effect on CDS spreads due to the divergence in opinion.

In a separate study involving the CDS, corporate bond and equity markets in the U.S. over the sample period from July 2002 to September 2008, Jacoby et al. (2009) find that liquidity spillovers from the CDS to both bond and equity markets, contradicting the findings of Tang and Yan (2006). Unlike the previous study, Jacoby et al. (2009) measure liquidity in each market using the first principal component of a set of liquidity measures in the respective asset markets. A later study by Haas and Reynolds (2017) which examines the interconnectedness between liquidity in the CDS market and equity market in the U.S. finds similar results with Jacoby et al. (2009) when stock market liquidity is measured by the *ILLIQ*. Using data covering the sample period from January 2008 to December 2015, the authors find that a one standard deviation increase in CDS illiquidity is associated with a 1.3% increase in the *ILLIQ*. Granger causality test which reveals causation from CDS liquidity to *ILLIQ* further reinforces the lead-lag relationship between these two liquidity indicators. However, when liquidity is measured using either the relative bid-ask spread, the direction of causation is reversed, and the percent-cost aspect of liquidity is found to lead liquidity in the CDS market. Lastly, when stock market liquidity is proxied by Roll, no evidence of interdependencies between the liquidity of the stock and CDS markets is discovered.

2.7.6 Stock, Oil, Treasuries and Eurodollar

Zafeiridou (2015) examines liquidity spillovers across four asset classes traded in the U.S. futures markets, namely oil, Treasuries, Eurodollar and the Standard & Poor's 500 (S&P 500) over the sample period from July 1986 to April 2015. The author uses a reduced-form VAR model estimated over a 1-year rolling-window of daily data. In this framework, the intensity of spillovers is measured as the improvement of fit from allowing lagged liquidity shocks in one asset to affect the liquidity of another asset. It is discovered that in general, liquidity spillovers are higher during periods of financial and macroeconomic turbulence as liquidity suppliers experience higher funding constraints. The crude oil and Eurodollar futures are the recipients of liquidity spillovers during the great recession and the European sovereign debt crisis whereas liquidity spillovers to the S&P 500 contract have dropped significantly after the Global Financial Crisis. The author measures liquidity from the price impact perspective, using the *ILLIQ* for all the four markets.

2.8 Time-Varying Dynamic Spillovers Framework and Its Applications

Section 2.7 shows that liquidity spillovers in the extant literature are mainly examined in a VAR and Granger causality framework. This is in stark contradiction to the return and return volatility literature which have moved beyond VAR and Granger causality to adopt the Diebold and Yilmaz (2009, 2012, 2014) connectedness framework (hereafter referred to as DY connectedness framework) and the time-varying parameter vector autoregressive (TVP-VAR) connectedness framework of Antonakakis et al. (2020) in examining, amongst others, return, return volatility and monetary policy uncertainty spillovers. These two frameworks, which link the variance decomposition of a VAR model to aspects of network topology theory, are superior in quantifying spillovers as they represent weighted directed networks among the nodes in a system. Not only is it able to quantify pairwise spillovers, the DY connectedness framework is also able to measure total connectedness in a system of interest unlike Granger causality which is exclusively pairwise and testing only zero versus nonzero coefficients. This section highlights the superiorities of using the DY connectedness framework and the TVP-VAR connectedness framework as well as empirical studies that adopt these methodologies.

2.8.1 Diebold and Yilmaz Connectedness Framework

In the first paper in which the connectedness index is coined, Diebold and Yilmaz (2009) introduce a spillover index derived from the forecast error variance composition (FEVD) of a Cholesky-type VAR model. The authors then apply the framework to measure return spillovers and return volatility spillovers of 19 markets over January 1992 to November 2007. In a static framework, returns of all 19 sample markets are found to be connected at 35.5% whereas volatility spillovers are marginally stronger at 39.5%. In a rolling-window framework, return spillovers are found to exhibit increasing trend while return volatility spillovers display no trend but clear bursts.

Their next paper, Diebold and Yilmaz (2012), presents two improvements over the earlier framework. First is the use of generalized VAR framework to replace the Cholesky-type VAR, hence solving the problem of having to order the variables in the process of obtaining variance decompositions from the VAR model. The second improvement is the introduction of directional spillovers – to a market, from a market and net spillovers, as opposed to their earlier framework which reports only the total spillovers in a system. The improved methodology in this paper is applied to examine cross-market volatility spillovers among the stock, bond, foreign exchange and commodities markets in the U.S. from January 1999 to January 2010. In the static framework, cross-market volatility spillovers are rather low at 12.6%. The dynamic framework, also done in a rolling-window approach, reveals a surge in volatility spillovers only during the GFC in 2007 which intensifies as the financial crisis worsens. Following the collapse of Lehman Brothers in September 2009, volatility spillovers mainly originate from the stock market to other markets.

Later in Diebold and Yilmaz (2014), the authors link their framework to the network theory, showing that the connectedness measures proposed in their earlier works are intimately related to key measures of connectedness used in the network literature. In this paper, the authors examine return volatility connectedness of 13 major U.S. financial institutions over the sample period from May 1999 to April 2010, with special focus given to the periods before and during the Global Financial Crisis. In the full-sample static connectedness framework, volatility connectedness is measured at a whopping 78.3%, which the authors attribute to the firms operating in the same industry and hence are more susceptible to similar industry-wide and macroeconomic shocks.

The DY connectedness framework has been widely adopted in the current literature. In the cross-market spectrum, studies have used this framework to examine return or volatility spillovers between currency and commodity markets (Antonakakis & Kizys, 2015), commodity and stock markets (Awartani & Maghyereh, 2013; Maghyereh, Awartani, & Bouri, 2016; Zhang, 2017), economic policy uncertainty and commodity (Antonakakis, Chatziantoniou, & Filis, 2014), cryptocurrency and other financial assets (Corbet, Meegan, Larkin, Lucey, & Yarovaya, 2018), sovereign and bank CDS (Alter & Beyer, 2014), stock, bond, CDS and foreign exchange (Tiwari et al., 2018), stock, bond, commodity and VIX (Kang et al., 2019) and real estate, stock, bond, money and foreign exchange (Liow, 2015).

Within the same market, scholars have also employed the DY connectedness framework to explore spillovers of bond yield spread (Antonakakis & Vergos, 2013;

Claeys & Vašíček, 2014; Fernández-Rodríguez, Gómez-Puig, & Sosvilla-Rivero, 2015), spillovers of macroeconomic uncertainties (Tsai, 2017; Yin & Han, 2014), connectedness among financial institutions (Demirer et al., 2017; Diebold & Yilmaz, 2016), connectedness among foreign exchange markets (Antonakakis, 2012), connectedness among global stock markets (Bekaert, Ehrmann, Fratzscher, & Mehl, 2014; Gamba-Santamaria, Gomez-Gonzalez, Hurtado-Guarin, & Melo-Velandia, 2016; Yilmaz, 2010; Zhou, Zhang, & Zhang, 2012), connectedness among cryptocurrency markets (Ji, Bouri, Lau, & Roubaud, 2019; Yi, Xu, & Wang, 2018) and connectedness among global commodity markets (Diebold, Liu, & Yilmaz, 2017; Zhang & Broadstock, 2018).

2.8.2 Time-Varying Parameter VAR Dynamic Connectedness

In terms of examining dynamic connectedness, note that the DY connectedness framework advocates the use of rolling-window approach. While it is easy to implement, the rolling-window approach is subject to several criticisms: (i) the size of the rolling-window will have to be arbitrary determined, (ii) there is loss of observations in the calculation of the dynamic connectedness measure, (iii) the inability to determine which exact data point causes potential changes in the connectedness measure, and lastly (iv) the sensitivity of the connectedness measure to outliers.

In view of these shortcomings, Antonakakis et al. (2020) then extend the DY connectedness framework by applying a time-varying parameter vector autoregressive model (TVP-VAR) with a time-varying covariance structure. In this paper, the authors compare the performance of the TVP-VAR connectedness approach to the rolling-window approach of DY connectedness framework by examining the dynamic connectedness among four currencies – the Euro dollar (EUR), the Great Britain pound (GBP), the Swiss Franc (CHF) and the Japanese yen (JPY). They find that while the connectedness measure obtained from their approach adjusts swiftly to underlying events in these foreign exchange markets, the rolling-window-based connectedness measure generally overreact, when the window-size is too small, or smooth out, when the window size is too large, the effect of underlying events.

This extension, first conceptualized in 2017, has garnered considerable attention from scholars and has been adopted since then to examine dynamic connectedness of various spillovers. Specifically on economic uncertainty, Antonakakis, Gabauer, Gupta and Plakandaras (2018) investigate the macroeconomic policy spillovers among the U.S., the European Union, the U.K., Japan and Canada, Gabauer and Gupta (2018) examine the internal and external categorical economic policy uncertainty spillovers between the U.S. and Japan, Antonakakis, Gabauer and Gupta (2018) explore the spillovers of economic policy uncertainty within Greece and across Europe, Antonakakis, Gabauer and Gupta (2019) look at monetary policy spillovers among the U.S., the Euro Area, Japan and the U.K., and Jiang, Zhu, Tian and Nie (2019) study the within and cross-country economic policy spillovers between the U.S. and China.

Other than that, the TVP-VAR connectedness approach has also been applied to examine implied volatility shocks among oil, energy commodities, stocks, bonds, exchange rates and precious metals (Antonakakis, Cunado, Filis, Gabauer, & Perez de Gracia, 2019), the dynamic connectedness of housing prices and sales volume in four of U.S. regional housing markets (Antonakakis, Chatziantoniou, & Gabauer, 2019), the influence of U.S. monetary policy in the spillovers of speculative activities in gold, equity, Treasury bonds and crude oil markets (Demirer, Gabauer, & Gupta, 2020), dynamic spillovers between oil returns and policy uncertainty (Wang & Lee, 2020), the transmission of sovereign bond yields in Asia-Pacific (Subramaniam, Gabauer, & Gupta, 2018), the dynamic spillovers of macroeconomic, real estate and financial uncertainties (Gabauer & Gupta, 2020), the dynamic return connectedness and information spillovers across different industries in the Indian stock market (Chatziantoniou, Gabauer, & Marfatia, 2020) and the dynamic volatility connectedness between Bitcoin return and equity market returns in Brazil, Russia, India, China and South Africa (Dahir, Mahat, Amin Noordin, & Hisyam Ab Razak, 2019).

2.9 Summary of the Chapter

The main takeaways from this literature review are as follows. First, the literature has identified that aggregate stock market liquidity is important for macroeconomic policy making as well as asset pricing and allocation. Nonetheless, the level of attention given to aggregate stock market liquidity remains low when compared to firm-level liquidity studies, especially in the context of emerging stock markets. Second, from the extensive menu of low-frequency liquidity proxies available in the literature, the comprehensive liquidity horserace by Fong et al. (2017) has helped to identify the best performing liquidity proxy for the Malaysian stock market – the Closing Percent Quoted Spread (*CPQS*) by Chung and Zhang (2014). Third, while the liquidity impact of foreign investors' presence in a local market is not a new topic, this relationship has been studied mostly using annual foreign ownership as a proxy for foreign participation, which does not capture the dynamic liquidity effect of their trading activity. Instead, this thesis advocates the use of actual foreign trade data to examine the relationship between foreign participation and local market liquidity, which permits a clean test of the two competing theoretical channels of asymmetric information and noise trading. The literature gaps identified here motivate the first research objective to examine the liquidity impact of foreign investors' trade in the local stock market. Fourth, day trading is a very thin literature with most scholars focusing on the profitability/performance of day traders and less so on the liquidity impact of their participation in the stock market. Extending this strand of literature to consider the second and third moments of liquidity is also academically justified considering the handful of liquidity volatility and liquidity skewness studies found thus far. The thin literature on day trading, liquidity volatility and liquidity skewness has led to the formation of the second research question to examine the association between proprietary day trading and higher-order moments of aggregate liquidity in Malaysia. Fifth, studies on liquidity spillovers largely involve only two different asset markets and are still lagging behind the return and volatility spillovers literature methodologically, as the former largely employ VAR and Granger causality framework. Therefore, the third objective to quantify the magnitude of liquidity spillovers in the four main assets in Malaysia aims to close this literature gap by employing the time-varying parameter vector autoregression (TVP-VAR) model. Lastly, the lack of liquidity studies in the Malaysian context has deprived policymakers and stock exchange regulators of valuable inputs and assessments of the efficacies of the policies introduced to further improve liquidity in the local bourse.

CHAPTER 3

THEORIES AND METHODOLOGIES

This chapter discusses the theories that underlie the three research questions outlined in Chapter 1 of this thesis. To recall, the first research question examines the causal relationship between foreign investors' trades and the aggregate liquidity of the Malaysian stock market. The second research question draws attention to proprietary day traders (PDTs) and how their trades affect aggregate liquidity and its higher-order moments i.e. liquidity volatility and liquidity skewness in the Malaysian stock market. The final research question then explores the connectedness of liquidity across the four main asset markets in Malaysia, namely stock market, bond market, money market and foreign exchange market.

This chapter is structured as follows. Section 3.1 outlines the theories and empirical studies leading to the formulation of the three research questions in this thesis. Section 3.2 specifies the model specifications to answer each research question. The next section then provides descriptions for all dependent variables used in all models as well as their sources. Section 3.4 discusses all key control variables employed in this thesis. Tests and models used to perform robustness checks are outlined in Section 3.5 while models to perform additional analysis for the first research question are described in Section 3.6. The last section concludes this chapter.

3.1 Theories

This section discusses the theories that explain the liquidity dynamics at the level, higher-order moments of volatility and skewness, as well as cross-market spillovers.

3.1.1 Investor Groups and Aggregate Stock Market Liquidity

Two main theoretical channels – information asymmetry and noise trading – are present in the liquidity literature to explain the liquidity enhancing or eroding effect of investors' trading. The asymmetric information model, which predicts a negative relationship between liquidity and trading activities, is the brainchild of Easley and O'Hara (1987), Glosten and Milgrom (1985) and Kyle (1985). These authors argue that the privileged access to private firm-specific information by informed traders drives a gap in market knowledge between them and their uninformed counterparts. When these privately informed investors capitalize on such superior information in their trading activities, bid-ask spreads widen and hence liquidity declines due to increased adverse selection costs.

On the other hand, the noise trading model contends that there is a positive relationship between liquidity and trading activities. In the noise trading model of Admati and Pfleiderer (1988), liquidity is an increasing function of noise trading. The presence of more informed traders in a market causes market depth to increase, which in turn incentivizes more noise traders to participate. The entrance of more noise traders, who are uninformed and often do not have exogenous reasons to trade, then allows specialists to recoup their losses from their trades with informed traders. The reduction in adverse selection costs permits specialists to offer lower spreads, therefore boosting liquidity in the market. Notwithstanding that the information asymmetry and noise trading models are developed to explain the liquidity impact of investors' trades in markets with market makers, which is common in the financial markets of developed countries, these theories are also used to explain liquidity in emerging markets which are commonly order-driven given the validity of their predictions.

The contradicting theoretical predictions from information asymmetry and noise trading models have been used by existing empirical studies to identify informed and noise traders in the market, especially on whether foreign or local investors are better informed (see Brockman et al., 2009; Lee and Chung, 2018; Ng et al., 2016). In these studies, an investor group is identified as informed (noise) traders if their trading activities reduce (improve) liquidity. Empirically, while the shareholding of an investor group is commonly used as a determinant of liquidity, it does not provide a clean test on the theoretical predictions of information asymmetry and noise trading because percentage ownership data do not capture trading activities. Investor groups that prefer longer investment horizon might resort to buy-and-hold strategy and rarely engage in active trading, hence the detected causal relationship from ownership to liquidity might operate through other non-trading channels such as information competition (see references cited in Lim et al., 2017) and corporate governance (see Chung et al., 2010; Prommin et al., 2016).

From the literature survey, only a handful of studies use the actual trades of investor groups. For instance, Wang and Zhang (2015) utilize a comprehensive retail trading dataset for U.S. stocks, and report a positive relationship between liquidity and trading activities of individual investors, which is in line with the prediction of noise trading model. Agudelo (2010) finds that foreign trades have a negative impact on the aggregate liquidity of the Jakarta Stock Exchange, suggesting the informed trading of foreign investors exacerbates information asymmetry and increases adverse selection costs. On the other hand, Vagias and van Dijk (2012), using a panel of 46 countries, find that foreign trades have a positive impact on the liquidity of stock markets in host countries, which lead them to conclude that foreign investors are noise traders who supply liquidity.

The "Trading Participation by Category of Investors" dataset assembled by Bursa Malaysia provides the actual trades of local and foreign investors in the Malaysian stock market. This market-level dataset permits this thesis to provide a clean test on the competing theoretical models of information asymmetry and noise trading in explaining the liquidity enhancing or eroding role of two major market participants, namely foreign investors and proprietary day traders (PDTs).

3.1.2 Liquidity Volatility and Liquidity Skewness

Literature in the domain of liquidity volatility and liquidity skewness are generally scarce with little or no explicit theory to explain the distribution of liquidity (Roll & Subrahmanyam, 2010). In both the liquidity skewness papers of Roll and Subrahmanyam (2010) and Hsieh et al. (2018), the authors cite competition among market makers, which reduces their ability to cross-subsidize across periods of high and low asymmetric information, as the cause of changes in liquidity skewness, making reference to the asymmetric information model of Glosten and Milgrom (1985). This theory, however, is not applicable to the Malaysian stock market as it operates on an order-driven trading system. Therefore, this thesis refers to models developed to explain negative skewness in stock market returns to discuss the impact of proprietary day traders on liquidity skewness in the Malaysian stock market. Two hypotheses are available in the return skewness literature which attribute return volatility as the channel through which changes in share prices lead to negative skewness in stock market returns.

The first is the leverage effect hypothesis introduced by Black (1976) and Christie (1982). This hypothesis states that changes in investors' financial and operating leverages contribute to greater variation in stock prices. Given the negative relationship between stock prices and volatility, such changes in financial and operating leverages would lead to lower stock prices and subsequently negative skewness in stock market returns. In the liquidity literature, Brunnermeier and Pedersen (2009) find that a trader's funding, which includes capital and margin requirements, affects market liquidity in a profound way.

When traders refuse to take on positions during periods of tight funding, market liquidity reduces and this in turn heightens liquidity volatility in the market.

The second is the volatility-feedback hypothesis, also known as the time-varying risk premium theory, by Pindyck (1984) and French, Schwert and Stambaugh (1987). This theory relies on two assumptions. The first assumption is that the arrival of both good and bad news raises current and future volatility while the second assumption is the existence of a positive intertemporal relation between expected return and conditional variance. Therefore, an increase in volatility would lead to higher expected return and lower share prices. The arrival of good (bad) news then has a dampening (heightening) effect on volatility. From the liquidity perspective, the link between news and liquidity volatility has been established by Cahan et al. (2017).

Given that PDTs trade using the firms' capital, a tightening of funding liquidity faced by their employers, mainly brokerage and investment firms, might negatively affect PDTs' ability to take on open positions. Drawing inference from the leverage effect hypothesis, such inability to participate in the market would then lead to lower market liquidity, thereby affecting liquidity volatility and liquidity skewness. On the other hand, PDTs could also affect the second and third moments of liquidity through the information channel as proposed by the volatility-feedback hypothesis. Several scholarly works have found that day traders are privy to private information (Barber et al., 2014) or are quick to respond to public information (Harris & Schultz, 1998). This thesis further contends that PDTs could also have an information advantage given their access to in-house analyst reports.

3.1.3 Liquidity Spillover

The third research question, which aims to examine liquidity spillovers among stock, bond, foreign exchange and money markets in Malaysia, is primarily motivated by the introduction of a spillover index by Diebold and Yilmaz (2009). The computation of the spillover index uses variance decomposition derived from a Vector Autoregression (VAR) framework, following the intuition of assessing shares of forecast error variation of an entity due to shocks arising elsewhere. In Diebold and Yilmaz (2012, 2014), the authors introduce pairwise spillover index on top of the system-wide spillover index introduced in their 2009 paper and link their work to the modern network theory. In a network with N different entities, there is an N x N adjacency matrix A of zeros and ones, where zero indicates no link between nodes i and j and one indicates otherwise. The spillover index framework proposed by Diebold and Yilmaz (2009, 2012, 2014) is a more sophisticated version of the network topology in the sense the variance decomposition matrix, which is analogous to the network adjacency matrix A, is not filled with zeros and ones but weights which indicate the strength of connectedness between i and j. Secondly, unlike the symmetric nature of links in the network theory, links in the spillover index framework are directed and generally asymmetric as the strength of ij link is likely to be different from the ji link. Lastly, given that the links are variance shares, the row sum has to be one. In the finance arena, the network theory has been employed to study, amongst other, the structure of the federal funds market (Bech & Atalay, 2010), the effect of trading network variables on market liquidity (Adamic, Brunetti, Harris, & Kirilenko, 2017), the interbank market in the U.K. (Langfield, Liu, & Ota, 2014), systemic risk of different interbank networks (Lenzu & Tedeschi, 2012) as well as the stability of financial network in Colombia (León & Berndsen, 2014).

Having explained the theory which Diebold and Yilmaz (2009, 2012, 2014) based their spillover index upon, it is equally important to consider the channels through which liquidity shocks in one asset market would transmit to another asset market. First, the portfolio diversification theory, developed by economist Harry Markowitz, often assumes investors such as fund managers and institutional investors holding a portfolio of assets for the purpose of diversification. When these investors rebalance their portfolios, the shift in assets between different markets is likely to see changes in liquidity in the markets where assets are reallocated. Second, in the papers by Chordia et al. (2005) and Goyenko and Ukhov (2009), the authors explain how the notion of "flight-to-quality" or "flight-to-liquidity" during stressed periods, as well as shocks arising from changes in monetary policy stance by the central banks, lead to price pressures and subsequently impact liquidity in both the stock and bond markets. During episodes of "flight-to-quality" or "flight-to-liquidity", investors sell stocks and rush into Treasury bonds which are perceived as safe haven, causing greater strain in the liquidity of both the stock and bond markets. Meanwhile, an expansionary monetary policy would have positive effect on the order flows of stock and bond, potentially causing liquidity to move in the same direction.

Third, liquidity among different markets could also be affected by funding constraints faced by investors as demonstrated by the theory of liquidity spirals by Brunnermeier and Pedersen (2009) and Acharya and Viswanathan (2011). When hit with funding constraints such as margin calls, traders might be forced to liquidate assets in one market to meet margin requirements in another asset market, causing cross-market liquidity changes. Mancini et al. (2013) provide evidence of lower foreign exchange market liquidity when funding liquidity, proxied by liquidity in the money market, deteriorates. Meanwhile, Banti (2016) shows that liquidity of small-cap stocks, which are more exposed to funding constraints, are more strongly related to foreign exchange liquidity.

Additionally, Cespa and Foucault (2014) postulate that liquidity in one asset market could propagate to another through cross-asset learning. Consider a liquidity provider in an asset class, say A, uses price of another asset, say B, as a source of information. When asset B becomes less liquid, information cannot be efficiently incorporated into its price and it then becomes a noisy signal for liquidity providers in asset *A*. In line with the information asymmetric model of Glosten and Milgrom (1985), providers for asset *A* would charge a wider spread given the loss of information, causing liquidity in asset *A* to drop as a result of rising illiquidity in asset *B*.

3.2 Model Specifications

This section specifies the models for addressing the three research questions in this thesis.

3.2.1 Foreign Equity Flows and Aggregate Stock Market Liquidity

To examine the impact of gross foreign inflows on the aggregate liquidity of the Malaysian stock market, more specifically, the causal relationship between these two policy variables, the empirical analysis uses the Vector Autoregression (VAR) methodology followed by the Granger non-causality test. Prior to estimating the VAR, unit root test is necessary to determine the stationarity of all the variables to avoid spurious regression. In this regard, the modified Dickey-Fuller *t*-test proposed by Elliott, Rothenberg and Stock (1992) and the Ng and Perron (2001) unit root test are employed. The baseline VAR model of order p used in this thesis to examine the impact of gross foreign inflows on the aggregate liquidity of Bursa Malaysia is expressed as follows:

$$Flow_t = c_{1t} + \sum_{i=1}^{p} a_{11}^{i} Flow_{t-i} + \sum_{i=1}^{p} a_{12}^{i} CPQS_{t-i} + b_{11}RET_t + b_{12}TO_t + b_{13}VOL_t + b_{14}SPREAD_t + b_{15}REER_t + b_{16}LMCAP_t + b_{17}RETREG_t + \varepsilon_{1t}$$

$$CPQS_t = c_{2t} + \sum_{i=1}^{p} a_{21}^{i} Flow_{t-i} + \sum_{i=1}^{p} a_{22}^{i} CPQS_{t-i} + b_{21}RET_t + b_{22}TO_t + b_{23}VOL_t + b_{24}SPREAD_t + b_{25}REER_t + b_{26}LMCAP_t + b_{27}RETREG_t + \varepsilon_{2t} \quad (1)$$

where the gross inflows of foreign investors (*Flow*) and the aggregate market liquidity of the Malaysian stock market (*CPQS*), computed following Chung and Zhang (2014), are the endogenous variables in the VAR model. In addition, seven exogenous variables that are standard determinants of liquidity and/or portfolio flows according to previous studies are also included as control variables. These variables are market returns (*RET*), market return volatility (*VOL*), market turnover ratio (*TO*), real effective exchange rate (*REER*) and natural logarithm of stock market capitalization (*LMCAP*). The model also accounts for interest rate differential between Malaysia and the developed economies by including *SPREAD*. Lastly, the regional stock return (*RETREG*) variable is derived from the MSCI All Country Asia ex Japan Index. c and ε denote the intercept and error term, respectively. Optimal lag length p is determined using the Akaike Information Criterion (AIC). All variables are winsorized at the 1^{th} and 99^{th} percentiles to eliminate extreme values.

After estimating the VAR, the causal relationships between gross inflows at both, aggregate and disaggregate levels, and liquidity are then examined through the Granger non-causality test. Finally, in line with Vagias and van Dijk (2012), the liquidity enhancing/reducing nature of foreign investors' gross inflows will be determined using the Generalized Impulse Response Functions (GIRs) proposed by Pesaran and Shin (1998), mainly because it is not sensitive to the ordering of variables in the VAR model.

3.2.2 Proprietary Day Trading and Higher-Order Moments of Liquidity

The second research question examines the liquidity effect of proprietary day trading. The relationships between the trade volume of PDTs and the level of liquidity, as well as its conditional second and third moments in the Malaysian stock market are specified as follows:

(i) PDTs' trade volume and aggregate liquidity

$$LIQ_t = \beta_0 + \beta_1 PDT_t + \beta_2 PDT_{t-1} + \beta_3 RET_{t-1} + \beta_4 VOL_{t-1} + \beta_5 LIQ_{t-1} + \varepsilon_t \qquad (2)$$

(ii) PDTs' trade volume and conditional volatility of aggregate liquidity

$$LIQ_t^{Vol} = \theta_0 + \theta_1 PDT_t + \theta_2 PDT_{t-1} + \theta_3 RET_{t-1} + \theta_4 VOL_{t-1} + \theta_5 LIQ_{t-1} + u_t \qquad (3)$$

(iii) PDTs' trade volume and conditional skewness of aggregate liquidity

$$LIQ_t^{Skew} = \omega_0 + \omega_1 PDT_t + \omega_2 PDT_{t-1} + \omega_3 VOL_{t-1} + \omega_4 \Delta LMCAP_{t-1} + \omega_5 CRISIS_{t-1} + \omega_6 LIQ_{t-1} + v_t \quad (4)$$

where LIQ_t, LIQ_t^{Vol} and LIQ_t^{Skew} each denotes aggregate liquidity, conditional volatility of aggregate liquidity and conditional skewness of aggregate liquidity on day t, respectively. LIQ_t^{Vol} is defined in Equation (13), and LIQ_t^{Skew} is estimated by κ_t in Equation (18). *PDT* represents the trade volume of proprietary day traders in billion shares, *RET* is the daily aggregate stock market returns, *VOL* is daily return volatility, *LMCAP* denotes total market capitalization in natural logarithm, *CRISIS* is a dummy variable which takes the value of one when *LIQ* is greater than the 70th percentile and zero otherwise and lastly, ε_t, u_t and v_t are the error terms, while Δ is the difference operator. Following Hsieh et al. (2018), independent variables in Equation (2) to Equation (4) are specified in lagged by one day to control for endogeneity and possible "look-ahead" bias. Given the trading restrictions where purchase positions have to be closed on the same trading day, a contemporaneous term for the trade volume of PDTs is also included.

The high frequency daily trade and liquidity data are expected to be autocorrelated. In addition to this issue, LIQ_t, LIQ_t^{Vol} and LIQ_t^{Skew} also display signs of non-constant variance (see analysis in Section 5.1). To circumvent these issues, Generalized Autoregressive Conditional Heteroskedasticity (GARCH) is used to model the error processes of Equations (2), (3) and (4). The variance equation for all the models above is specified as follows:

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \upsilon_{t-i}^2 + \sum_{j=1}^{p} \delta_j h_{t-j} \quad (5)$$

where υ_t represents the error terms ε_t, u_t and v_t. h_t is the conditional variance of the error process. The p and q parameters in GARCH, which control the number of lagged shocks and conditional variance of the error process, are determined such that the autoregressive conditional heteroskedasticity in the error process is eliminated. They are also chosen to preserve parsimony of the model and to ensure stability of variance of the error terms.

Two liquidity measures, namely the *CPQS* and its impact version, *CPQSIM* are used in this section. Hence, they will enter Equations (2), (3) and (4) separately. Similarly, *PDT* will take on three different measures of PDTs' trade volume, namely total trade volume, purchase volume and sale volume, in separate models. Note that prior to estimating the models, all data series are winsorized at the 1st and 99th percentiles to eliminate extreme values.

3.2.3 Illiquidity Connectedness

The time-varying parameter VAR (TVP-VAR) estimation, an innovation of Antonakakis et al. (2020), is employed to examine liquidity spillovers across the four main asset markets in Malaysia. While Diebold and Yilmaz (2009, 2012, 2014) have mentioned in their introductory paper that they also compute the time-varying spillover index, it is worth highlighting that they account for time variation in the index using rolling-window and not via a Kalman Filter estimation. The latter estimation method is superior to the rolling-window estimation in at least three ways. First, the width of rolling-window is often arbitrarily determined with little or no statistical backing (Antonakakis et al., 2020; Ibrahim & Aziz, 2003). Second, the need to set a window size to perform rolling sample analysis also means the loss of valuable observations which commensurate the width of the window. Finally, unlike Kalman Filter which produces coefficients for all the data points in the sample, rolling-window estimation does not allow the identification of which data points contribute to a spike or a dip in the spillover index in a particular window.

As such, Antonakakis et al. (2020) combine the TVP-VAR methodology of Koop and Korobilis (2013) and the spillover index approach of Diebold and Yilmaz (2014) to overcome the drawbacks of using rolling-window estimation. A TVP-VAR model with one lag can be written as follows:

$$\Delta y_t = \theta_t \Delta y_{t-1} + \mu_t \qquad \mu_t \sim N(0, \Sigma_t) \tag{6}$$

$$vec(\theta_t) = vec(\theta_{t-1}) + \tau_t \qquad \tau_t \sim N(0, Q_t) \tag{7}$$

where Δy_t, Δy_{t-1} and μ_t are vectors of $N \times 1$ dimension, θ_t and Σ_t are matrices of $N \times N$ dimension, $vec(\theta_t)$ and τ_t are parameter matrices with $N^2 \times 1$ dimension and lastly, Q_t is an $N^2 \times N^2$ dimensional matrix. Having estimated the above time-varying parameters, Antonakakis et al. (2020) then transform the TVP-VAR to a time-varying parameter vector moving average (TVP-VMA) representation using the Wold representation theorem. The resulting coefficients are then extracted to compute the generalized forecast error variance decomposition (GFEVD), developed by Koop, Pesaran and Potter (1996) and Pesaran and Shin (1998), on which the spillover index of Diebold and Yilmaz (2014) is built upon.

The spillover index framework of Diebold and Yilmaz (2012, 2014) is best understood by analyzing the connectedness table below:

Table 3.1: Connectedness Table

	X_1	X_2	X_3	X_4	From Others
X_1	d_{11}^H	d_{12}^H	d_{13}^H	d_{14}^H	$\Sigma_{j=1}^4 d_{1j}^H, j \neq 1$
X_2	d_{21}^H	d_{22}^H	d_{23}^H	d_{24}^H	$\Sigma_{j=1}^4 d_{2j}^H, j \neq 2$
X_3	d_{31}^H	d_{32}^H	d_{33}^H	d_{34}^H	$\Sigma_{j=1}^4 d_{3j}^H, j \neq 3$
X_4	d_{41}^H	d_{42}^H	d_{43}^H	d_{44}^H	$\Sigma_{j=1}^4 d_{4j}^H, j \neq 4$
To Others	$\Sigma_{i=1}^4 d_{i1}^H, i \neq 1$	$\Sigma_{i=1}^4 d_{i2}^H, i \neq 2$	$\Sigma_{i=1}^4 d_{i3}^H, i \neq 3$	$\Sigma_{i=1}^4 d_{i4}^H, i \neq 4$	$\frac{1}{4}\Sigma_{i,j=1}^4 d_{ij}^H, i \neq j$

Take d_{ij}^H as the ij-th H-step ahead variance decomposition, that is, the fraction of i's H-step ahead forecast error variance due to shocks arising from variable j. The Total

Connectedness Index (TCI), also known as the system-wide connectedness index, is the sum of all d_{ij}^{H} except the fraction of a variable's own H-step forecast error variance due to its own shocks, divided by the number of variables. The off-diagonal row sum, which forms the "From Others" column, denotes the share of the H-step forecast error variance of a variable coming from shocks arising from variables other than itself. In other words, it reflects how much of the variation in a variable is due to spillover from all other variables in the network. On the other hand, the column sum, which forms the "To Others" row, denotes the total share of the H-step forecast error variance of that particular variable to all other variables due to shocks arising from that variable. In other words, it is the spillover effect from that particular variable to all other variables in the network. Note that all the pairwise directional connectedness indices discussed thus far are in "gross" term. Diebold and Yilmaz (2012, 2014) also introduce a "net" pairwise directional connectedness index, defined as d_{ij}^{H}-d_{ji}^{H}. This net pairwise directional connectedness index measures the net spillovers from variable j to variable i, after taking out the effect of spillovers from variable i to variable j. In a way, this measure gives an indication of who are the net receiver and net transmitter of spillovers in a network.

3.3 Dependent and Key Independent Variables

This section provides descriptions of the dependent and key independent variables in models (1) to (7) to address all three research questions in this thesis, along with their respective data sources.

3.3.1 Aggregate Stock Market Liquidity: Closing Percent Quoted Spread (*CPQS*) and Closing Percent Quoted Spread Impact (*CPQSIM*)

The high-frequency bid-ask spread is considered the gold standard in measuring liquidity. This is evidenced in its usage as one of the benchmarks to examine the efficacy of existing and newly introduced liquidity proxies in the literature (see the liquidity horseraces of

Fong et al., 2017; Goyenko et al., 2009; Holden, 2009; Lesmond, 2005; Marshall et al., 2013). While liquidity is best measured using high-frequency bid-ask spread, the lack of such data, especially in the emerging markets, has led to the introduction of their low-frequency counterparts. Two prominent low-frequency liquidity proxies that are closely associated with the bid-ask spread are the High-Low by Corwin and Schultz (2012) and the Closing Percent Quoted Spread (*CPQS*) by Chung and Zhang (2014). The former computes bid-ask spread using daily high and low prices whereas the latter uses closing bid and ask prices. These raw data, namely the daily high prices, daily low prices, daily closing bid prices and daily closing ask prices are readily available in Refinitiv (formerly Thomson Reuters) Datastream for most stock exchanges worldwide.

Because of its multifaceted nature, the empirical literature witnesses a rapid expansion of liquidity measures. Faced with the enormous menu of liquidity proxies, several liquidity horseraces as cited above have been conducted to guide researchers in selecting the most appropriate liquidity measures for each stock exchange. These horseraces are important development in the liquidity literature as they provide guidance on which low-frequency liquidity proxies best capture the state of liquidity in a particular stock exchange, therefore saving researchers the computational time, subscription cost as well as increasing the accuracy of liquidity research. The selection of liquidity proxies to be employed in this thesis is based upon the horserace by Fong et al. (2017). This horserace is by far the most extensive in the liquidity literature, encompassing 8 billion trades for 24,240 firms across 42 global stock markets over the sample period of 1996 to 2007. In the Malaysian context, the authors show that the Closing Percent Quoted Spread (*CPQS*) proposed by Chung and Zhang (2014) is the best-performing liquidity measure in the percent-cost spectrum whereas its impact version (*CPQSIM*) is the winner in the cost-per-volume segment.

The *CPQS* and *CPQSIM* for stock *i* on day *t* is calculated as follows:

$$CPQS_{i,t} = \frac{\text{Closing Ask}_{i,t} - \text{Closing Bid}_{i,t}}{(\text{Closing Ask}_{i,t} + \text{Closing Bid}_{i,t})/2} \tag{8}$$

$$CPQSIM_{i,t} = \frac{CPQS_{i,t}}{\text{P}_{i,t} \times \text{Volume}_{i,t}} \tag{9}$$

where Closing $\text{Ask}_{i,t}$ and Closing $\text{Bid}_{i,t}$ are respectively the closing ask and bid prices of stock *i* on day *t*, $\text{P}_{i,t}$ is the closing price of stock *i* on day *t*, and lastly $\text{Volume}_{i,t}$ is the total number of shares traded for stock *i* on day *t*. All data required to compute *CPQS* and *CPQSIM* are obtained from Refinitiv (formerly Thomson Reuters) Datastream. The weekly liquidity estimates for each individual stock are obtained by averaging the daily *CPQS* and *CPQSIM*. To compute the weekly aggregate liquidity measure for the whole Malaysian stock market, the weekly firm-level liquidity estimates are aggregated using market value weighting scheme. Daily aggregate liquidity measures for the Malaysian stock exchange, on the other hand, are obtained by aggregating daily firm-level *CPQS* and *CPQSIM* estimates using the respective market capitalization of the firms as weights. The *CPQS*, which is a variant of the high-frequency bid-ask spread that represents the cost facing an investor to trade immediately, is thus an inverse measure of liquidity. In similar interpretation, the *CPQSIM* represents the marginal transaction costs per currency unit of volume.

3.3.2 Aggregate Bond Market Liquidity: Percentage High-Low Spread

Measuring liquidity in the bond market poses a few challenges to researchers due to its market structure, trade size and most importantly, data availability (Schestag, Schuster, & Uhrig-Homburg, 2016). First, intraday data on quotes are unavailable as most bonds are traded over-the-counter (OTC) and illiquid. Therefore, established stock liquidity measures such as the intraday effective bid-ask spread cannot be computed for the bond market. Additionally, the absence of intraday quote data also makes assessing the impact of a trade on the quoted midpoint impossible. Other problems with measuring price impact in the OTC bond market include the less transparent incorporation of information into bond prices in a decentralized market and negative price impact of trade given that transaction costs decrease with trade size.

The paper by Schestag et al. (2016) is the first to perform a horserace of liquidity proxies using U.S. corporate bond market transaction data obtained from Enhanced Historic Trade Reporting and Compliance Engine (TRACE). Using intraday data of 3,495 bonds and 31,285,666 trades spanning from 1st October 2004 to 30th September 2012, the authors find that the High-Low measure introduced by Corwin and Schultz (2012), the Gibbs measure by Hasbrouck (2009) as well as the Roll (Roll, 1984) are the best liquidity proxies for the U.S. corporate bond market.

For the Malaysian bond market, Hameed, Helwege, Li and Packer (2019) use data obtained from the Electronic Trading Platform (ETP), an initiative by the Malaysian government to enhance liquidity in the corporate bond market, to perform a horserace between ten price- and quantity-based liquidity measures for the Malaysian corporate bond market. Five price-based liquidity measures are used in the study, namely (i) the Amihud price impact measure; (ii) the ratio of volume-weighted variance of traded bond price to volume-weighted average price of the bond; (iii) the ratio of the difference in monthly high and low traded bond prices to their average; (iv) same as (iii) but calculated daily; and (v) the average bid-ask spread. On the other hand, five quantity-based liquidity measures employed in the study are (i) the number of trades in a year; (ii) the number of days a bond is traded during the year; (iii) turnover calculated as trading amount divided by total outstanding; (iv) the percentage of days with zero returns; and lastly, (v) the average number of days since the bond's last trade.

Hameed et al. (2019) conclude that for the Malaysian corporate bond market, quantity-based liquidity measures are more reliable than its price-based counterparts in gauging liquidity of corporate bonds in Malaysia. Despite their conclusion, this thesis maintains that price-based bond liquidity measures are still preferred on two grounds. First, their finding, which is of stark contrast to that of Schestag et al. (2016) who find that price-based measures of corporate bond liquidity record better performance, is likely contributed by the different assessment methods employed in the two papers. Hameed et al. (2019) assess the performance of bond liquidity measures by regressing them on a list of determinants such as bond size, age and remaining maturity, which departs from the usual high-frequency liquidity benchmarking exercises adopted by other liquidity horseraces (Fong et al., 2017; Goyenko et al., 2009; Marshall et al., 2013; Schestag et al., 2016). Second, as is the case with stock market liquidity, trade- or quantity-based measures such as turnover and number of days with zero trading or zero returns might be capturing market activities caused by knee-jerk reactions to good or bad news and not liquidity.

Therefore, with the limited variables in the bond transaction data made available to the public on Bond Info Hub, an initiative by the central bank of Malaysia, this thesis employs the high-low dispersion measure to quantify liquidity in the Malaysian bond market.[15] The daily Percentage High-Low Spread (*PHLS*) is computed as follows:

$$PHLS_{i,t} = \frac{\text{High Price}_{i,t} - \text{Low Price}_{i,t}}{(\text{High Price}_{i,t} + \text{Low Price}_{i,t})/2} \tag{10}$$

where High $\text{Price}_{i,t}$ is the daily high price of bond *i* on day *t* and Low $\text{Price}_{i,t}$ is the daily low price of bond *i* on day *t*. The list of intraday transactions in the Malaysian bond market

[15] Information available in the Historical Intraday Trades Summary include trade date, type of instrument, stock code, stock description, issuer, rating, number of trades for that particular bond/note, maturity date, remaining tenures in days, closing yield, low and high yields, issue date, coupon rate and lastly, total amount transacted in million ringgit.

is downloaded from Bond Info Hub for the period from July 2005 to December 2018. Given that only low and high yields data are available in the Bond Info Hub database, the high and low prices of a bond are calculated as follows:

With coupon payment:

$$\text{Price}_i = \left(\text{CR}_i \times \frac{1 - {}^{1}/_{(1+\text{Yield}_i)^n}}{\text{Yield}_i} \right) + \left(\text{FV}_i \times \frac{1}{(1+\text{Yield}_i)^n} \right) \tag{11}$$

Without coupon payment:

$$\text{Price}_i = \frac{\text{FV}_i}{(1+\text{Yield}_i)^n} \tag{12}$$

where Price_i denotes the price of bond i, CR_i denotes the coupon rate offered by bond i, Yield_i is the high or low yield of bond i, FV_i denotes the face value of bond i which is arbitrarily set to be RM100 for all bonds in the study and lastly, n is the number of years to maturity calculated by dividing the number of days to maturity from the day the bond is traded by 365 days.

