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# Volatility spillover across spot and futures markets: Evidence from dual financial system

Ahmed H. Elsayed [a,*,1], Mehmet Asutay [b,2], Abdelkader O. ElAlaoui [c], Hashim Bin Jusoh [d]

[a] Department of Economics and Finance, United Arab Emirates University, United Arab Emirates
[b] Middle Eastern and Islamic Political Economy & Finance, Durham Centre for Islamic Economics and Finance, Department of Economics & Finance, Durham University, UK
[c] Rabat Business School, International University of Rabat, Morocco
[d] Faculty of Business and Management, Universiti Sultan Zainal Abidin, Kuala Terengganu, Malaysia

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ABSTRACT

This paper investigates dynamic returns and volatility spillovers between spot and futures markets in a dual financial system. It further analyses the shock transmission of both volume trading and open interest in the futures market. Empirical results suggest that both spot and futures indices are net transmitters of return spillovers to the volume and open interest of the futures market, whereas the futures volume is the only net transmitter of volatility spillovers to all other variables. This is consistent with the Information Arrival Hypothesis theory. The empirical analysis also evidences the presence of a dynamic interdependence between both Islamic and conventional spot market volatilities and the futures market. In particular, the returns and volatility spillover are bidirectional and ricocheting-off transmission in nature. Specifically, such interdependence is stronger in the case of the Islamic spot index than the conventional spot index and during financial shocks.

## 1. Introduction

Returns and volatility spillovers between spot and futures markets have gained a renewed interest among researchers, traders and investors due to a certain consistency in recurrent and periodical financial shocks happening sporadically or insistently. In fact, traders and investors are keen to open positions in futures markets, allowing them to offset their risky positions in spot markets. Therefore, they are eager to learn new techniques brought by researchers to hedge their investments better.

In this study, the spillover approach developed by Diebold and Yilmaz (2009), (2012), (2014) is employed to investigate the return and volatility spillover transmission patterns between spot and futures markets in the case of Malaysian markets, which is an emerging economy with the dual financial system. In addition, we analyse the dynamic interdependence between futures and both Islamic and conventional spot markets and the total volume of trading and open interest of futures in the Malaysian stock markets. In fact, the total volume of trading is considered to represent speculative demand, while open interest is more dedicated to hedging activities in the

* Corresponding author.
*E-mail addresses:* ahmed.elsayed@uaeu.ac.ae (A.H. Elsayed), mehmet.asutay@durham.ac.uk (M. Asutay).
[1] ORCIC: 0000-0002-7506-5963
[2] ORCIC: 0000-0003-4939-6053

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futures market, whereby the information from both is used to forecast futures spot returns and volatilities (Bessembinder and Seguin, 1993; Donaldson and Kamstra, 2005; Le and Zurbruegg, 2010; Antonakakis et al., 2016). This work is based on the Sequential Arrival of Information Hypothesis (SAIH) brought by Copeland (1976) and extended by others, such as Morse (1981), Jennings et al. (1981), Jennings and Barry (1983), Lamoureux and Lastrapes (1990). SAIH suggests that total trading volume and open interest of futures are two information channels through which the shocks are transmitted to different markets. Specifically, total trading volume can predict future's price volatility.

Despite the extensive literature on the relationship and volatility transmission mechanisms among conventional spot and futures markets and the increasing importance of the Islamic finance sector, there is a gap in the literature. In particular, the lack of understanding of the linkages between futures and the Islamic spot stock index should be identified as a field where hardly any work exists. In fact, nothing is known about the process according to which returns and volatility spillovers between futures markets and other markets. In addition, what futures parameter is the most determining in those interactions with the Islamic stock index remains an important question to be examined.

This paper, hence, attempts to fill the observed gap in the literature by examining the dynamic spillover transmissions between the Islamic spot index, conventional spot index and futures markets by benefiting the dual banking system of Malaysia. Accordingly, the following research questions are developed: (i) Do differences exist in patterns of returns and volatility spillovers across spot and futures markets and which type of shock spillover – returns or volatility - is more impactful in those markets? (ii) Specifically, do any asymmetric patterns exist in returns and volatility spillovers across Islamic and conventional markets vis-à-vis futures markets, and which market dominates the shock transmission process? (iii) Does the Sequential Arrival of Information Hypothesis (SAIH) hold or help forecast the return of stock index futures in an emerging economy such as the Malaysian market? These three questions are not trivial because understanding the source of shock spillovers for both returns and volatility can guide portfolios and risk management of investment decisions.

The results show strong evidence that spot and futures volatilities in the Malaysian market are mainly net receivers of spillovers to the total volume of futures trading. The findings also support a bi-directional interdependence between spot and futures volatilities, which are affected by major financial shocks. Moreover, the forecast error variance of open interest is significantly impacted by shocks from the total futures trading volume. Specifically, the Islamic spot index is the net transmitter of returns spillovers to the futures volume but a receiver of volatility shock spillovers from the futures volume. Consequently, the SAIH concerning inter-markets information transmission is found to hold only for total trading volume but not in the case of open interest, as the latter has a weak characterisation of the Malaysian stock markets. This study, hence, shows evidence of significant volatility spillovers from trading volume to the three examined indices and open interest in the futures market, concluding that there are strong returns spillovers from indices toward the trading volume.

The analyses presented in this study on the multiple linkages in Malaysian domestic markets, including futures and Islamic and conventional stock indices, bring practical insights to traders, investors and financial analysts in terms of forecasting the risk of spot and futures investment by capturing the information taken from returns and volatilities spillover, to hedge their positions and secure their optimal investment strategies. Finally, the fact that spot and futures volatilities in Malaysian markets are net receivers of volatility spillovers from total futures trading volume may represent for the regulators an efficient tool to better supervise Islamic financial markets by anticipating excessive speculative positions in the futures market due to artificial and wide price swings based on markets structure between contango and backwardation.

This