A few criteria are used to determine the inclusion of a transaction in the final sample. First, only bonds with maturity of more than a year are selected so as to capture liquidity of bonds and not commercial papers or notes. Second, bonds with negative remaining maturity are excluded as these entries are deemed flawed. Third, bonds without issue date are also excluded from the sample. Finally, bonds with incomplete or erroneous high or low yields data are excluded from the sample. The aggregate bond market liquidity indicator is then calculated by averaging *PHLS* of all bonds transacted on the same trading day.

3.3.3 Aggregate Money Market Liquidity: 3-month KLIBOR and 3-month Treasury Bill Spread

The spread between a 3-month LIBOR and 3-month Overnight Index Swap (LIBOR-OIS spread) used in Nyborg and Östberg (2014) is arguably a more precise measure of interbank liquidity/tightness given that the LIBOR-OIS spread is the difference between two interbank rates, rather than an interbank and a Treasury rate. However, OIS rate in Malaysia is only available after the 2007-2008 Global Financial Crisis with data from 5th June 2009, which excludes the Global Financial Crisis. However, such exclusion is undesirable as the crisis may give rise to interesting observations on how different asset markets are connected during stressed market periods. Therefore, this thesis resorts to using the next best alternative, the spread between 3-month Kuala Lumpur Interbank Offered Rate (KLIBOR) and 3-month Treasury Bill, as a measure of interbank market tightness.

3.3.4 Foreign Exchange Market Liquidity: Closing Percent Quoted Spread (*CPQS*)

The pivotal studies of Mancini et al. (2013) and Karnaukh et al. (2015) greatly facilitate the expansion of scholarship in the foreign exchange liquidity domain. The former represents the first systematic study of liquidity in the foreign exchange market by using high-frequency transaction data. Recognizing the challenges in obtaining such quality data in other parts of the world, especially developing countries, the latter introduces a low-frequency liquidity measure for the foreign exchange market. The low-frequency closing percent bid-ask spread by Karnaukh et al. (2015) is similar to the Closing Percent Quoted Spread (*CPQS*) introduced by Chung and Zhang (2014) for the stock market. Therefore, this thesis uses the same Equation (8) for stock to compute daily market liquidity series for the Malaysian Ringgit (MYR), using closing bid and closing ask prices of the USD/MYR currency pair.[16]

3.3.5 Liquidity Volatility

Liquidity volatility, also commonly known as liquidity risk, is broadly measured in two ways. The first approach of measuring liquidity volatility stems from the seminal paper of Pástor and Stambaugh (2003) whose "liquidity beta" is defined as the covariance between individual stock returns and market liquidity. Their measure was later adopted in the Liquidity-Adjusted Capital Asset Pricing Model (LCAPM) of Acharya and Pedersen (2005), alongside two other liquidity risk measures, namely: (i) the covariance between individual stock liquidity and market liquidity, and (ii) the covariance between individual stock liquidity and market returns. Another strand of literature measures volatility of liquidity using the standard deviation of the liquidity series (Blau & Whitby, 2015; Lang & Maffett, 2011) or the coefficient of variation (Barinov, 2015; Chordia et al., 2001). This thesis specifies at the onset that it refrains from using "liquidity risk" to avoid confusion as the term has been widely used in the asset pricing literature, pioneered by Pástor and Stambaugh (2003).

Furthermore, the stylized observation that financial time series often exhibit volatility clustering and leptokurtosis, coupled with the importance of time-variation in the conditional variance of these time series in derivative pricing and risk management, underline the need to employ time-varying variance models in estimating and predicting the volatility of financial time series. This has been made possible following the seminal work of Engle (1982) on Autoregressive Conditional Heteroskedasticity (ARCH) model, and the subsequent development of the Generalized ARCH (GARCH) family models.

[16] While the use of the USD/MYR currency pair in the analysis of liquidity connectedness may appear to be inconsistent with the REER used in analyses of the first empirical chapter, it should be noted that the latter is merely a measure of the value of a country's currency to a basket of foreign currencies, deflated by a price deflator or costs index. Therefore, the REER is an index which is not traded and does not have bid and ask prices to compute the liquidity measure of bid-ask spreads.

Hanselaar, Stulz and van Dijk (2019) is perhaps the first study to use ARCH/GARCH family models to generate conditional liquidity volatility series. Building on the work of these authors, this thesis employs the Exponential GARCH (EGARCH) model, which accounts for asymmetric effect, to generate conditional liquidity volatility series for the Malaysian stock market. The liquidity series, which follows a log-normal distribution, is best modelled using the EGARCH model according to Lupu and Lupu (2007) and Miron and Tudor (2010) who examine the performance of GARCH variant models in modelling returns volatility in the Bucharest Stock Exchange. Additionally, taking log for conditional volatility of liquidity is also desirable to ensure that convergence is achieved in the estimation process given the large fluctuations seen in the liquidity series.

The employment of EGARCH model to generate conditional liquidity volatility for the local stock market is based on the observation that the liquidity series follows a log-normal distribution

The variance equation of the EGARCH (p, q) model can be written as follows:

$$\log LIQ_t^{VOL} = \alpha_0 + \sum_{i=1}^{q} \alpha_i \left| \xi_{t-i} / (\log LIQ_{t-i}^{VOL})^{1/2} \right| + \sum_{j=1}^{p} \delta_j \log LIQ_{t-j}^{VOL}$$

$$+ \sum_{k=1}^{m} \beta_k \, \xi_{t-k} / (\log LIQ_{t-k}^{VOL})^{\frac{1}{2}} \quad (13)$$

where $\log LIQ_t^{VOL}$ is the log of conditional variance of liquidity, ξ_t is the residuals and $\log LIQ_{t-j}^{VOL}$ is the lagged log of conditional variance that differentiates the GARCH from the ARCH model. Significance of the lagged conditional variance terms indicates volatility clustering of the financial time series, in this case, the aggregate liquidity of the Malaysian stock market. The asymmetric impact of news on liquidity volatility is captured by β_k.

The optimum orders of GARCH and ARCH terms are determined first by estimating the models with GARCH and ARCH orders up to a maximum of five lags using three different error distributions, namely, Normal (Gaussian), Student's *t* and Generalized Error, respectively. To preserve the parsimony of the models, the combination with the lowest Schwarz Information Criterion (SIC) is then selected for each error distribution. Finally, the order combination with the lowest SIC among the three error distributions is chosen as the final model.

3.3.6 Liquidity Skewness

The limited studies on liquidity skewness mainly adopt the unconditional measure. Roll and Subrahmanyam (2010) and Hsieh et al. (2018) both use annual equally-weighted average of individual firm-level skewness to examine liquidity skewness in the U.S. and London stock markets, respectively. Wei et al. (2018), on the other hand, calculate skewness for a sample of 50 bonds from seven European countries using snapshot observations at 15-minute interval, and later aggregated at different frequencies over three distinct periods – calm period, the Global Financial Crisis and European sovereign debt crisis. This thesis contends that, like return skewness which has been found by Bekaert, Erb, Harvey and Viskanta (1998) and Ghysels, Plazzi and Valkanov (2016) to vary over time, liquidity skewness should exhibit similar time-varying behavior. Therefore, a conditional skewness measure of liquidity is warranted. While the concept of conditional skewness has not been applied in the liquidity literature, there is already a large body of literature on conditional return skewness, fueled largely by the seminal papers of Hansen (1994) and Harvey and Siddique (1999).

Following Hashmi (2001), this thesis combines the methodologies of Hansen (1994) and Harvey and Siddique (1999) to model the conditional skewness of aggregate liquidity for the Malaysian stock market. First, aggregate liquidity is modelled as a

Generalized Autoregressive Conditional Heteroskedasticity-in-mean (GARCH-M) process. Second, residuals from the conditional mean equation, normalized using estimates for conditional mean and variance from the GARCH-M model, are modelled using the generalized *t*-density distribution proposed by Hansen (1994) which allows higher-order moments to vary over time.

The generalized *t*-density which has zero mean and unit variance is as follows:

$$f(z|\eta,\kappa)=bc\left(1+\frac{1}{\eta-2}\left(\frac{bz+a}{1-\kappa}\right)^2\right)^{\frac{\kappa+1}{2}} \qquad \text{when} \quad z<-a/b$$

$$f(z|\eta,\kappa)=bc\left(1+\frac{1}{\eta-2}\left(\frac{bz+a}{1+\kappa}\right)^2\right)^{\frac{\kappa+1}{2}} \qquad \text{when} \quad z\geq -a/b \qquad (14)$$

where z is the normalized residuals, η is the degree of freedom and κ is a shape parameter. Note that the following constraints, $2<\eta<\infty$ and $-1<\kappa<1$, are also imposed. The constant a, b and c are given as:

$$a = 4\kappa c\left(\frac{\eta-2}{\eta-1}\right) \qquad (15)$$

$$b^2 = 1 + 3\kappa^2 - a^2 \qquad (16)$$

$$c = \frac{\Gamma\left(\frac{\eta+1}{2}\right)}{\sqrt{\pi(\eta-2)}\,\Gamma\left(\frac{\eta}{2}\right)} \qquad (17)$$

Following Harvey and Siddique (1999), skewness and the degrees of freedom parameters are specified as follows:

$$\kappa_t = c_1 + c_2 z_{t-1}^3 + c_3 \kappa_{t-1} \qquad (18)$$

$$\eta_t = c_4 \qquad (19)$$

where c_1, c_2, c_3 and c_4 are to be estimated by maximizing the log likelihood function of the distribution given in Equation (14), using the Berndt-Hall-Hall-Hausman (BHHH) optimization algorithm.

3.3.7 Foreign Trading

Bursa Malaysia, through its Information Services Division, began the compilation of trading participation data of both local and foreign investors as part of its commercial database. The original dataset named "Trading Participation by Category of Investors" is available at the market level and at daily (M5), weekly (M6) and monthly (M7) frequencies. A check with Bursa Malaysia reveals that the stock exchange does not compile trading data at the firm level. In the dataset, trading volume (in million shares) and trading value (in million ringgit) are provided for six investor types namely foreign institutions, foreign retail investors, local institutions, local nominees, local proprietary day traders (PDTs) and local retail investors. The dataset provides further breakdown of buys and sales for each investor type. The first research question uses weekly M6 data where gross inflow is calculated as gross foreign purchase minus gross foreign sale of local equities. Gross inflows of foreign equity flows are denoted in three ways, namely *FTFLOW*, *FIFLOW* and *FRFLOW*, each representing the gross inflows of foreign investors as a whole, gross inflows of foreign institutional investors and lastly, gross inflows of foreign retail investors.

3.3.8 Proprietary day trading

PDTs in Malaysia are individuals with a Dealer's Representative License and at least five years of trading experience. They are employed by investment banks or brokerage firms in Malaysia to generate investment profits for the firms by performing day trading. PDTs trade using the firms' capital, and they share 60% of the profits earned with the firms but absorb 100% of losses incurred. Among the benefits that PDTs enjoy are exemption of brokerage fees and clearing fee rebates upon reaching a certain trade quota in a month. When PDTs were launched in January 2007, the Malaysian government lifted the ban on short selling imposed in the aftermath of the Asian financial crisis, and granted them the exclusive rights to perform intraday short selling (IDSS). This exclusivity ended in April 2018 when Bursa Malaysia and the Securities Commission Malaysia (SCM) allowed all investors to participate in IDSS to further enhance liquidity in the local stock market. Notwithstanding the privileges, PDTs are subject to strict trading requirements. All purchase positions entered into by PDTs must be closed within two days of the transaction date while all short positions must be closed within the day. Also, PDTs are not allowed to trade on the ACE Market and they are prohibited to trade for clients of brokers.

Proprietary day trading data are sourced from Refinitiv (formerly Thomson Reuters) Datastream, with daily trade data only made available from October 2012, which dictates the starting point of the sample period in the empirical analysis for the second research question. Day trading is measured by the aggregate daily trade volume of PDTs, as well as the disaggregated purchase and sale volume. Total trade volume (total number of shares purchased + total number of shares sold) is selected as the measurement of proprietary day trading for two reasons. First, PDTs have a bigger presence in terms of trade volume vis-à-vis trade value. Second, since PDTs are mandated to close their positions within two days for buy and a day for sell orders, their net trade is very small relative to total trade volume, hence the former is not expected to exert any significant effect on liquidity.

3.4 Control Variables

This section provides descriptions of all the control variables in models (1) to (4) for addressing the first and second questions in this thesis, arranged based on the order they appear. All data required to construct the control variables are sourced from Refinitiv (formerly Thomson Reuters) Datastream.

3.4.1 Stock Return (*RET*)

Stock return is present in models (1) to (3) given its association with liquidity (Chordia, Roll, & Subrahmanyam, 2002; Hameed, Kang, & Viswanathan, 2010; Rhee & Wang, 2009), liquidity volatility (Blau & Whitby, 2015; Pereira & Zhang, 2010), foreign investment (Bohn & Tesar, 1996; Griffin et al., 2004) as well as the trading of proprietary day traders (Linnainmaa, 2005). In model (1), weekly returns are calculated following the standard convention of Wednesday-to-Wednesday change in Total Return Index of each firm listed on the Malaysian stock market. On the other hand, daily returns used in models (2) and (3) are computed as the daily change in the Total Return Index of each firm. To obtain the aggregate stock returns for both daily and weekly intervals, the individual firm-level daily and weekly returns are aggregated using the market value weighting scheme.

3.4.2 Stock Return Volatility (*VOL*)

Stock return volatility is included in models (1) to (4). It has been widely established that stock liquidity is negatively associated with return volatility (Agarwal, 2007; Benston & Hagerman, 1974) as greater volatility implies greater adverse selection risk faced by liquidity providers as well as greater inventory risk arising from order imbalances (Ho & Stoll, 1981; Stoll, 1978, 2000). In models (3) and (4), this thesis follows Blau and Whitby (2015) and Hsieh et al. (2018) to include stock return volatility as control variable for liquidity volatility and liquidity skewness, respectively. Following Vagias and van Dijk (2012), daily (weekly) aggregate return volatility (*VOL*) is generated by fitting the daily (weekly) aggregate stock return series to the EGARCH(1,1) specification which accounts for asymmetries between positive and negative returns.

3.4.3 Turnover (*TO*)

Turnover ratio, commonly known as a determinant of stock liquidity, is included as a control variable in model (1). Existing empirical evidence finds that higher turnover is associated with higher liquidity because it provides opportunities for market makers to manage their inventory and recoup losses from informed investors (Agarwal, 2007; Lim et al., 2017; Rhee & Wang, 2009). Turnover ratio (*TO*) is computed as the ratio of total number of shares traded to the total number of shares outstanding. Note that turnover ratio is not included in models (2) to (4) due to multicollinearity concern as the trades of proprietary day traders form part of total turnover in the Malaysian stock exchange. Turnover ratios are first computed for each trading day at the firm level. They are then averaged to obtain weekly values and finally aggregated across stocks using market value weighting scheme to derive the weekly market-level turnover ratio.

3.4.4 Real Effective Exchange Rate (*REER*)

The real effective exchange rate (*REER*) is included in model (1) as a determinant of foreign equity flows. This is because the purchase and sale of shares in another country involves exchanging currency of the home country, which an investor resides in, with currency of the investment destination. Besides, a foreign investor's return is also subject to exchange conversion risk. Agarwal (1997) and Hau and Rey (2006) find that foreign capital inflow is an increasing function of a country's currency strength. In this thesis, the variable *REER* is the Malaysia real effective exchange rate based on Consumer Price Index (2010=100) compiled by JPMorgan. The data is obtained from Refinitiv (formerly Thomson Reuters) Datastream.

3.4.5 Aggregate Market Capitalization (*MCAP*)

Market capitalization is included in model (1) and model (4). In model (1), market capitalization is included because empirical evidence shows that larger firms tend to have higher liquidity (Agarwal, 2007; Lim et al., 2017; Rhee & Wang, 2009). It is also included as a determinant of foreign equity flows since foreign investors are drawn to larger firms (Edison and Warnock, 2004). Its inclusion in model (4), on the other hand, is justified by the finding of Hsieh et al. (2018) that bid-ask spread skewness increases with firm size. Aggregate daily (weekly) market capitalization is computed as the sum of market capitalization of all firms listed on Bursa Malaysia at the end of each day (week).

3.4.6 Interest Rate Differential (*SPREAD*)

International interest rate has been found to be one of the key determinants of international capital flows (Calvo, Leiderman, & Reinhart, 1993; Grubel, 1968; Reinhart & Reinhart, 2008). This is because when interest rate in a home country is low, investors often seek higher yields from foreign markets to increase their returns. Therefore, this thesis includes interest rate differential as one of the control variables in model (1). The interest rate differential (*SPREAD*) is the difference between the Malaysia Band 4 (68 to 91 days to maturity) Treasury-Bill and average short-term interest rates of the G-7 countries, weighted by each country's Gross Domestic Product (GDP) in the year before. The latter is computed according to the world interest rate indicator in Vagias and van Dijk (2012).

3.4.7 Regional Stock Return (*RETREG*)

Griffin et al. (2004) and Richards (2005) highlight the importance of both regional and local returns in explaining inflows of foreign funds into emerging markets. Therefore, regional return (*RETREG*), calculated following the Wednesday-to-Wednesday approach using the MSCI All Country Asia ex Japan Index, is included in model (1) as a control variable. The MSCI All Country Asia ex Japan Index is sourced from Refinitiv (formerly Thomson Reuters) Datastream.

3.4.8 Extreme Market Liquidity Event (*CRISIS*)

This variable is included in model (4) and model (25). The evaporation of liquidity during the bankruptcy of Lehman Brothers is a classic example of how market liquidity can be severely undermined during financial market turmoil. The studies by Anand, Irvine, Puckett and Venkataraman (2013), Aragon and Strahan (2012) as well as Hameed et al. (2010) provide empirical support to the above statement. This thesis follows Vagias and van Dijk (2012) to assign the value of one to the *CRISIS* dummy when the level of liquidity on day *t* is greater than the 70^{th} percentile, and zero otherwise. The inclusion of this variable in model (4) as a control variable is also in accordance with the empirical model adopted by Hsieh et al. (2018) in their study of skewness in the London Stock Exchange.

3.5 Robustness Tests

The first research question examines the causal relationship between foreign investors' trades and the aggregate liquidity of the Malaysian stock market. To ensure reliable statistical inferences drawn from the baseline model (1), a series of robustness checks are performed. This section provides a brief description of the additional robustness tests.

3.5.1 Incorporating Structural Breaks

The unexpected announcement made by the then Federal Reserve Chairman Ben Bernanke to begin tapering the central bank's pace of asset purchase, known as Quantitative Easing (QE), sent financial markets, especially those in emerging economies, tumbling as investors began fleeing these markets. This event, notoriously known as the "Taper Tantrum", had also affected foreign equity flows into Malaysia as shown by the sudden fall in gross foreign inflows in Figure 4.1 (page 111). Besides that, *CPQS* also shows signs of breaks at various points in the sample period. This thesis thus accounts for such structural breaks to establish the robustness of the baseline results.

The most prominent structural break test to date is the work of Bai and Perron (1998). Their framework, which is incorporated in EViews, has five different tests that can be performed, namely the sequential test of $l+1$ versus l breaks, test of breaks in all recursively determined partitions, the double maximum test (test of 1 to M globally determined breaks), test of $l+1$ versus l globally determined breaks and lastly, test for information criterion for 0 to M globally determined breaks.

According to Perron (2006) and Bai and Perron (2006), it is recommended 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 among the rest 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 $l+1$ versus l globally determined breaks. Given that the estimates of break dates in the double maximum test are obtained from a global minimization of the sum of squared residuals, this thesis hence considers only tests where break dates estimates are obtained in a similar manner.

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

$$V_t = \alpha_0 + u_t \quad (20)$$

where V_t is the gross foreign inflows or *CPQS* at time t, α_0 is the intercept and u_t is the error term. One of the advantages of the Bai and Perron (1998) method is that it allows for serial correlation and heteroskedasticity in the error terms. When errors are serially correlated and/or heteroskedastic, the selection of kernel and bandwidth for the construction of covariance matrix would then be along the lines of Andrews (1991).[17]

[17] Using univariate series pre-whitened by AR(1), Andrews (1991) finds that the Quadratic-Spectral is the asymptotically optimal kernel in producing consistent Heteroskedasticity- and Autocorrelation-Consistent (HAC) estimators whereas the Andrews's

After a structural break date is established for the series, a dummy will be created for each break date and included in the following regressions:

$$\begin{aligned} Flow_t &= c_1 + \theta_1 Flow_{t-1} + \theta_2 Flow_{t-2} + \theta_3 CPQS_{t-1} + \theta_4 CPQS_{t-2} + \theta_5 RET_t \\ &+ \theta_6 VOL_t + \theta_7 TO_t + \theta_8 \Delta SPREAD_t + \theta_9 \Delta REER_t + \theta_{10} \Delta LMCAP_t \\ &+ \theta_{11} RETREG_t + \theta_{12} \sum_{i=1}^{2} FLOWDUM_i + \varepsilon_{1t} \end{aligned} \quad (21)$$

$$\begin{aligned} CPQS_t &= c_2 + \gamma_1 Flow_{t-1} + \gamma_2 Flow_{t-2} + \gamma_3 CPQS_{t-1} + \gamma_4 CPQS_{t-2} + \gamma_5 RET_t \\ &+ \gamma_6 VOL_t + \gamma_7 TO_t + \gamma_8 \Delta SPREAD_t + \gamma_9 \Delta REER_t + \gamma_{10} \Delta LMCAP_t \\ &+ \gamma_{11} RETREG_t + \gamma_{12} \sum_{j=1}^{4} LIQDUM_j + \varepsilon_{2t} \end{aligned} \quad (22)$$

where $Flow_t$ represents *FTFLOW*, *FIFLOW* and *FRFLOW*, each entering the regression separately. *FLOWDUM* is the structural break dummy for gross inflows which takes the value of one in the break week and zero otherwise. Similarly, *LIQDUM* is the structural break dummy for the *CPQS* series that takes the value of one in the break week and zero otherwise. The null hypothesis of no Granger causality from aggregate liquidity to gross inflows is examined by performing a Wald test on the restriction $\theta_3 = \theta_4 = 0$. On the other hand, the null hypothesis of $\gamma_1 = \gamma_2 = 0$ is tested for no Granger causality from gross inflows to aggregate liquidity.

3.5.2 Alternative Liquidity Indicators

As mentioned in Section 3.3.1, low-frequency liquidity indicators are grouped into percent-cost and cost-per-volume segments, with the former capturing the transaction cost required to execute a small trade whereas the latter measures marginal transaction cost per currency unit of volume. The *CPQS*, a percent-cost liquidity proxy introduced

automatic bandwidth parameters perform best in most of the simulations. Therefore, the OLS regression described above will be estimated using the HAC options proposed by Andrews (1991) to obtain standard errors that are robust to serial correlation and heteroskedasticity problems present in the residuals.

by Chung and Zhang (2014), is the main liquidity proxy in addressing the first research question. As a robustness check, the VAR model, as specified in model (1), is re-estimated with two alternative liquidity measures from the cost-per-volume spectrum. According to Fong et al. (2017), the best cost-per-volume liquidity proxy for the Malaysian stock market is the impact version of *CPQS – CPQSIM* (formula given in Equation (9)). Due to its popularity in the liquidity literature, the Amihud (2002) illiquidity ratio (*ILLIQ*) is also included as one of the liquidity proxies in the robustness test for the first empirical analysis.

The *ILLIQ* is calculated as follows:

$$ILLIQ_{i,t} = \frac{|R_{i,t}|}{P_{i,t} \times Volume_{i,t}} \tag{23}$$

where $|R_{i,t}|$ denotes the absolute return of firm i on day t, $P_{i,t}$ is the closing price of firm i on day t, and $Volume_{i,t}$ is the trading volume of firm i on day t in number of shares traded. Similar to how aggregate weekly *CPQS* and *CPQSIM* are derived, weekly *ILLIQ* for each firm is first calculated by averaging daily individual *ILLIQ* over the week. These firm-level weekly *ILLIQ* are later aggregated using the market value weighting scheme to form the aggregate *ILLIQ* for the Malaysian stock market.

3.5.3 Large- and Small-Capitalization Liquidity Proxies

The market value weighting scheme which uses market capitalization of firms as weights in aggregating individual firm observations to form a market index generally places more emphasis on large-capitalization stocks given their size. To ensure the robustness of the baseline results as well as to provide greater insights on how the trading of foreign investors affects liquidity of large- and small-capitalization stocks, this thesis thus computes liquidity indicators for large- and small-capitalization stocks and re-estimate the VAR in model (1). Large-capitalization stocks are defined as those with market capitalization at the top 20^{th} percentile whereas small-capitalization stocks are those with market capitalization at the bottom 20^{th} percentile of the population of stocks listed on Bursa Malaysia. The liquidity indicator for large-capitalization (small-capitalization) stocks is then computed by aggregating weekly liquidity proxy of firms categorized as large (small) using the equal weighting scheme. To ensure consistency, three other control variables, namely market returns, return volatility and turnover ratio are also computed for large- and small-capitalization stocks.

3.5.4 Bootstrap Wald Test

The paper by Kim (2014) advocates the use of bootstrap with Estimated Generalized Least-Squares (EGLS) as the resampling estimator to test for linear restrictions in a stationary VAR model. According to the author, the use of bootstrap with EGLS overcomes the shortcomings of conventional asymptotic method popularized by Lütkepohl (2005). One advantage of bootstrap with EGLS over the conventional asymptotic method is its desirable small sample properties. This thesis performs the Bootstrap Wald Test using the package VAR.etp available in R.

3.5.5 Additional Endogenous Variable

In the baseline model (1), liquidity and gross inflows of foreign investors are the only endogenous variables in the VAR. The existing literature, however, also shows that market returns and return volatility are related to both, market liquidity as well as foreign portfolio flows. Amihud (2002) and Bekaert et al. (2007) find evidence that liquidity is associated with stock returns whereas Griffin et al. (2004) and Griffin, Nardari and Stulz (2007) show that foreign portfolio flows are positively associated with local market returns. On the other hand, Chordia et al. (2000) show that liquidity generally deteriorates during volatile periods while Wang (2007) finds that foreign selling has the highest explanatory power for return volatility in the stock markets of Thailand and Indonesia. Given the relationships between market returns and return volatility with the key dependent variables in the first empirical analysis, this thesis therefore includes these two variables as additional endogenous variables in the VAR and re-estimate model (1).

3.6 Additional Analyses

The richness of the "Trading Participation by Category of Investors" dataset permits this thesis to conduct additional analyses that yield deeper insights into the relationship between foreign equity flows and aggregate liquidity. This section provides a brief discussion on the methodologies for these additional analyses.

3.6.1 Uncertainty, Flows and Liquidity

The study by Sarno, Tsiakas and Ulloa (2016) reports that over 80% of the variations in bond and equity flows into 55 countries are due to push factors from the U.S., the world's largest economy. Given that Malaysia is one of the sample countries in the above study, it therefore warrants an investigation of whether the authors' finding still holds in a single country framework. In exploring the push factors originating from the U.S. that are crucial in affecting international portfolio flows, Forbes and Warnock (2012) and Fratzscher (2012) find that the implied volatility of the Chicago Board Options Exchange (CBOE), more commonly known as VIX, has been frequently cited. This additional analysis also contributes to the literature given that the effects of VIX on foreign equity flows and market liquidity in Malaysia have not been explored. The daily VIX index, sourced from Refinitiv (Formerly Thomson Reuters) Datastream, is converted to weekly index by averaging daily VIX over a week. The causal relationship between VIX, gross foreign inflows and market liquidity in the Malaysian stock market is then examined in a VAR framework by including the weekly VIX index as an additional endogenous variable. The extended VAR model is expressed below:

$$Flow_t = c_{1t} + \sum_{i=1}^{p} a_{11}^{i} Flow_{t-i} + \sum_{i=1}^{p} a_{12}^{i} CPQS_{t-i} + \sum_{i=1}^{p} a_{13}^{i} VIX_{t-i} + b_{11} RET_t + b_{12} TO_t + b_{13} VOL_t + b_{14} SPREAD_t + b_{15} REER_t + b_{16} LMCAP_t + b_{17} RETREG_t + \varepsilon_{1t}$$

$$CPQS_t = c_{2t} + \sum_{i=1}^{p} a_{21}^{i} Flow_{t-i} + \sum_{i=1}^{p} a_{22}^{i} CPQS_{t-i} + \sum_{i=1}^{p} a_{23}^{i} VIX_{t-i} + b_{21} RET_t + b_{22} TO_t + b_{23} VOL_t + b_{24} SPREAD_t + b_{25} REER_t + b_{26} LMCAP_t + b_{27} RETREG_t + \varepsilon_{2t}$$

$$VIX_t = c_{3t} + \sum_{i=1}^{p} a_{31}^{i} Flow_{t-i} + \sum_{i=1}^{p} a_{32}^{i} CPQS_{t-i} + \sum_{i=1}^{p} a_{33}^{i} VIX_{t-i} + b_{31} RET_t + b_{32} TO_t + b_{33} VOL_t + b_{34} SPREAD_t + b_{35} REER_t + b_{36} LMCAP_t + b_{37} RETREG_t + \varepsilon_{3t} \quad (24)$$

where the gross inflows of foreign investors (*Flow*), the aggregate market liquidity of the Malaysian stock market (*CPQS*) computed following Chung and Zhang (2014) and the VIX index (*VIX*) are the endogenous variables in the VAR model. The same set of control variables are included, namely market returns (*RET*), market return volatility (*VOL*), market turnover ratio (*TO*), real effective exchange rate (*REER*) and natural logarithm of stock market capitalization (*LMCAP*), interest rate differential between Malaysia and the developed economies (*SPREAD*) and regional stock return (*RETREG*). Optimal lag length *p* is determined using the Akaike Information Criterion (AIC).

3.6.2 Destabilizing impact of foreign investors' participation

Foreign portfolio flows are sometimes termed "hot money" as investors can easily repatriate their funds when the destination country no longer offers attractive yields to their investments. Malaysia is not spared from such reversals of foreign funds as evidenced by the huge outflows of funds following the taper tantrum. Given the economy's susceptibility to such volatile portfolio flows, this thesis thus examines whether gross inflows of foreign investors have a destabilizing effect on the Malaysian stock market through their adverse impact on liquidity. In the extant literature, the topic of whether foreign investors destabilize the capital markets has also been examined but in different contexts through stock volatility (Han et al., 2015), stock returns (Choe et al., 1999) and trading behavior (Kim & Wei, 2002).

Following Vagias and van Dijk (2012), this thesis examines the destabilizing effect of foreign investors' gross inflows by defining liquidity crisis (*CRISIS*) as incidence where the *CPQS* is at the top 70th percentile of the distribution, as defined in Section 3.4.8. The adverse effect on market liquidity, if any, during liquidity crisis periods is then examined by estimating the following equation:

$$\Delta CPQS_t = c + \beta_1 \Delta Flow_t + \beta_2\, CRISIS_t + \beta_3\, \Delta Flow_t \times CRISIS_t + \theta_i \sum_{i=1}^{p} \Delta CPQS_{t-i}$$

$$+\beta_4\, \Delta RET_t + \beta_5\, \Delta VOL_t + \beta_6\, \Delta TO_t + \beta_7\, \Delta SPREAD_t + \beta_8\, \Delta REER_t \qquad (25)$$

$$+\beta_9\, \Delta LMCAP_t + \beta_{10}\, \Delta RETREG_t + \varepsilon_t$$

where $CRISIS_t$ is the dummy variable that assumes the value of one when *CPQS* is equal to or above the 70th percentile on week *t* and zero otherwise. Equation (25) is specified in first difference as it is less likely to generate spurious relations than regression using level variables (see Chung et al., 2010; Chung & Zhang, 2011). To control for persistence in the dependent variable, four lags of the first-differenced *CPQS* are initially included in the equation and lagged terms that are insignificant at the 10% level are eliminated. In case the lagged dependent variable is insufficient in addressing autocorrelation problem, Huber-White standard errors will be estimated. If the model suffers from both heteroskedasticity and autocorrelation, standard errors are corrected using Newey and West (1987) Heteroskedasticity- and Autocorrelation-Consistent (HAC) estimator. The destabilizing impact of gross inflows during liquidity crisis weeks is then investigated by testing the null hypothesis of $\beta_3 = 0$. If the null is rejected, it indicates that gross inflows have a destabilizing impact on the Malaysian stock market.

3.6.3 Liquidity Role of Local Investors

Given that the "Trading Participation by Category of Investors" dataset also provides data of local investors' trades, it is therefore of interest to examine the liquidity role of local investors in the Malaysian stock market. As trades can only take place when liquidity demand from a party is met by liquidity supplied by another party, examining the liquidity role of local investors helps to provide credence to our baseline results if their role is found to be opposite of foreign investors. In the dataset, local investors are disaggregated into institutions, retails, nominees and proprietary day traders (PDTs). The net purchases of local equities, calculated as purchases minus sales, by these investors are then denoted as *LTNET* for all local investors, *LINET* for local institutions, *LRNET* for local retail investors, *LNNET* for local nominees and lastly, *LPDTNET* for local proprietary day traders. The liquidity effect of local investors' trades is then examined using the same VAR specification as model (1) but substituting gross inflows of foreign investors with net purchase of local investors:

$$LOCAL_t = c_{1t} + \sum_{i=1}^{p} a_{11}^{i} LOCAL_{t-i} + \sum_{i=1}^{p} a_{12}^{i} CPQS_{t-i} + b_{11}RET_t + b_{12}TO_t + b_{13}VOL_t + b_{14}SPREAD_t + b_{15}REER_t + b_{16}LMCAP_t + b_{17}RETREG_t + \varepsilon_{1t}$$

$$CPQS_t = c_{2t} + \sum_{i=1}^{p} a_{21}^{i} LOCAL_{t-i} + \sum_{i=1}^{p} a_{22}^{i} CPQS_{t-i} + b_{21}RET_t + b_{22}TO_t + b_{23}VOL_t + b_{24}SPREAD_t + b_{25}REER_t + b_{26}LMCAP_t + b_{27}RETREG_t + \varepsilon_{2t} \qquad (26)$$

where *LOCAL* denotes the net purchase of local investors, proxied by *LTNET* (total local investors), *LINET* (local institutions), *LRNET* (local retail investors), *LNNET* (local nominees) and *LPDTNET* (local proprietary day traders), each entering the model separately. *CPQS* is the aggregate liquidity proxy for the Malaysian stock market computed following Chung and Zhang (2014), *RET* is the aggregate market returns, *VOL* is the market return volatility, *TO* is the market turnover ratio, *REER* is the real effective exchange rate, *LMCAP* denotes the natural logarithm of stock market capitalization, *SPREAD* is the interest rate differential between Malaysia and the developed economies and lastly, *RETREG* is the regional stock return. Optimal lag length p is determined using the Akaike Information Criterion (AIC).

3.7 Summary of the Chapter

This chapter briefly discusses the theories and methodologies employed to answer the three research questions formulated in Chapter 1. First, motivated by the frequent outflows of foreign funds since the taper tantrum and the ambiguous theoretical predictions and empirical evidence, Chapter 4 empirically examines the effect of gross foreign equity inflows on the aggregate liquidity of the Malaysian stock market. Second, motivated by the dearth of studies on the effect of proprietary day trading on stock market liquidity, Chapter 5 investigates the relationship between trading activities of PDTs and aggregate liquidity of the Malaysian stock market. Lastly, Chapter 6 computes and analyzes the spillovers among the four main asset markets in Malaysia, namely stock, bond, money and foreign exchange markets.

Methodologically, the baseline model (1) for the first research question is estimated using VAR with lags adjusted to eliminate autocorrelation problem. Models (2), (3) and (4) for the second research question are estimated using GARCH due to the observations that daily liquidity, liquidity volatility and liquidity skewness have non-constant variance. Lastly, the spillover indices for stock, bond, money and foreign exchange markets in Malaysia are calculated by adopting the TVP-VAR connectedness approach introduced by Antonakakis et al. (2020). Key dependent variables and control variables employed for addressing the first two research questions are discussed thoroughly in Section 3.3 and Section 3.4, respectively. This thesis uses all firms listed in the Malaysian stock exchange, Bursa Malaysia, dead or alive to compute the aggregate liquidity, returns, turnover and market capitalization to avoid survivorship bias. All variables are winsorized at the 1st and 99th percentiles to reduce the influence of outliers, with the exception of all liquidity series employed in the third empirical Chapter 6 so as to capture any surge or dip in connectedness due to extreme events. All data used in this thesis are sourced from Bursa Malaysia, Refinitiv (formerly Thomson Reuters) Datastream and Bond Info Hub Malaysia.

In the empirical analysis for the first research question, a series of robustness checks and additional analyses are conducted. The former, discussed in Section 3.5, is to ensure the reliability of results obtained from the baseline model (1). Section 3.6 then provides a brief discussion on the methodologies for the additional analyses, which aim to yield deeper insights into the relationship between foreign equity flows and aggregate liquidity.

CHAPTER 4

FOREIGN EQUITY FLOWS AND AGGREGATE STOCK MARKET LIQUIDITY

This chapter presents and discusses the empirical results for the first research question of this thesis, that is, to examine the impact of foreign investors' trades, measured by gross foreign equity inflows, on the aggregate liquidity of the Malaysian stock market. Section 4.1 presents graphical plots and brief descriptions of key variables. Section 4.2 provides descriptive statistics for the dependent variable of Closing Percent Quoted Spread (*CPQS*), key independent variable of gross foreign equity flows which is examined at both aggregate (total) and disaggregate (foreign institutions and foreign retail investors) levels, as well as seven other control variables. Results of the unit root tests to examine the stationarity of all variables are presented in Section 4.3. Section 4.4 then discusses the empirical results for the baseline foreign equity flows-aggregate liquidity model with Vector Autoregression (VAR) and Granger causality as the main estimation methods. A series of robustness checks, which include incorporating structural breaks in main variables, constructing alternative liquidity indicators (*CPQS* Impact and Amihud illiquidity ratio), employing alternative weighting scheme to compute aggregate liquidity indicators for large and small stocks, using bootstrap Wald test to establish causation and lastly expanding the list of endogenous variables, are then performed and reported in Section 4.5. Section 4.6 conducts further analyses to explore how global uncertainty affects the causal relationship between foreign equity flows and aggregate liquidity in the Malaysian stock market, to assess whether the participation of foreign investors destabilizes the Malaysian stock market, and to establish the causal relationship between local investors' trades and aggregate liquidity in the local bourse. The last section provides a summary of the key findings in this first empirical chapter.

4.1 The Data

The sample period spans from October 2009 to December 2016, yielding 379 observations at weekly interval for each variable. The starting date is dictated by the availability of foreign trade data in the newly assembled database of "Trading Participation by Category of Investors", subscribed from the Malaysian stock exchange.

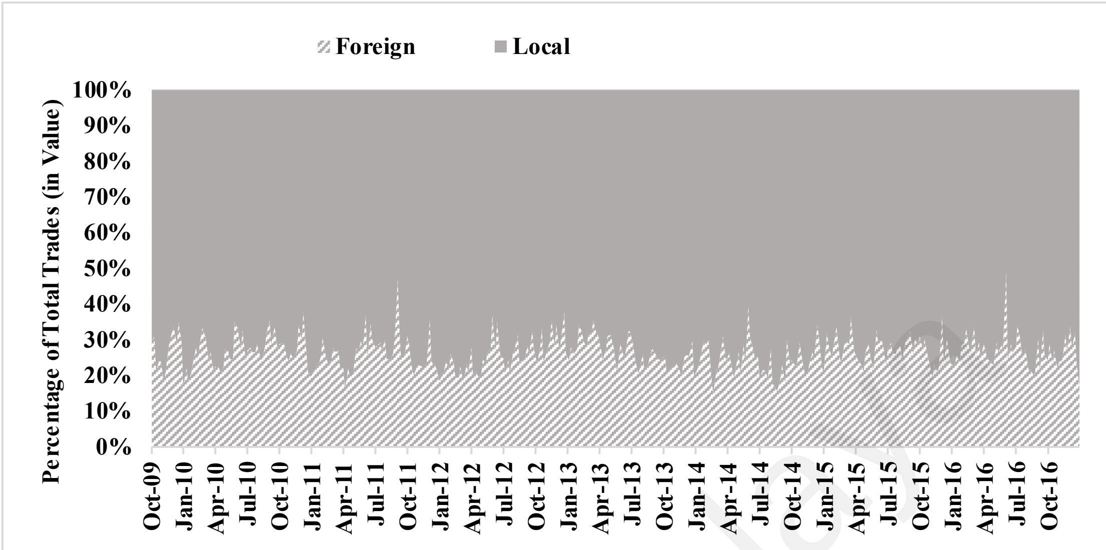
Panel A of Figure 4.1 plots the proportion of trades by foreign and local investors as a percentage of total trades in Bursa Malaysia over the sample period, while Panel B charts the cumulative net purchases of local equities by disaggregated categories of foreign and local investors.[18] From Panel A, it is observed that foreign participation in the local market was fairly consistent, averaging 26.27% over the seven-year sample period. Foreign investors were least active in year 2014, with the proportion of trades in value term averaging only 24.19% of total trades in Bursa Malaysia vis-à-vis 27.15% in year 2015 when they were most active. Nevertheless, activities in 2015 were driven mainly by the sell-off of Malaysian equities following the taper tantrum.

Panel B shows that foreign institutions had been actively accumulating their holdings of Malaysian equities since October 2009 with cumulative gross inflows peaked at MYR48.8 billion in the week ended 23rd May 2013. However, such trend was reversed thereafter following the taper tantrum. Other observations include the almost perfectly opposite trend of foreign and local institutions' net purchases of local equities, and gradual but consistent sell-off of local equities by local nominees and local retail investors over the sample period.

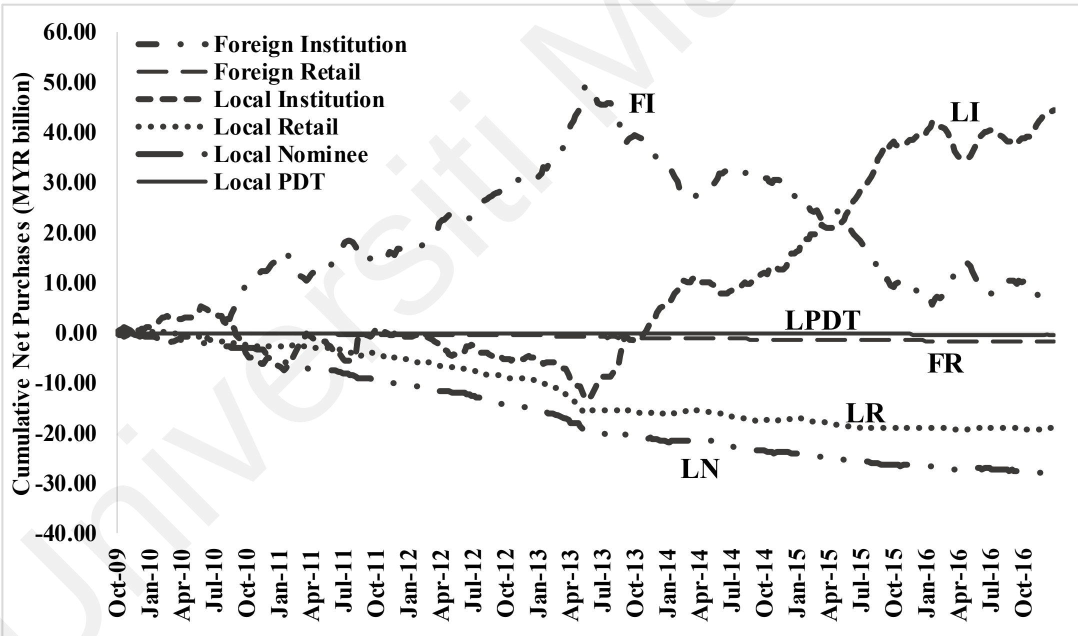
[18] Net purchase is calculated as the gross purchase of local equities minus gross sale of local equities by a specific group of investors.

Figure 4.1: Foreign Trading in the Malaysian Stock Market (October 2009 to December 2016)

Panel A: Proportion of Trades



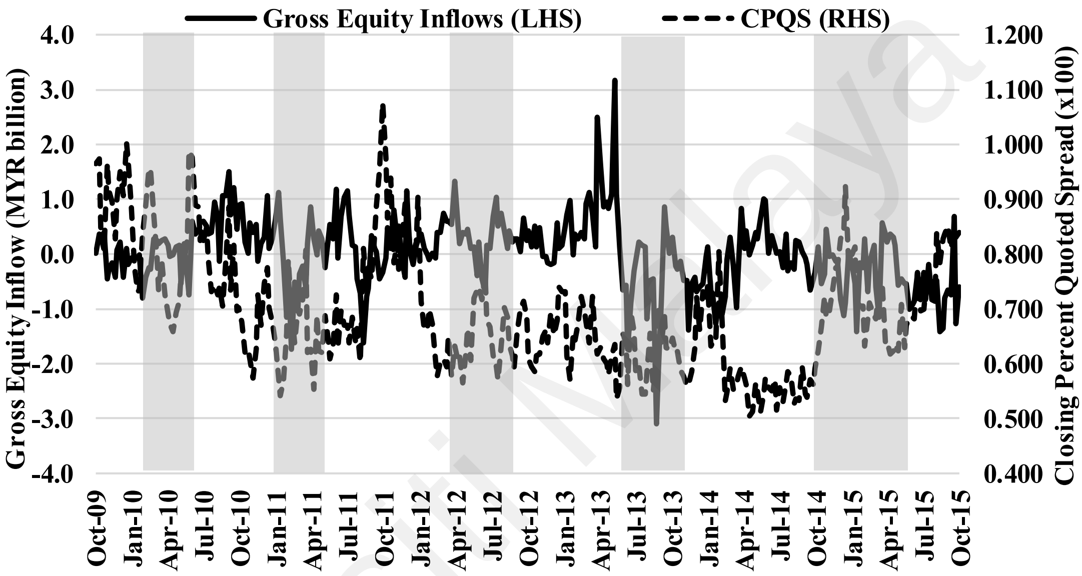
Panel B: Cumulative Net Purchases of Local Equities



Notes: In Panel A, the proportions of trades for foreign and local investors are calculated as their respective dollar trading volume for the week divided by the total dollar trading volume of the Malaysian stock market in the same week. In Panel B, net purchase is calculated as gross purchase of local equities minus gross sale of local equities by a specific group of investors. Net purchases are cumulated since the week ended 2nd October 2009.

Figure 4.2 maps weekly gross inflows on the left-hand side and *CPQS* on the right-hand side. It can be seen that *CPQS* generally increases following net sales of local equities by foreign investors, as depicted by the shaded areas. Motivated by this observation, this thesis hypothesizes that liquidity in the Malaysian stock market is directly affected by the trading activities of foreign investors, vis-à-vis the null hypothesis that trading activities of foreign investors have no impact on the aggregate liquidity of Bursa Malaysia.

Figure 4.2: Weekly Gross Equity Inflows and Aggregate Market Liquidity (October 2009 to December 2016)



Notes: Gross equity inflow is calculated as gross foreign purchase minus gross foreign sale of local equities. *CPQS* is the aggregate Closing Percent Quoted Spread of each stock weighted by its market capitalization.

4.2 Descriptive Statistics

Table 4.1 provides the descriptive statistics of all the variables used in this first empirical chapter. Foreign investors, as a whole, were net buyers of Malaysian stocks with an average gross inflow of MYR8.2 million. This positive gross inflow was mainly contributed by foreign institutions, whose net purchases averaged MYR13.1 million. Their largest weekly net sale of MYR3.1 billion occurred in the week ending 23rd August 2013 whereas the largest gross inflow that amounted to MYR3.2 billion took place in the week ended 10th May 2013. Foreign retail investors, on the other hand, sold an average of MYR4.9 million of local shares over the same period. Their gross inflows peaked at

MYR26.1 million in the week ended 11th February 2011 while the largest net sale of MYR67.2 million occurred in the week ended 10th May 2013, contrasting that of foreign institutions' trades. The week ended 10th May 2013 is the week after the 13th General Election held on 5th May 2013, which also witnessed the FTSE Bursa Malaysia Kuala Lumpur Composite Index (FBM KLCI) soaring to its all-time-high of 1,776.73 points on 7th May 2013. Therefore, the gross inflows of foreign institutions can be construed as a sign of increased confidence following the victory of the incumbent Barisan Nasional. The net selling by foreign retailers, on the other hand, is likely due to profit-taking.

Table 4.1: Descriptive Statistics

	Mean	Median	Maximum	Minimum	Std. Dev
Gross Inflows (MYR billion)					
Foreign Aggregate	0.0082	0.0501	3.1681	-3.0959	0.6657
Foreign Institutions	0.0131	0.0629	3.2353	-3.1134	0.6697
Foreign Retailers	-0.0048	-0.0048	0.0261	-0.0672	0.0090
CPQS	0.0070	0.0068	0.0108	0.0050	0.0010
RET	0.1877	0.2891	4.1560	-7.0011	1.3563
TO	1.3051	1.2374	4.0446	0.5895	0.3406
VOL	2.0534	1.4434	19.7895	0.5491	1.9169
SPREAD	2.6843	2.7809	3.2601	1.6733	0.3730
REER	96.5116	98.5086	104.8552	81.7963	5.3457
MCAP (MYR billion)	1474.33	1532.40	1776.75	926.90	230.80
RETREG	0.0575	0.1711	11.2821	-9.9506	2.4581

Notes: *CPQS* is the aggregate Closing Percent Quoted Spread of each stock weighted by its market capitalization. *RET*, *VOL* and *TO* are the aggregate market returns, EGARCH(1,1) return volatility and turnover ratio of all stocks in Bursa Malaysia weighted by their respective market capitalization. *SPREAD* denotes the interest rate differential between the Malaysia Band 4 (68 to 91 days to maturity) Treasury-Bill and average short-term interest rate of the G7 countries. *REER* is the Malaysia real effective exchange rate based on Consumer Price Index (2010=100) compiled by JPMorgan. *MCAP* is the aggregate weekly market capitalization. *RETREG* is the regional stock return.

Looking at other variables, *CPQS* averaged 0.0070 during the sample period with a standard deviation of 0.0010. This figure is of magnitude comparable to that of Fong et al. (2017).[19] Trading activity in the local bourse has an average turnover of 1.3051 times.

[19] Fong et al. (2017) report a mean *CPQS* of 0.025 for Malaysian stocks over the sample period from January 1996 to December 2007. The higher liquidity in this thesis is reasonable as it coincides with the aggressive unconventional monetary policy easing by major central banks in developed countries.

The Malaysian stock market recorded an average return of 0.1877% with standard deviation averaging 1.3563%. Short-term interest rate differential between Malaysia and G7 was rather high at 2.6843% per annum, providing explanation to the inflows of foreign funds in search of higher yields. Although foreign investors were net buyers of local stocks, the higher demand for the local currency did not lead to its appreciation. The *REER* remained weak during the sample period. This could be attributed to the sharp deterioration of the Malaysian ringgit seen in most parts of 2015 and 2016 in response to bleaker economic growth prospect, weaker investor sentiment and benign global oil prices. The total market capitalization averaged MYR1,474.33 billion during the sample period. Lastly, market returns in the Asian region excluding Japan recorded a mean of only 0.0575%, less than one third of Bursa Malaysia's average return for the same period.

4.3 Unit Root Tests

The unit root testing is performed to determine stationarity of all the variables in the baseline model (1). Three categories of gross inflows are examined, i.e., gross inflows of total foreign investors (*FTFLOW*), foreign institutions (*FIFLOW*) and foreign retail investors (*FRFLOW*). As presented in Table 4.2, results from both unit root tests are consistent, showing that except for *SPREAD, REER* and *LMCAP*, all other variables are stationary at level. Thus, the VARs are estimated with gross inflows (*FTFLOW, FIFLOW* and *FRFLOW*), *CPQS, RET, VOL, TO* and *RETREG* in level form and *SPREAD, REER* and *LMCAP* in first difference.

Table 4.2: Unit Root Tests Results

Variables	Dickey-Fuller GLS	Ng-Perron				I(d)
		MZa	MZt	MSB	MPT	
FTFLOW	-7.7807***	-96.4738***	-6.9449***	0.0720***	0.9460***	I(0)
FIFLOW	-7.7863***	-96.5533***	-6.9478***	0.0720***	0.9451***	I(0)
FRFLOW	-15.3811***	-179.1120***	-9.4619***	0.0528***	0.5133***	I(0)
CPQS	-3.1879**	-20.3069**	-3.1028**	0.1528**	5.0042**	I(0)
RET	-16.2725***	-183.2270***	-9.5698***	0.0522***	0.5024***	I(0)
VOL	-8.1670***	-96.5422***	-6.9448***	0.0719***	0.9553***	I(0)
TO	-3.7965***	-20.7843**	-3.1963**	0.1538**	4.5545**	I(0)
SPREAD	-0.9214	-2.4787	-0.9341	0.3768	30.1619	
ΔSPREAD	-14.5406***	-258.3810***	-11.3646***	0.0440***	0.3567***	I(1)
REER	-1.2121	-3.7484	-1.2195	0.3253	22.2767	
ΔREER	-13.2567***	-163.7130***	-9.0433***	0.0552***	0.5695***	I(1)
LMCAP	-1.0389	-3.0546	-1.0304	0.3373	25.1457	
ΔLMCAP	-19.4273***	-188.4990***	-9.7058***	0.0515***	0.4903***	I(1)
RETREG	-18.7412***	-188.7640***	-9.7138***	0.0515***	0.4864***	I(0)

Notes: *FTFLOW*, *FIFLOW* and *FRFLOW* denote the gross inflows of total foreign investors, foreign institutions and foreign retail investors, respectively. *CPQS* is the aggregate Closing Percent Quoted Spread of each stock weighted by its market capitalization. *RET*, *VOL* and *TO* are the aggregate market returns, EGARCH(1,1) return volatility and turnover ratio of all stocks in Bursa Malaysia weighted by their respective market capitalization. *SPREAD* denotes the interest rate differential between the Malaysia Band 4 (68 to 91 days to maturity) Treasury-Bill and average short-term interest rate of the G7 countries. *REER* is the Malaysia real effective exchange rate based on Consumer Price Index (2010=100) compiled by JPMorgan. *MCAP* is the aggregate weekly market capitalization. *RETREG* is the regional stock return. Δ denotes first-difference.
The Dickey-Fuller GLS and Ng and Perron (2001) equations are estimated by including a constant and trend with optimal lag length selected based on the Schwarz Information Criterion (SIC).
***, ** and * denote significance at the 1%, 5% and 10% levels, respectively for rejecting the null hypothesis of a unit root.

4.4 Foreign Equity Flows and Aggregate Stock Liquidity

The key objective of this chapter is to examine the liquidity effect of foreign investors' equity flows on the aggregate liquidity of the Malaysian stock market. As outlined in Chapter 3, this section reproduces the baseline Vector Autoregression (VAR) model (1) expressed as follows:

$$Flow_t = c_{1t} + \sum_{i=1}^{p} a_{11}^{i} Flow_{t-i} + \sum_{i=1}^{p} a_{12}^{i} CPQS_{t-i} + b_{11}RET_t + b_{12}TO_t + b_{13}VOL_t + b_{14}SPREAD_t + b_{15}REER_t + b_{16}LMCAP_t + b_{17}RETREG_t + \varepsilon_{1t}$$

$$CPQS_t = c_{2t} + \sum_{i=1}^{p} a_{21}^{i} Flow_{t-i} + \sum_{i=1}^{p} a_{22}^{i} CPQS_{t-i} + b_{21}RET_t + b_{22}TO_t + b_{23}VOL_t + b_{24}SPREAD_t + b_{25}REER_t + b_{26}LMCAP_t + b_{27}RETREG_t + \varepsilon_{2t} \quad (1)$$

where the gross inflows of foreign investors (*Flow*) and the aggregate market liquidity (*CPQS*) are the endogenous variables in the VAR model. Seven exogenous variables are included, namely market returns (*RET*), market turnover ratio (*TO*), market return volatility (*VOL*), interest rate differential (*SPREAD*), real effective exchange rate (*REER*), natural logarithm of stock market capitalization (*LMCAP*) and regional stock return (*RETREG*). Based on the unit root test results tabulated in Table 4.2, all forms of foreign gross equity inflows (*FTFLOW, FIFLOW* and *FRFLOW*), *CPQS, RET, VOL, TO* and *RETREG* enter the model at level while *SPREAD, REER* and *LMCAP* enter the model in first difference.

Results of the VAR estimations are presented in Table 4.3. Using the Akaike Information Criterion (AIC) and elimination of autocorrelation in the residuals to guide the selection of lag length, the baseline models for aggregate foreign gross inflows (*FTFLOW*) and gross inflows of foreign institutions (*FIFLOW*) are estimated with two lags. On the other hand, five lags are used for the model with foreign retail investors' gross inflows as one of the endogenous variables. The VAR results show that the estimated coefficients of the variables in the model for total foreign investors and that of foreign institutions are of comparable magnitude. This observation can be explained by the high proportion of foreign institutions' gross inflows which account for approximately 98% of total gross inflows. As the main objective of a VAR model is to draw inferences from subsequent Granger non-causality test, impulse response function (IRF) and forecast error variance decomposition (FEVD), this thesis does not attempt to interpret the estimated coefficients reported in Table 4.3.

Table 4.3: Results of Baseline VAR Model

	Foreign Aggregate		Foreign Institutions		Foreign Retailers	
	Flow Equation	Liquidity Equation	Flow Equation	Liquidity Equation	Flow Equation	Liquidity Equation
Constant	-0.0489	0.0913***	-0.0473	0.0914***	-0.0054	0.0953***
	(0.1852)	(0.0206)	(0.1860)	(0.0206)	(0.0034)	(0.0225)
$Flow_{t-1}$	0.4438***	-0.0134**	0.4422***	-0.0134**	0.0780*	0.8806***
	(0.0473)	(0.0053)	(0.0472)	(0.0052)	(0.0460)	(0.3097)
$Flow_{t-2}$	0.1370***	0.0073	0.1371***	0.0072	0.0689	0.4698
	(0.0455)	(0.0051)	(0.0454)	(0.0050)	(0.0454)	(0.3058)
$Flow_{t-3}$					0.0874**	-0.2008
					(0.0439)	(0.2955)
$Flow_{t-4}$					0.0219	-0.3776
					(0.0450)	(0.3025)
$Flow_{t-5}$					0.0016	0.1137
					(0.0437)	(0.2942)
$CPQS_{t-1}$	-0.1555	0.6154***	-0.1515	0.6151***	0.0112	0.5527***
	(0.4438)	(0.0494)	(0.4456)	(0.0494)	(0.0076)	(0.0511)
$CPQS_{t-2}$	0.1342	0.2503***	0.1277	0.2506***	0.0063	0.2380***
	(0.4299)	(0.0478)	(0.4315)	(0.0478)	(0.0087)	(0.0583)
$CPQS_{t-3}$					-0.0193**	-0.0111
					(0.0085)	(0.0573)
$CPQS_{t-4}$					-0.0007	0.0598
					(0.0084)	(0.0568)
$CPQS_{t-5}$					0.0050	0.0250
					(0.0069)	(0.0464)
RET	0.1943***	-0.0137***	0.1986***	-0.0137***	-0.0039***	-0.0141***
	(0.0290)	(0.0032)	(0.0291)	(0.0032)	(0.0005)	(0.0032)
TO	0.0341	-0.0022	0.0354	-0.0022	0.0006	-0.0030
	(0.0669)	(0.0074)	(0.0671)	(0.0074)	(0.0011)	(0.0077)
VOL	-0.0033	0.0036**	-0.0033	0.0036**	-0.00001	0.0043***
	(0.0149)	(0.0017)	(0.0150)	(0.0017)	(0.0002)	(0.0015)
ΔSPREAD	0.9842*	-0.0478	0.9883*	-0.0480	-0.0048	-0.0426
	(0.5866)	(0.0653)	(0.5890)	(0.0653)	(0.0095)	(0.0640)
ΔREER	0.1691***	0.0062	0.1712***	0.0062	-0.0017***	0.0062
	(0.0382)	(0.0043)	(0.0383)	(0.0043)	(0.0006)	(0.0042)
ΔLMCAP	-7.0818***	-0.3487	-7.2291***	-0.3467	0.0862**	-0.3829
	(2.3445)	(0.2608)	(2.3552)	(0.2609)	(0.0372)	(0.2502)
RETREG	0.0250**	-0.0020	0.0245*	-0.0020	0.0006***	-0.0016
	(0.0127)	(0.0014)	(0.0127)	(0.0014)	(0.0002)	(0.0014)

Notes: *FTFLOW*, *FIFLOW* and *FRFLOW* denote the gross inflows of total foreign investors, foreign institutions and foreign retail investors, respectively. *CPQS* is the aggregate Closing Percent Quoted Spread of each stock weighted by its market capitalization. *RET*, *VOL* and *TO* are the aggregate market returns, EGARCH(1,1) return volatility and turnover ratio of all stocks in Bursa Malaysia weighted by their respective market capitalization. *SPREAD* denotes the interest rate differential between the Malaysia Band 4 (68 to 91 days to maturity) Treasury-Bill and average short-term interest rate of the G7 countries. *REER* is the Malaysia real effective exchange rate based on Consumer Price Index (2010=100) compiled by JPMorgan. *MCAP* is the aggregate weekly market capitalization. *RETREG* is the regional stock return. Δ denotes first-difference. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

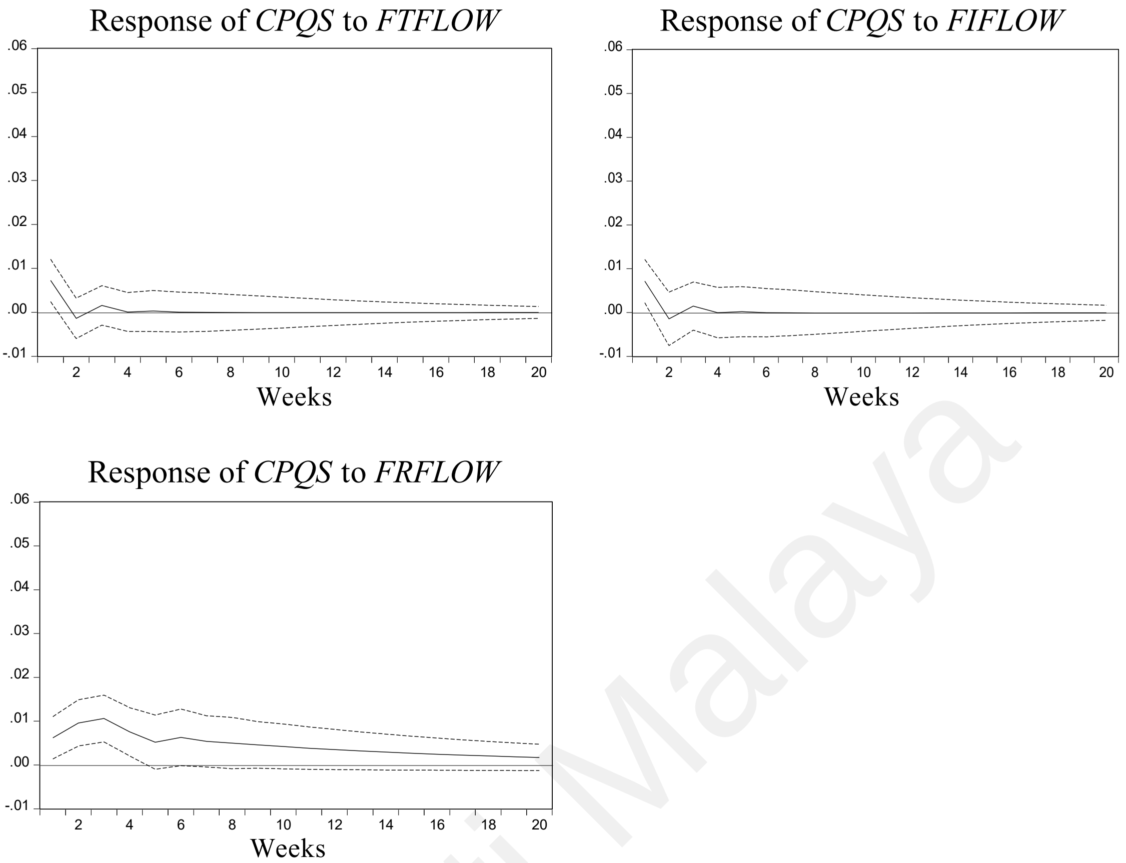
After estimating the VARs, Granger non-causality test is performed on the endogenous variables. Results of the Granger non-causality test, tabulated in Table 4.4, show a unidirectional relationship flowing from total gross inflows to aggregate liquidity of the Malaysian stock market, thus ruling out the usual reverse causality concern that foreigners are inclined to trade in liquid stocks. At the granular level, this causal relationship is manifested in both the gross inflows of foreign institutions and foreign retail investors. Given the dearth of research on the liquidity of Bursa Malaysia, this thesis compares the findings to the sole study by Lim et al. (2017) who examine the association between corporate ownership of various investor groups and firm-level liquidity. These authors find that foreign shareholdings are only significantly associated with liquidity through the nominee accounts, where most of the beneficial owners are foreign institutions. In this respect, the results obtained contradict Lim et al. (2017) who report an insignificant liquidity role for foreign retail investors, which can be attributed to the use of trading data at higher weekly frequency versus the authors' compilation of annual shareholdings.

Table 4.4: Granger Non-Causality Test Results

Null Hypotheses	χ^2-Statistics	*p*-value	Lag Order	Remarks
Foreign Aggregate				
CPQS does not Granger cause *FTFLOW*	0.1242	0.9398	2	—
FTFLOW does not Granger cause *CPQS*	6.4851	0.0391	2	*FTFLOW* → *CPQS*
Foreign Institutions				
CPQS does not Granger cause *FIFLOW*	0.1161	0.9436	2	—
FIFLOW does not Granger cause *CPQS*	6.5646	0.0375	2	*FIFLOW* → *CPQS*
Foreign Retailers				
CPQS does not Granger cause *FRFLOW*	7.6521	0.1765	5	—
FRFLOW does not Granger cause *CPQS*	13.1231	0.0223	5	*FRFLOW* → *CPQS*

Notes: *FTFLOW*, *FIFLOW* and *FRFLOW* denote the gross inflows of total foreign investors, foreign institutions and foreign retail investors, respectively. *CPQS* is the aggregate Closing Percent Quoted Spread of each stock weighted by its market capitalization.
→ is interpreted as "Granger-causes". — indicates insignificant Granger causation from the first variable to second variable.

Figure 4.3: Generalized Impulse Response Functions



Notes: Dotted lines represent the 95% confidence interval. *FTFLOW*, *FIFLOW* and *FRFLOW* denote the gross inflows of total foreign investors, foreign institution and foreign retail investors, respectively. *CPQS* is the aggregate Closing Percent Quoted Spread of each stock weighted by its market capitalization.

The Generalized Impulse Response Functions (GIRs) in Figure 4.3 show the impact of gross inflows on aggregate stock liquidity. It is observed that *CPQS* responds positively to a one standard deviation positive shock in the errors of gross inflows, at both aggregate and disaggregate levels. An increase in *CPQS* in response to positive innovations in gross inflows implies that foreign investors' gross inflows reduce aggregate liquidity, indicating their participation in the Malaysian stock market is liquidity consuming. While both foreign institutions and retail investors' gross inflows affect local market liquidity, the negative liquidity impact imposed by the former is rather short-lived with GIRs statistically significant only in the first week. On the contrary, the effect of foreign retail investors' gross inflows on the liquidity of Bursa Malaysia persists for four weeks. Nevertheless, this prolonged effect should not raise any concern as gross inflows of foreign retailers only account for 2% of total gross inflows.

Inferring from the two strands of theoretical models, namely the asymmetric information model (Easley & O'Hara, 1987; Glosten & Milgrom, 1985; Kyle, 1985) and the noise trading model of Admati and Pfleiderer (1988), the findings of this thesis are aligned with the former which predicts a negative relationship between foreign trading and liquidity. According to the asymmetric information model, bid-ask spreads widen when privately informed investors capitalize and trade on their superior information, thus driving up adverse selection costs. Given the liquidity reduction effect of foreign trading, this thesis thus infers that foreign institutions and foreign retail investors are informed traders whose informed trading reduces the aggregate liquidity of the Malaysian stock market. The theoretical model suggests that such information advantage is obtained through privileged access to private firm-specific information, which is possible when foreign shareholdings become substantially large. For instance, existing empirical evidence shows that foreign blockholders with large shareholdings reduce liquidity because they have privileged access to private information and thus exacerbate information asymmetry (He, Li, Shen, & Zhang, 2013; Ng et al., 2016). Recent studies, however, show that information advantage can also be derived from the skilled analysis of systematic market-wide factors (Bardong, Bartram, & Yadav, 2009; Engelberg, Reed, & Ringgenberg, 2012). Indeed, Lim, Hooy, Chang and Brooks (2016) report such evidence for the Malaysian stock market as foreigners are found to possess superior skills in processing public news.

The results shown thus far contradict the findings of Vagias and van Dijk (2012) who perform a multi-country analysis, Malaysia included, on the interaction between international capital flows and aggregate liquidity. In their VAR models for six different regions, these authors discover that capital flows from the U.S. to emerging Asian markets improve local aggregate liquidity, which lead them to conclude that foreign investors are noise traders who supply liquidity to these developing countries. Instead, the findings of this thesis are more in line with that of Agudelo (2010) who examines the effect of foreign trading on local market-wide liquidity in six Asian markets – India, Indonesia, the Philippines, South Korea, Taiwan and Thailand. The author finds that foreign investors exert negative pressure on aggregate liquidity and thus are aggressive liquidity demanders though this harmful effect is short-lived. Returning to the Malaysian stock market, it is observed from Figure 4.3 that the negative effect of gross inflows on aggregate liquidity is no longer statistically significant after one week for foreign institutions and four weeks for foreign retail investors.

4.5 Robustness Checks

In this section, a series of robustness checks are performed to ensure the reliability of the baseline results obtained in the previous Section 4.4.

4.5.1 Incorporating Structural Breaks

Figure 4.2 suggests that the time series of gross inflows might be subject to structural break in mid-2013 while the *CPQS* time series exhibits signs of structural breaks at various points in the sample period. Therefore, this thesis formally tests for the presence of structural breaks using the well-known Bai and Perron (1998) test. According to Perron (2006), the double maximum test, arguably the most useful test in verifying the presence of structural changes, should be performed first. The structural break results are presented in Panel A of Table 4.5. As *FTFLOW* bears close resemblance to *FIFLOW,* they share the same number of structural breaks and break dates in the weeks ended 6th July 2012 and 31st May 2013. On the other hand, there are a total of four breaks in the *CPQS* series. Estimation results of Equations (21) and (22), shown in Panel B, indicate that the earlier baseline findings of unidirectional Granger causality from *FTFLOW, FIFLOW* and *FRFLOW* to *CPQS* are robust even after taking structural breaks into account.

Table 4.5: Robustness Check by Incorporating the Presence of Structural Breaks

Panel A: Bai and Perron (1998) Structural Break Tests

	Bai-Perron Double Maximum Test		Bai-Perron Test of $l+1$ vs. l Globally Determined Breaks	
	UD Max	WD Max	Breaks	Week Ended
FTFLOW	1	1	2	17/2/2012; 31/5/2013
FIFLOW	1	1	2	17/2/2012; 31/5/2013
FRFLOW	0	0	–	–
CPQS	2	5	4	29/10/2010; 13/1/2012; 29/3/2013; 17/10/2014

Panel B: OLS with Structural Break Dummies

Null Hypotheses	**χ^2-Statistics**	***p*-value**	**Lag Order**	**Remarks**
Foreign Aggregate				
CPQS does not Granger cause *FTFLOW*	0.7048	0.7030	2	—
FTFLOW does not Granger cause *CPQS*	6.7056	0.0350	2	*FTFLOW* → *CPQS*
Foreign Institutions				
CPQS does not Granger cause *FIFLOW*	0.7950	0.6720	2	—
FIFLOW does not Granger cause *CPQS*	6.8045	0.0333	2	*FIFLOW* → *CPQS*
Foreign Retailers				
CPQS does not Granger cause *FRFLOW*	7.6521	0.1765	5	—
FRFLOW does not Granger cause *CPQS*	15.8663	0.0072	5	*FRFLOW* → *CPQS*

Notes: *UD* denotes the equally-weighted *F*-statistics in the double maximum test while *WD* denotes the *F*-statistics whose weights depend on the degree of freedom and the significance level of the test. Break dates provided in the table are expressed as dd/mm/yyyy. *CPQS* is the aggregate Closing Percent Quoted Spread of each stock weighted by its market capitalization. *FTFLOW*, *FIFLOW* and *FRFLOW* denote the gross inflows of total foreign investors, foreign institutions and foreign retail investors, respectively.

The joint significance of the lag terms for gross inflows and *CPQS* in the respective liquidity and flow equations are tested by performing Wald tests on the estimated OLS equations with aggregate market returns, return volatility, market turnover, interest rate differential, currency, market capitalization and regional stock return as control variables. For flow equation, structural break dummies for *FTFLOW* and *FIFLOW* are included as exogenous variables. For liquidity equation, structural break dummies for breaks in liquidity time series are included as exogenous variables. Lag length is selected based on the Akaike Information Criterion (AIC). Robust standard errors are calculated using the Huber-White method should the model suffers autocorrelation and Newey and West (1987) Heteroskedasticity- and Autocorrelation-consistent (HAC) estimator is employed if the model suffers both autocorrelation and heteroskedasticity.

→ is interpreted as "Granger-causes". — indicates insignificant Granger causation from the first variable to second variable.

4.5.2 Alternative Liquidity Indicators

Low-frequency liquidity proxies are generally classified into percent-cost and cost-per-volume. The *CPQS* is a representative from the percent-cost universe. Due to the multifaceted nature of liquidity, the baseline VAR models are re-estimated with two alternative liquidity measures from the cost-per-volume category, namely *CPQS* Impact (*CPQSIM*) and Amihud (2002) illiquidity ratio (*ILLIQ*).[20] Panel A of Table 4.6 presents the results of Granger non-causality test with *CPQSIM* as the liquidity measure while the results for *ILLIQ* are presented in Panel B. Both panels consistently show that only the gross inflows of foreign retail investors Granger cause aggregate liquidity. The earlier detected causal relationships between *FTFLOW* and *FIFLOW* with *CPQS* are no longer significant when price impact measures are used. This implies that foreign retail investors affect both the marginal transaction costs per currency unit of volume and the transaction costs required to execute a small trade. The gross inflows of foreign institutional investors, however, only influence the latter as shown in Table 4.4. The disappearance of Granger causations at the aggregate and institutional levels, when liquidity indicators from the cost-per-volume category are used, is not surprising given that they measure a different dimension of liquidity vis-à-vis the percent-cost liquidity proxy. For instance, the study by Lee and Chung (2018) finds that greater foreign ownership is positively associated with the price impact of trades but negatively associated with the bid-ask spread. These authors, who rationalize their findings as foreign investors reducing liquidity by aggravating adverse selection risks but improve liquidity by increasing competition, stress the need of distinguishing these two groups of liquidity proxies.

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[20] *CPQSIM* is found to be the best cost-per-volume proxy for Malaysian stocks in the horserace conducted by Fong *et al.* (2017). While *ILLIQ* is not a top performer, it is the most popular price impact measure in the empirical literature, including Vagias and van Dijk (2012).

Table 4.6: Robustness Check with Alternative Liquidity Indicators

Null Hypotheses	χ^2-Statistics	*p*-value	Lag Order	Remarks
Panel A: CPQS Impact				
Foreign Aggregate				
CPQSIM does not Granger cause *FTFLOW*	11.4171	0.0763	6	—
FTFLOW does not Granger cause *CPQSIM*	7.1191	0.3100	6	—
Foreign Institutions				
CPQSIM does not Granger cause *FIFLOW*	11.3597	0.0779	6	—
FIFLOW does not Granger cause *CPQSIM*	7.0749	0.3140	6	—
Foreign Retailers				
CPQSIM does not Granger cause *FRFLOW*	4.4667	0.6138	6	—
FRFLOW does not Granger cause *CPQSIM*	12.6863	0.0483	6	*FRFLOW* → *CPQSIM*
Panel B: Amihud Illiquidity Ratio				
Foreign Aggregate				
ILLIQ does not Granger cause *FTFLOW*	10.2326	0.0689	5	—
FTFLOW does not Granger cause *ILLIQ*	2.9207	0.7122	5	—
Foreign Institutions				
ILLIQ does not Granger cause *FIFLOW*	10.1494	0.0711	5	—
FIFLOW does not Granger cause *ILLIQ*	2.9967	0.7005	5	—
Foreign Retailers				
ILLIQ does not Granger cause *FRFLOW*	7.7267	0.1720	5	—
FRFLOW does not Granger cause *ILLIQ*	12.2552	0.0315	5	*FRFLOW* → *ILLIQ*
Panel C: Dollar Bid-Ask Spread				
Foreign Aggregate				
DBA does not Granger cause *FTFLOW*	4.6273	0.0989	2	—
FTFLOW does not Granger cause *DBA*	8.9728	0.0113	2	*FTFLOW* → *DBA*
Foreign Institutions				
DBA does not Granger cause *FIFLOW*	4.5464	0.1030	2	—
FIFLOW does not Granger cause *DBA*	9.0169	0.110	2	*FIFLOW* → *DBA*
Foreign Retailers				
DBA does not Granger cause *FRFLOW*	6.7312	0.0810	3	—
FRFLOW does not Granger cause *DBA*	1.6997	0.6370	3	—

Notes: *FTFLOW*, *FIFLOW* and *FRFLOW* denote the gross inflows of total foreign investors, foreign institutions and foreign retail investors, respectively. In Panel A, *CPQSIM* is the impact version of *CPQS*, calculated as the ratio of *CPQS* to dollar trading volume raised to the power of 10^5 in natural logarithm form. In Panel B, *ILLIQ* is the Amihud (2002) illiquidity ratio in natural logarithm form. In Panel C, *DBA* is the dollar bid-ask spread calculated as the closing ask price minus the closing bid price.

In Panels A, B and C, the VAR models are estimated with gross inflows and *CPQSIM, ILLIQ* and *DBA* as endogenous variables, respectively, while the exogenous variables included are aggregate market returns, market return volatility, market turnover, interest rate differential, currency, market capitalization and regional stock return. Lag length is selected based on the Akaike Information Criterion (AIC).

→ is interpreted as "Granger-causes". — indicates insignificant Granger causation from the first variable to second variable.

The negative relationship between stock price levels and percentage bid-ask spreads (Aitken & Frino, 1996; Stoll, 1978) raises concern that the causality running from gross inflows to *CPQS* reported in Table 4.4 is mainly the outcome of stock price levels responding to trading by foreign investors. To mitigate this concern, a robustness test with the dollar bid-ask spread (defined as the closing ask price minus closing bid price) as alternative liquidity measure is performed. The results, tabulated in Panel C of Table 4.6, are largely consistent with the baseline findings of causality running from *FTFLOW* and *FIFLOW* to dollar bid-ask spread.

4.5.3 Large- and Small-Capitalization Liquidity Proxies

All earlier estimations involve variables aggregated using the market value weighting scheme, which places more emphasis on large-capitalization (large-cap) stocks relative to their small-capitalization (small-cap) counterparts. To provide further insights, this thesis re-estimates the baseline VAR models using aggregate liquidity indicators computed for large- and small-cap stocks using the equal weighting scheme. Large-cap stocks are defined as firms with market capitalization at the top 20th percentile while small-cap stocks are those with market capitalization at the bottom 20th percentile. For consistency, the three exogenous variables calculated by aggregating firm-level observations, namely local market returns, market turnover ratio and market return volatility, are also computed based on the corresponding large- and small-cap stocks. Table 4.7 shows that foreign institutions' gross inflows Granger cause liquidity of only large-cap stocks. On the other hand, foreign retail investors appear to be more influential in the small-cap universe with their gross inflows depicting ability to predict the liquidity of small-cap stocks. However, a two-way Granger causality between *FRFLOW* and $CPQS^{S}$ also means that their choice of small-cap stocks is skewed towards those that are more liquid.

Table 4.7: Robustness Check with Equal-Weighted Variables

Null Hypotheses	χ^2-Statistics	*p*-value	Lag Order	Remarks
Panel A: Aggregate Liquidity for Large-Cap Stocks				
Foreign Aggregate				
$CPQS^L$ does not Granger cause *FTFLOW*	2.6505	0.7537	5	—
FTFLOW does not Granger cause $CPQS^L$	11.6067	0.0498	5	*FTFLOW* → $CPQS^L$
Foreign Institutions				
$CPQS^L$ does not Granger cause *FIFLOW*	2.7949	0.7316	5	—
FIFLOW does not Granger cause $CPQS^L$	11.6067	0.0406	5	*FIFLOW* → $CPQS^L$
Foreign Retailers				
$CPQS^L$ does not Granger cause *FRFLOW*	6.0335	0.3030	5	—
FRFLOW does not Granger cause $CPQS^L$	6.6322	0.2495	5	—
Panel B: Aggregate Liquidity for Small-Cap Stocks				
Foreign Aggregate				
$CPQS^S$ does not Granger cause *FTFLOW*	2.1953	0.3337	2	—
FTFLOW does not Granger cause $CPQS^S$	0.2770	0.8706	2	—
Foreign Institutions				
$CPQS^S$ does not Granger cause *FIFLOW*	2.2447	0.3255	2	—
FIFLOW does not Granger cause $CPQS^S$	0.2947	0.8630	2	—
Foreign Retailers				
$CPQS^S$ does not Granger cause *FRFLOW*	13.8121	0.0079	4	$CPQS^S$ → *FRFLOW*
FRFLOW does not Granger cause $CPQS^S$	12.6786	0.0130	4	*FRFLOW* → $CPQS^S$

Notes: *FTFLOW*, *FIFLOW* and *FRFLOW* denote the gross inflows of total foreign investors, foreign institutions and foreign retail investors, respectively. $CPQS^L$ ($CPQS^S$) is calculated as the equal-weighted *CPQS* of stocks with market capitalization equal to or above the 80th percentile (below the 20th percentile). The VAR models are estimated with gross inflows and aggregate liquidity as endogenous variables while the exogenous variables included are aggregate market returns, market return volatility, market turnover, interest rate differential, currency, market capitalization and regional stock return. To be consistent with aggregate liquidity indicator, the first three exogenous variables are also aggregated using equal weighting scheme. Lag length is selected based on the Akaike Information Criterion (AIC).
→ is interpreted as "Granger-causes". — indicates insignificant Granger causation from the first variable to second variable.

4.5.4 Bootstrap Wald Test

Kim (2014) argues that the conventional Ordinary Least Squares-based Wald test employed to determine Granger non-causality suffers from small sample bias and tends to over-reject the true null hypothesis, particularly when the model is near non-stationary. Thus, the author advocates the use of Generalized Least-Squares (EGLS) estimator to perform bootstrap Wald test which is generally more efficient, free from size distortion and has desirable power properties. According to Kim (2014), the power of such bootstrap Wald test increases with sample size and is stronger when the model is near non-stationary and has highly correlated contemporaneous error terms. Results of this bootstrap Wald test, given in Table 4.8, are generally consistent with the baseline findings in Section 4.4, showing a one-way Granger causality running from gross inflows to market liquidity at the aggregate and disaggregate levels.

Table 4.8: Robustness Check with Bootstrap Wald Test under Stationary Vector Autoregressive

Null Hypotheses	χ^2-Statistics	*p*-value	Bootstrap *p*-value	Lag Order	Remarks
Foreign Aggregate					
CPQS does not Granger cause *FTFLOW*	1.3742	0.2543	0.2500	2	—
FTFLOW does not Granger cause *CPQS*	3.8377	0.0224	0.0270	2	*FTFLOW* → *CPQS*
Foreign Institutions					
CPQS does not Granger cause *FIFLOW*	1.3962	0.2488	0.2610	2	—
FIFLOW does not Granger cause *CPQS*	3.9361	0.0203	0.0250	2	*FIFLOW* → *CPQS*
Foreign Retailers					
CPQS does not Granger cause *FRFLOW*	1.1213	0.3403	0.3640	3	—
FRFLOW does not Granger cause *CPQS*	3.2230	0.0227	0.0250	3	*FRFLOW* → *CPQS*

Notes: *FTFLOW*, *FIFLOW* and *FRFLOW* denote the gross inflows of total foreign investors, foreign institutions and foreign retail investors, respectively. *CPQS* is the aggregate Closing Percent Quoted Spread of each stock weighted by its market capitalization. The R code for this bootstrap Wald test (VAR.etp) does not allow the inclusion of exogenous variables, and thus the analysis is performed in a bivariate framework involving only gross inflows and aggregate liquidity. Lag length is selected based on the Akaike Information Criterion (AIC) allowing for maximum lags of 10.
→ is interpreted as "Granger-causes". — indicates insignificant Granger causation from first variable to second variable.

4.5.5 Additional Endogenous Variables

This thesis expands the existing set of endogenous variables (gross inflows and aggregate liquidity) to include aggregate market returns and return volatility. In the case of market returns, the relationship between liquidity and stock returns has been widely established in the finance literature (see Amihud, 2002; Bekaert et al., 2007). There is also evidence of a positive relationship between market returns and foreign portfolio flows (Griffin et al., 2004, 2007). As for return volatility, Chordia et al. (2000) find evidence of liquidity erosion in financial markets during volatile periods as investors refrain from trading. On the other hand, Wang (2007) reports strong contemporaneous relationship between foreign trading and market volatility in Indonesia and Thailand.

This thesis thus re-estimates the baseline VAR models but expands the set of endogenous variables. Panel A of Table 4.9 shows results of the Granger non-causality test for a trivariate VAR model with gross inflows, aggregate liquidity and market returns as endogenous variables whereas Panel B considers gross inflows, aggregate liquidity and return volatility. Panel C presents the results for four endogenous variables – gross inflows, aggregate liquidity, market returns and return volatility. It is observed that when market returns alone is included into the VAR system, the relationship between gross inflows and aggregate liquidity is akin to the baseline results with gross inflows of both foreign institutions and foreign retail investors Granger cause local market liquidity. When return volatility is included as the third endogenous variable, a unidirectional relationship flowing from gross inflows to aggregate liquidity is discovered for both foreign institutions and foreign retail investors. Lastly, the 4-variable VAR model presents similar results as the baseline findings in Table 4.4, suggesting that the earlier statistical inferences are robust even after market returns and return volatility are endogenized.

Table 4.9: Robustness Check with Additional Endogenous Variables

	Sources of Causation				Remarks
	Flow	***CPQS***	***RET***	***VOL***	
Panel A: Gross Inflows, Aggregate Liquidity & Market Returns					
Foreign Aggregate					
Flow	-	2.7502	8.1281**		*RET* → *FTFLOW*
CPQS	7.6743**	-	5.3994*		*FTFLOW* → *CPQS*
RET	17.5967***	16.7616***	-		*FTFLOW* → *RET*, *CPQS* → *RET*
Foreign Institutions					
Flow	-	2.7939	8.3572**		*RET* → *FIFLOW*
CPQS	7.8714**	-	5.2941*		*FIFLOW* → *CPQS*
RET	18.0289***	16.8303***	-		*FIFLOW* → *RET*, *CPQS* → *RET*
Foreign Retailers					
Flow	-	3.3622	5.8533		—
CPQS	9.6536**	-	12.0919***		*FRFLOW* → *CPQS*, *RET* → *CPQS*
RET	16.8053***	13.6066***	-		*FRFLOW* → *RET*, *CPQS* → *RET*
Panel B: Gross Inflows, Aggregate Liquidity & Return Volatility					
Foreign Aggregate					
Flow	-	1.0307		1.4236	—
CPQS	19.4736***	-		0.6707	*FTFLOW* → *CPQS*
VOL	47.3764***	32.5309***		-	*FTFLOW* → *VOL*, *CPQS* → *VOL*
Foreign Institutions					
Flow	-	1.0423		1.3521	—
CPQS	19.7790***	-		0.676676	*FIFLOW* → *CPQS*
VOL	47.6367***	32.2416***		-	*FIFLOW* → *VOL*, *CPQS* → *VOL*
Foreign Retailers					
Flow	-	1.3765		2.9654	—
CPQS	20.5203***	-		1.8230	*FRFLOW* → *CPQS*
VOL	15.6530***	28.7327***		-	*FRFLOW* → *VOL*, *CPQS* → *VOL*
Panel C: Gross Inflows, Aggregate Liquidity, Market Returns & Return Volatility					
Foreign Aggregate					
Flow	-	1.9295	6.8240**	0.1986	*RET* → *FTFLOW*
CPQS	7.0323**	-	5.5136*	0.7580	*FTFLOW* → *CPQS*
RET	17.8040***	10.7817***	-	6.5914**	*FTFLOW* → *RET*, *CPQS* → *RET*, *VOL* → *RET*
VOL	5.1556*	14.2381***	272.8066***	-	*CPQS* → VOL, *RET* → *VOL*
Foreign Institutions					
Flow	-	1.9525	7.1306**	0.2071	*RET* → *FIFLOW*
CPQS	7.2137**	-	5.4016*	0.7506	*FIFLOW* → *CPQS*
RET	18.2056***	10.8329***	-	6.5710**	*FIFLOW* → *RET*, *CPQS* → *RET*, *VOL* → *RET*
VOL	5.2390*	14.2131***	272.5500***	-	*CPQS* → *VOL*, *RET* → *VOL*
Foreign Retailers					
Flow	-	3.4223	4.1320	1.2963	—
CPQS	9.6850**	-	11.2746**	1.1501	*FRFLOW* → *CPQS*, *RET* → *CPQS*
RET	16.1501***	9.6834**	-	8.0395**	*FRFLOW* → *RET*, *CPQS* → *RET*, *VOL* → *RET*
VOL	12.9665***	15.5220***	329.3393***	-	*FRFLOW* → *VOL*, *CPQS* → *VOL*, *RET* → *VOL*

Notes: *CPQS* is the aggregate Closing Percent Quoted Spread of each stock weighted by its market capitalization. *FTFLOW*, *FIFLOW* and *FRFLOW* denote the gross inflows of total foreign investors, foreign institutions and foreign retail investors, respectively. *RET* and *VOL* are the aggregate market returns and EGARCH(1,1) return volatility of all stocks in Bursa Malaysia weighted by their respective market capitalization. Entries in the table are χ^2-square statistics of Granger non-causality test.
***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.
→ is interpreted as "Granger-causes". — indicates no Granger causality.

4.6 Further Analyses

The richness of the data permits additional analyses that yield deeper insights into the relationship between foreign equity flows and aggregate liquidity to be performed. First, given that the relationships between VIX, commonly known as the "investor fear gauge", and equity flows as well as liquidity have not been studied in Malaysia, this thesis thus examines their causal relationships to provide more insights on how foreign flows and liquidity react to uncertainties in the U.S., the world's largest economy. Second, since gross inflows lead to lower aggregate liquidity, it then warrants further investigation to determine whether such negative impact destabilizes the Malaysian market. Lastly, the key finding that foreign investors are liquidity consumers leads to the question of who then, are liquidity providers in the Malaysian stock market.

4.6.1 Uncertainty, Flows and Liquidity

Investors in developed economies that embark on massive asset purchase programs are flushed with footloose funds, also termed as hot money. These investors are in constant search for markets which offer relatively higher yields. However, country-specific factors, also known as pull factors, are not the only determinants of cross-border capital flows. A study by Sarno et al. (2016) shows that more than 80% of the variations in bond and equity flows are explained by push factors that are external to the recipients of international portfolio flows.

Among the push factors, the VIX, a measure of global risk aversion derived from the volatility of the Chicago Board Options Exchange (CBOE), has been frequently cited as a crucial determinant of international portfolio flows (Forbes & Warnock, 2012; Fratzscher, 2012). On the other hand, empirical evidence in the VIX-liquidity literature is somewhat inconclusive. The study by Chung and Chuwonganant (2014) shows that the effect of VIX on market-wide liquidity is stronger than the combined effects of all other common determinants of liquidity in the U.S. stock markets. On the contrary, Lee, Ryu and Kutan (2016) find limited role of VIX in affecting the liquidity of the Korean stock market. In Malaysia, the effects of VIX on foreign equity flows and stock market liquidity have hitherto been unexplored. Therefore, this section seeks to provide additional insights into the reactions of gross inflows and aggregate liquidity of the Malaysian stock market to uncertainties in the U.S. by examining the causal relationship(s) between these three variables in a VAR framework. The VIX, which is stationary at level, gross inflows and *CPQS* enter the VAR framework as endogenous variables while the same control variables used in the baseline model are included as exogenous variables.

Table 4.10: VIX, Gross Inflows and Aggregate Liquidity

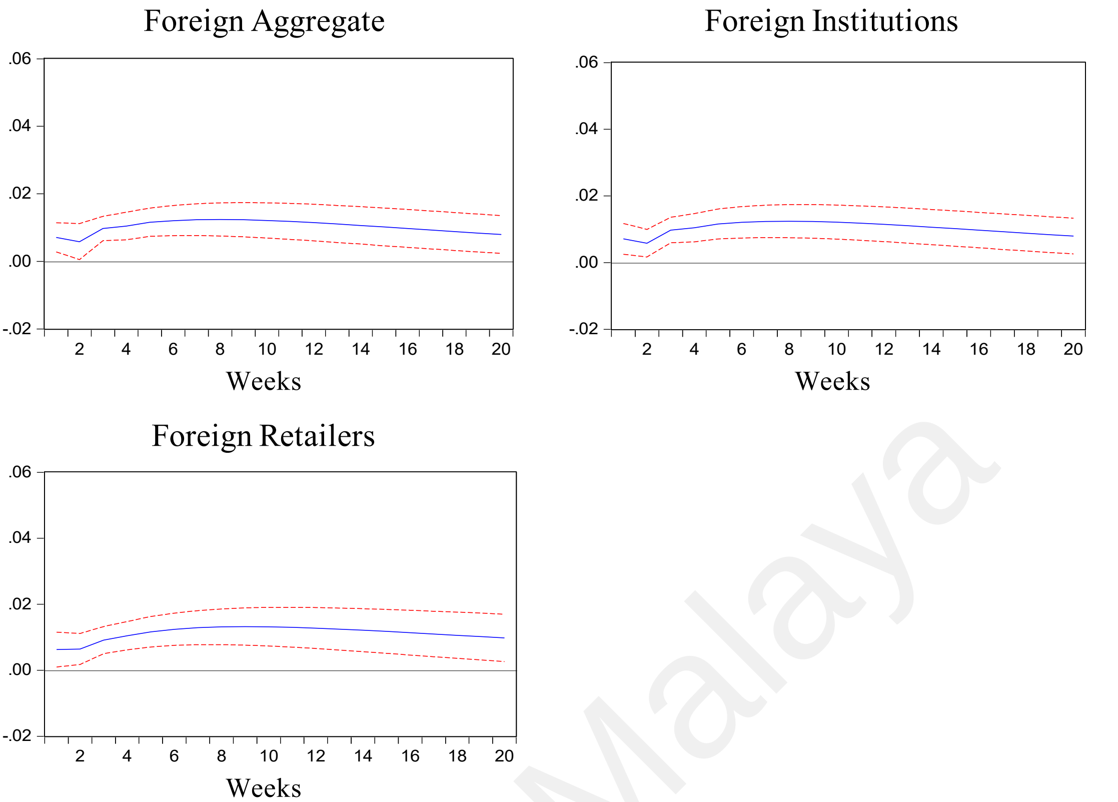
	Sources of Causation			Remarks
	VIX	*Flow*	*CPQS*	
Foreign Aggregate				
VIX	-	2.7732	1.4134	—
Flow	6.9233**	-	4.7373*	*VIX* → *FTFLOW*
CPQS	19.8879***	9.1057**	-	*VIX* → *CPQS*, *FTFLOW* → *CPQS*
Foreign Institutions				
VIX	-	2.6760	1.4186	—
Flow	6.7511**	-	4.6229*	*VIX* → *FIFLOW*
CPQS	19.9221***	9.2382***	-	*VIX* → *CPQS*, *FIFLOW* → *CPQS*
Foreign Retailers				
VIX	-	3.3909	1.0651	—
Flow	4.8295*	-	0.4472	—
CPQS	19.7407***	8.0327**	-	*VIX* → *CPQS*, *FRFLOW* → *CPQS*

Notes: *CPQS* is the aggregate Closing Percent Quoted Spread of each stock weighted by its market capitalization. *FTFLOW*, *FIFLOW* and *FRFLOW* denote the gross inflows of total foreign investors, foreign institutions and foreign retail investors, respectively. The VAR models are estimated with VIX, gross inflows and *CPQS* as endogenous variables while the exogenous variables included are aggregate market returns, return volatility, interest rate differential, currency, market capitalization and regional stock return. Lag length is selected based on the Akaike Information Criterion (AIC).
→ is interpreted as "Granger-causes". — indicates insignificant Granger causation from the first variable to second variable.

Granger non-causality test results tabulated in Table 4.10 reveal a unidirectional Granger causality from VIX to gross inflows of total foreign investors, which is driven solely by foreign institutions. VIX is also found to Granger cause liquidity in the local stock market at both the aggregate and disaggregate levels. Apart from the direct impact, uncertainties in the U.S. stock markets affect local liquidity indirectly through the gross inflows of foreign institutions given the significance of causation from VIX to *FIFLOW* and *FIFLOW* to *CPQS*. GIRs in Figure 4.4 show that *CPQS* responds positively to a one standard deviation positive shock in the VIX, indicating that greater uncertainties in the U.S. lower market-wide liquidity in the Malaysian stock market. Looking at the indirect causal relationship between VIX and *CPQS* in the case of foreign institutional investors, GIRs in Figure 4.5 demonstrate that gross inflows of foreign institutions respond positively to a one standard deviation positive shock in the VIX, which in turn reduce liquidity in the local bourse. The response of liquidity to *FIFLOW* is consistent with the baseline results reported in Section 4.4.

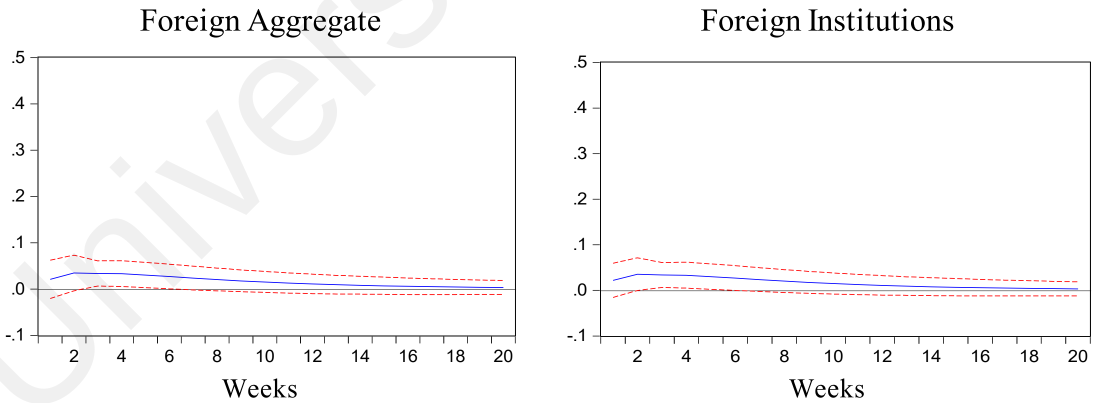
With the VIX commonly referred to as the global fear index, it may be counterintuitive that a positive shock in the VIX, which means heightened global risk aversion, would lead to greater gross inflows into emerging markets under the notion of “flight-to-safety” or “flight-to-quality”. However, this thesis contends that the VIX, which is based solely on the Standard & Poor’s 500 (S&P500) Index, is representative of only uncertainties in the U.S. Therefore, when volatility in the U.S. is expected to increase, investors would flee the market and relocate their funds to alternative stock markets with lower volatility.

Figure 4.4: Impulse Response Functions – Responses of *CPQS* to VIX



Notes: The graphs chart the responses of *CPQS* to VIX for foreign aggregate, foreign institutions and foreign retailers. Dotted lines represent the 95% confidence interval.

Figure 4.5: Impulse Response Functions – Responses of foreign trades to VIX



Notes: The graphs chart the responses of gross inflows of foreign aggregate (*FTFLOW*) and foreign institutions (*FIFLOW*) to VIX. Dotted lines represent the 95% confidence interval.

4.6.2 Do Foreign Investors Destabilize the Malaysian Stock Market?

Malaysia had been one of the preferred destinations of foreign portfolio flows since the opening of the liquidity floodgates by major central banks to stimulate their respective economies, until the strengthening of the U.S. economy prompted a reversal of such hot money flows in the mid-2013. Given the economy's susceptibility to such volatile portfolio flows, it is thus imperative to examine whether the gross inflows of foreign investors have a destabilizing effect on the Malaysian stock market through their adverse impact on aggregate liquidity, an issue picked up earlier by Vagias and van Dijk (2012). In the extant literature, the topic of whether foreign investors destabilize the capital markets has also been examined but in different contexts through stock volatility (Han et al., 2015), stock returns (Choe et al., 1999) and trading behavior (Kim & Wei, 2002).

This thesis examines the destabilizing effect of gross inflows during liquidity crisis periods following Vagias and van Dijk (2012) who define liquidity crisis as when the *CPQS* is at or above the 70th percentile of the distribution. Whether market liquidity is undermined during periods of crisis is then tested by estimating Equation (25) as explained in Section 3.6.2 (page 104-106). Table 4.11 presents the results for Equation (25). It is observed that the dummy variable is significant across all three categories of foreign investors, indicating that liquidity crisis periods negatively affect the aggregate liquidity of the Malaysian stock market. Turning to the variable of interest, the interaction term is only significant in the regressions with gross inflows of total foreign investors and foreign institutions. Thus, it can be inferred that the destabilizing impact of gross inflows on local market liquidity during the sample period is contributed solely by foreign institutional investors at times when the market becomes very illiquid. This finding contradicts the multi-country study of Vagias and van Dijk (2012) who find no statistically significant evidence of foreign investors destabilizing local equity markets. Apart from differences in data for the two key variables of foreign portfolio flows and aggregate liquidity, the regression estimates in the large sample panel study of Vagias and van Dijk (2012) assume a uniform impact across diverse countries and thus ignore institutional heterogeneity.

In the literature, positive feedback trading is often cited as one of the causes for the destabilizing effect of investors (Lakonishok et al., 1992; Schuppli & Bohl, 2010). This thesis formally addresses this possibility using similar framework as Froot et al. (2001), Griffin et al. (2004), Richards (2005) and Vo (2017) who infer feedback trading from a VAR framework when the null hypothesis that stock return does not Granger cause gross inflows is rejected.[21] In this section, three VAR models of two lags with gross inflows, local and regional returns as endogenous variables are estimated and the results are tabulated in Table 4.12. A bidirectional relationship is detected between the gross inflows of foreign institutional investors and local stock market returns. The same is observed for total foreign investors, mainly driven by the large share of foreign institutions' gross inflows.

The presence of causality running from local stock market returns to gross inflows of foreign institutions thus suggests evidence of feedback trading. However, subsequent inspection of the corresponding GIRs is needed to infer whether this group of investors engages in positive or negative feedback trading. The GIRs for total foreign investors and foreign institutions, shown in Figure 4.6, indicate that the response of foreign institutions' gross inflows to local market returns is positive and statistically significant. The evidence thus shows foreign institutional investors are positive feedback traders, providing further support to the findings derived from Table 4.11 that gross inflows of foreign institutions destabilize the local market.

[21] These authors examine positive and negative feedback trading through impulse response functions. If net purchases respond positively (negatively) to innovations in local market returns, then an investor is said to be engaged in positive (negative) feedback trading. Positive (Negative) feedback traders are also known as momentum traders (contrarians) where they buy (sell) past winners and sell (buy) past losers.

Table 4.11: Destabilizing Impact from Trading during Liquidity Crisis Periods

	C	$\Delta Flow$	$CRISIS$	$\Delta Flow^{*}$ $CRISIS$	$\Delta CPQS_{t-1}$	$\Delta CPQS_{t-2}$	$\Delta CPQS_{t-3}$	ΔRET	ΔTO	ΔVOL	Δ $SPREAD$	$\Delta REER$	Δ $LMCAP$	Δ $RETREG$
Foreign Aggregate	-0.0066**	0.0120**	0.0267***	0.0223**	-0.3222***	-0.0956*	-0.1250**	-0.0061**	-0.0133	0.0026	-0.0313	-0.0019	-1.4662***	-0.0155***
	(0.0029)	(0.0058)	(0.0074)	(0.0112)	(0.0581)	(0.0560)	(0.0495)	(0.0030)	(0.0089)	(0.0035)	(0.0647)	(0.0035)	(0.2752)	(0.0056)
Foreign Institutions	-0.0066**	0.0119**	0.0267***	0.0223**	-0.3223***	-0.0954*	-0.1253**	-0.0062**	-0.0133	0.0026	-0.0314	-0.0019	-1.4649***	-0.0156***
	(0.0029)	(0.0058)	(0.0074)	(0.0111)	(0.0581)	(0.0561)	(0.0496)	(0.0030)	(0.0089)	(0.0035)	(0.0647)	(0.0035)	(0.2747)	(0.0056)
Foreign Retailers	-0.0066**	0.2332	0.0289***	-0.5385	-0.3446***	-0.1049*	-0.1227**	-0.0020	-0.0106	0.0012	-0.0339	0.0002	-1.5211***	-0.0095*
	(0.0030)	(0.3042)	(0.0078)	(0.5811)	(0.0583)	(0.0580)	(0.0505)	(0.0032)	(0.0088)	(0.0034)	(0.0695)	(0.0037)	(0.2934)	(0.0053)
Local Aggregate	-0.0069**	-0.0072	0.0264***	-0.0139	-0.3300***	-0.0997*	-0.1242**	-0.0047	-0.0107	0.0033	-0.0481	-0.0017	-1.2528***	-0.0013
	(0.0033)	(0.0063)	(0.0080)	(0.0118)	(0.0613)	(0.0580)	(0.0523)	(0.0033)	(0.0088)	(0.0033)	(0.0676)	(0.0041)	(0.2451)	(0.0013)
Local Institutions	-0.0067**	-0.0073	0.0274***	-0.0124	-0.3483***	-0.0994*	-0.1301**	-0.0041	-0.0086	0.0030	-0.0407	-0.0017	-1.3442***	-0.0011
	(0.0030)	(0.0067)	(0.0076)	(0.0147)	(0.0591)	(0.0561)	(0.0507)	(0.0031)	(0.0085)	(0.0033)	(0.0651)	(0.0038)	(0.2393)	(0.0012)
Local Nominees	-0.0068**	-0.0199	0.0287***	0.0053	-0.3488***	-0.1035**	-0.1233***	-0.0024	-0.0137	0.0024	-0.0434	-0.0004	-1.3170***	-0.0010
	(0.0032)	(0.0238)	(0.0059)	(0.0512)	(0.0515)	(0.0489)	(0.0474)	(0.0023)	(0.0092)	(0.0023)	(0.0678)	(0.0042)	(0.2294)	(0.0010)
Local PDTs	-0.0063**	0.8113**	0.0273***	-0.0528	-0.3343***	-0.1052*	-0.1250**	-0.0027	-0.0113	0.0017	-0.0360	-0.00009	-1.4436***	-0.0077
	(0.0029)	(0.3656)	(0.0073)	(0.9312)	(0.0562)	(0.0573)	(0.0506)	(0.0028)	(0.0085)	(0.0035)	(0.0697)	(0.0037)	(0.2818)	(0.0053)
Local Retailers	-0.0069**	0.0016	0.0283***	-0.0484	-0.3417***	-0.0992**	-0.1236***	-0.0029	-0.0122	0.0028	-0.0467	-0.0004	-1.2705***	-0.0009
	(0.0032)	(0.0246)	(0.0058)	(0.0374)	(0.0521)	(0.0487)	(0.0472)	(0.0023)	(0.0078)	(0.0023)	(0.0677)	(0.0042)	(0.2358)	(0.0010)

Notes: The dependent variable is $\Delta CPQS$, where *CPQS* is the aggregate Closing Percent Quoted Spread of each stock weighted by its market capitalization. *Flow* denotes gross inflows of total foreign investors, foreign institutions, foreign retail investors, total local investors, local institutions, local nominees, local proprietary day traders (PDTs) and local retail investors. $CRISIS$ is a dummy variable that takes the value of 1 if $CPQS$ during the week is equal to or above the 70th percentile of the $CPQS$ time series. *RET*, *VOL* and *TO* are the aggregate market returns, EGARCH(1,1) return volatility and turnover ratio of all stocks in Bursa Malaysia weighted by their respective market capitalization. *SPREAD* denotes the interest rate differential between the Malaysia Band 4 (68 to 91 days to maturity) Treasury-Bill and average short-term interest rate of the G7 countries. *REER* is the Malaysia real effective exchange rate based on Consumer Price Index (2010=100) compiled by JPMorgan. *MCAP* is the aggregate weekly market capitalization. *RETREG* is the regional stock return. Δ denotes first-difference. Numbers in parentheses denote standard errors corrected using Newey-West (1987) Heteroskedasticity- and Autocorrelation-consistent (HAC) estimator as all three equations suffer heteroskedasticity problem.
***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

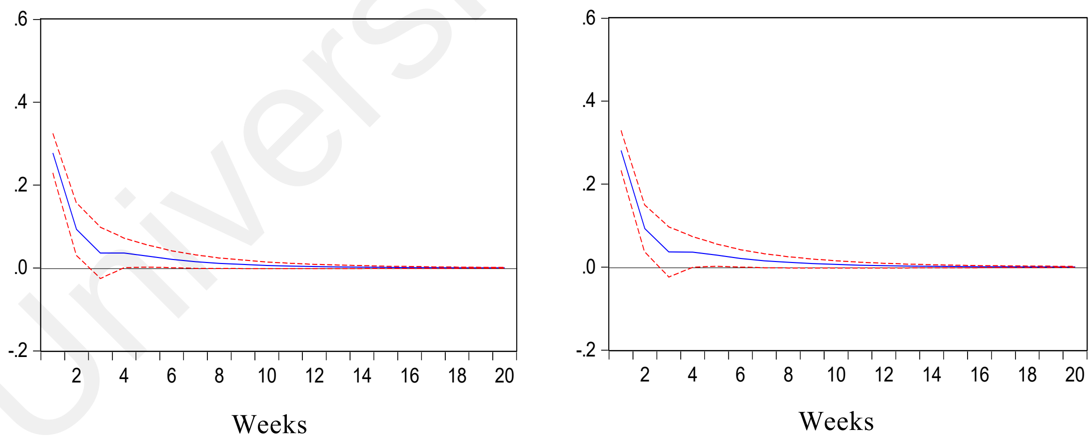
Table 4.12: Feedback Trading by Foreign Investors

	Sources of Causation			Remarks
	Flow	***RET***	***RETREG***	
		Panel A: Foreign Aggregate		
Flow	-	6.5249**	1.6074	*RET* → *FTFLOW*
RET	11.6298***	-	2.5632	*FTFLOW* → *RET*
RETREG	5.4807*	1.8407	-	—
		Panel B: Foreign Institutions		
Flow	-	6.6866**	1.6068	*RET* → *FIFLOW*
RET	11.9818***	-	2.5576	*FIFLOW* → *RET*
RETREG	5.4836*	1.8612	-	—
		Panel C: Foreign Retailers		
Flow	-	4.5650	1.7757	—
RET	16.2634***	-	6.0676**	*FRFLOW* → *RET*, *RETREG* → *RET*
RETREG	0.8646	1.1090	-	—

Notes: *FTFLOW*, *FIFLOW* and *FRFLOW* denote the gross inflows of total foreign investors, foreign institutions and foreign retail investors, respectively. *Flow* denotes gross inflows. *RET* is the aggregate market returns of all stocks in Bursa Malaysia weighted by their respective market capitalization. *RETREG* is the regional stock return. Entries in the table are χ^2-square statistics of Granger non-causality test.
→ is interpreted as "Granger-causes". — indicates insignificant Granger causation from the first variable to second variable.

Figure 4.6: Generalized Impulse Responses – Foreign Feedback Trading

Response of *FTFLOW* to *RET*	Response of *FIFLOW* to *RET*



Notes: Dotted lines represent the 95% confidence interval. *FTFLOW* and *FIFLOW* denote the gross inflows of total foreign investors and foreign institutions, respectively. *RET* is the market returns of the Malaysian stock market, calculated by aggregating individual stock's returns using the market value weighting scheme.

The same analyses are also performed for local investors at aggregate and disaggregate levels. As manifested in Table 4.11, coefficients for the interaction terms in Equation (25) for net purchases of local equities by total local investors (*LTNET*), local institutional investors *(LINET),* local nominees (*LNNET*), local proprietary day traders (*LPDTNET*) and local retail investors (*LRNET*) are all insignificant, indicating that the net purchases of local equities by local investors do not destabilize the domestic stock market. Results of Granger non-causality test, tabulated in Table 4.13, and GIRs in Figure 4.7, reveal that local investors as a whole pursue negative feedback trading and this is solely contributed by local retail investors. These findings are consistent with Grinblatt and Keloharju (2000) who show that foreign investors are positive feedback traders while domestic investors are contrarians in the Finland stock market. In the emerging markets, Vo (2017b) finds that foreign investors are positive feedback traders in the Vietnamese stock market.

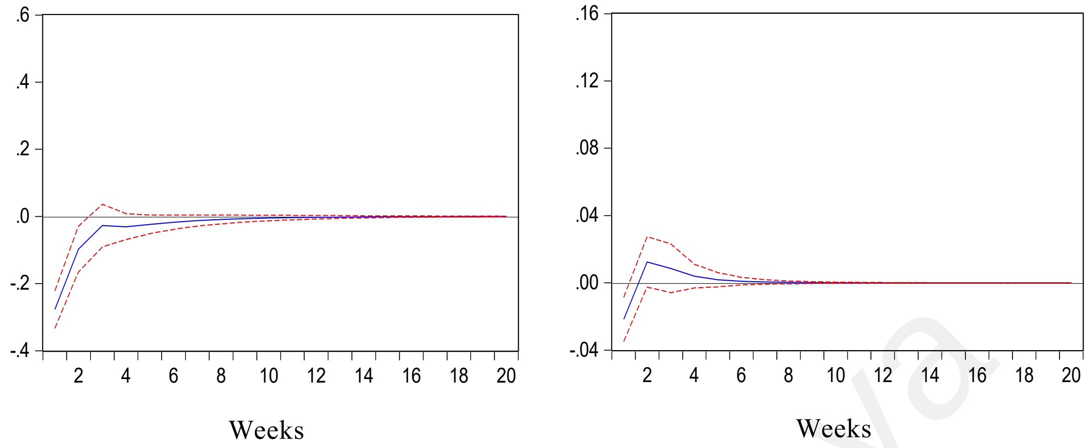
Table 4.13: Feedback Trading by Local Investors

	Sources of Causation			Remarks
	Net	***RET***	***RETREG***	
		Panel A: Local Aggregate		
Net	-	6.1005**	0.8260	*RET* → *LTFLOW*
RET	10.1480***	-	2.5392	*LTFLOW* → *RET*
RETREG	5.7316*	1.7090	-	—
		Panel B: Local Institutions		
Net	-	2.5062	0.4459	—
RET	2.2684	-	3.4508	—
RETREG	4.7425*	1.3057	-	—
		Panel C: Local Nominees		
Net	-	3.3116	0.3314	—
RET	10.8911***	-	3.7136	—
RETREG	1.4876	1.7288	-	—
		Panel D: Local PDTs		
Net	-	0.3590	0.6824	—
RET	3.8482	-	4.2816	—
RETREG	1.2680	1.2659	-	—
		Panel E: Local Retailers		
Net	-	7.7730**	1.7679	*RET* → *LRFLOW*
RET	24.0648***	-	3.4222	*LRFLOW* → *RET*
RETREG	1.8111	1.4227	-	—

Notes: *LTNET*, *LINET*, *LRNET*, *LNNET* and *LPDTNET* denote the net purchases of local equities by total local investors, local institutions, local retail investors, local nominees and local proprietary day traders, respectively. *Net* denotes net purchases. *RET* is the aggregate market returns of all stocks in Bursa Malaysia weighted by their respective market capitalization. *RETREG* is the regional stock return. Entries in the table are χ^2-square statistics of Granger non-causality test.
→ is interpreted as "Granger-causes". — indicates insignificant Granger causation from the first variable to second variable.

Figure 4.7: Generalized Impulse Responses – Local Feedback Trading

Response of *LTNET* to *RET* | Response of *LRNET* to *RET*



Notes: Dotted lines represent the 95% confidence interval. *LTNET* and *LRNET* denote the net purchase of total local investors and local retail investors, respectively. *RET* is the market returns of the Malaysian stock market, calculated by aggregating individual stock's returns using the market value weighting scheme.

4.6.3 Local Investors' Trading

Having established that foreign investors are liquidity demanders whose gross inflows reduce the aggregate liquidity of the Malaysian stock market, it is imperative to examine who then, are meeting such liquidity requirements. Although the relationship between local investors and stock liquidity has been widely examined in the existing literature, only evidence of association is provided rather than causation. Furthermore, while these studies do cover local investor heterogeneity, their focus is on ownership rather than the trading of local investors (see references cited in Lim et al., 2017). In this analysis, the total net purchases of local equities by local investors (*LTNET*) calculated from data provided by Bursa Malaysia are further disaggregated into institutions (*LINET)*, retail investors (*LRNET*), nominees (*LNNET*) and proprietary day traders (*LPDTNET)*, allowing a more thorough investigation of not only the liquidity role played by local investors as a whole but also by different types of local market players. The results for unit root tests presented in Table 4.14 suggest that all disaggregated net purchases of local equities series are stationary at level. Therefore, similar to the case of foreign investors, the VAR models are estimated with net purchases by local investors (*LTNET*, *LINET, LRNET, LNNET* and *LPDTNET*), *CPQS*, *RET*, *VOL*, *TO* and *RETREG* in level form and *SPREAD, REER* and *LMCAP* in first difference. Using the AIC, the optimal lag length is two for all the estimated VAR models.

Table 4.14: Unit Root Tests Results – Local Investors

Variables	Dickey-Fuller GLS	Ng-Perron				I(d)
		MZa	MZt	MSB	MPT	
LTNET	-9.324***	-103.485***	-7.192***	0.070***	0.886***	I(0)
LINET	-9.557***	-108.722***	-7.373***	0.068***	0.838***	I(0)
LNNET	-12.598***	-132.956***	-8.144***	0.061***	0.718***	I(0)
LPDTNET	-25.981***	-140.132***	-8.370***	0.060***	0.653***	I(0)
LRNET	-11.751***	-64.935***	-5.684***	0.088***	1.466***	I(0)

Notes: *LTNET*, *LINET*, *LRNET*, *LNNET* and *LPDTNET* denote the net purchases of local equities by total local investors, local institutions, local retail investors, local nominees and local proprietary day traders, respectively.
The Dickey-Fuller GLS and Ng and Perron (2001) equations are estimated by including a constant and trend with optimal lag length selected based on the Schwarz Information Criterion (SIC).
***, ** and * denote significance at the 1%, 5% and 10% levels, respectively for rejecting the null hypothesis of a unit root.

Results of the Granger non-causality test reported in Table 4.15 show that the net purchases of local equities by domestic investors as a whole have an effect on aggregate liquidity. By investor type, local institutions which account for an average of 54% of total local equity flows are seen dominating the relationship with a one-way Granger causality from net purchases to aggregate liquidity. However, a bidirectional causality is found between net purchases and aggregate liquidity in the case of local PDTs. Finally, net purchases of local retail investors and local nominees have no effect on the liquidity of Bursa Malaysia. The liquidity supplying/consuming role of local investors is further determined through the GIRs, reported in Figure 4.8. The GIRs show that local investors as a whole supply liquidity to the Malaysian stock market given the negative response of *CPQS* to a one standard deviation positive shock in *LTNET*. At the disaggregate level, the graphs show that both local institutions and local PDTs are liquidity providers in the domestic stock market.

Table 4.15: Liquidity Roles of Local Investors

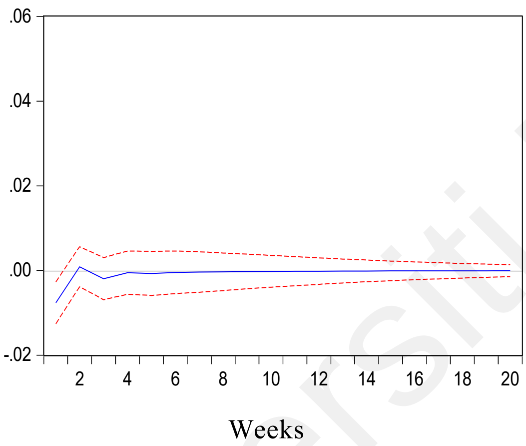
Null Hypotheses	χ^2-Statistics	*p*-value	Lag Order	Remarks
Local Total				
CPQS does not Granger cause *LTNET*	0.4159	0.8122	2	—
LTNET does not Granger cause *CPQS*	6.6538	0.0359	2	*LTNET* → *CPQS*
Local Institutions				
CPQS does not Granger cause *LINET*	0.0959	0.9532	2	—
LINET does not Granger cause *CPQS*	7.8206	0.0200	2	*LINET* → *CPQS*
Local Retailers				
CPQS does not Granger cause *LRNET*	2.3995	0.3013	2	—
LRNET does not Granger cause *CPQS*	0.9275	0.6289	2	—
Local Nominees				
CPQS does not Granger cause *LNNET*	5.1989	0.0743	2	—
LNNET does not Granger cause *CPQS*	0.1597	0.9232	2	—
Local PDTs				
CPQS does not Granger cause *LPDTNET*	10.2158	0.0060	2	*CPQS* → *LPDTNET*
LPDTNET does not Granger cause *CPQS*	12.0062	0.0025	2	*LPDTNET* → *CPQS*

Notes: *CPQS* is the aggregate Closing Percent Quoted Spread of each stock weighted by its market capitalization. *LTNET*, *LINET*, *LRNET*, *LNNET* and *LPDTNET* denote the net purchases of local equities by total local investors, local institutions, local retail investors, local nominees and local proprietary day traders, respectively.
→ is interpreted as "Granger-causes". — indicates insignificant Granger causation from the first variable to second variable.

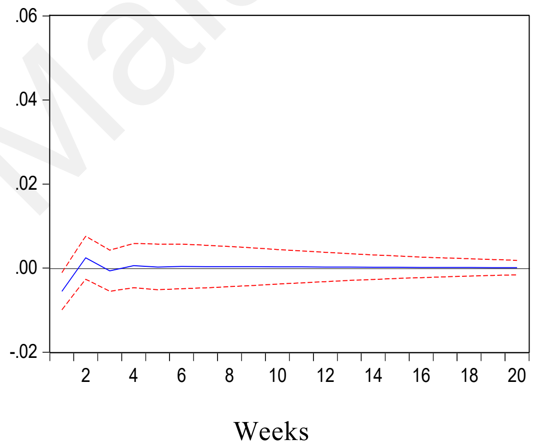
It is often reported by the Malaysian press that when foreign investors exit the market in droves, local institutional investors would step in to support the market and provide the much-needed liquidity. Empirical evidence from Table 4.4 suggests that gross inflows of foreign investors reduce the liquidity of Malaysian stock market, and Table 4.15 supports the assertion made by the local press that local institutions play a vital role as liquidity providers. This is unsurprising because the major local institutional investors in Bursa Malaysia such as Employees Provident Fund, the Armed Forces Fund Board, the National Equity Corporation, the Pilgrimage Fund Board and the Social Security Organization are government-controlled. These state-backed institutions might be obliged to calm the local market. In the case of local PDTs, while the result shows that they improve liquidity in the stock market, their participation is also induced by the condition of liquidity. PDTs were introduced by Bursa Malaysia in January 2007 with the aim of increasing liquidity in the market through their participation. On the other hand, the short positions that this category of investors hold have to be closed on the same day that they are entered into and all purchase positions must be closed within two trading days from the transaction date. Therefore, a liquid market is deemed a prerequisite for day traders to participate in the market.

Figure 4.8: Generalized Impulse Responses – Local Investors

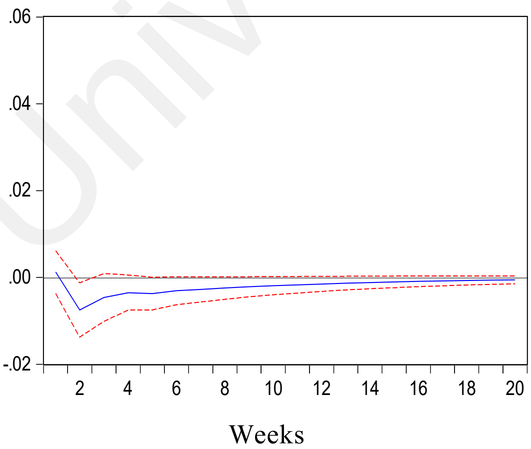
Response of *CPQS* to *LTNET*



Response of *CPQS* to *LINET*



Response of *CPQS* to *LPDTNET*



Notes: Dotted lines represent the 95% confidence interval. *LTNET*, *LINET* and *LPDTNET* denote the net purchases of local equities by total local investors, local institutions and local proprietary day traders, respectively. *CPQS* is the aggregate Closing Percent Quoted Spread of each stock weighted by its market capitalization.

4.7 Summary of Empirical Results

To answer the first research question of whether gross inflows enhance or erode overall liquidity of the Malaysian stock market, this thesis employs a Vector Autoregression (VAR) framework using weekly trading participation data provided by Bursa Malaysia over a seven-year period from October 2009 to December 2016, whereas aggregate liquidity is proxied by the Closing Percent Quoted Spread introduced by Chung and Zhang (2014) which is empirically proven to provide accurate measurement of liquidity for the Malaysian stock market.[22] The baseline results in Table 4.4 reveal evidence of a unidirectional causality running from the gross inflows of all foreign investors to aggregate liquidity. At the granular level, this causal relationship is manifested in both the gross inflows of foreign institutions and foreign retail investors. Through the Generalized Impulse Response Functions (GIRs), it is found that both foreign institutions and foreign retail investors' gross inflows reduce aggregate liquidity, suggesting that foreign investors act as informed traders who consume liquidity in the Malaysian stock market. The key finding of foreign equity flows Granger cause aggregate liquidity passes a battery of robustness checks – accounting for the presence of structural breaks in the endogenous variables, employing bootstrap Wald test in the Granger non-causality testing procedure, and including stock returns and return volatility as additional endogenous variables.

The above baseline results contribute to the ongoing debate of whether foreign investors are relatively more informed than their domestic counterparts. The existing theoretical models generally assume the information advantage of domestic investors,

[22] For Malaysian stocks, Fong et al. (2017) find that the monthly version of Closing Percent Quoted Spread from Chung and Zhang (2014) significantly outperforms its closest competitor by margins of 57% in the cross-sectional dimension, 28% in the portfolio time-series dimension and 105% in the individual stock time-series dimension. At the daily frequency, only two proxies, namely the Closing Percent Quoted Spread and the High-Low by Corwin and Schultz (2012), are assessed and the former is again found to be the best daily liquidity proxy for the Malaysian stock market.

mainly because these models are developed to rationalize the home bias phenomenon (see, for example, Brennan & Cao, 1997; Brennan, Cao, Strong, & Xu, 2005; Hatchondo, 2008). Empirically, numerous approaches have been used to infer which investor groups are better informed (see the literature review in Dvořák, 2005), but evidence is still inconclusive.[23] A growing number of recent studies instead use direct measures of stock price informativeness such as the probability of information-based trading (He et al., 2013; Ng et al., 2016), stock price synchronicity (He et al., 2013; Kim & Yi, 2015; Vo, 2017a) and stock price delay (Bae, Ozoguz, Tan, & Wirjanto, 2012; Kang, Kwon, & Park, 2016; Lim et al., 2016). The consensus emerges from these studies suggests foreigners are informed traders who facilitate the incorporation of value-relevant information into the prices of local stocks. This thesis provides a different perspective to this unresolved issue, inferring from the underlying foreign trading-liquidity relationship based on the two competing theoretical models of asymmetric information and noise trading. Following similar line of interpretation as in Agudelo (2010) and Vagias and van Dijk (2012), this thesis concludes that foreign investors reduce the aggregate liquidity of the Malaysian stock market because their information-based trading exacerbates information asymmetry and widens bid-ask spreads. The information advantage of foreign investors in Bursa Malaysia has earlier been established by Lim et al. (2016) who show that foreigners are elite processors of public news, and they might have privileged access to private information when their shareholdings become substantially large. This thesis notes, however, such superior information will only lead to lower market liquidity if foreign investors trade actively to exploit their information advantage, consistent with the prediction of asymmetric information model.

[23] Dvořák (2005) and Hau (2001) find that domestic investors earn higher trading profits than foreign investors, while Choe, Kho and Stulz (2005) and Kalev, Nguyen and Oh (2008) report trading advantages for domestic investors as they are able to transact at more favorable prices than their foreign counterparts. There is, however, no lack of evidence showing foreign investors yield better trading performance which can be attributed to their access to expertise and superior investment skills (Bae, Yamada, & Ito, 2006; Grinblatt & Keloharju, 2000).

Three additional analyses have been performed. First, given that the relationships between VIX, commonly known as the "investor fear gauge", and equity flows as well as liquidity have not been studied in Malaysia, this thesis examines their causal relationships to provide more insights on how foreign flows and liquidity react to uncertainties in the U.S. Results from VAR analysis reveal that VIX exerts a direct negative impact on local aggregate liquidity, and indirectly through the gross inflows of foreign institutional investors. Second, since gross inflows lead to lower aggregate liquidity, it then warrants further investigation to determine whether such negative impact destabilizes the Malaysian market. During liquidity crisis periods, only the gross inflows of foreign institutions destabilize the local stock market through an adverse impact on aggregate liquidity, which is largely caused by their positive feedback trading strategy. Lastly, the key finding that foreign investors are liquidity consumers leads to the question of who then, are liquidity providers in the Malaysian stock market. When the variable of foreign investors is replaced by local investors in the VAR framework, the results show that local institutions and local proprietary day traders are supplying liquidity to the local bourse, thus providing empirical support to the assertion frequently made by Malaysian press that local state-backed institutional funds often step in to support the market when foreign investors are fleeing the country.[24]

[24] See http://www.focusmalaysia.my/Mainstream/local-funds-move-in-to-arrest-market-decline and https://www.nst.com.my/news/2016/12/194781/rm7805mln-outflow-market-well-supported-says-midf (retrieved on 31st December 2017).

CHAPTER 5

PROPRIETARY DAY TRADING AND HIGHER-ORDER MOMENTS OF LIQUIDITY

This second empirical chapter reports and deliberates the empirical results of the relationship between proprietary day trading and the different moments of aggregate stock market liquidity in Malaysia. Section 5.1 provides graphical plots of the key variables in this analysis, namely daily trade volume of proprietary day traders, aggregate stock market liquidity, conditional volatility of aggregate stock market liquidity and conditional skewness of aggregate stock market liquidity. Descriptive statistics and unit root test results of all variables used to answer the second research question are given in Section 5.2. The following section then discusses the regression results and key findings of the relationships between proprietary day trading and aggregate liquidity, conditional volatility of aggregate liquidity and conditional skewness of aggregate liquidity. Section 5.4 reports results of robustness checks where the baseline models are re-estimated using alternative distribution of GARCH innovations. Lastly, Section 5.5 concludes the chapter by providing a summary of the empirical results for the second research question.

5.1 Graphical Plots of the Key Variables

This section provides a preliminary overview of the key variables used in the analysis, namely the collected daily data of proprietary day trading, the computed aggregate liquidity for Malaysian stock market, the generated conditional volatility and conditional skewness of aggregate liquidity.

5.1.1 Proprietary Day Trading

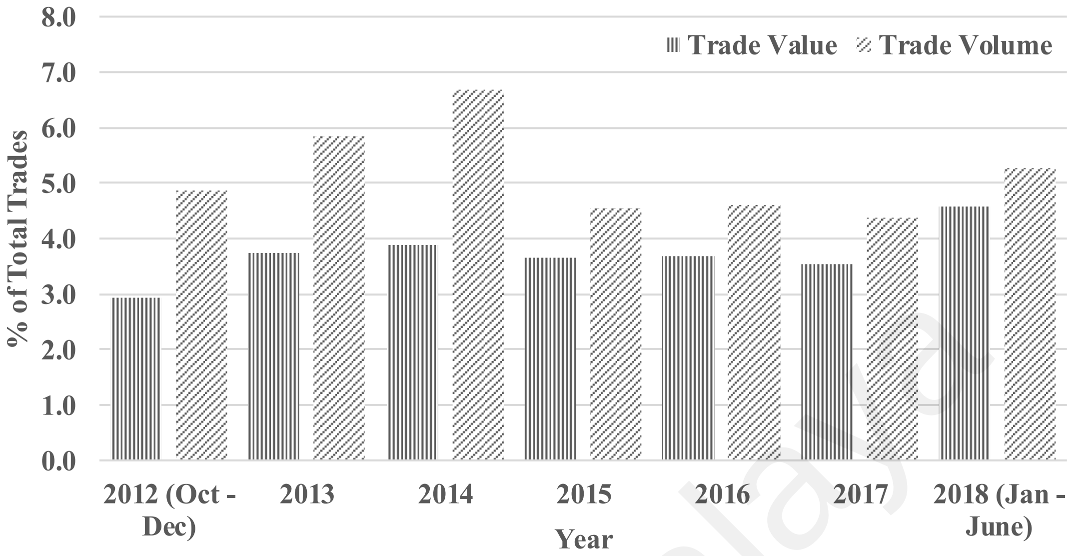
The daily trade data for proprietary day traders (PDTs) are only made available in Refinitiv (formerly Thomson Reuters) Datastream from October 2012, which dictate the starting point of the sample used to answer the second research question. Thus, the sample period in this chapter spans from 1st October 2012 to 30th June 2018, resulting in 1,409 daily observations after excluding public holidays and weekends. Looking at the trading shares of local PDTs in the Malaysian stock exchange in Panel A of Figure 5.1, a steady increase is observed in their participation in the local bourse from 2012 to 2014, followed by a dip in 2015 and another rising trend since then. Trade values of PDTs are usually lower than their trade volume, mainly due to the concentration of PDTs' trading activities in the penny shares segment – shares that are valued below RM1.00.[25]

Over the sample period, PDTs' participation in the local stock exchange averaged 3.71% and 5.17% of total trades in terms of value and volume, respectively. Comparing the share of PDTs' trades in Malaysia with evidence in the literature, their participation rate is significantly lower than the 17% reported by Barber et al. (2014) for the Taiwan Stock Exchange and 21% for the Korean Stock Exchange in 2000 by Chung et al. (2009). However, it is worth noting that the substantial difference between the local number vis-à-vis that of its regional peers can be largely attributed to the measurement of day trading. Note that Barber et al. (2014) and Chung et al. (2009) use ex-ante measure of day trading by selecting transaction data that include buying and selling of a stock on the same trading day. On the other hand, this thesis is strictly focusing on trades by PDTs which exclude possible day trading activities by other investor groups.

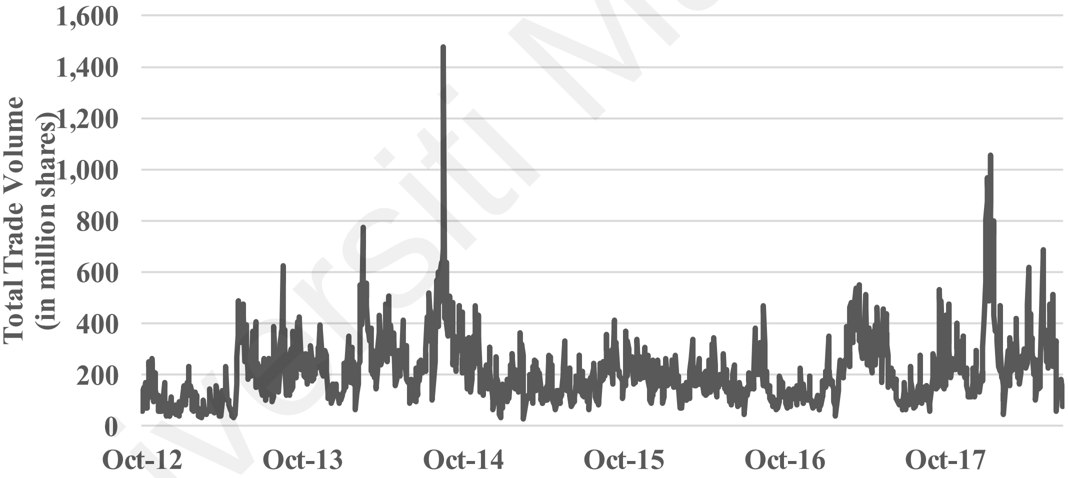
[25] Due to the dearth of information on PDTs in Malaysia, this study refers to news article written by market analyst that is published in reputable local newspapers, accessible from https://www.thestar.com.my/business/business-news/2014/08/23/dont-be-fooled-by-the-high-trading-volume/ (retrieved on 15th September 2018).

Figure 5.1: Proprietary Day Trading (October 2012 – June 2018)

Panel A: Trade participation by local proprietary day traders



Panel B: Daily trade volume by local proprietary day traders



Notes: Panel A shows the trading shares of local proprietary day traders, both in terms of trading value and trading volume, as a percentage of total trades by all investors in the Malaysian stock exchange. Panel B shows the daily trade volume of local proprietary day traders, in million shares, in the Malaysian stock exchange.

Looking at the daily trade volume of PDTs as charted in Panel B of Figure 5.1, PDTs traded more actively after mid of 2013, as evidenced by the shift in the average trade level observed in the graph. The highest trade volume recorded during the sample period is 1.48 billion shares on 20th August 2014. In the absence of unusual market event both on the global and local fronts, it is reported in the local news portal that ten small-capitalization counters contributed to 50% of such abnormal trade volume observed, with some putting the blame on speculative activities undertook by PDTs.[26] On the contrary, heightened trading activities observed in January 2018, with 1.06 billion shares traded on 16th January 2018, were driven by improved sentiment as Asian shares rose to record closing highs due to the optimism on global growth prospects.

5.1.2 Aggregate market liquidity

It can be observed from Figure 5.2 that aggregate market liquidity displays volatility clustering behavior that varies over time. Liquidity in the Malaysian stock market generally improved from October 2012 to late 2014, followed by a period of rather illiquid market from early 2015 to late 2016. The marginal improvement in liquidity during 2017 was later reversed in the first six months of 2018, despite the upward trend seen on the benchmark stock index of FTSE Bursa Malaysia KLCI (FBM KLCI) over the same period. The figure also reveals the large fluctuations in *CPQS* and *CPQSIM* over time when liquidity is observed at the daily frequency.

5.1.3 Conditional volatility of aggregate liquidity

Figure 5.3 plots the conditional volatility of liquidity for both *CPQS* and *CPQSIM*, derived from the EGARCH (1, 1) model with Student's *t* distribution.[27] The time series behavior of conditional liquidity volatility is similar to that of the level of liquidity seen in Figure 5.2, where the period from October 2012 to late 2014 was characterized by falling liquidity volatility, albeit rather minimal, while the period from 2015 to 2016 as

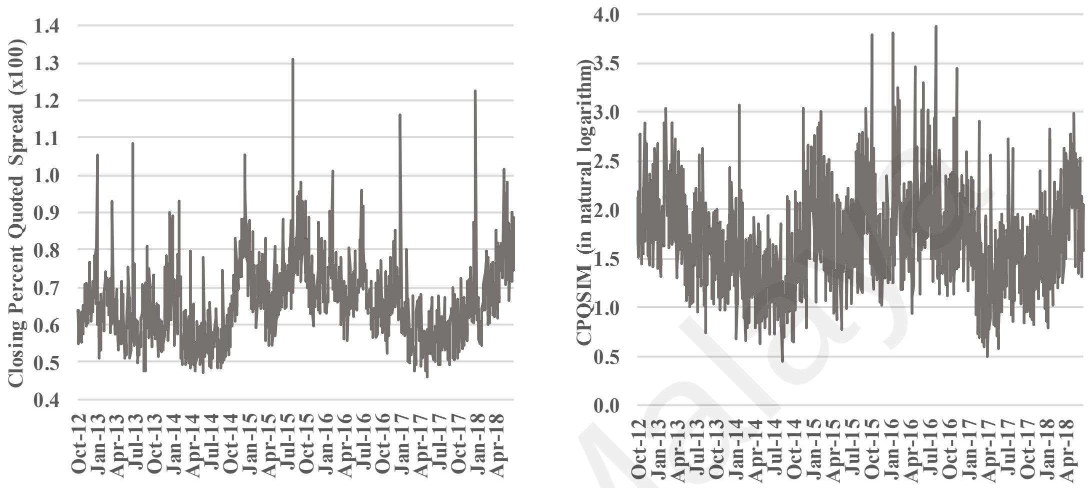
[26] News article commenting on the abnormal trading activities on the local bourse observed on 20th August 2014 is retrieved from http://www.focusmalaysia.my/Mainstream/high-volumes-could-signal-pullback-of-small-cap-stocks, whereas the attribution of such abnormal trading volume to speculative activities by PDTs is accessible from https://www.thestar.com.my/business/business-news/2014/08/23/dont-be-fooled-by-the-high-trading-volume/ (retrieved on 15th September 2018).

[27] Following the procedures outlined in Section 3.3.5 (page 89-91), it is found that the Student's *t* error distribution consistently gives the lowest SIC values for all models, and hence is used in the empirical analyses.

well as 2018 saw heightened volatility of liquidity in the local stock market. Again, volatility clustering behavior is displayed in this series.

Figure 5.2: Aggregate Market liquidity (October 2012 – June 2018)

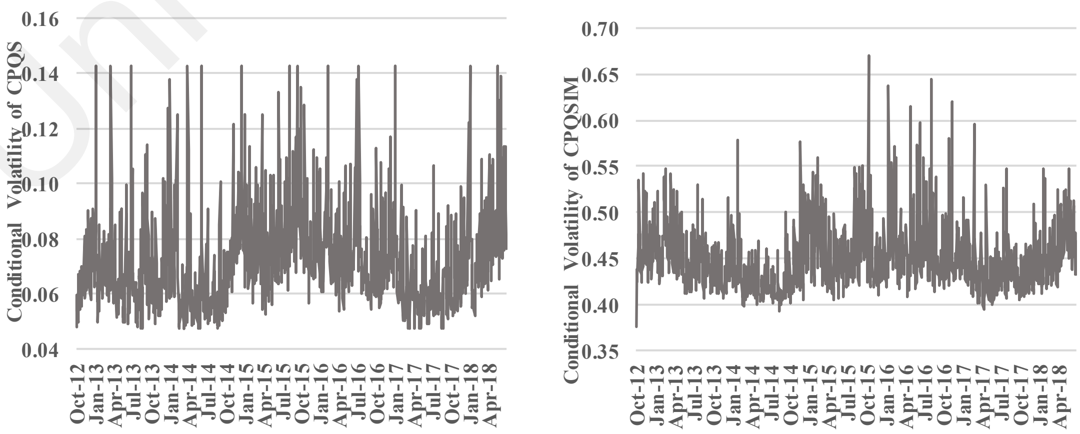
Panel A: CPQS *Panel B: CPQSIM*



Notes: The figure plots the daily aggregate liquidity for the Malaysian stock market, where daily liquidity estimates are first computed for each listed firm and these firm-level values are then aggregated using their respective market capitalization. *CPQS* denotes the Closing Percent Quoted Spread introduced by Chung and Zhang (2014) while *CPQSIM* is the impact version of *CPQS*, calculated as the ratio of *CPQS* to trade volume in local currency term raised to the power of 10^5. *CPQS* is multiplied by 100 to give meaningful readings while *CPQSIM* is specified in natural logarithm. Both *CPQS* and *CPQSIM* are inverse measures of liquidity where higher value indicates lower level of liquidity.

Figure 5.3: Conditional Volatility of Aggregate Liquidity (October 2012 – June 2018)

Panel A: CPQS *Panel B: CPQSIM*



Notes: *CPQS* denotes the Closing Percent Quoted Spread introduced by Chung and Zhang (2014) while *CPQSIM* is the impact version of *CPQS*, calculated as the ratio of *CPQS* to trade volume in local currency term raised to the power of 10^5. Conditional volatility of both, *CPQS* and *CPQSIM*, is obtained by taking the square root of the variance series produced from fitting *CPQS* (in multiple of 100) and *CPQSIM* (in natural logarithm) separately to an EGARCH (1, 1) model.

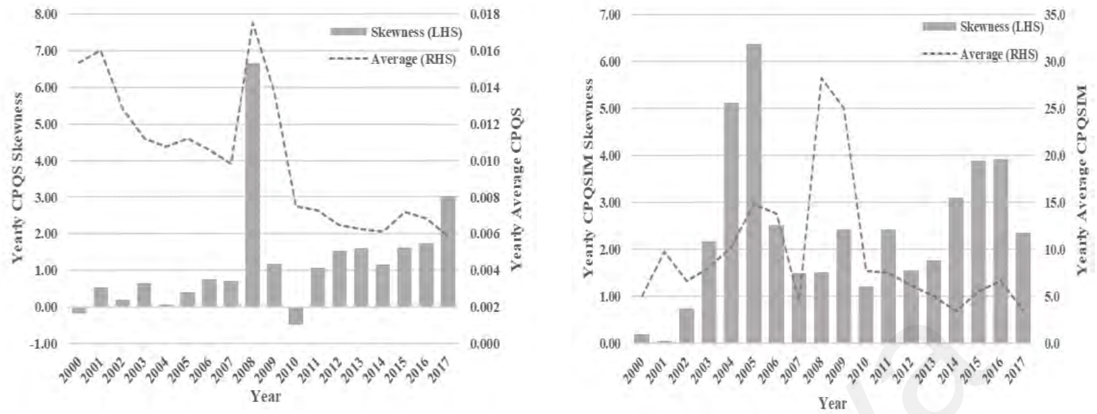
5.1.4 Conditional skewness of aggregate liquidity

Moving on to liquidity skewness, Roll and Subrahmanyam (2010) and Hsieh et al. (2018) both report rising skewness despite improved liquidity in the U.S. and London stock markets respectively, citing greater competition among market makers who widen bid-ask spreads during periods of high information asymmetry. Using annual data from the Malaysian stock market from 2000 to 2017, the annual averages for aggregate liquidity and unconditional liquidity skewness are plotted. Panel A of Figure 5.4 demonstrates, with the exception of the anomaly seen in 2008 due to the Global Financial Crisis, *CPQS* trends downward over the 18-year period while skewness increases over the same period. This observation is consistent with that reported by Roll and Subrahmanyam (2010) and Hsieh et al. (2018). Similar trend, however, is not observed in Panel B of Figure 5.4 for *CPQSIM*. While the same uptick in average market illiquidity is seen in 2008, the downward trend in average *CPQSIM* was not as steep as that of *CPQS*. In contrast to the clear upward trend seen in the skewness for *CPQS*, *CPQSIM* skewness mainly fluctuates over the sample period. The differences in the time series properties of mean and skewness for *CPQS* and *CPQSIM* further highlight the various liquidity dimensions that different liquidity proxies capture.

Figure 5.5 plots the conditional liquidity skewness of *CPQS* on Panel A and *CPQSIM* on Panel B. It can be seen from the graphs that conditional liquidity skewness in the local stock market displays great variations over time with spikes in skewness seen along the sample period. While surges in conditional skewness of *CPQS* are mostly seen throughout the sample period, conditional skewness of *CPQSIM* generally experiences frequent increases in the second half of the sample period. The large and time dependent variations seen in annual unconditional and daily conditional liquidity skewness strengthen the case for adopting time-varying measure of skewness for liquidity series.

Figure 5.4: Trend in Aggregate Liquidity and Liquidity Skewness (2000-2017)

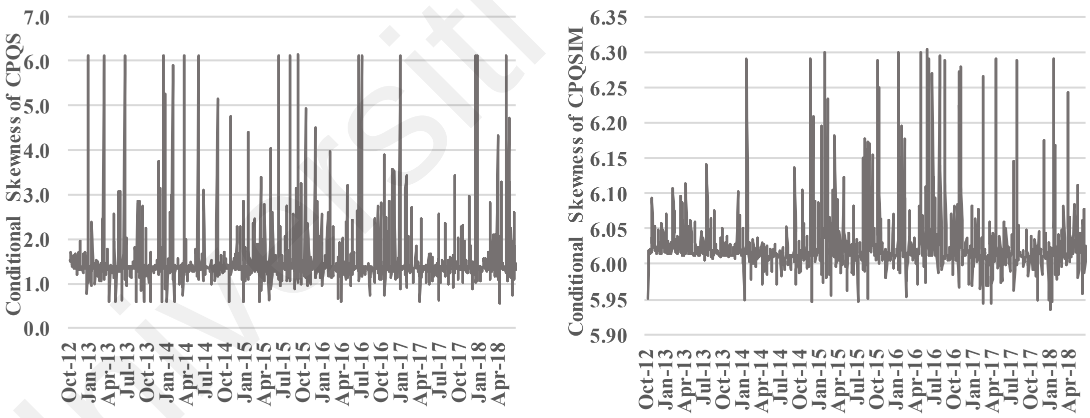
Panel A: CPQS *Panel B: CPQSIM*



Notes: *CPQS* denotes the Closing Percent Quoted Spread introduced by Chung and Zhang (2014) while *CPQSIM* is the impact version of *CPQS*, calculated as the ratio of *CPQS* to trade volume in local currency term raised to the power of 10^5. Annual averages for the level and skewness of *CPQS* and *CPQSIM* are calculated by taking the mean and skewness of their daily estimates over 1-year period.

Figure 5.5: Conditional Skewness of Aggregate Liquidity (October 2012 – June 2018)

Panel A: CPQS *Panel B: CPQSIM*



Notes: *CPQS* denotes the Closing Percent Quoted Spread introduced by Chung and Zhang (2014) while *CPQSIM* is the impact version of *CPQS*, calculated as the ratio of *CPQS* to trade volume in local currency term raised to the power of 10^5. Conditional skewness of both, *CPQS* and *CPQSIM*, is obtained by fitting the standardized residuals of a GARCH-M model to the Harvey and Siddique (1999) skewness equation which is later modelled using the generalized *t*-density distribution introduced by Hansen (1994).

5.2 Descriptive statistics and Unit Root Test Results

Table 5.1 summarizes the descriptive statistics of all variables used in this chapter. On an average trading day, PDTs bought and sold a total of 213.45 million of shares. At its peak, PDTs traded 1.48 billion shares on 20th August 2014, of which, 751.75 million shares were sold while only 725.09 million shares were bought. As explained earlier, such high volume was merely speculative activities by investors on few selected counters. PDTs, given the surge in their trade volume, also came into the limelight and were named the culprits behind such speculation due to their exclusive rights to short sell. The lowest PDTs trade volume, on the other hand, occurred on 18th February 2015 where only a total of 25.85 million shares changed hands, with sale volume of 13.13 million shares, outpacing buy volume by 1.41 million shares. In the absence of any extraordinary market event both, globally and locally, the lack of trade volume by PDTs could be attributed to the pre-Chinese New Year effect whereby most of the traders were probably away from their desks.

Table 5.1: Descriptive Statistics

Variables	Mean	Median	Max.	Min.	Standard Deviation	Skewness
Total Volume (millions)	213.45	187.10	1476.84	25.85	131.3244	2.1947
Buy Volume (millions)	106.69	93.92	725.09	11.72	65.9036	2.2270
Sale Volume (millions)	106.76	93.30	751.75	13.13	65.6082	2.1617
CPQS	0.6528	0.6440	1.3094	0.4605	0.0999	1.0554
CPQSIM	6.0701	5.1009	48.2426	1.5622	3.8867	3.8237
$CPQS^{VOL}$	0.0727	0.0683	0.5065	0.0437	0.0245	7.4688
$CPQSIM^{VOL}$	0.4486	0.4406	0.6702	0.3756	0.0342	1.5653
$CPQS^{SKEW}$	1.4927	1.3598	6.1501	0.5526	0.6705	4.8721
$CPQSIM^{SKEW}$	6.0231	6.0153	6.3041	3.7598	0.0783	-17.6339
RET	0.0306	0.0462	3.3401	-2.8067	0.5142	-0.6036
VOL	0.2546	0.1713	1.8397	0.0606	0.2273	3.0229
MCAP (MYR billions)	1680.89	1677.09	1879.68	1438.81	97.7942	-0.4384

Notes: Total Volume is the sum of buy and sale volume of PDTs in Malaysia. *CPQS* is the Closing Percent Quoted Spread introduced by Chung and Zhang (2014), specified in multiple of 100 to give the indicator more meaningful readings. *CPQSIM* is the impact version of *CPQS*, calculated as the ratio of *CPQS* to volume traded in local currency term raised to the power of 10^5. $CPQS^{VOL}$ ($CPQSIM^{VOL}$) is the conditional volatility of *CPQS* (*CPQSIM*) derived from the EGARCH (1, 1) model. $CPQS^{SKEW}$ ($CPQSIM^{SKEW}$) is the conditional skewness of *CPQS* (*CPQSIM*), obtained by fitting the standardized residuals of a GARCH-M model to the Harvey and Siddique (1999) skewness equation which is later modelled using the generalized *t*-density distribution introduced by Hansen (1994). *RET* is the market returns for the Malaysian stock market, calculated by aggregating daily returns of all stocks in the exchange using the market value-weighting scheme. *VOL* denotes return volatility of the Malaysian stock market, derived from the variance of *RET* fitted to an EGARCH (1, 1) model. *MCAP* is the aggregate market capitalization of the Malaysian stock exchange.

As for liquidity, *CPQS* and its impact version averaged 0.6528 and 6.0701, respectively, over the sample period. Looking at the standard deviation and skewness of these two series, it is observed that *CPQS* has relatively lower variation as well as skewness relative to its impact version. These observations are consistent with the conditional volatility and conditional skewness generated for both the aggregate liquidity measures. On the other hand, market returns averaged 0.03% during the sample period but with standard deviation that was almost 8-fold the average. Over the sample period, market returns recorded the highest daily gain of 3.34% on 6th May 2013 whereas the worst daily plunge of -2.81% took place on 30th May 2018.

In this chapter, the stationarity of all the variables used in Equations (2), (3) and (4) are examined using the Augmented Dickey-Fuller (ADF), the modified Dickey-Fuller *t* test proposed by Elliott et al. (1996) as well as the Phillips-Perron test. Results of the unit root tests which are tabulated in Table 5.2 show that, with the exception of market capitalization which requires first-differencing to achieve stationarity, all the series are integrated of order zero. Therefore, trade volume of PDTs, aggregate market liquidity, conditional liquidity volatility, conditional liquidity skewness, aggregate returns and aggregate return volatility enter Equations (2), (3) and (4) at level whereas aggregate market capitalization enters Equation (4) in the first-difference form.

Table 5.2: Unit Root Test Results

Variable	ADF	DF-GLS	PP	I(d)
Total Volume (millions)	-6.9130***	-6.3321***	-14.1194***	I(0)
Buy Volume (millions)	-6.9394***	-6.3736***	-14.8081***	I(0)
Sale Volume (millions)	-6.9246***	-6.3258***	-13.9729***	I(0)
CPQS	-5.3640***	-5.2029***	-28.2388***	I(0)
CPQSIM	-7.4428***	-6.5987***	-36.7898***	I(0)
$CPQS^{VOL}$	-12.9191***	-9.5125***	-31.3947***	I(0)
$CPQSIM^{VOL}$	-8.1582***	-5.9304***	-33.9093***	I(0)
$CPQS^{SKEW}$	-39.8794***	-39.8068***	-39.9796***	I(0)
$CPQSIM^{SKEW}$	-45.7946***	-3.2362**	-47.2482***	I(0)
RET	-33.2793***	-14.3877***	-33.3026***	I(0)
VOL	-7.2518***	-7.0015***	-7.2298***	I(0)
MCAP (MYR billions)	-2.5767	-1.6404	-2.6005	I(1)
Δ*MCAP* (MYR billions)	-33.9625***	-13.7610***	-33.9616***	

Notes: Total Volume is the sum of buy and sale volume of PDTs in Malaysia. *CPQS* is the Closing Percent Quoted Spread introduced by Chung and Zhang (2014), specified in multiple of 100 to give the indicator more meaningful readings. *CPQSIM* is the impact version of *CPQS*, calculated as the ratio of *CPQS* to volume traded in local currency term raised to the power of 10^5. $CPQS^{VOL}$ ($CPQSIM^{VOL}$) is the conditional volatility of *CPQS* (*CPQSIM*) derived from the EGARCH (1, 1) model. $CPQS^{SKEW}$ ($CPQSIM^{SKEW}$) is the conditional skewness of *CPQS* (*CPQSIM*), obtained by fitting the standardized residuals of a GARCH-M model to the Harvey and Siddique (1999) skewness equation which is later modelled using the generalized *t*-density distribution introduced by Hansen (1994). *RET* is the market returns for the Malaysian stock market, calculated by aggregating daily returns of all stocks in the exchange using the market value-weighting scheme. *VOL* denotes return volatility of the Malaysian stock market derived from the variance of *RET* fitted to an EGARCH (1, 1) model. *MCAP* is the aggregate market capitalization of the Malaysian stock exchange. Δ denotes first-difference and I(d) indicates integration of order d.
ADF is the Augmented Dickey-Fuller unit root test, DF-GLS is the modified Dickey-Fuller *t* test proposed by Elliott et al. (1996), and lastly, PP is the Phillips-Perron unit root test. All the three unit root tests are estimated by including a constant and time trend with optimal lag length selected based on the Schwarz Information Criterion (SIC).
***, ** and * denote significance at the 1%, 5% and 10% levels, respectively, for rejecting the null hypothesis that a time series contains unit root.

5.3 Trade Volume of PDTs and Aggregate Liquidity at Different Orders

After the visualization of key variables, this section presents the regression results and discusses the key findings.

5.3.1 PDTs' Trade Volume and Aggregate Liquidity

Table 5.3 tabulates the results of the GARCH estimations with mean equation as specified in Equation (2). Panel A shows the results for *CPQS* while Panel B presents the estimation outcomes for *CPQSIM*. In general, trade volume of PDTs exerts negative impact on both

CPQS and *CPQSIM*. Since both are inverse measures of liquidity, the negative coefficients for *PDT* suggest improved market liquidity in the Malaysian stock exchange due to trading activities by proprietary day traders. A RM1 million increase in the trade volume of PDTs on the previous trading day reduces *CPQS* by 0.0513. The effect, however, is stronger in the cost-per-volume dimension as not only is lagged PDTs' trade volume significant in enhancing liquidity, but also its contemporaneous term. Coefficients estimated in Panel B of Table 5.3 show that total trade by PDTs on the previous trading day reduces *CPQSIM* by 0.3549 whereas total trade on the same day lowers *CPQSIM* by 0.6816, almost twice the effect of the previous trading day.

At a more granular level, when buy volume and sale volume by PDTs are examined individually, their positive effects on market liquidity are larger than when they are examined jointly as total trade volume. For instance, in the case of *CPQS*, a RM1 million increase in buy volume and sale volume causes *CPQS* to drop by 0.0994 and 0.1053, respectively, vis-à-vis 0.0513 observed for total trade volume. This smaller coefficient for total trade volume is expected given that *CPQS* is an inverse measure of liquidity. While their role is significant, the statistical significance of the GARCH terms of the error process indicates that the time-varying behavior in liquidity is not totally accounted for by the trading activities of PDTs.

Table 5.3: PDTs' Trades and Aggregate Market Liquidity

Panel A: CPQS as the Proxy for LIQ

Mean Equation

	β_0	PDT_t	PDT_{t-1}	RET_{t-1}	VOL_{t-1}	$CPQS_{t-1}$
Buy	0.2677***	-0.0825*	-0.0994**	-0.0115***	0.0943***	0.5753***
	(0.0153)	(0.0458)	(0.0455)	(0.0033)	(0.0089)	(0.0233)
Sale	0.2652***	-0.0682	-0.1053**	-0.0116***	0.0936***	0.5782***
	(0.0153)	(0.0479)	(0.0474)	(0.0033)	(0.0089)	(0.0233)
Total	0.2666***	-0.0378	-0.0513**	-0.0115***	0.0940***	0.5766***
	(0.0153)	(0.0236)	(0.0234)	(0.0033)	(0.0089)	(0.0233)

Conditional Variance Equation

	α_0	ε^2_{t-1}	h_{t-1}
Buy	0.0010***	0.1318***	0.6483***
	(0.0004)	(0.0407)	(0.0943)
Sale	0.0010***	0.1328***	0.6446***
	(0.0004)	(0.0409)	(0.0950)
Total	0.0010***	0.1322***	0.6467***
	(0.0004)	(0.0408)	(0.0946)

Panel B: CPQSIM as the Proxy for LIQ

Mean Equation

	β_0	PDT_t	PDT_{t-1}	RET_{t-1}	VOL_{t-1}	$CPQSIM_{t-1}$
Buy	1.2377***	-1.3016***	-0.7666**	-0.0270	0.4455***	0.3089***
	(0.0525)	(0.3063)	(0.3142)	(0.0231)	(0.0538)	(0.0262)
Sale	1.2388***	-1.4100***	-0.6585**	-0.0256	0.4442***	0.3084***
	(0.0528)	(0.3208)	(0.3319)	(0.0232)	(0.0537)	(0.0262)
Total	1.2390***	-0.6816***	-0.3549**	-0.0264	0.4448***	0.3085***
	(0.0527)	(0.1583)	(0.1630)	(0.0231)	(0.0538)	(0.0262)

Conditional Variance Equation

	α_0	ε^2_{t-1}	h_{t-1}
Buy	0.0188	0.0421**	0.8500***
	(0.0119)	(0.0203)	(0.0806)
Sale	0.0181	0.0414**	0.8544***
	(0.0115)	(0.0199)	(0.0781)
Total	0.0185	0.0418**	0.8521***
	(0.0117)	(0.0201)	(0.0793)

Notes: Mean Equation: $LIQ_t = \beta_0 + \beta_1 PDT_t + \beta_2 PDT_{t-1} + \beta_3 RET_{t-1} + \beta_4 VOL_{t-1} + \beta_5 LIQ_{t-1} + \varepsilon_t$
Conditional Variance Equation: $h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \gamma_1 h_{t-1}$
CPQS is the Closing Percent Quoted Spread by Chung and Zhang (2014) in multiple of 100. *CPQSIM* is the natural logarithm of the impact version of *CPQS* raised to the power of 10^5. *RET* is the market returns series aggregated from daily firm-level observations. *VOL* is the return volatility series derived as the EGARCH (1, 1) of the aggregate return series. *PDT* denotes the trade volume of proprietary day traders in the Malaysian stock market. Numbers in parentheses are standard errors.
***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

From the theoretical perspective, the finding that trade volume of PDTs is positively associated with aggregate liquidity in the local stock market is more in line with the competition model of Subrahmanyam (1991) and Spiegel and Subrahmanyam (1992). The authors posit that increased competition among informed traders to incorporate information into stock prices reduces the degree of information asymmetry in the market, hence leading to increased market liquidity. Another plausible explanation to the finding is the noise trading model of Admati Pfleiderer (1988) which states that the increase in market depth from the entrance of more informed traders in the market creates a strong incentive for noise traders to participate. As the presence of noise traders allows specialists to recoup their losses from trading with informed traders, specialists would then be able to offer a lower bid-ask spread, hence boosting liquidity in the market. This thesis conjectures that PDTs in Malaysia are informed traders given that they are mainly hired by well-capitalized investment firms and would, most probably, have access to information processed by in-house analysts to guide their orders. Moreover, they are professional stock traders with at least five years of trading experience. This interpretation is consistent with the studies by Barber et al. (2014) and Harris and Schultz (1998), who find that day traders are privy to private information or are quick to respond to public information.

Given that the relationship between proprietary day trading and aggregate liquidity in the Malaysian stock market has hitherto been unexplored, this thesis compares the above results to the findings obtained in Section 4.6.3 (page 139-142) where the causal relationship between trade value of PDTs and aggregate liquidity is investigated using weekly data in a Granger causality framework. Results from Section 4.6.3 (page 139-142) show that while PDTs improve liquidity in the Malaysian stock exchange, their trading activities are also affected by liquidity condition in the local bourse. The latter finding is justified as PDTs having strict trading restrictions to close any purchase position within two days and sell position on the same trading day. Despite not using the same measure for trading activities of PDTs, the finding in this section is still consistent with that of Section 4.6.3 (page 139-142) where both also find evidence that PDTs' trades have a positive impact on the aggregate liquidity of the Malaysian stock market. Internationally, the day trading-liquidity papers by Chou et al. (2015) for the Taiwan Index Futures Market and Chung et al. (2009) for the Korean Stock Exchange also find day traders as suppliers of liquidity in their respective markets. The consistency of the finding in this section with the few previous studies reaffirms the liquidity provision role of PDTs, hence addressing the disconnect between academia and Malaysian stock exchange regulator by providing empirical evidence on the liquidity-enhancing benefit of proprietary day trading. This commends the introduction of PDTs by Bursa Malaysia in January 2007 as one of the key measures to boost liquidity of the Malaysian stock market.

5.3.2 PDTs' Trade Volume and the Conditional Volatility of Aggregate Liquidity

Moving on to the relationship between trade volume of PDTs and liquidity volatility, results of GARCH estimations with mean equation as specified in Equation (3) are presented in Table 5.4. The results for conditional volatility of *CPQS* are outlined in Panel A. It is observed that trading activities of PDTs on a trading day increase volatility in the cost that an investor must incur to trade immediately on the same day. At the aggregate level, total trade volume of PDTs on the trading day and the day before increases conditional volatility of *CPQS* by 0.5880 and 0.3780, respectively. Sale volume of PDTs on a trading day appears to have a greater impact on $CPQS^{Vol}$ given its coefficient of 1.3046 vis-à-vis that of buy volume which raises $CPQS^{Vol}$ by only 0.8740. As for the previous trading day, the positive effect of total trade volume on $CPQS^{Vol}$ seems to be driven solely by buy volume of PDTs given the statistical significance of its PDT_{t-1} term vis-à-vis that of sale volume which is only weakly significant at the 10% level. The insignificance of previous day sale volume on conditional volatility of *CPQS* can be attributable to the trading mechanism of PDTs where sale positions are mandated to be closed on the same trading day.

Contrary to the volatility-heightening effect of PDTs' trade volume seen for the percent-cost liquidity proxy, results for *CPQSIM*, tabulated in Panel B of Table 5.4, show that trade volume of PDTs has a contemporaneous negative effect on the conditional volatility of *CPQSIM*. A RM1 million increase in total trade volume of PDTs reduces conditional volatility of *CPQSIM* by 0.0219. At the disaggregate level, sale volume of PDTs has a greater volatility dampening effect given its coefficient of 0.0519 compared to that of buy volume which reduces $CPQSIM^{Vol}$ by only 0.0404.

The contradicting effects of PDTs' trade volume on conditional volatility of *CPQS* and *CPQSIM* are not uncommon in the literature as Lee and Chung (2018) and results from Section 4.5.2 (page 123-125) report inconsistent findings when using liquidity proxies that measure different aspects of liquidity. In examining the relationship between foreign ownership and liquidity, Lee and Chung (2018) find that foreign ownership is positively associated with liquidity measures from the cost-per-volume category but negatively associated with those from the percent-cost spectrum. The additional analysis reported in Section 4.5.2 of Chapter 4 for the first research question (page 123-125), on the other hand, find that the causal relationship between gross inflows of foreign institutional investors and aggregate liquidity in the Malaysian stock exchange is only present in the percent-cost dimension.

Table 5.4: PDTs' Trades and Conditional Volatility of Aggregate Liquidity

Panel A: $CPQS^{VOL}$ as a Proxy for LIQ^{VOL}

Mean Equation

	θ_0	PDT_t	PDT_{t-1}	RET_{t-1}	VOL_{t-1}	$CPQS_{t-1}$
Buy	-3.8182***	0.8740**	0.7603**	-0.0505**	-1.1014***	16.8471***
	(0.1124)	(0.3452)	(0.3526)	(0.0246)	(0.0699)	(0.1666)
Sale	-4.1499***	1.3046***	0.6732*	-0.0758***	-1.2412***	17.3929***
	(0.1180)	(0.4030)	(0.4034)	(0.0269)	(0.0731)	(0.1730)
Total	-4.1187***	0.5880***	0.3780**	-0.0278	-1.1864***	17.3244***
	(0.1085)	(0.1767)	(0.1822)	(0.0242)	(0.0678)	(0.1604)

Conditional Variance Equation

	δ_0	u_{t-1}^2	h_{t-1}	u_{t-2}^2	h_{t-2}	u_{t-3}^2	h_{t-3}
Buy	0.1076***	0.3378***	0.4389**	-0.0257	0.0087	-0.0049	-0.0493***
	(0.0382)	(0.0575)	(0.2217)	(0.0926)	(0.0156)	(0.0685)	(0.0142)
Sale	0.1595***	0.2225***	0.4080***		-0.0355		-0.0419
	(0.0266)	(0.0395)	(0.1470)		(0.0949)		(0.0333)
Total	0.1012***	0.3710***	0.4250***		-0.0260***		-0.0331***
	(0.0115)	(0.0524)	(0.0573)		(0.0022)		(0.0083)

Panel B: $CPQSIM^{VOL}$ as a Proxy for LIQ^{VOL}

Mean Equation

	θ_0	PDT_t	PDT_{t-1}	RET_{t-1}	VOL_{t-1}	$CPQSIM_{t-1}$
Buy	0.3979***	-0.0404**	-0.0214	-0.0039***	0.0224***	0.0265***
	(0.0027)	(0.0164)	(0.0165)	(0.0012)	(0.0027)	(0.0013)
Sale	0.3973***	-0.0519***	-0.0091	-0.0034***	0.0238***	0.0265***
	(0.0017)	(0.0173)	(0.0171)	(0.0012)	(0.0026)	(0.0006)
Total	0.3981***	-0.0219***	-0.0092	-0.0045***	0.0227***	0.0264***
	(0.0027)	(0.0076)	(0.0082)	(0.0012)	(0.0027)	(0.0013)

Conditional Variance Equation

	δ_0	u_{t-1}^2	h_{t-1}	u_{t-2}^2	h_{t-2}
Buy	0.0004**	-0.0413***	0.4859**	0.1559***	0.0484
	(0.0002)	(0.0072)	(0.2194)	(0.0507)	(0.1829)
Sale	0.0004*	-0.0439***	0.5373**	0.1074***	
	(0.0002)	(0.0117)	(0.2129)	(0.0404)	
Total	0.0004**	-0.0413***	0.4743**	0.1564***	0.0399
	(0.0002)	(0.0104)	(0.2089)	(0.0510)	(0.1555)

Notes: Mean Equation: $LIQ_t^{Vol} = \theta_0 + \theta_1 PDT_t + \theta_2 PDT_{t-1} + \theta_3 RET_{t-1} + \theta_4 VOL_{t-1} + \theta_5 LIQ_{t-1} + u_t$
Conditional Variance Equation: $h_t = \delta_0 + \sum_{i=1}^{q} \delta_i u_{t-i}^2 + \sum_{j=1}^{p} \rho_j h_{t-j}$
LIQ refers to aggregate liquidity, which is proxied by *CPQS* and *CPQSIM*. *CPQS* is the Closing Percent Quoted Spread by Chung and Zhang (2014) in multiple of 100. *CPQSIM* is the natural logarithm of the impact version of *CPQS* raised to the power of 10^5. $CPQS^{Vol}$ and $CPQSIM^{Vol}$ are the conditional volatility of *CPQS* and *CPQSIM*, derived using the EGARCH (1, 1) model, respectively. *RET* is the market return series aggregated from daily firm-level observations. *VOL* is the return volatility series derived as the EGARCH (1, 1) of the aggregate return series. *PDT* denotes the trading volume of proprietary day traders in the Malaysian stock market. Numbers in parentheses are standard errors.
***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

As the *CPQS* measures the cost that an investor must face to trade immediately, the finding that PDTs' trade volume causes greater volatility in *CPQS* could be engendered by the strict trading requirements imposed on PDTs to close their open positions within a very short time frame. For instance, on days that a PDT still has unclosed short positions near the end of a trading day, he/she might be forced to accept much lower bid prices for his/her orders. Similarly, higher ask prices would need to be paid when a PDT is faced with the pressure to close any buy position near the end of a trading day. Therefore, this immediacy to close open positions might give rise to greater fluctuations in the bid-ask spreads. On the other hand, lower volatility in the price impact dimension of liquidity from PDTs' trade volume could be explained by the anecdotal evidence that PDTs in Malaysia often trade lower-priced stocks in large volume to make profit from small price gain. Given that the *CPQSIM* is computed as the ratio of *CPQS* to volume in local currency, such trading pattern is likely to produce lower variations in *CPQSIM*. This is compounded by the way this measure of liquidity is constructed. The volume in local currency, which is the denominator of the measure as shown in Equation (9), is often large. When higher-order moments of *CPQSIM* are estimated, the amplification of the denominator has a larger bearing in reducing the scale of the results. This amplification effect can thus offset, or more than offset, any increases in liquidity volatility when measured by *CPQS*, which is also the numerator of *CPQSIM*.

5.3.3 PDT's trade volume and the conditional skewness of aggregate liquidity

Table 5.5 tabulates the results of the GARCH estimations with mean equation as specified in Equation (4) to examine the relationship between trade volume of PDTs and conditional liquidity skewness. Panel A of the table shows that conditional skewness of *CPQS* is positively associated with trading activities of PDTs on the previous trading day. A RM1 million increase in total trade volume heightens $CPQS^{Skew}$ by 0.0948. This positive association indicates that aggregate *CPQS* in the Malaysian stock market becomes more right-skewed following the participation of PDTs in the market. The shift of *CPQS* distribution to the right therefore suggests that their participation has increased the chances of a higher market illiquidity on any trading day. Roll and Subrahmanyam (2010) and Hsieh et al. (2018) both argue that increasingly right-skewed liquidity distribution is a manifestation of increased competition among market makers who are unable to cross-subsidize across periods of high and low information asymmetry. This explanation, however, is not applicable to the Malaysian market given that Bursa Malaysia operates on an order-driven trading system.

This thesis thus draws inference from the paper by Wei et al. (2018) who contend that positive skewness reflects lower liquidity during volatile periods, which, in their case, refer to the Global Financial Crisis and the European sovereign debt crisis. This thesis opines that the positive effect of PDTs' trades on the conditional skewness of *CPQS* can be explained by their exclusivity to intraday short selling (IDSS) during the sample period as well as the ability of day traders to react quickly to public information (Barber et al., 2014; Harris & Schultz, 1998). In the theory postulated by Brunnermeier and Pedersen (2005), front running, an act of liquidating a position via short selling, by predatory traders results in less liquidity when liquidity is needed the most. Furthermore, Blau and Whitby (2018) find that short selling activities generally lead to wider bid-ask spreads in small-capitalization stocks. Given that PDTs in Malaysia are granted the exclusive rights to perform IDSS and their tendency to trade small-capitalization stocks, their trades are likely to result in higher *CPQS* readings especially during stressed periods as hypothesized by Brunnermeier and Pedersen (2005), hence causing the *CPQS* distribution to be more right-skewed.

Table 5.5: PDTs' Trades and Conditional Skewness of Aggregate Liquidity

Panel A: $CPQS^{Skew}$ as a Proxy of LIQ^{Skew}

Mean Equation

	ω_0	PDT_t	PDT_{t-1}	VOL_{t-1}	$\Delta LMCAP_{t-1}$	$CRISIS_{t-1}$	$CPQS_{t-1}$
Buy	1.1114***	-0.0568	0.1615**	-0.0813***	-0.1604	0.0372***	0.3959***
	(0.0285)	(0.0707)	(0.0730)	(0.0144)	(0.5338)	(0.0128)	(0.0433)
Sale	1.1261***	-0.0508	0.1827**	-0.0774***	-0.4515	0.0342***	0.3701***
	(0.0276)	(0.0725)	(0.0736)	(0.0146)	(0.5339)	(0.0127)	(0.0421)
Total	1.1260***	-0.0284	0.0948**	-0.0713***	-0.0103	0.0320***	0.3655***
	(0.0277)	(0.0360)	(0.0373)	(0.0142)	(0.5258)	(0.0123)	(0.0422)

Conditional Variance Equation#

	φ_0	v^2_{t-1}	h_{t-1}	v^2_{t-2}	h_{t-2}	v^2_{t-3}	h_{t-3}
Buy	0.2413***	0.4702	0.0554	-0.0342	0.0026	-5.98E-07	-0.1092**
	(0.5161)	(1.0147)	(0.0725)	(0.0791)	(0.0403)	(0.0237)	(0.0452)
Sale	0.1192	0.4408	0.9032***	-0.4045	0.0845	-0.0387	-0.1915
	(0.2835)	(1.1067)	(0.1393)	(1.0715)	(0.1926)	(0.0355)	(0.1556)
Total	0.1129	0.3280	0.2974***	-0.1015	0.0166	-0.0093	-0.1422**
	(0.1413)	(0.4292)	(0.1148)	(0.1560)	(0.0705)	(0.0128)	(0.0580)

Panel B: $CPQSIM^{Skew}$ as a Proxy of LIQ^{Skew}

Mean Equation

	ω_0	PDT_t	PDT_{t-1}	VOL_{t-1}	$\Delta LMCAP_{t-1}$	$CRISIS_{t-1}$	$CPQSIM_{t-1}$
Buy	6.0126***	-0.0002	-0.0298***	0.0045**	0.1178	0.0019	0.0032***
	(0.0018)	(0.0110)	(0.0111)	(0.0021)	(0.0785)	(0.0015)	(0.0009)
Sale	6.0120***	-0.0022	-0.0327***	0.0044**	0.0997	0.0018	0.0035***
	(0.0017)	(0.0110)	(0.0111)	(0.0020)	(0.0747)	(0.0014)	(0.0008)
Total	6.0125***	1.24E-05	-0.0151***	0.0048**	0.1045	0.0019	0.0032***
	(0.0017)	(0.0055)	(0.0056)	(0.0020)	(0.0757)	(0.0014)	(0.0008)

Conditional Variance Equation

	φ_0	v^2_{t-1}	h_{t-1}	h_{t-2}	h_{t-3}	h_{t-4}	h_{t-5}
Buy	0.0006**	0.1032**	0.4282*	0.0120	0.0027	-0.0023	-0.0063
	(0.0002)	(0.0473)	(0.2593)	(0.2857)	(0.1677)	(0.0577)	(0.0089)
Sale	0.0004***	0.0789***	0.4235*	0.0146	0.0031	-0.0021	-0.0061
	(0.0001)	(0.0289)	(0.2573)	(0.2546)	(0.1708)	(0.0851)	(0.0157)
Total	0.0006**	0.0693**	0.4400	0.0215	0.0021	-0.0033	-0.0072
	0.0003	0.0328	0.2880	0.2246	0.1206	0.1308	0.0379

Notes: Mean Equation: $LIQ_t^{Skew} = \omega_0 + \omega_1 PDT_t + \omega_2 PDT_{t-1} + \omega_3 VOL_{t-1} + \omega_4 \Delta LMCAP_{t-1} + \omega_5 CRISIS_{t-1} + \omega_6 LIQ_{t-1} + v_t$

Conditional Variance Equation: $h_t = \varphi_0 + \sum_{i=1}^{q} \varphi_i v_{t-i}^2 + \sum_{i=1}^{p} \sigma_j h_{t-j}$

LIQ refers to aggregate liquidity, which is proxied by *CPQS* and *CPQSIM*. *CPQS* is the Closing Percent Quoted Spread by Chung and Zhang (2014) in multiple of 100. *CPQSIM* is the natural logarithm of the impact version of *CPQS* raised to the power of 10^5. $CPQS^{SKEW}$ and $CPQSIM^{SKEW}$ are the conditional skewness of *CPQS* and *CPQSIM*, respectively. *PDT* denotes the trading volume of proprietary day traders in the Malaysian stock market. *VOL* is the return volatility series derived as the EGARCH (1, 1) of the aggregated return series (*RET*). *LMCAP* is the aggregate market capitalization of the Malaysian stock market in natural logarithm. $CRISIS_t$ is the extreme market liquidity event dummy which takes the value of one when *LIQ* on day *t* is greater than the 70^{th} percentile and zero otherwise. Numbers in parentheses are standard errors.

***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

In Panel A, GARCH(4,4) is used to model Equation (4). However, this thesis only reports variance equation of up to three lags due to space constraint.

Apart from short selling, the positive association of PDTs' trades and conditional skewness of *CPQS* can also arise from the volatility-heightening effect of their trades, as evidenced in Table 5.4. In the return skewness literature, the leverage effects hypothesis proposed by Black (1976) and Christie (1982), as well as the volatility-feedback hypothesis by Pindyck (1984) and French et al. (1987) attribute return volatility as the channel through which changes in share prices lead to negative skewness in stock market returns. In the leverage effects hypothesis, volatility is induced by changes in investors' financial and operating leverages. Volatility-feedback hypothesis, on the other hand, conjectures that volatility is caused by the arrival of good and bad news. Applying these hypotheses to the concept of liquidity skewness, this thesis therefore contends that the positive impact of PDTs' trade volume on conditional skewness of *CPQS* is also in part related to the positive impact of their trades on conditional volatility. This also explains the negative association observed between lagged PDTs' trade volume and conditional skewness of *CPQSIM*, as shown in Panel B of Table 5.4. It is important to highlight that such negative association should not be construed as the conditional skewness of *CPQSIM* being negatively-skewed, but rather a reduction in the degree of right-skewness of the *CPQSIM* distribution. This underscores the earlier explanation on the scaling effect due to the large denominator of the *CPQSIM* measure when higher-order moments are involved.

5.4 Robustness Check

All the results shown thus far use the Student's *t* distribution to model GARCH innovations in Equations (2), (3) and (4). To ensure the robustness of the findings, these models are re-estimated using the Generalized Error Distribution (GED) by Nelson (1991), an alternative distribution of GARCH innovations. Results of the re-estimation of Equations (2), (3) and (4) with GED innovations, tabulated in Tables 5.6, 5.7 and 5.8

respectively, demonstrate that the baseline findings are robust to alternative distribution of GARCH error terms. At the level, trading activities of PDTs on the previous trading day is negatively associated with *CPQS* while *CPQSIM* reacts negatively to trading activities of PDTs on both the current as well as the previous trading days. Additionally, the estimated coefficients of PDT_t and PDT_{t-1} are comparable in Table 5.3 and Table 5.6.

In the second moment, while the positive (negative) association of PDTs' trade volume with conditional volatility of *CPQS* (*CPQSIM*) is preserved when innovations are modelled using GED, PDTs' trades on the previous trading day (PDT_{t-1}) lose its significance on $CPQS^{Vol}$ but significantly affect $CPQSIM^{Vol}$. Lastly, it is observed that when GARCH innovations are modelled using GED, both PDT_t and PDT_{t-1} affect $CPQS^{Skew}$ positively but $CPQSIM^{Skew}$ negatively, indicating a stronger effect of PDTs' trade volume on conditional skewness of liquidity compared to when innovations are modeled using Student's *t* distribution.

Table 5.6:
PDTs' Trades and Aggregate Liquidity with Generalized Error Distribution

Panel A: CPQS as the Proxy for LIQ

Mean Equation

	β_0	PDT_t	PDT_{t-1}	RET_{t-1}	VOL_{t-1}	$CPQS_{t-1}$
Buy	0.2628***	-0.0837*	-0.0914**	-0.0106***	0.0944***	0.5814***
	(0.0148)	(0.0431)	(0.0436)	(0.0033)	(0.0088)	(0.0225)
Sale	0.2606***	-0.0738	-0.0937**	-0.0106***	0.0939***	0.5839***
	(0.0148)	(0.0452)	(0.0454)	(0.0033)	(0.0088)	(0.0225)
Total	0.2618***	-0.0402*	-0.0457**	-0.0106***	0.0942***	0.5826***
	(0.0148)	(0.0223)	(0.0225)	(0.0033)	(0.0088)	(0.0225)

Conditional Variance Equation

	α_0	ε_{t-1}^2	h_{t-1}
Buy	0.0009***	0.1186***	0.6884***
	(0.0003)	(0.0369)	(0.0849)
Sale	0.0009***	0.1188***	0.6869***
	(0.0003)	(0.0369)	(0.0854)
Total	0.0009***	0.1186***	0.6878***
	(0.0003)	(0.0369)	(0.085)

Panel B: CPQSIM as the Proxy for LIQ

Mean Equation

	β_0	PDT_t	PDT_{t-1}	RET_{t-1}	VOL_{t-1}	$CPQSIM_{t-1}$
Buy	1.2453***	-1.3715***	-0.7135**	-0.0274	0.4425***	0.3070***
	(0.0532)	(0.3101)	(0.3164)	(0.0234)	(0.0551)	(0.0264)
Sale	1.2460***	-1.4856***	-0.6003*	-0.0257	0.4417***	0.3067***
	(0.0534)	(0.3245)	(0.3334)	(0.0234)	(0.0551)	(0.0264)
Total	1.2465***	-0.7189***	-0.3263**	-0.02671	0.4421***	0.3067***
	(0.0533)	(0.1602)	(0.1640)	(0.0234)	(0.0551)	(0.0264)

Conditional Variance Equation

	α_0	ε_{t-1}^2	h_{t-1}
Buy	0.0156*	0.0373**	0.8728***
	(0.0092)	(0.0173)	(0.0628)
Sale	0.0152*	0.0370**	0.8757***
	(0.0089)	(0.0171)	(0.0613)
Total	0.0154*	0.0372**	0.8742***
	(0.0090)	(0.0172)	(0.0621)

Notes: Mean Equation: $LIQ_t = \beta_0 + \beta_1 PDT_t + \beta_2 PDT_{t-1} + \beta_3 RET_{t-1} + \beta_4 VOL_{t-1} + \beta_5 LIQ_{t-1} + \varepsilon_t$
Conditional Variance Equation: $h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \gamma_1 h_{t-1}$
LIQ refers to aggregate liquidity, which is proxied by *CPQS* and *CPQSIM*. *CPQS* is the Closing Percent Quoted Spread by Chung and Zhang (2014) in multiple of 100. *CPQSIM* is the natural logarithm of the impact version of *CPQS* raised to the power of 10^5. *RET* is the market return series aggregated from daily firm-level observations. *VOL* is the return volatility series derived as the EGARCH (1, 1) of the aggregate return series. *PDT* denotes the trade volume of proprietary day traders in the Malaysian stock market. Numbers in parentheses are standard errors.
***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table 5.7: PDTs' Trades and Conditional Volatility of Aggregate Liquidity with Generalized Error Distribution

Panel A: $CPQS^{VOL}$ as a Proxy for LIQ^{VOL}

Mean Equation

	θ_0	PDT_t	PDT_{t-1}	RET_{t-1}	VOL_{t-1}	$CPQS_{t-1}$
Buy	-3.5079***	0.7325***	0.5379*	-0.0415*	-0.9464***	16.3789***
	(0.0908)	(0.2744)	(0.2819)	(0.0215)	(0.0599)	(0.1417)
Sale	-3.5291***	0.7298**	0.5422*	-0.0424**	-0.9520***	16.4111***
	(0.0929)	(0.2889)	(0.2945)	(0.0216)	(0.0605)	(0.1448)
Total	-3.5095***	0.3814***	0.2724*	-0.0421*	-0.9459***	16.3750***
	(0.0937)	(0.1422)	(0.1456)	(0.0216)	(0.0605)	(0.1459)

Conditional Variance Equation

	δ_0	u_{t-1}^2	h_{t-1}
Buy	0.1330***	0.8756***	0.1576***
	(0.0163)	(0.1263)	(0.0518)
Sale	0.1331***	0.8791***	0.1550***
	(0.0163)	(0.1264)	(0.0515)
Total	0.1342***	0.8743***	0.1555***
	(0.0164)	(0.1264)	(0.0519)

Panel B: $CPQSIM^{VOL}$ as a Proxy for LIQ^{VOL}

Mean Equation

	θ_0	PDT_t	PDT_{t-1}	RET_{t-1}	VOL_{t-1}	$CPQSIM_{t-1}$
Buy	0.3933***	-0.0244**	-0.0293***	-0.0032***	0.0206***	0.0261***
	(0.0013)	(0.0100)	(0.0094)	(0.0009)	(0.0021)	(0.0006)
Sale	0.3938***	-0.0293***	-0.0269***	-0.0032***	0.0205***	0.0260***
	(0.0012)	(0.0107)	(0.0097)	(0.0008)	(0.0021)	(0.0006)
Total	0.3934***	-0.0132***	-0.0139***	-0.0032***	0.0209***	0.0261***
	(0.0013)	(0.0050)	(0.0048)	(0.0008)	(0.0021)	(0.0006)

Conditional Variance Equation

	δ_0	u_{t-1}^2	h_{t-1}	u_{t-2}^2
Buy	1.44E-05*	-0.0276***	0.9461***	0.0662***
	(7.53E-06)	(0.0067)	(0.0156)	(0.0116)
Sale	1.60E-05*	-0.0271***	0.9431***	0.0670***
	(8.34E-06)	(0.0065)	(0.0168)	(0.0120)
Total	1.68E-05*	-0.0270***	0.9414***	0.0677***
	(8.70E-06)	(0.0063)	(0.0173)	(0.0122)

Notes: Mean Equation: $LIQ_t^{Vol} = \theta_0 + \theta_1 PDT_t + \theta_2 PDT_{t-1} + \theta_3 RET_{t-1} + \theta_4 VOL_{t-1} + \theta_5 LIQ_{t-1} + u_t$

Conditional Variance Equation: $h_t = \delta_0 + \sum_{i=1}^{q} \delta_i u_{t-i}^2 + \sum_{j=1}^{p} \rho_j h_{t-j}$

LIQ refers to aggregate liquidity, which is proxied by *CPQS* and *CPQSIM*. *CPQS* is the Closing Percent Quoted Spread by Chung and Zhang (2014) in multiple of 100. *CPQSIM* is the natural logarithm of the impact version of *CPQS* raised to the power of 10^5. $CPQS^{Vol}$ and $CPQSIM^{Vol}$ are the conditional volatility of *CPQS* and *CPQSIM*, derived using the EGARCH (1, 1) model, respectively. *RET* is the market return series aggregated from daily firm-level observations. *VOL* is the return volatility series derived as the EGARCH (1, 1) of the aggregate return series. *PDT* denotes the trading volume of proprietary day traders in the Malaysian stock market. Numbers in parentheses are standard errors.

***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table 5.8: PDTs' Trades and Conditional Skewness of Aggregate Liquidity with Generalized Error Distribution

Panel A: $CPQS^{Skew}$ as a Proxy of LIQ^{Skew}							
Mean Equation							
	ω_0	PDT_t	PDT_{t-1}	VOL_{t-1}	$\Delta LMCAP_{t-1}$	$CRISIS_{t-1}$	$CPQS_{t-1}$
Buy	0.0179**	0.4454***	0.6535***	-0.4119***	-4.0451***	0.0073	2.0794***
	(0.0076)	(0.0457)	(0.0442)	(0.0101)	(0.2703)	(0.0087)	(0.0118)
Sale	-0.1821***	0.1815***	1.1038***	-0.4465***	-1.7004**	0.0305***	2.3527***
	(0.0047)	(0.0178)	(0.0282)	(0.0074)	(0.4276)	(0.0033)	(0.0059)
Total	-0.1936***	0.2444***	0.3921***	-0.4481***	-2.0903***	-0.0403***	2.3828***
	(0.0060)	(0.0248)	(0.0249)	(0.0127)	(0.3702)	(0.0127)	(0.0068)
Conditional Variance Equation							
	φ_0	v_{t-1}^2	h_{t-1}				
Buy	0.0784***	0.0805	0.4887***				
	(0.0256)	(0.0583)	(0.1581)				
Sale	0.0737***	0.0850	0.5108***				
	(0.0226)	(0.0551)	(0.1418)				
Total	0.0740	0.0222	0.5081*				
	(0.0458)	(0.0269)	(0.2976)				
Panel B: $CPQSIM^{Skew}$ as a Proxy of LIQ^{Skew}							
Mean Equation							
	ω_0	PDT_t	PDT_{t-1}	VOL_{t-1}	$\Delta LMCAP_{t-1}$	$CRISIS_{t-1}$	$CPQSIM_{t-1}$
Buy	6.0133***	-0.0266***	-0.0364***	0.0062***	-0.0628***	0.0053***	0.0047***
	(0.0001)	(0.0011)	(0.0010)	(0.0001)	(0.0066)	(0.0002)	(1.97E-05)
Sale	6.0108***	0.0094***	-0.0190***	0.0023***	-0.0145	0.0002	0.0023***
	(0.0002)	(0.0015)	(0.0017)	(0.0003)	(0.0110)	(0.0002)	(0.0001)
Total	6.0121***	-0.0095***	-0.0144***	0.0070***	-0.0457***	-0.0026***	0.0040***
	(0.0002)	(0.0014)	(0.0014)	(0.0007)	(0.0053)	(0.0002)	(0.0002)
Conditional Variance Equation							
	φ_0	v_{t-1}^2	h_{t-1}	v_{t-2}^2	h_{t-2}	v_{t-3}^2	v_{t-4}^2
Buy	0.0039***	-0.0046	0.4727***	-0.0226			
	(0.0010)	(0.0439)	(0.0307)	(0.0202)			
Sale	0.0003***	0.7786***	0.4792***	-0.3087			
	(0.0001)	(0.2883)	(0.1106)	(0.2117)			
Total	0.0004***	0.6748**	0.4162**	-0.0854	-0.0833	-0.0367	0.0458***
	(0.0001)	(0.2777)	(0.1713)	(0.2063)	(0.0537)	(0.0541)	(0.0144)

Notes: Mean Equation: $LIQ_t^{Skew} = \omega_0 + \omega_1 PDT_t + \omega_2 PDT_{t-1} + \omega_3 VOL_{t-1} + \omega_4 \Delta LMCAP_{t-1} + \omega_5 CRISIS_{t-1} + \omega_6 LIQ_{t-1} + v_t$

Conditional Variance Equation: $h_t = \varphi_0 + \sum_{i=1}^{q} \varphi_i v_{t-i}^2 + \sum_{i=1}^{p} \sigma_j h_{t-j}$

LIQ refers to aggregate liquidity, which is proxied by *CPQS* and *CPQSIM*. *CPQS* is the Closing Percent Quoted Spread by Chung and Zhang (2014) in multiple of 100. *CPQSIM* is the natural logarithm of the impact version of *CPQS* raised to the power of 10^5. $CPQS^{SKEW}$ and $CPQSIM^{SKEW}$ are the conditional skewness of *CPQS* and *CPQSIM*, respectively. *PDT* denotes the trading volume of proprietary day traders in the Malaysian stock market. *VOL* is the return volatility series derived as the EGARCH (1, 1) of the aggregated return series (*RET*). *LMCAP* is the aggregate market capitalization of the Malaysian stock market in natural logarithm. $CRISIS_t$ is the extreme market liquidity event dummy which takes the value of one when *LIQ* on day *t* is greater than the 70th percentile and zero otherwise. Numbers in parentheses are standard errors.

***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

5.5 Summary of Empirical Results

This section employs the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model to answer the question of how trading activities of PDTs are associated with aggregate liquidity and its higher-order moments in the Malaysian stock market. Using daily data spanning October 2012 to June 2018, it is found that daily trade volume of PDTs is positively associated with daily aggregate liquidity in the local stock market, proxied by the *CPQS* and *CPQSIM* (the impact version of *CPQS*). This positive relationship is attributable to a reduction in information asymmetry in the market due to rising competition between PDTs and other informed traders to incorporate information into stock prices, consistent with the competition model of Subrahmanyam (1991) and Spiegel and Subrahmanyam (1992). At the second moment where conditional liquidity volatility is derived by fitting *CPQS* and *CPQSIM* to the Exponential GARCH (1,1) model, evidence on the relationship between PDTs' trade volume and volatility of liquidity is mixed. PDTs' participation in the local stock market is found to be positively associated with the conditional volatility of *CPQS* but negatively associated with that of C*PQSIM*. This thesis interprets the positive liquidity volatility-PDTs relationship as greater fluctuations in the bid and ask prices due to PDTs' immediacy to close open positions. Their strategy of trading large volume to profit from small price gain, however, reduces volatility in the price impact of a trade as measured by *CPQSIM*.

Moving to the third moment, conditional skewness for both *CPQS* and *CPQSIM* are computed using Harvey and Siddique's (1999) specification for conditional skewness and fitting normalized residuals from a GARCH-in-mean model to the generalized *t*-density distribution proposed by Hansen (1994). In exploring the relationship between PDTs' trade volume and conditional liquidity skewness, this thesis reports that trade volume of PDTs is positively associated with conditional skewness of *CPQS*, which is found to be right-skewed. This positive relationship, interpreted as increased possibilities of illiquidity during stressed periods, can be attributed to PDTs' exclusive rights to engage in intraday short selling during most parts of the sample period as well as the liquidity volatility-heightening effect of their trades. The negative coefficient of PDTs' trade volume on conditional skewness of *CPQSIM*, on the other hand, is interpreted as PDTs moderating the right-skewness of *CPQSIM*, consistent with its negative association with the conditional volatility of *CPQSIM*.

CHAPTER 6

LIQUIDITY CONNECTEDNESS AMONG STOCK, BOND, MONEY AND FOREGIN EXCHANGE MARKETS

The third and final research question in this thesis explores the liquidity connectedness among four main asset markets in Malaysia, with their empirical results presented in this chapter. The four asset markets chosen are stock market, bond market, money market and foreign exchange market. Section 6.1 provides graphical overview of the constructed liquidity series for all four asset markets. The descriptive statistics and unit root test results of the four liquidity series are presented in the following two sections. Section 6.4 then reports and deliberates the static liquidity connectedness among the four asset markets in Malaysia. The proposed time-varying liquidity connectedness among the chosen markets is then presented and examined extensively in Section 6.5. To put the results into perspective, Section 6.6 compares with previous studies that employ the dynamic framework of Diebold and Yilmaz (2009, 2012, 2014). Finally, Section 6.7 concludes the chapter by providing a summary of the empirical results for the third research question.

6.1 Graphical Plots of Constructed Liquidity Series

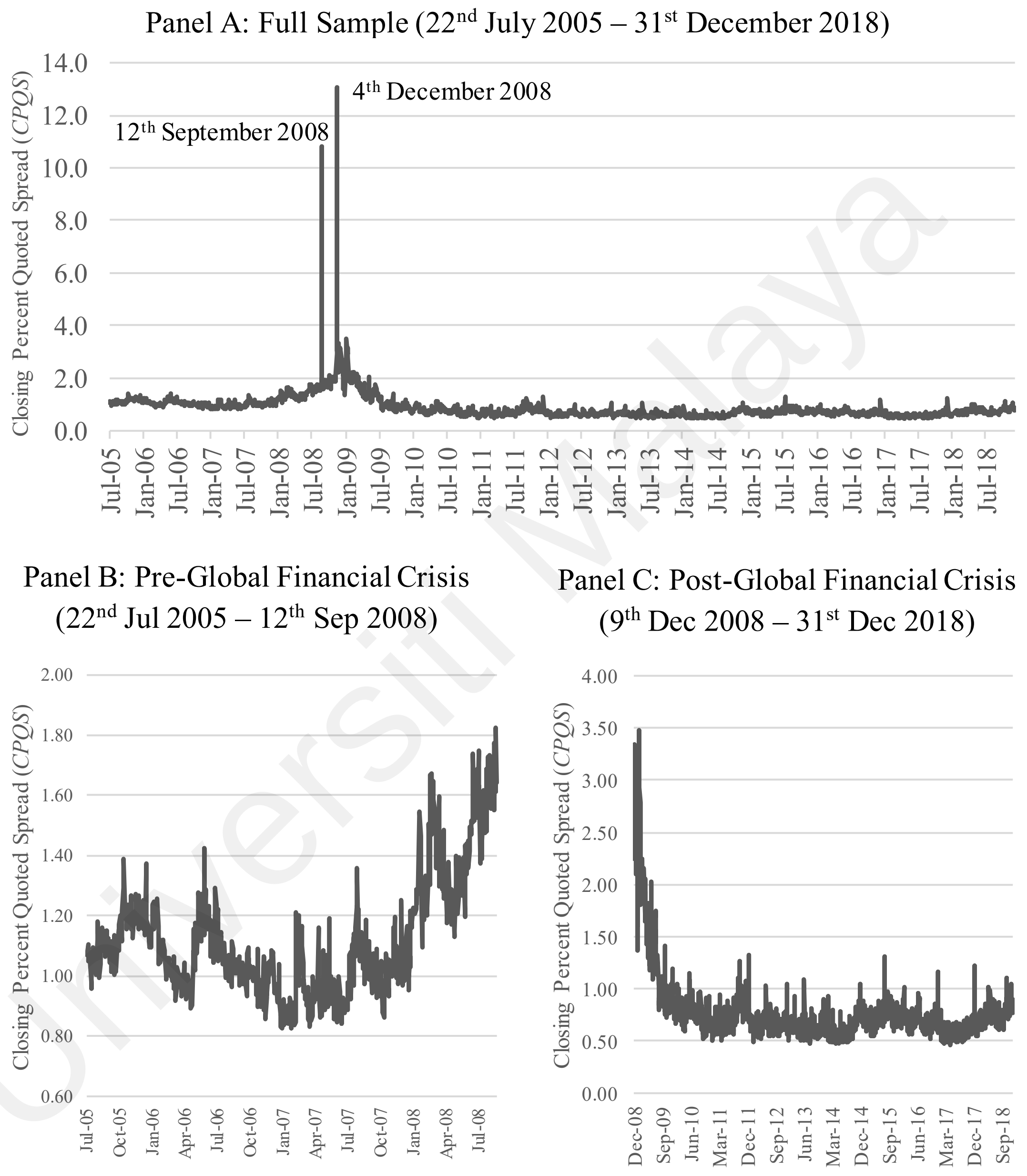
This section provides a graphical overview of the key variables used to accomplish the last research objective of examining liquidity connectedness among the four main asset markets in Malaysia. The variables presented in this section include the daily aggregate liquidity measure of the Malaysian stock market, the daily aggregate liquidity measure of the Malaysian bond market, the liquidity indicator of the Malaysian money market and finally, the liquidity measure of the USD/MYR currency pair. As the ringgit was pegged to the U.S. dollar from 2nd September 1998 to 21st July 2005, the sample period of this study begins from 22nd July 2005 and ends on 31st December 2018.

6.1.1 Aggregate Liquidity of the Malaysian Stock Market

Panel A of Figure 6.1 charts the daily aggregate liquidity of the Malaysian stock market over the full sample period, proxied by the Closing Percent Quoted Spread (*CPQS*) proposed by Chung and Zhang (2014), an inverse measure of liquidity. It can be observed that the Malaysian stock market was relatively liquid after the Global Financial Crisis (GFC), manifested by the drop in the level of aggregate liquidity after July 2009 compared to the period before July 2008. Two outliers are observed in the aggregate stock market liquidity series. The first outlier, which occurred on 12th September 2008, coincides with the day when U.S. officials met to decide on the fate of Lehman Brothers, which fell through and led to the declaration of the investment bank's bankruptcy on 15th September 2008. The second outlier happened on 4th December 2008, when the European Central Bank (ECB), the Bank of England (BoE) as well as central banks in Sweden and Denmark slashed their respective benchmark interest rates in response to news that the Eurozone slipped into a recession in the third quarter of 2008. Three days ago, on 1st December 2008, the National Bureau of Economic Research (NBER) had also confirmed the U.S. recession.

As movements of the aggregate stock market liquidity series are muffled by the larger scale needed to reflect outliers due to the GFC, the liquidity series is split into two subsamples, namely pre-GFC (22nd July 2005 – 12th September 2008), presented in Panel B of Figure 6.1, and post-GFC (9th December 2008 – 31st December 2018), presented in Panel C of Figure 6.1, to enable closer examination of the time series trend of the series. The period from 13th September 2008 to 8th December 2008 is omitted in the plotting of charts to avoid large scale needed to accommodate abnormally high Closing Percent Quoted Spread (*CPQS*) readings during this period due to the unfolding of the GFC.

Figure 6.1: Aggregate Stock Market Liquidity



Notes: Aggregate stock market liquidity is measured by the Closing Percent Quoted Spread (*CPQS*) introduced by Chung and Zhang (2014), which is an inverse liquidity measure. It is first calculated as the ratio of the difference of the closing ask and bid prices to their average for each firm listed on Bursa Malaysia. These firm level observations are then aggregated using the firms' respective market capitalization as weights. The final aggregate *CPQS* indicator is specified in multiple of 100 for more meaningful readings.

Panel B of Figure 6.1 shows that aggregate liquidity in the Malaysian stock market had already exhibited signs of tightening in early-2007 following the announcement made by HSBC on its losses linked to the U.S. subprime mortgage in February 2007. In the period from July 2005 to end-2006, aggregate liquidity hovered around the mean of 1.10. However, liquidity in the local bourse quickly vaporized during the period leading to the GFC, as manifested by the steep incline of the series from early-2007 to September 2008 with the *CPQS* seen surpassing the 1.80 level. Looking at liquidity of the Malaysian stock market post-GFC, Panel C of Figure 6.1 shows that aggregate liquidity improved exponentially from December 2008 to early-2010. This phenomenon can be explained by the injection of mass liquidity[28] when the U.S. Federal Reserve and other major central banks loosened their respective monetary policies to combat the slowdown in their respective economies due to the crisis. The increase in money supply in the advanced economies had resulted in investors rushing to emerging markets to hunt for higher yields, hence explaining the drop in *CPQS* and higher aggregate stock market liquidity in the post-GFC period.

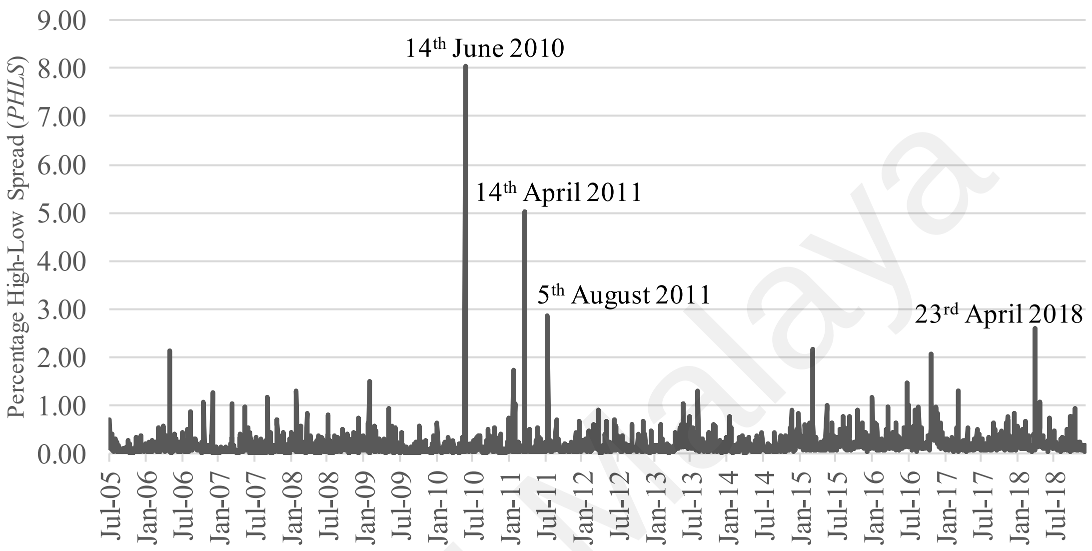
6.1.2 Aggregate Liquidity of the Malaysian Bond Market

Figure 6.2 plots the aggregate liquidity of the Malaysian bond market over the sample period of 22nd July 2005 to 31st December 2018, measured by the Percentage High-Low Spread (*PHLS*), an inverse measure of liquidity. Unlike the aggregate liquidity series for the Malaysian stock market, bond market liquidity largely falls below 1.00 and does not exhibit discernible sign of break in the level nor any noticeable trend. There are, however, a few incidences of acute illiquidity in the local bond market, indicated by spikes in the series. First, the most illiquid day in the bond market during the sample period was on

[28] Liquidity in this context refers to macroeconomic liquidity in the form of total money supply in the economy and not the ease of trading with minimal price impact.

14th June 2010, when Greece's sovereign credit rating was downgraded to junk by Moody's.

Figure 6.2: Aggregate Bond Market Liquidity
(22nd July 2005 – 31st December 2018)



Notes: Aggregate bond market liquidity is measured by the Percentage High-Low Spread (*PHLS*), which is an inverse liquidity measure. It is calculated as the ratio of the difference of the daily high and low prices to their average. The *PHLS* is first computed for all individual bonds transacted on a trading day and later aggregated using the equal weighting scheme to produce the market-level bond liquidity indicator.

The next severe illiquidity episode took place on 14th April 2011. While there is no particular market event on that day to explain this illiquidity episode, market sentiment at the beginning of the week was dampened by global growth concerns and growing worries on the severity of Japan's nuclear disaster after two consecutive days of earthquake. Four months later, on 5th August 2011, there was another liquidity shock in the Malaysian bond market though at a smaller scale. This time, it is due to the downgrade of U.S. sovereign credit rating, deemed the world's safest, from AAA to AA+ with a negative outlook by international credit rating agency Standard & Poor's. Lastly, the spike seen on 23rd April 2018 is mainly contributed by rising U.S. Treasury yields during the same period. On 24th April 2018, the benchmark 10-year U.S. Treasury yield hit the psychological 3.00% mark for the first time since January 2014. This had resulted in investors repositioning their investments in view of the higher yields seen in the U.S. and prompted fears of massive sell-off of risky assets in the emerging markets.

6.1.3 Aggregate Liquidity of the Malaysian Money Market

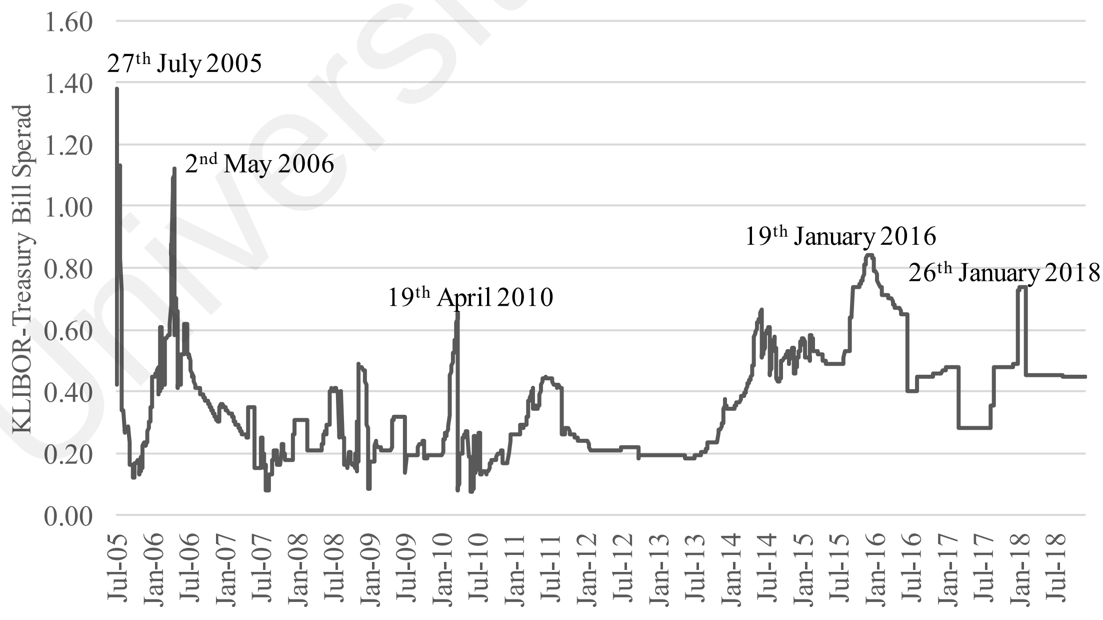
Liquidity in the Malaysian money market is measured as the difference between the 3-month Kuala Lumpur Interbank Offered Rate (KLIBOR) and the short-term Malaysian Treasury bill (TBill) rate. Similar to the interpretations of the *CPQS* and *PHLS*, higher reading of the three-month KLIBOR-TBill spread signifies tighter liquidity in the money market as banks charge higher premium over the risk-free rate for lending monies to their counterparts.

The Malaysian money market liquidity series has more observable trends than the rest of the liquidity series in this section of analysis. The series has multiple peaks over the sample periods, which signify tighter money market liquidity possibly due to heightened risk aversion or a change in the Overnight Policy Rate (OPR) by the Malaysian central bank – Bank Negara Malaysia (BNM). The first peak, which took place on 27th July 2005, can be construed as an after-effect of the de-pegging of the USD/MYR currency pair by the Malaysian government. Slightly less than a year later on 2nd May 2006, there was again a drop in the liquidity in the local money market as the interbank market adjusted to a 25 basis points increase in the OPR by the central bank on 26th April 2006.

On 19th April 2010, money market liquidity experienced a drop, albeit at a lower magnitude than the previous two incidents. This time, the tightening of money market liquidity could be attributed to growing concerns as well as risk aversion over the European sovereign debt crisis as the sovereign credit ratings of Portugal, Spain and

Greece were downgraded by Standard & Poor's eight days later. The upward shift in the three-month KLIBOR-TBill spreads seen from July 2013 to July 2014, which indicates lower level of liquidity in the Malaysian money market, was largely due to the repatriation of funds from emerging markets to developed markets following announcement made by the U.S. Federal Reserve that its economy had seen signs of improvement and would hence begin trimming the size of its asset purchase. Subsequently, renewed concerns over slower global growth prospects, falling crude oil price and the weakening of the Malaysian ringgit against the U.S. dollar trigger flight-to-liquidity, leading to a fall in the rates of the Malaysian Treasury bill and sending the three-month KLIBOR-TBill spread to another peak in January 2016. Lastly, the spike seen on 26th January 2018 is an outcome of the hike in OPR from 3.00% to 3.25% on the day before.

Figure 6.3: Aggregate Money Market Liquidity (22nd July 2005 – 31st December 2018)



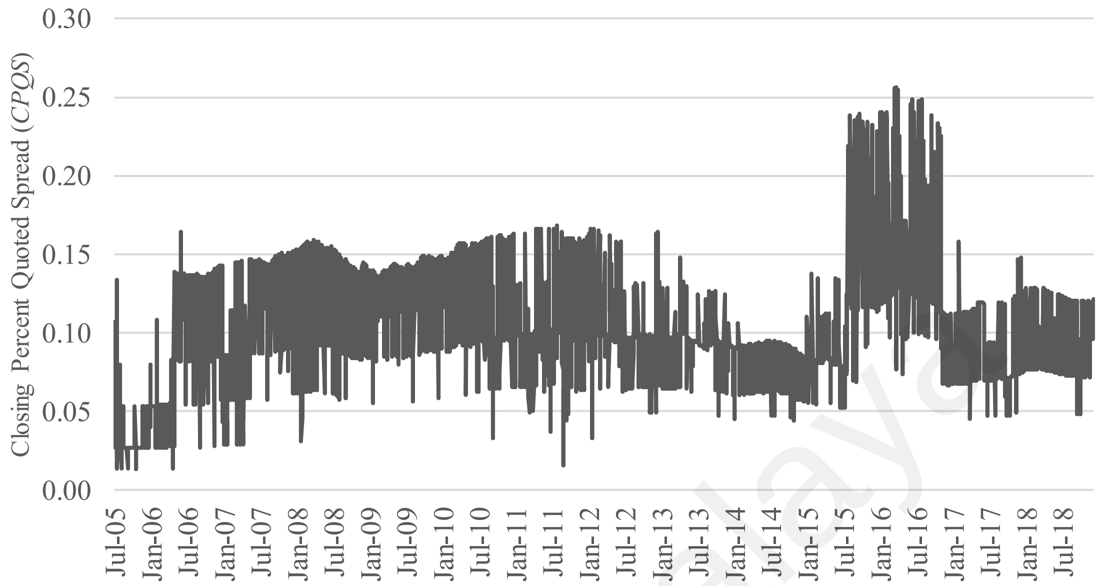
Notes: Liquidity in the money market is measured as the spread between the three-month Kuala Lumpur Interbank Offered Rate (KLIBOR) and the rate of Malaysian Treasury Bill (TBill) with 68 to 91 days of remaining maturity (Band 4). It is an inverse liquidity measure because higher reading indicates tighter liquidity in the Malaysian money market.

6.1.4 Aggregate Liquidity of the USD/MYR Currency Pair

Aggregate liquidity in the Malaysian foreign exchange market, proxied by the Closing Percent Quoted Spread (*CPQS*) of the USD/MYR currency pair, can be seen fluctuating in a band over the sample period. This is likely due to the managed float foreign exchange rate regime adopted by the central bank following the de-pegging of the USD/MYR currency pair on 22nd July 2005. Right after the de-pegging of the USD/MYR pair, foreign exchange market in Malaysia was deemed the most liquid with the series largely hovering in the range of 0.00 to 0.05 with occasional spikes above the 0.10 level. However, in the periods leading up to the GFC, during the GFC as well as during the European sovereign debt crisis, foreign exchange market liquidity was relatively tight, with the indicator drifting in a higher range of 0.10 to 0.15. From mid-2012 to mid-2015, liquidity in the local currency market improved marginally, evidenced by the *CPQS* of the USD/MYR pair hovering at a lower range of 0.05 to 0.10.

During the period from mid-2015 to end-2016, the USD/MYR pair was battered by a squeeze in its liquidity as well as greater volatility with the *CPQS* seen fluctuating in a larger range of 0.10 to 0.25. The sudden surges in illiquidity and volatility are contributed by a number of factors, including the weakening of the Malaysian ringgit above the psychologically important 4.000 level against the U.S. dollar (on 12th August 2015), bleak global crude oil price outlook, the devaluation of the Chinese yuan and the 1Malaysia Development Berhad (1MDB) scandal. While foreign exchange market liquidity improved thereafter from 2017 to 2018, the market was relatively less liquid compared to that of the mid-2012 to mid-2015 with the *CPQS* of the USD/MYR pair hovering around the mean of 0.10.

Figure 6.4: Aggregate Foreign Exchange Market Liquidity (22nd July 2005 – 31st December 2018)



Notes: Following Karnaukh et al. (2015), liquidity in the foreign exchange market in Malaysia is measured as the ratio of the difference between the closing ask and closing bid prices of the USD/MYR currency pair to its mean, in similar fashion as the Closing Percent Quoted Spread (*CPQS*) introduced by Chung and Zhang (2014) for stocks.

6.2 Descriptive Statistics

Table 6.1 provides descriptive statistics of all variables used in the empirical analysis of this chapter. Aggregate liquidity in the stock market ($CPQS^{Stock}$), proxied by the Closing Percent Quoted Spread (*CPQS*) of Chung and Zhang (2014) in multiple of 100, averaged 0.8761 over the sample period with standard deviation of 0.5192. The most illiquid day in the Malaysian stock market with $CPQS^{Stock}$ reading of 13.0614 fell on 4th December 2008. As explained in Section 6.1.1 above, this is mainly due to concerns over the Eurozone economy when data show the region had slipped into a recession in the third quarter of 2008. On the other hand, the most liquid day in the stock market with $CPQS^{Stock}$ registering 0.4605, was seen on 9th May 2017. The surge in liquidity on that trading day is most probably bolstered by rising optimism after the Standard & Poor's 500 (S&P 500)

Index and the NASDAQ in the U.S. stock markets reached record highs on the Friday before.

Moving on to the Malaysian bond market, aggregate liquidity, measured by the Percentage High-Low Spread (*PHLS*) as explained in Section 3.3.2 (page 84-87), averaged 0.1642 over the sample period with standard deviation of 0.2418. This series is also the most right-skewed among all the liquidity series, indicating greater instances of highly illiquid days in the local bond market vis-à-vis the rest of the asset markets. Consistent with the plot in Figure 6.2, 14th June 2010 marked the most illiquid day in the Malaysian bond market with a *PHLS* reading of 8.0423 when Greek government bonds were rated junk by Moody's whilst the most liquid day in the market with *PHLS* reading of 0.0042 fell on 29th May 2006.

The Malaysian money market, on the other hand, registered a mean of 0.3614 over the sample period with standard deviation of 0.1736, approximately two times its mean. The series recorded a maximum reading of 1.3800 on 27th July 2005, which can be interpreted as an anomaly in the market after the Malaysian ringgit was de-pegged from the U.S. dollar on 22nd July 2005. In contrast, the minimum reading of 0.0750 lasted for six trading days from 23th to 30th June 2010. An examination of the raw data reveals that such narrowing of spreads between the 3-month KLIBOR and Treasury bills of the same tenure is due to a 11.5 basis points jump in the yields of the Treasury bills.

Lastly, liquidity of the Malaysian foreign exchange market, proxied by the *CPQS* but calculated using the closing ask and bid prices of the USD/MYR currency pair, averaged 0.1034 over the sample period with standard deviation that is one-third its mean. This series is also the least right-skewed among all the four asset markets, possibly due to the central bank's management of the exchange rate. The $CPQS^{FX}$ series recorded the maximum level of 0.2561 on 15th April 2016, the day where the stock market barometer, the FTSE Bursa Malaysia Kuala Lumpur Index (FBM KLCI), surged to 1,727.99, its highest level in 2016. The lowest point of the series with a reading of 0.0132 occurred on 9th November 2005, with no specific market event to explain why the foreign exchange market was most liquid on that day.

It is worth highlighting that the standard deviations of all series mentioned above cannot be compared across the series to examine which liquidity series are the most volatile due to differences in computation methods. Therefore, the coefficients of variation for all the series are computed to facilitate such comparison. The statistics show that the aggregate stock market liquidity series is the most dispersed around the mean among all the series with a coefficient of variation of 59.2626. Even after removing the two most evident outliers, namely on 12th September 2008 and 4th December 2008, the coefficient of variation remains elevated at 50.7528. This can be explained by sustained periods of unusually illiquid market during the GFC. Consistent with the lowest standard deviation reading among all the series, the $CPQS^{FX}$ is also the least dispersed series as shown by a coefficient variation of only 0.3694.

Table 6.1: Descriptive Statistics (22nd July 2005 – 31st December 2018)

Variables	Mean	Median	Maximum	Minimum	Standard Deviation	Skewness	Coefficient of Variation
$CPQS^{Stock}$	0.8761	0.7382	13.0614	0.4605	0.5192	11.3638	59.2626
PHLS	0.1642	0.1125	8.0423	0.0042	0.2418	15.0677	1.4726
KT Spread	0.3614	0.3200	1.3800	0.0750	0.1736	0.9979	0.4804
$CPQS^{FX}$	0.1034	0.0968	0.2561	0.0132	0.0382	0.5667	0.3694

Notes: $CPQS^{Stock}$ is the aggregate liquidity measure for the Malaysian stock market, computed as the Closing Percent Quoted Spread introduced by Chung and Zhang (2014), and specified in multiple of 100 to give the indicator more meaningful readings. *PHLS* is the Percentage High-Low Spread measure, computed as ratio of the difference between daily high and low prices to their average and aggregated across all bond transactions in a day using equal weighting scheme. *KT Spread* is the liquidity indicator for the Malaysian money market, measured as the difference between 3-month KLIBOR and 3-month Malaysian Treasury Bill rate. $CPQS^{FX}$ is the liquidity indicator of the USD/MYR currency pair, measured as the ratio of the difference between closing ask and bid prices to their average as per the low-frequency foreign exchange market liquidity indicator introduced by Karnaukh et al. (2015).

6.3 Unit Root Test Results

As the connectedness index is computed from the forecast error variance decomposition (FEVD) of a Vector Autoregressive (VAR) model, it is therefore essential to ascertain the stationarity of all four liquidity series. Similar to Chapter 5, the stationarity of all the variables used to compute the connectedness index as laid out in Section 3.2.3 (page 80-82), is examined using the Augmented Dickey-Fuller (ADF), the modified Dickey-Fuller *t* test proposed by Elliott et al. (1996), and the Phillips-Perron test. Results of all the unit root tests, presented in Table 6.2, indicate that liquidity series for the four asset markets are all stationary at level. Therefore, these series can be estimated at level in Equations (6) and (7) (page 81), to derive the FEVD for the construction of the connectedness indices.

Table 6.2: Unit Root Test Results (22nd July 2005 – 31st December 2018)

Variable	ADF	DF-GLS	PP	I(d)
$CPQS^{Stock}$	-6.1129^{***}	-5.9351^{***}	-27.0794^{***}	I(0)
PHLS	-35.8284^{***}	-3.7002^{***}	-53.0276^{***}	I(0)
KT Spread	-5.7446^{***}	-4.9466^{***}	-5.2082^{***}	I(0)
$CPQS^{FX}$	-5.3349^{***}	-5.3240^{***}	-55.6393^{***}	I(0)

Notes: $CPQS^{Stock}$ is the aggregate liquidity measure for the Malaysian stock market, computed as the Closing Percent Quoted Spread introduced by Chung and Zhang (2014), and specified in multiple of 100 to give the indicator more meaningful readings. *PHLS* is the Percentage High-Low Spread measure, computed as ratio of the difference between daily high and low prices to their average and aggregated across all bond transactions in a day using equal weighting scheme. *KT Spread* is the liquidity indicator for the Malaysian money market, measured as the difference between 3-month KLIBOR and 3-month Malaysian Treasury Bill rate. $CPQS^{FX}$ is the liquidity indicator of the USD/MYR currency pair, measured as the ratio of the difference between closing ask and bid prices to their average.
ADF is the Augmented Dickey-Fuller unit root test, DF-GLS is the modified Dickey-Fuller *t* test proposed by Elliott et al. (1996), and PP is the Phillips-Perron unit root test. All the three unit root tests are estimated by including a constant and time trend with optimal lag length selected based on the Schwarz Information Criterion (SIC). I(d) indicates integration of order d.
***, ** and * denote significance at the 1%, 5% and 10% levels, respectively, for rejecting the null hypothesis that a time series contains unit root.

6.4 Static Liquidity Connectedness

This section presents the static connectedness indices for the stock, bond, money and foreign exchange markets in Malaysia over the sample period of 22nd July 2005 to 31st December 2018. Static connectedness, introduced in Diebold and Yilmaz (2009, 2012), is first examined for the full sample and later split into pre- and post-GFC subperiods. The examination of static connectedness prior to estimating time-varying connectedness provides the basis for considering time variation in the study of connectedness or spillover among different asset markets.

6.4.1 Full Sample Static Connectedness

Table 6.3 reports the static connectedness measures for each series in a full sample analysis. The exceptionally high readings of diagonal elements in the table show that own-market liquidity spillovers explain the highest share of forecast error variance decompositions (FEVD) for the respective asset markets. Liquidity of the Malaysian bond market, for instance, explains 99.156% of the 10-days-ahead FEVD of itself. Even the lowest own-market spillover, which is seen in the foreign exchange market, has a high reading of 98.128%. Overall, the four asset markets in Malaysia are connected to each other by only 1.129% in the static framework. This low Total Connectedness Index (hereafter referred to as TCI) is not surprising given the elevated values seen for all diagonal elements.

Looking at liquidity spillovers by market, the local stock market emerges as the main transmitter of liquidity spillovers, as shown by the highest "Total TO" reading of 1.579%. In other words, shocks in aggregate stock market liquidity explain a total of 1.579% of the 10-days-ahead FEVD of liquidity of the bond, money and foreign exchange markets. As a receiver of liquidity spillovers, the stock market ranks second among the four asset markets with a "Total FROM" reading of 1.288%. In net spillovers term, calculated by subtracting spillovers received from spillovers transmitted, the Malaysian stock market is the largest net transmitter of liquidity spillovers among the four asset markets. Trailing the stock market in the transmission of liquidity spillovers is the money market, whose liquidity shocks explain a total of 1.449% of the 10-days-ahead FEVD of the stock, bond and foreign exchange markets combined. Notwithstanding its position as the second largest transmitter of liquidity, the money market also receives the largest share of liquidity spillovers as suggested by the highest "Total FROM" reading of 1.510%. Given that the share of liquidity spillovers the money market receives is greater than the liquidity spillovers that it transmits, the market is a net receiver of liquidity spillovers.

Table 6.3: Static Liquidity Connectedness over Full Sample (22nd July 2005 – 31st December 2018, n=3,296)

	From (j)				Total
To (i)	$CPQS^{Stock}$	*PHLS*	*KT Spread*	$CPQS^{FX}$	FROM
$CPQS^{Stock}$	98.712	0.091	1.031	0.166	1.288
PHLS	0.045	99.156	0.135	0.664	0.844
KT Spread	1.431	0.030	98.490	0.049	1.510
$CPQS^{FX}$	0.103	0.487	0.283	99.128	0.872
Total TO	1.579	0.607	1.449	0.879	4.514
Contribution including own	100.291	99.764	99.938	100.007	-
Net spillovers	0.291	-0.236	-0.062	0.007	**1.129**

Notes: $CPQS^{Stock}$ is the aggregate liquidity measure for the Malaysian stock market, computed as the Closing Percent Quoted Spread introduced by Chung and Zhang (2014), and specified in multiple of 100 to give the indicator more meaningful readings. *PHLS* is the Percentage High-Low Spread measure, computed as ratio of the difference between daily high and low prices to their average and aggregated across all bond transactions in a day using equal weighting scheme. *KT Spread* is the liquidity indicator for the Malaysian money market, measured as the difference between 3-month KLIBOR and 3-month Malaysian Treasury Bill rate. $CPQS^{FX}$ is the liquidity indicator of the USD/MYR currency pair, measured as the ratio of the difference between closing ask and bid prices to their average.
Total TO indicates the total directional spillovers from asset *j* to asset *i* excluding own spillovers. Total FROM denotes the total directional spillovers received by asset *i* from asset *j* excluding own spillovers. Net spillovers is calculated by subtracting total spillovers received (Total FROM) from total spillovers transmitted (Total TO).
Values reported are variance decompositions based on 10-step ahead forecasts of TVP-VAR model with lag length of five as selected by the Schwarz Information Criterion (SIC). Value in bold is the Total Connectedness Index.

With a "Total TO" reading of 0.879%, the Malaysian foreign exchange market is the third largest liquidity spillover transmitter among the four asset markets. Its influence is greatest to the liquidity of the local bond market at 0.664%. As a recipient of liquidity spillovers, the foreign exchange market also ranked third as liquidity shocks in the other three asset markets account for 0.872% of the 10-days-ahead FEVD of liquidity in the local foreign exchange market. By a small margin of 0.007%, the foreign exchange market is also a net transmitter of liquidity spillovers in the Malaysian context. Shifting attention to the Malaysian bond market, not only is it the market which transmits the least liquidity spillovers with a "Total TO" reading of 0.607%, it is also the market which receives the least liquidity spillovers from the rest of the markets, as shown by the lowest "Total FROM" reading of just 0.844%. Nevertheless, in net spillovers term, it is still a larger net receiver of liquidity spillovers vis-à-vis that of the money market.

6.4.2 Pre- and Post-Global Financial Crisis Subperiods

Splitting the sample into pre- and post-GFC by using the date 29th September 2008 as the midpoint[29], static liquidity connectedness of the four asset markets in Malaysia is re-estimated and results are tabulated in Table 6.4. The pre-GFC period, which spans 22nd July 2005 to 29th September 2008, yields 781 observations whereas the post-GFC period, which covers the period from 30th September 2008 to 31st December 2018, has a total of 2,515 observations. Looking at connectedness of the four asset markets as a whole, it is observed that the markets were more connected during the period before the GFC than they were after the crisis. Before the GFC, connectedness in the four asset markets was 2.818% vis-à-vis that of 2.026% after the crisis. While the TCIs obtained in this section is approximately 2.5 times the TCI recorded in the full sample analysis, liquidity

[29] 29th September 2008 was the day which witnessed the Dow Jones Industrial Average (DJIA), a key barometer of the U.S. stock market, plummeting 777.68 points, equivalent to 6.98%. The largest single-day loss of the index in the history of Dow Jones up to that point in time, was an outcome of the U.S. Congress' rejection of the bank bailout bill on the same day.

connectedness observed in the pre- and post-GFC periods are still considerably low in absolute term.

Dissecting liquidity connectedness by asset class, it is observed that during the pre-GFC period, the foreign exchange market plays a significant role, both in transmitting and receiving liquidity spillovers in the Malaysian financial market. As a liquidity spillover transmitter, the foreign exchange market explains a total of 4.12% of the 10-days-ahead FEVD of all other markets. As a liquidity spillovers receiver, 5.801% of its 10-days-ahead FEVD is explained by liquidity shocks arising from the other three markets. The Malaysian stock market, on the other hand, appears to be least affected by liquidity shocks in the other three asset markets given its low "Total FROM" reading of only 1.027%. With a "Total TO" reading of only 1.622%, it is also the market which transmits the least liquidity spillovers to the rest of the markets. During the pre-GFC period, the stock market and bond market are the net transmitters of liquidity spillovers, affecting liquidity in other markets by a margin of 0.594% and 1.952% respectively than what they are affected. On the contrary, the money market and foreign exchange market are the net receivers of liquidity spillovers as they receive 0.866% and 1.681% more liquidity spillovers than they transmit.

After the GFC, the Malaysian stock market took over the role as the largest transmitter of liquidity spillovers, explaining 4.592% of the 10-days-ahead FEVD of the other three asset markets. One possible explanation to the emergence of the stock market as the main liquidity transmitter after the GFC could be the hot money flowing in from developed countries. When these countries loosen their respective monetary policies to combat the crisis, investors generally turn to emerging market equities in search of higher yields. As demonstrated in Chapter 4, foreigners are consumers of liquidity in the local bourse. Hence, their substantial liquidity demand in the Malaysian stock market could very well be the source of liquidity spillovers to the other markets. The foreign exchange market is the second largest emitter of liquidity spillovers in the post-GFC period, transmitting 1.798% of its liquidity shocks to the other three markets with the stock market being the most affected. This is in line with the argument of this thesis that foreign funds are pouring into the local stock market following monetary easing in developed nations. As foreign investors would need to first convert their currencies to the Malaysian ringgit before investing in the local stock market, their liquidity demand in the stock market is expected to be affected by how liquid the foreign exchange market is. On the other end of the spectrum, liquidity of the Malaysian bond market is the least transmittable with a "Total TO" reading of only 0.352%.

Shifting the attention to the receiving end of liquidity spillovers in the Malaysian financial market post-GFC, it is observed from Panel B of Table 6.4 that liquidity in the money market is most affected by liquidity shocks arising from the rest of the markets. The latter explains 4.006% of the money market's 10-days-ahead FEVD, of which 3.977% is contributed by liquidity shocks from the stock market. The reaction of liquidity in the money market to that of the stock market could be explained by the work of Brunnermeier and Pedersen (2009) which theorizes a reinforcing relationship between funding liquidity, in this case proxied by money market liquidity, and stock market liquidity. According to these authors, tightness in stock market liquidity, which squeezes capital and margin requirements facing investors or traders, has an adverse impact on funding liquidity, vice versa. The second largest receiver of liquidity spillovers is the local stock market where 1.958% of its 10-days-ahead FEVD is explained by liquidity shocks arising from the other three markets. As stated in the previous paragraph, foreign exchange market liquidity is the largest liquidity spillovers contributor to the stock market due to intense participation of foreign investors in the latter in the post-GFC period.

Table 6.4: Static Liquidity Connectedness Pre- and Post-Global Financial Crisis

Panel A: Pre-GFC (22nd July 2005 - 29th September 2008, n = 781)

To (i)	From (j) $CPQS^{Stock}$	$PHLS$	$KT\ Spread$	$CPQS^{FX}$	Total FROM
$CPQS^{Stock}$	98.973	0.077	0.147	0.804	1.027
$PHLS$	0.102	98.796	0.418	0.684	1.204
$KT\ Spread$	0.375	0.230	96.762	2.633	3.238
$CPQS^{FX}$	1.145	2.849	1.807	94.199	5.801
Total TO	1.622	3.156	2.372	4.120	11.270
Contribution including own	100.594	101.952	99.134	98.319	-
Net spillovers	0.594	1.952	-0.866	-1.681	**2.818**

Panel B: Post-GFC (30th September 2008 - 31st December 2018, n = 2,515)

To (i)	From (j) $CPQS^{Stock}$	$PHLS$	$KT\ Spread$	$CPQS^{FX}$	Total FROM
$CPQS^{Stock}$	98.042	0.036	0.784	1.138	1.958
$PHLS$	0.104	98.832	0.422	0.642	1.168
$KT\ Spread$	3.977	0.012	95.994	0.017	4.006
$CPQS^{FX}$	0.511	0.303	0.156	99.029	0.971
Total TO	4.592	0.352	1.362	1.798	8.103
Contribution including own	102.633	99.184	97.356	100.827	-
Net spillovers	2.633	-0.816	-2.644	0.827	**2.026**

Notes: $CPQS^{Stock}$ is the aggregate liquidity measure for the Malaysian stock market, computed as the Closing Percent Quoted Spread introduced by Chung and Zhang (2014), and specified in multiple of 100 to give the indicator more meaningful readings. *PHLS* is the Percentage High-Low Spread measure, computed as ratio of the difference between daily high and low prices to their a verage and aggregated across all bond transactions in a day using equal weighting scheme. *KT Spread* is the liquidity indicator for the Malaysian money market, measured as the difference between 3-month KLIBOR and 3-month Malaysian Treasury Bill rate. $CPQS^{FX}$ is the liquidity indicator of the USD/MYR currency pair, measured as the ratio of the difference between closing ask and bid prices to their average.
Total TO indicates the total directional spillovers from asset *j* to asset *i* excluding own spillovers. Total FROM denotes the total directional spillovers received by asset *i* from asset *j* excluding own spillovers. Net spillovers is calculated by subtracting total spillovers received (Total FROM) from total spillovers transmitted (Total TO).
Values reported are variance decompositions based on 10-step ahead forecasts of TVP-VAR model. Guided by the Schwarz Information Criterion (SIC), Panel A is estimated with three lags while Panel B is estimated with four lags. Value in bold is the Total Connectedness Index.

In terms of net liquidity spillovers, both the stock market and the foreign exchange market are the net transmitters of liquidity spillovers whilst the bond market and the money market are the net receivers of liquidity spillovers. While these combinations are identical to that of the full sample analysis, their magnitudes are markedly different. For instance, as the largest net transmitter of liquidity spillovers, the stock market transmits a net 2.633% of liquidity spillovers to the other markets in the post-GFC period vis-à-vis 0.291% seen in the full sample analysis. On the other hand, the money market, being the largest net receiver of liquidity spillovers, has its liquidity being affected by a net 2.644% compared to only 0.062% reported in the full sample analysis. Comparing these figures to the full sample Total Connectedness Index, it can be seen that connectedness among the four asset markets is understated in the full sample analysis. The sensitivity of the total connectedness index to variations in subperiods suggests that more robust time-varying estimation of the Total Connectedness Index is warranted.

6.5 Time-Varying Liquidity Connectedness

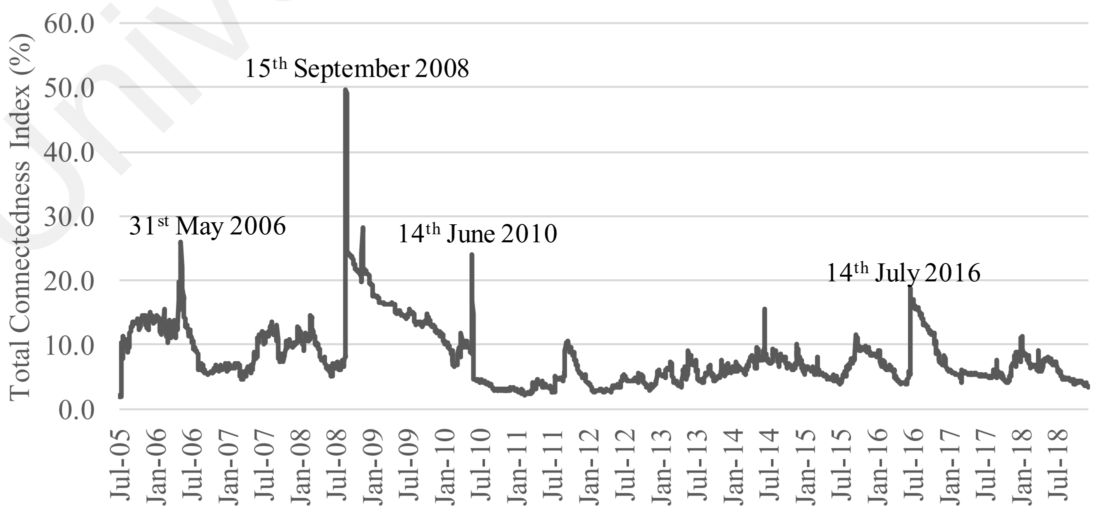
This section presents the time-varying liquidity connectedness of the four main asset markets in Malaysia, namely stock, bond, money and foreign exchange markets. Taking into account the dynamics of liquidity connectedness over time in the estimation process, it can be observed that liquidity connectedness among the four asset markets in Malaysia is strikingly higher than that suggested by a static model. Table 6.5 shows that, on average, the Malaysian stock, bond, money and foreign exchange markets are connected at 8.040% as opposed to a mere 1.129% obtained from the static model presented in Table 6.3. In other words, the influence that liquidity shocks of all other markets have on a market's FEVD throughout time is 8.040%. Given the higher connectedness observed, the diagonal elements which indicate own-market liquidity spillovers have also reduced, ranging from 89.261% to 93.829% vis-à-vis 98.450% to 99.156% in the static model.

Table 6.5: Time-Varying Liquidity Connectedness (22nd July 2005 – 31st December 2018)

To (i)	From (j) $CPQS^{Stock}$	*PHLS*	*KT Spread*	$CPQS^{FX}$	Total FROM
$CPQS^{Stock}$	93.829	2.022	1.264	2.886	6.171
PHLS	2.009	93.032	2.148	2.812	6.968
KT Spread	3.066	1.914	91.717	3.302	8.283
$CPQS^{FX}$	3.571	3.557	3.611	89.261	10.739
Total TO	8.646	7.492	7.023	9.000	32.161
Contribution including own	102.475	100.524	98.740	98.261	-
Net spillovers	2.475	0.524	-1.260	-1.739	**8.040**

Notes: $CPQS^{Stock}$ is the aggregate liquidity measure for the Malaysian stock market, computed as the Closing Percent Quoted Spread introduced by Chung and Zhang (2014), and specified in multiple of 100 to give the indicator more meaningful readings. *PHLS* is the Percentage High-Low Spread measure, computed as ratio of the difference between daily high and low prices to their average and aggregated across all bond transactions in a day using equal weighting scheme. *KT Spread* is the liquidity indicator for the Malaysian money market, measured as the difference between 3-month KLIBOR and 3-month Malaysian Treasury Bill rate. $CPQS^{FX}$ is the liquidity indicator of the USD/MYR currency pair, measured as the ratio of the difference between closing ask and bid prices to their average.
Total TO indicates the total directional spillovers from asset *j* to asset *i* excluding own spillovers. Total FROM denotes the total directional spillovers received by asset *i* from asset *j* excluding own spillovers. Net spillovers is calculated by subtracting total spillovers received (Total FROM) from total spillovers transmitted (Total TO).
Values reported are average variance decompositions based on 10-step ahead forecasts of TVP-VAR model with lag length of five as selected by the Schwarz Information Criterion (SIC). Value in bold is the Total Connectedness Index.

Figure 6.5: Time-Varying Total Liquidity Connectedness (22nd July 2005 – 31st December 2018)



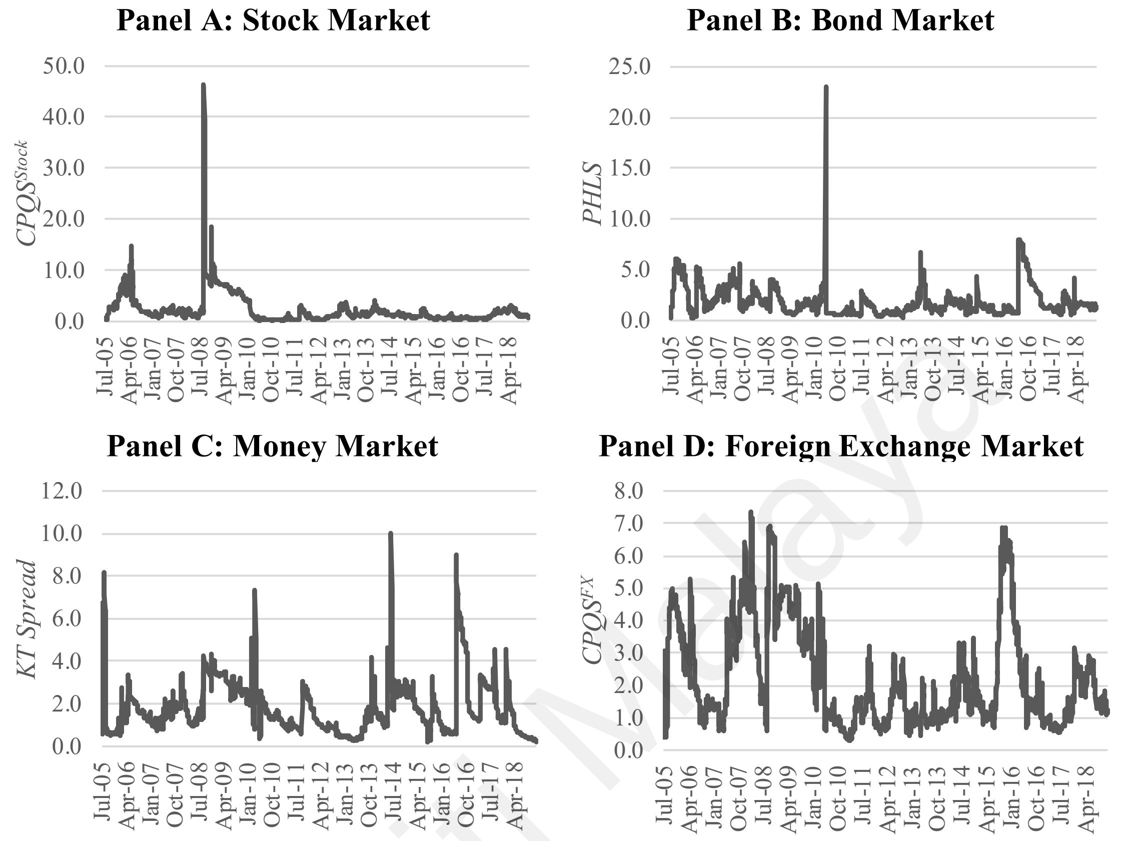
Notes: The graph plots the Total Connectedness Index (TCI) of the four asset markets in Malaysia – stock, bond, money and foreign exchange markets, based on the TVP-VAR model estimated with five lags as specified in Equations (6) and (7).

Looking at the graphical plot of the Total Connectedness Index (TCI) over time in Figure 6.5, one can observe that the index generally fluctuates between 0% – 20%. There are, however, important exceptions to the plot where the TCI touches the 50% mark on the day Lehman Brothers declared its bankruptcy on 15th September 2008. Apart from responding to the GFC, liquidity connectedness among assets in the local financial market is also very responsive to other economic events such as the market correction which took place after the U.S. Federal Reserve hiked its key interest rate for the 16th straight time on 10th May 2006, the downgrade of Greece's sovereign credit rating to junk by Moody's on 14th June 2010, and on the local front when Bank Negara Malaysia (BNM) unexpectedly cut its benchmark Overnight Policy Rate (OPR) to 3.00% on 13th July 2016. Such variations in the TCI further stress the importance of examining connectedness, be it liquidity or other aspects of the financial market, in a time-varying model as static model tends to mask economic shocks that might have impacts on the interconnectedness of variables in the financial markets.

In the dynamic model, the foreign exchange market is the largest transmitter of liquidity spillovers in the Malaysian financial markets, explaining 3.302%, 2.886% and 2.812% of the 10-days-ahead forecast error variance of liquidity changes in the Malaysian money, stock and bond markets, respectively. Trailing the foreign exchange market is the Malaysian stock market, which influences a total of 8.646% of liquidity changes in the other three markets, with the foreign exchange market as the most affected by liquidity shocks from the stock market. Looking at their individual total directional connectedness of liquidity to other markets, as presented in Figure 6.6, it is easily noticeable that the foreign exchange market is actively spilling over its liquidity shocks to other markets given the magnitude of its fluctuations in the "Total TO" plot. There are generally three episodes in which the foreign exchange market has a great influence over liquidity of other markets. The first episode took place right after the de-pegging of the Malaysian ringgit to the U.S. dollar which lasted from mid-2015 to mid-2016. The next wave of spillovers occurred during the GFC, with high liquidity spillovers seen over a three-year period since mid-2007. The last episode was when the U.S. Federal Reserve began signaling a tightening of its monetary policy which put emerging market currencies under downward pressure during mid-2015 to mid-2017. The stock market, on the other hand, seems to exert its influence mainly during the GFC given its high "Total TO" plot from mid-2008 to mid-2010. The spike in liquidity spillovers to other markets seen in the bond market corresponds to the day when Moody's downgraded Greece's sovereign credit rating.

Turning attention to the receiving ends of liquidity spillovers, numbers in Table 6.3 suggest that the foreign exchange market also receives the greatest amount of liquidity spillovers from the rest of the markets. On average, a total 10.739% of its 10-days-ahead FEVD is explained by liquidity shocks arising from the stock, bond and money markets. The graphical plots of the "Total FROM" directional liquidity spillovers for all asset markets, presented in Figure 6.7, reveal that liquidity of the foreign exchange market is most affected during the GFC from mid-2008 to mid-2010. The two spikes observed in Panel D of Figure 6.7 correspond to the refusal of U.S. officials to bail out Lehman Brothers on 12th September 2008 and the downgrade of Greece's sovereign credit rating on 14th June 2010, respectively.

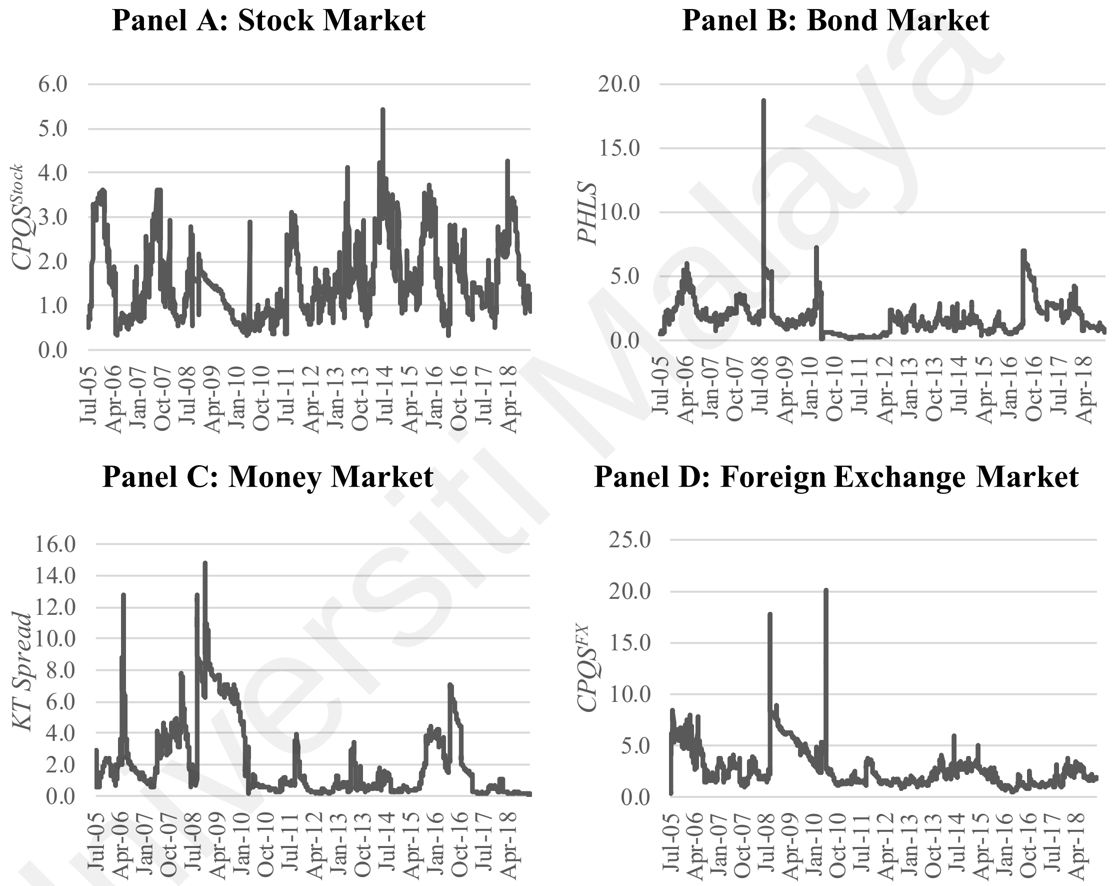
Figure 6.6: Total Directional Spillovers TO Other Markets
(22nd July 2005 – 31st December 2018)



Notes: These graphs plot the directional connectedness of each of the four asset markets in Malaysia (i.e. stock, bond, money and foreign exchange) to the other three markets based on the TVP-VAR model with lag length of five as specified in Equations (6) and (7).
$CPQS^{Stock}$ is the aggregate liquidity measure for the Malaysian stock market, computed as the Closing Percent Quoted Spread introduced by Chung and Zhang (2014), and specified in multiple of 100 to give the indicator more meaningful readings. *PHLS* is the Percentage High-Low Spread measure, computed as ratio of the difference between daily high and low prices to their average and aggregated across all bond transactions in a day using equal weighting scheme. *KT Spread* is the liquidity indicator for the Malaysian money market, measured as the difference between 3-month KLIBOR and 3-month Malaysian Treasury Bill rate. $CPQS^{FX}$ is the liquidity indicator of the USD/MYR currency pair, measured as the ratio of the difference between closing ask and bid prices to their average.

The Malaysian money market, on the other hand, is found to be the second largest receiver of liquidity spillovers with liquidity shocks in other markets explaining 8.283% of its 10-days-ahead FEVD. Panel C of Figure 6.7 shows that apart from being affected by high liquidity observed in the Malaysian bond market in late May 2006, the money market receives the most liquidity spillovers during the GFC with the plot seen surpassing the 14.0% mark in December 2008. This thesis conjectures that such elevated liquidity spillovers from other markets, especially in the mid-2008 to early-2010 period is due to the loss of autonomy in the conduct of monetary policy as the local central bank began reducing the Overnight Policy Rate (OPR) from 3.50% in November 2008 to as low as 2.00% in 2009 before raising it again in March 2010.

Figure 6.7: Total Spillovers FROM Other Markets
(22nd July 2005 – 31st December 2018)

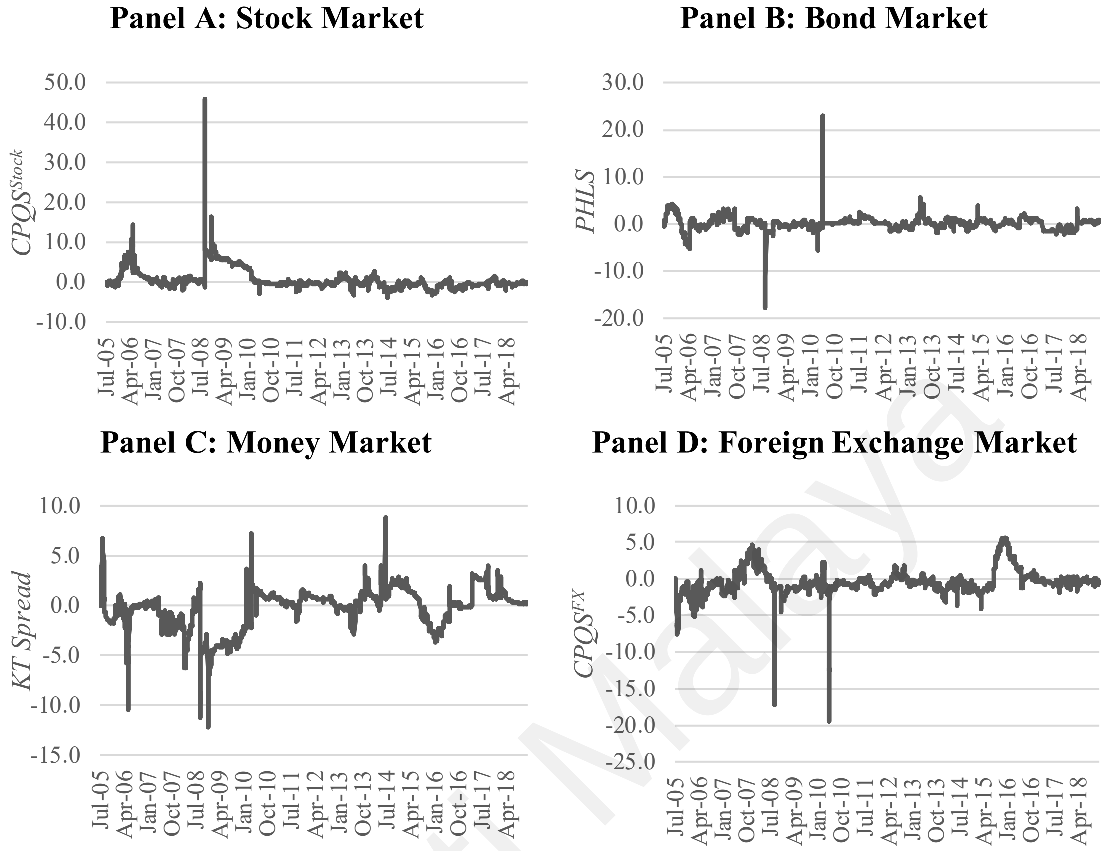


Notes: These graphs plot the directional connectedness of each of the four asset markets in Malaysia (i.e. stock, bond, money and foreign exchange) from the other three markets based on the TVP-VAR model with lag length of five as specified in Equations (6) and (7).
$CPQS^{Stock}$ is the aggregate liquidity measure for the Malaysian stock market, computed as the Closing Percent Quoted Spread introduced by Chung and Zhang (2014), and specified in multiple of 100 to give the indicator more meaningful readings. *PHLS* is the Percentage High-Low Spread measure, computed as ratio of the difference between daily high and low prices to their average and aggregated across all bond transactions in a day using equal weighting scheme. *KT Spread* is the liquidity indicator for the Malaysian money market, measured as the difference between 3-month KLIBOR and 3-month Malaysian Treasury Bill rate. $CPQS^{FX}$ is the liquidity indicator of the USD/MYR currency pair, measured as the ratio of the difference between closing ask and bid prices to their average.

While the stock market's "Total FROM" directional liquidity spillover plot appears to be the most volatile, it is worth highlighting that the magnitudes of spillovers that it receives are low, mostly ranging between 0% – 4.0%. Such low magnitudes of spillovers from other markets are consistent with the numbers in Table 6.5, which show that the stock market only receives an average of 6.171% of liquidity spillovers from the rest of the markets over the sample period. Lastly, as is the case with the foreign exchange and money markets, the local bond market also receives the largest amount of liquidity spillovers on the day Lehman Brothers announced its bankruptcy.

In terms of net liquidity spillovers, Table 6.5 shows that both the Malaysian stock and bond markets are the net transmitters of liquidity spillovers whereas the money and foreign exchange markets are net receivers of liquidity spillovers. Looking at the graphical plots of the dynamic total net liquidity spillovers in Figure 6.8, it can be observed that the stock market is a larger transmitter of liquidity spillovers than the bond market given that the former's plot has greater incidence of fluctuations above the 0% line. Unsurprisingly, net liquidity spillovers to other markets are greatest during the GFC with the rejection of the bailout of Lehman Brothers marking the highest point in Panel A of Figure 6.8. On the other hand, total net liquidity spillovers plot for the bond market, depicted in Panel B of Figure 6.8, mainly fluctuates around zero. Notably, the bond market receives the largest net spillovers on the day Lehman Brothers announced its bankruptcy while transmits the largest net spillovers when Moody's announced the downgrading of Greece's sovereign credit rating.

Figure 6.8: Net Liquidity Spillovers (22nd July 2005 – 31st December 2018)



Notes: These graphs plot the net total directional connectedness of each of the four asset markets in Malaysia (i.e. stock, bond, money and foreign exchange), calculated as the difference between TO directional connectedness and FROM directional connectedness, based on the TVP-VAR model with lag length of five as specified in Equations (6) and (7).
CPQS^Stock is the aggregate liquidity measure for the Malaysian stock market, computed as the Closing Percent Quoted Spread introduced by Chung and Zhang (2014), and specified in multiple of 100 to give the indicator more meaningful readings. *PHLS* is the Percentage High-Low Spread measure, computed as ratio of the difference between daily high and low prices to their average and aggregated across all bond transactions in a day using equal weighting scheme. *KT Spread* is the liquidity indicator for the Malaysian money market, measured as the difference between 3-month KLIBOR and 3-month Malaysian Treasury Bill rate. *CPQS^FX* is the liquidity indicator of the USD/MYR currency pair, measured as the ratio of the difference between closing ask and bid prices to their average.

Moving on to the net receivers of liquidity spillovers, the foreign exchange market is the larger receiver of liquidity spillovers, as indicated by its plot hovering below the 0% mark at a greater frequency vis-à-vis that of the money market. This observation is also in line with numbers presented in Table 6.5 where the foreign exchange market receives 1.739% of liquidity spillovers more than it transmits whereas the money market only receives 1.260% more liquidity shocks than it spilled. Over the sample period, the foreign exchange market is net transmitter of liquidity spillovers during two major episodes. First was during the 14-month period leading up to the GFC from June 2007 to August 2008, and second during the period from September 2015 to December 2016 when the U.S. Federal Reserve debated and tightened its monetary policy. The money market, on the other hand, records the largest net liquidity spillovers during the GFC.

6.6 Comparison with Previous Studies

Having computed both the static and dynamic cross-market connectedness indices for Malaysia, this section compares the findings obtained with previous studies to put the magnitude of liquidity connectedness among the four asset markets in Malaysia into perspective. The comparison covers return or volatility connectedness with global markets, as well as the level of return, volatility or liquidity connectedness across different assets observed in other countries. Given the connectedness and spillover indices are pioneered by Diebold and Yilmaz (2009, 2012, 2014), this section draws comparison mainly with indices published in the authors' website, http://financialconnectedness.org, as well as relevant studies that employ their framework. These indices are summarized in Table 6.6.

The closest comparison that this thesis can draw is with the seminal study of Diebold and Yilmaz (2012) which looks at the return volatility connectedness of the U.S. stock, bond, foreign exchange and commodity markets. Using daily data spanning January 1999 to January 2010, the authors find that return volatility of these four markets are connected at 12.60% in a full sample static analysis. This figure, while relatively high for the 1.129% that this thesis computed for the stock, bond, money and foreign exchange markets in a static framework, is comparable to the 8.040% obtained when a time-varying framework is adopted. Besides, it is also the lowest reading among all TCIs reported in

Table 6.6. This signifies that return volatility spillover and liquidity spillover are low across asset markets. Even though the other cross-asset market study by Kang et al. (2019) records very high connectedness of 78.60%, it is not comparable to the finding of this thesis given that it examines the return connectedness of a large group of assets, comprising of eighteen stock exchanges, six currency pairs, two bond indices and two implied volatility indices. The same can be concluded for the relatively high TCIs for return connectedness (42.41%) and return volatility connectedness (25.70%) observed for five commodities and four currency pairs by Antonakakis and Kizys (2015).

Moving on to studies focusing on own asset market connectedness, it is observed from Table 6.6 that connectedness of exchanges within the same asset class is generally stronger than those across different asset classes. Another observation is that return volatility has a higher spillover effect among stock market of different exchanges than return connectedness. Looking at studies which include Bursa Malaysia as one of the sample countries, it can be seen from the studies of Diebold and Yilmaz (2009) and Yilmaz (2010) that return volatility of Malaysian stocks is more connected to its East Asian counterparts at 77.70% over the period from January 1992 to April 2009, than to the global stock markets with TCI of only 39.50% from January 1992 to November 2007. This thesis conjectures that such high TCI recorded in the work of Yilmaz (2010) is mainly driven by the Asian Financial Crisis which occurred in 1997 in the East and Southeast Asian countries. At a more global level and over a longer sample period, the global stock exchange return volatility spillover index from Diebold and Yilmaz's website reveals that return volatility of Bursa Malaysia is connected to the global stock markets at 62.18%.

Table 6.6: Comparison of Total Connectedness Indices

Sources/ Studies	Sample Period	Financial Variable	Asset Market(s)	No. of Exchanges /Countries	Include M'sia?	TCI	M'sia From Others	M'sia To Others
Diebold and Yilmaz Website	Since Aug 2004 (Daily)	Return Volatility	Stock	45	Yes	62.18%	44.13%	30.15%
Diebold and Yilmaz Website	Since Oct 2000 (Daily)	Return Volatility	Forex	31	No	55.97%	–	–
Diebold and Yilmaz Website	Since Aug 2000 (Daily)	Return Volatility	Sovereign Bond	12	No	60.06%	–	–
Diebold and Yilmaz Website	Since Sep 2009 (Daily)	Return Volatility	CDS	26	Yes	74.11%	81.27%	74.42%
Diebold and Yilmaz (2009)	Jan 1992 - Nov 2007 (Weekly)	Return	Stock	19	Yes	35.50%	31.00%	16.00%
		Return Volatility	Stock	19	Yes	39.50%	29.00%	40.00%
Kang et al. (2019)	Jul 2010 - Dec 2017 (Daily)	Return	Equity, CMDTY, Bond & VIX	Stock: 18 CMDTY: 6 Bond: 2 VIX: 2	No	78.60%	–	–
Diebold and Yilmaz (2012)	Jan 1999 - Jan 2010 (Daily)	Return Volatility	Stock, Bond, Forex & CMDTY	1 - US	No	12.60%	–	–
Guimaraes-Filho and Hong (2016)	Jan 1996 - Oct 2015 (Daily)	Return	Stock	Asian: 13 Advanced: 4 Emerging: 3	Yes	70-75% pre-GFC 80-90% 2008 - 2014	No breakdown by country data available for Malaysia	
		Return Volatility			Yes	65-75% pre-GFC 80-90% 2008 - 2014		
Yilmaz (2010)	Jan 1992 - Apr 2009 (Weekly)	Return	Stock	10 East Asian countries	Yes	31.60%	34.10%	5.20%
		Return Volatility				77.70%	59.60%	33.30%
Diebold et al. (2017)	May 2006 - Jan 2016 (Daily)	Return Volatility	CMDTY	19 Bloomberg Commodity Price Indices	No	40.00%	–	–
Antona-kakis and Kizys (2015)	Jan 1987 - Jul 2014 (Weekly)	Return	CMDTY & Forex	CMDTY: 5 Forex: 4	No	42.41%	–	–
		Return Volatility				25.70%	–	–

Notes: All connectedness indices reported here, with the exception of the connectedness indices reported by Guimaraes-Filho and Hong (2016), are the static full sample connectedness as these studies do not publish the average time-varying connectedness over the respective sample periods. The four indices obtained from Diebold and Yilmaz's website at http://financialconnectedness.org are calculated by taking the mean of daily connectedness up to December 2019 for global stock and foreign exchange markets, and up to September 2018 for bond and CDS markets. CMDTY stands for commodity while TCI denotes Total Connectedness Index.

Turning the attention to return connectedness, Diebold and Yilmaz (2009) and Yilmaz (2010) both report similar return connectedness indices of 35.50% and 31.60% in their respective Asian and East Asian dominated samples. These numbers indicate that returns of the Malaysian stock market are more connected to that of its Asian counterparts than its liquidity connectedness to the liquidity of other asset classes in the same country. Using a longer sample from January 1996 to October 2015, Guimarães-Filho and Hong (2016) report significantly higher connectedness, both of return and return volatility, among twenty stock exchanges. Of the twenty stock exchanges, thirteen are from Asia (Australia, China, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, New Zealand, the Philippines, Singapore, Taiwan, Thailand), four are from the advanced economies (U.S., U.K., Germany, France) and three are from emerging economies (Brazil, Mexico, Turkey). As these authors only analyze time-varying connectedness using the rolling-window approach, the connectedness of stock return and return volatility can only be discerned by examining the plots in the article. In their work, return and return volatility connectedness of the twenty stock exchanges can be seen fluctuating in the range of 70% - 75% and 65% - 75% respectively before the GFC. In the post crisis period, both the TCIs are seen hovering in the 80% - 90% band. These findings reveal that both return and return volatility spillovers heightened during the financial crisis and remain elevated thereafter.

The finding of intensifying spillovers or connectedness during turbulent periods is also found in volatility spillovers among the U.S. stock, bond, foreign exchange and commodity markets (Diebold & Yilmaz, 2012), exchange rates and stock prices in Brazil, Russia, India, China and South Africa (Sui & Sun, 2016), monetary policy across the U.S., the Euro Area, the U.K. and Japan (Antonakakis et al., 2019) and, liquidity spillovers across oil, treasuries, Eurodollar and Standard & Poor's 500 (S&P500) futures in the U.S.

(Zafeiridou, 2015). Therefore, it can be established that the phenomenon of heightening connectedness during financial crisis periods is not idiosyncratic to the type of financial variable, asset type and geographical location of an exchange. This is supported by the surge in connectedness of return, return volatility and liquidity across various cross- and own-asset market studies.

6.7 Summary of Empirical Results

This chapter employs the methodology introduced by Antonakakis et al. (2020), which is built on the work of Diebold and Yilmaz (2009, 2012, 2014), to measure total and directional spillovers using forecast error variance decompositions (FEVD) of a generalized time-varying parameter vector autoregressive (TVP-VAR) framework to explore the cross-market liquidity connectedness of the Malaysian stock, bond, money and foreign exchange markets. Using daily data over the period from 22nd July 2005 to 31st December 2018, the static liquidity connectedness of the four markets is first investigated. In the full sample, a low level of liquidity connectedness, with Total Connectedness Index (TCI) recording only 1.129%, is detected among the four asset markets in Malaysia. The stock market emerges as the market which transmits the most liquidity spillovers to the rest of the markets while the money market is the largest receiver of liquidity spillovers originating from the others. When the sample is split with 29th September 2008 as the midpoint, the TCIs for pre- and post-Global Financial Crisis increase marginally to 2.818% and 2.026%, respectively. While the key transmitter and receiver of liquidity spillovers in the post-GFC period is identical to that identified in the full sample analysis, the foreign exchange market takes center stage in the pre-GFC period to be both the largest transmitter and receiver of liquidity spillovers.

Recognizing the need to account for time-variation in the analysis beyond the rolling-window approach of Diebold and Yilmaz (2009, 2012, 2014), this thesis utilizes the TVP-VAR framework of Antonakakis et al. (2020) to estimate the dynamic liquidity connectedness of the Malaysian stock, bond, money and foreign exchange markets. The results from the dynamic analysis show a marked increase in average total liquidity connectedness over the sample period, with liquidity shocks of all other markets influencing 8.040% of a market's FEVD. More in line with the pre-GFC static connectedness analysis but at higher magnitudes, the foreign exchange market, on average, transmits and receives the most liquidity spillovers to and from the other markets in this study. Another crucial revelation of the dynamic connectedness analysis is that liquidity connectedness of the four markets over time is very responsive to market events, international especially. Notably, liquidity connectedness skyrocketed during the 2007-2008 GFC with the TCI seen touching the 50.0% mark. Besides, the downgrading of Greece's sovereign credit rating to junk by Moody's also contributed to greater liquidity connectedness among the four markets. Domestically, the sudden hike of the OPR by Bank Negara Malaysia on 13th July 2016 stands out as the event which led to higher level of liquidity connectedness among the markets.

Comparing the results of this thesis to that of return and return volatility connectedness studies employing time-varying framework, it can be concluded that spillovers are stronger within own asset market rather than across asset markets. In terms of the type of spillovers, it is observed that liquidity spillovers, at least inferring from the Malaysian's case, is the weakest among the financial variables examined thus far in the literature. Return volatility spillovers, on the other hand, are the strongest followed by return spillovers. Lastly, return, return volatility and liquidity connectedness are stronger during financial crisis regardless of whether they are examined in a cross-asset market framework or within the same asset class.

CHAPTER 7

SUMMARY AND CONCLUSION

This thesis is motivated by the limited research on aggregate liquidity of the Malaysian stock market, the commercialization of investors' trading data by Bursa Malaysia and the recommendation of the best liquidity measures for individual stock exchange by the increasing number of liquidity horseraces. The last two developments enable this thesis to conduct in-depth analyses on the liquidity impacts of two distinct investor groups in the Malaysian stock market. This provides further insights on the liquidity implications of foreign hot money flows into the Malaysian stock market and the effectiveness of employing proprietary day traders (PDTs) to enhance liquidity in Bursa Malaysia. This thesis then applies the aggregate liquidity concept to another three asset markets in Malaysia, examining the liquidity connectedness among stock, bond, money and foreign exchange markets.

This thesis addresses three research questions related to aggregate liquidity of the Malaysian stock market. These research questions are answered in Chapter 4, Chapter 5 and Chapter 6 of this thesis, respectively. The structure of this concluding chapter is as follows. Section 7.1 discusses the key findings for all three research questions, which are then summarized in Table 7. Section 7.2 outlines the implications of the findings as well as relevant policy recommendations to regulators, policymakers and investors. Finally, Section 7.3 offers concluding remarks for future studies.

7.1 Summary of the Key Findings

This section provides a summary of the key empirical findings for all three research questions outlined in Chapter 1, as summarized in Table 7, and further discussed in the following three subsections.

Table 7: Summary of the Key Findings in Thesis

	Research Questions	Research Objectives	Key Research Findings
1.	Does foreign trading affect the aggregate liquidity of the Malaysian stock market?	To ascertain the impact of foreign trading on the aggregate liquidity of the Malaysian stock market.	Foreign trading is found to have short-lived negative impact on the aggregate liquidity of the Malaysian stock market.
2.	Is trading activity of proprietary day traders associated with higher-order moments of aggregate liquidity in Malaysia?	To examine the association between proprietary day trading and higher-order moments of aggregate liquidity in Malaysia.	The trading of proprietary day traders enhances liquidity of the Malaysian stock market at the cost of higher liquidity volatility and greater probability of extreme illiquidity on any trading day.
3.	Does liquidity spillover across the four main asset markets of stock, bond, money and foreign exchange in Malaysia?	To quantify the magnitude of liquidity spillovers across the four main asset markets of stock, bond, money and foreign exchange in Malaysia.	Liquidity spillover effects across the four main asset markets of stock, bond, money and foreign exchange in Malaysia are markedly low relative to global spillovers of return and return volatility.

7.1.1 Foreign Equity Flows and Aggregate Stock Market Liquidity

The first empirical chapter of this thesis, which aims to investigate the impact of foreign equity flows on aggregate liquidity in the Malaysian stock market, is motivated by three factors. First, the massive withdrawal of foreign portfolio investments seen after an announcement by the U.S. Federal Reserve to tighten its monetary policy, which receives constant coverage in the Malaysian financial press. Second, the commercialization of "Trading Participation by Category of Investors" dataset assembled by Bursa Malaysia, which provides actual trade data of local and foreign investors in the Malaysian stock market. Third, the unearthing of the best liquidity measure for the Malaysian stock market by the liquidity horserace of Fong et al. (2017), which enables greater accuracy in the quest to measure liquidity of the local stock market. Analyzing weekly data spanning the period from October 2009 to December 2016 using Vector Autoregression followed by Granger non-causality test, this thesis reveals evidence of a unidirectional causality running from gross foreign inflows to aggregate liquidity for both foreign institutions and foreign retail investors (Table 4.4, page 118).

Further inspection of the Generalized Impulse Response Functions (GIRs) suggests that foreign investors' equity flows reduce aggregate liquidity of the local bourse, with the negative liquidity impact lasting for one to four weeks (Figure 4.3, page 119). This thesis conjectures that the widening of bid-ask spreads is not solely due to foreign demand for immediacy, but because these informed foreign investors capitalize and trade on superior information that might be derived from privileged access to private information or skilled analysis of public news. A series of robustness checks further strengthen the baseline results of a negative causal relationship between foreign equity flows and aggregate liquidity of the local stock market. These robustness checks include incorporating the presence of structural breaks during the sample period (Table 4.5, page

122), splitting the sample based on market capitalization to explore if foreign trades affect the liquidity of large- and small-cap firms differently (Table 4.7, page 126), performing a bootstrap Wald test to address potential small sample bias in the use of Ordinary Least Square-based Wald test to examine Granger causality (Table 4.8, page 127), and lastly, the inclusion of additional endogenous variables in the Vector Autoregression model (Table 4.9, page 129). The only exception is when using alternative liquidity measures from the cost-per-volume category, which underscores the importance of distinguishing different dimensions of liquidity (Table 4.6, page 124).

In order to provide more insights, this thesis examines how uncertainties in the U.S. market, measured by the VIX index, affect the causal relationship between foreign equity flows and aggregate liquidity in the Malaysian stock market. It is found that while uncertainties in the U.S. have a direct negative impact on market liquidity in the local bourse, they also have an indirect impact on the liquidity of the Malaysian stock market through the trade flows of foreign institutional investors (Table 4.10, page 131). Besides, this thesis also addresses whether hot money flows exert a destabilizing effect on the local bourse during illiquid periods, which is confirmed by the statistically significant coefficient for the interaction term of foreign institutional investors and liquidity crisis dummy (Table 4.11, page 136). Further inspection of their trading strategy shows that it is the positive feedback trading adopted by foreign institutional investors that destabilizes the Malaysian bourse (Table 4.12, page 137). Despite the shocks, there is sufficient liquidity provision as the evidence shows that local institutions and local proprietary day traders always step in to provide the much-needed liquidity to the Malaysian stock market (Table 4.13, page 138).

7.1.2 Proprietary Day Trading and Higher-Order Moments of Liquidity

For the second research question, this thesis undertakes the first empirical study on proprietary day traders (PDTs) in Malaysia, given that little is known about PDTs despite more than thirteen years into its introduction by Bursa Malaysia to boost liquidity of the local bourse. In addition to providing empirical assessment on the effectiveness of this policy, this thesis also contributes to the limited day trading literature especially its effect on liquidity. The key novelty comes from the methodological contribution where this thesis expands the vast liquidity literature to higher-order moments with the proposal of conditional liquidity skewness.

Using daily data spanning October 2012 to June 2018, there is evidence that PDTs' trade volume is associated with increased market liquidity in Bursa Malaysia (Table 5.3, page 157), which is attributed to lower information asymmetry in the market due to rising competition between PDTs and other informed traders to incorporate information into stock prices, consistent with the competition model of Subrahmanyam (1991) and Spiegel and Subrahmanyam (1992). The information advantage of PDTs in the Malaysian market is justifiable as they are professional stock traders with at least five years of trading experience and are mainly hired by well-capitalized investment firms with in-house analysts that might grant them privileged access to valuable firm-specific information.

At the second moment of liquidity, PDTs' trade volume is associated with greater conditional volatility of transaction cost but lower conditional volatility of price impact (Table 5.4, page 161). This thesis attributes such heightened conditional volatility of transaction cost to the immediacy of PDTs to close their open positions within a very short time frame of one to two trading days. On the other hand, the fall in the conditional volatility of price impact is mainly a result of PDTs trading large volume of penny stocks, which reduce the magnitude of the price impact measure. The same statistically significant associations are observed when the analysis is extended to the third moment of conditional liquidity skewness, with the coefficients for PDTs' trades retaining their signs (Table 5.5, page 164).

Where the transaction cost is concerned, higher volatility in the bid-ask spreads due to the entrance of PDTs in the market has shifted the bid-ask spread distribution to the right, thereby increasing the chances of higher bid-ask spreads on any trading day. This thesis conjectures that such shift of the transaction cost distribution to the right is due to the exclusive rights granted to PDTs to perform intraday short selling, which is consistent with the front running theory, as well as the volatility-heightening effect of their trades based on the leverage effects and volatility feedback hypotheses. The latter two hypotheses are also applied to explain the reduction in right-skewness of the *CPQSIM* distribution due to the participation of PDTs in the Malaysian stock market. Given that the trades of PDTs lead to lower conditional volatility of the *CPQSIM*, the probability of extreme price impact in the market on any trading day is also reduced, hence resulting in a less right-skewed distribution of the *CPQSIM*.

Since all the innovations in the baseline GARCH models are modelled using the Student's *t* distribution, this thesis also re-estimates the models using the Generalized Error Distribution (GED) as an alternative distribution of GARCH innovations to ensure the robustness of the baseline findings. The results, tabulated in Table 5.6 (page 167), Table 5.7 (page 168) and Table 5.8 (page 169), are largely consistent with those shown in the baseline models. At the level, the participation of PDTs in Bursa Malaysia is still associated with higher aggregate liquidity, measured by both transaction cost and price impact proxies. Moving to the second moment, the conditional volatility-increasing effect of PDTs' trades in the transaction cost remains, albeit less impactful given that the significant effect of their previous day trades seen in the baseline model has vanished in the robustness check. On the other hand, the volatility-reducing effect of their trades on the conditional volatility of *CPQSIM* is stronger in the robustness check as both the contemporaneous and lagged terms are statistically significant vis-à-vis the baseline where statistical significance is observed only for the contemporaneous term. Finally, the positive (negative) association between PDTs' trades with conditional skewness of *CPQS* (*CPQSIM*) is stronger in the robustness check as the contemporaneous term for PDT in both models turn significant.

7.1.3 Dynamic Liquidity Connectedness among Asset Markets

In the connectedness literature, regardless of whether one is looking at return, volatility or liquidity spillovers, the debate is not on whether the different markets are connected but rather how strong are the connections among these markets. The final empirical chapter of this thesis thus aims to quantify the connectedness among the liquidity of four main asset markets in Malaysia, namely stock, bond, money and foreign exchange markets. This objective is achieved by constructing total and directional connectedness indices following the framework introduced by Diebold and Yilmaz (2009, 2012, 2014). However, instead of using the rolling-window approach advocated by the authors to examine dynamic connectedness, which has shortcomings such as having to choose an arbitrary window length and the inability to identify which data point actually contributes to the fluctuations in the index, this thesis adopts the time-varying parameter vector autoregression (TVP-VAR) approach of Antonakakis et al. (2020) to construct dynamic liquidity connectedness indices for the selected Malaysian asset markets.

In the full sample static model, a Total Connectedness Index (TCI) of only 1.129% indicates that liquidity connectedness among the four asset markets in Malaysia is very low. This implies that liquidity shocks in each of the asset market explain most of the forecast error variance of their respective market. When liquidity spillovers across asset markets do occur, stock market is found to be the main transmitter whereas the money market is the largest receiver (Table 6.3, page 185). Further analysis splits the sample into two with 29th September 2008 as the cut-off point. It is discovered that liquidity connectedness among the four markets is marginally higher before the global financial crisis, with the TCI registering 2.818% compared to 2.026% observed in the post-crisis period (Table 6.4, page 189). Before the crisis, the foreign exchange market is both the largest transmitter and receiver of liquidity spillovers, spilling over 4.120% of its liquidity shocks while receiving 5.801% of liquidity shocks from all the other three markets. In the post-crisis period, the stock market took over the role as the largest transmitter of liquidity spillovers, contributing 4.592% variations in the liquidity of the other three asset markets, with the money market being the most influenced at 3.977%. Such magnitude of liquidity spillovers from the stock market to the money market also witnesses the latter becoming the largest receiver of liquidity spillovers among the four asset markets, with a "Total FROM" reading of 4.006%.

The variation in the Total Connectedness Index across two sub-periods highlights the need to estimate liquidity connectedness of the four markets in a time-varying framework. Diebold and Yilmaz (2009, 2012, 2014) estimate the time-varying connectedness index in a rolling-window framework, but this thesis instead follows the time-varying parameter vector autoregression (TVP-VAR) approach of Antonakakis et al. (2020) due to the superiorities of the latter framework mentioned above. In the dynamic framework, average liquidity connectedness is markedly higher at 8.040% vis-à-vis 1.129% in the full sample static framework (Table 6.5, page 191). The plot of TCIs over the sample period (Figure 6.5, page 191) further shows the sensitivity of liquidity connectedness to important market events, with the most apparent being the surge in connectedness among the four markets to almost 50% on the day Lehman Brothers' bankruptcy was announced. Such heightened connectedness during crisis period is also observed in the volatility, monetary policy and liquidity spillovers literature.

In the dynamic model, the foreign exchange market emerges as the main transmitter as well as receiver of liquidity spillovers, matching the results observed during the pre-crisis period. The market emits the most liquidity spillovers right after the Malaysian ringgit was de-pegged from the U.S. dollar, during the Global Financial Crisis and lastly when foreign investors were rushing to cash out from emerging markets in view of a potential tightening of monetary policy in the U.S. in 2015 and 2016 (Figure 6.6, page 194). On the other hand, the foreign exchange market is also the largest receiver of liquidity spillovers. The graphical plots in Figure 6.7 (page 195) show that this observation is largely driven by massive liquidity spillovers to the foreign exchange market during the bankruptcy of Lehman Brothers and the downgrading of Greece's sovereign credit rating. The former being spillovers from the stock market while the latter from the bond market.

To put the findings of the third empirical chapter into perspective, Table 6.6 (page 200) summarizes previous studies which employ similar factor error variance decomposition framework of Diebold and Yilmaz (2009, 2012, 2014) to examine own-asset market and cross-asset market return and/or return volatility connectedness. It is found that liquidity connectedness among the four asset markets in Malaysia is the lowest in terms of percentage relative to previous studies, indicating the possibility of a systematic liquidity dry-up in the country's core asset markets is rather low.

7.2 Implications of the Findings

This thesis offers some policy implications from the empirical results. The adverse impact of foreign trading on aggregate liquidity has been found to destabilize the Malaysian stock market through the flows of foreign institutions, confirming the negative press reports on foreign investors during periods of volatile foreign equity flows. However, liquidity condition in Bursa Malaysia remains resilient when foreign investors flee the market as there is ample liquidity provision from local investors to cushion the negative impact arising from such capital flight, thus protecting the local market from liquidity dry-up. As such, the findings from the first empirical chapter lend support to the policy decision by the Malaysian government to refrain from imposing capital controls when Bursa Malaysia experienced persistent capital outflows in 2015. Despite lowering aggregate liquidity, evidence in this thesis and those reported by Lim et al. (2016) firmly establish the significant information role played by foreign investors in which they improve the local information environment and facilitate the incorporation of value-relevant information into the prices of Malaysian stocks. When formulating future polices on foreign portfolio flows, the Malaysian government should evaluate, among others, the trade-off between having improved information environment where stock prices serve to guide corporate investment decisions (see Bond et al., 2012 and references cited therein) and the cost of lower liquidity in the form of wider bid-ask spreads due to their informed trading.

This thesis also contends that liquidity provision should not be borne largely by the government-backed institutions[30] given its political economy implication, as the state

[30] It is widely reported in the local newspapers that local institutional investors, most of which are government-linked, always step in to support any liquidity needs of the Malaysian stock market. See articles in the links below (retrieved on 31st December 2017):

might end up holding substantial ownership and control of Malaysian corporate sector (see Gomez, Padmanabhan, Kamaruddin, Bhalla, & Fisal, 2018). On the other hand, the evidence does support the measure of Bursa Malaysia to introduce PDTs in January 2007 as they are found to complement local institutions in meeting the demand for immediacy by foreign investors, despite concerns they might flee to liquidity during market stress given the result of bidirectional causality between local PDTs and aggregate liquidity. Nevertheless, the stock exchange should intensify its efforts to increase the participation of local retail investors, which this thesis finds are contrarians in the local bourse. It is widely acknowledged in the academic literature that retail investors act as noise traders who have an exogenous liquidity motive for trade (see Barrot, Kaniel, & Sraer, 2016; Foucault, Sraer, & Thesmar, 2011), and their noise trading is expected to improve liquidity (see the theoretical model of Admati and Pfleiderer, 1988). Though retail shareholdings in Bursa Malaysia had hovered around 20% for the past two decades, it is worth highlighting the prevalence of ownership concentration in the hands of family (see Carney & Child, 2013). A recent paper by Chia et al. (2020b) finds that broadening investor base is an effective strategy to boost the liquidity of Malaysian public listed firms, particularly in expanding the number of retail investors. To achieve that, the management of public listed firms should play an active role as empirical evidence in Chia et al. (2020a) shows that higher stock liquidity is associated with higher market valuations of Malaysian firms.

Results at the level of liquidity from Chapter 5 indicates that the introduction of PDTs by Bursa Malaysia is commendable, as PDTs' trade volume is found to lower transaction cost and the price impact of trade. However, there is a trade-off to improved

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http://www.businesstimes.com.sg/government-economy/najib-delivers-rm20b-boost-for-malaysian-stock-market,
https://www.thestar.com.my/business/business-news/2016/01/13/khazanah-pumps-in-rm1bil-into-valuecap/
https://www.thestar.com.my/business/business-news/2017/03/30/local-funds-to-the-fore/

liquidity, particularly on the transaction cost facing investors as measured by the Closing Percent Quoted Spread (*CPQS*). It is found that both the conditional volatility and conditional skewness of spreads are positively associated with proprietary day trading. This suggests that improved liquidity comes at the expense of market noise induced by liquidity movements that are much more volatile than they otherwise are. This thesis postulates that the higher liquidity volatility induced by PDTs is due to the exchange-imposed immediacy for PDTs to close their open positions, whereas a higher degree in the skewness of bid-ask spread distribution can be attributed to the exclusive rights granted to PDTs to engage in intraday short selling (IDSS). This thesis reckons that such heightened conditional volatility and conditional skewness are necessary trade-offs that the exchange has to face to shore up aggregate liquidity in the local bourse. This is because relaxing the immediacy to close open positions would undermine the principle of day trading. On the other hand, before deciding to strip day traders of their rights to perform IDSS, the exchange should first assess if higher conditional skewness of the bid-ask spreads due to IDSS is idiosyncratic to this group of traders, or an effect of the trading strategy itself, when more data following the introduction of IDSS to all investors in April 2018 are available. Nonetheless, it is worth noting that this trade-off is detected for only one facet of the liquidity of the Malaysian stock market as the participation of PDTs in the market lowers conditional volatility and conditional skewness of the price impact.

Lastly, the finding of a relatively low connectedness among liquidity of the stock, bond, money and foreign exchange markets in Malaysia indicates that the possibility of a systematic liquidity dry-up in the country's core asset markets is rather low, providing some form of relief to policymakers and market regulators. This implies the liquidity spillovers experienced by the U.S. during the Global Financial Crisis have a lower probability of occurrence in Malaysia, mainly because the liquidity spillover from money market to stock market in Malaysia is the lowest among all pairwise spillover indices reported in Table 6.5 (page 191).[31] It appears that stock market liquidity, being the least affected by liquidity shocks stemming from other markets, is less of a concern to regulators. This is because local institutional investors and PDTs always step in to provide liquidity support to the Malaysian stock market, as reported in Chapter 4. Instead, regulatory policies aimed at lowering liquidity risk should be geared towards exchange rates as the evidence shows that the foreign exchange market emits the most of its liquidity shocks to other asset markets, as well as being the most affected by liquidity shocks arising from the rest of the markets. This is particularly challenging because the foreign exchange market is vulnerable to speculative attacks and is outside the regulatory oversight of the central bank mainly due to the presence of the non-deliverable forwards (NDF) market for currency. One example of the challenges that the central bank of Malaysia faced while trying to regulate the foreign exchange market is the on-going of offshore ringgit NDF transactions despite the central bank's warnings in November 2016.[32]

7.3 Conclusion

This thesis examines issues related to aggregate liquidity of the Malaysian stock market in a literature dominated by firm-level studies. The findings of this thesis have direct implications to stock exchange regulators, policymakers as well as portfolio managers.

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[31] On 9th August 2007, the U.S. interbank market froze completely due to the prevailing fear of uncertainties among banks following chains of bankruptcy filings of U.S. lenders in the preceding months, triggered by rising number of subprime mortgage defaults. Such vaporization of liquidity in the interbank market later have a contagion effect on the corporate debt market directly and the stock market indirectly through VIX (Flavin & Sheenan, 2015). Additionally, Brunnermeier (2009), which provides a detailed account of how the global financial crisis unfolded and its ripple effects on Wall Street, also shows that the evaporation of liquidity in the credit market severely affects the funding available to expert investors, therefore jeopardizing market liquidity. Brunnermeier and Pedersen (2009) later formalize the theoretical link between market liquidity and funding liquidity.

[32] Bank Negara Malaysia had on November 2016 instructed banks operating in Malaysia to send letters seeking commitments from their offshore counterparts and clients to cease trading the Malaysian ringgit on the NDF market. However, trading of ringgit NDF in foreign markets persisted even after five months since the central bank imposed such restriction. See links below for news reporting of such incident (retrieved on 31st December 2018):
https://www.reuters.com/article/malaysia-fx-controls/update-1-malaysias-central-bank-says-will-no-longer-tolerate-ringgit-trade-in-ndf-market-idUSL4N1DK04Y
https://themalaysianreserve.com/2017/04/03/ringgit-ndf-trading-continues-despite-bnms-warnings/

As policymakers are embarking on initiatives to enhance market liquidity, it is vital that the effectiveness of their policies is empirically examined. While findings of the first empirical Chapter 4 might not be generalizable to other emerging markets due to differences in institutional and market features, it demonstrates the additional insights offered by a single country study that can be replicated to other emerging markets for prescribing policies on foreign portfolio flows, using actual trading data of foreign investors and the best liquidity measure prescribed for each stock exchange by the existing liquidity horseraces.

In addition, with intraday short selling made available to all investors beginning April 2018, future study can be carried out to examine whether the effect of PDTs' trades on conditional volatility and conditional skewness of liquidity is unique to only this group of traders so as to provide policy guidance on whether to accept such cost of shoring up liquidity in the local stock market. As this thesis is the first to report the cost of supplying liquidity through day traders, more studies should be conducted to further confirm the existence of this trade-off from day trading, which will also add to the petite day trading-liquidity literature. In addition, the conditional liquidity skewness should also be given attention by future studies given the lukewarm reception to its unconditional counterparts introduced by Roll and Subrahmanyam (2010) almost a decade ago. Given the intense competition among specialists and dealers, liquidity skewness should be a time series phenomenon at higher trading frequency similar to the development in the stock return skewness literature. In the absence of theoretical models to explain the trading-liquidity skewness relationship, this thesis employs the volatility feedback and leverage effects hypotheses in the return skewness literature to explain the findings of Chapter 5. Therefore, more future studies on the theoretical explanations and also empirical modeling of how trading affects skewness of liquidity distribution should be conducted.

This thesis establishes the low liquidity connectedness across the four asset markets in the developing economy of Malaysia. Similar cross-market connectedness has been conducted by Diebold and Yilmaz (2012) for the developed U.S. financial markets, but in the context of return volatility connectedness. Using daily data spanning January 1999 to January 2010, the authors find that return volatility of U.S. stock, bond, foreign exchange and commodity markets are connected at 12.60% in a full sample static analysis, which is a relatively low reading among all TCIs reported in Table 6.6. Since cross-market connectedness is markedly low relative to connectedness within the same asset market across countries, future studies should construct liquidity connectedness indices for global stock markets, global currency markets, global bond markets and global money markets similar to the works of Diebold and Yilmaz (2009, 2012, 2014).[33]

[33] These authors share their return/volatility connectedness indices for global stock markets, foreign exchange markets, sovereign bond markets and credit default swaps (CDS) markets on their website at http://financialconnectedness.org/.

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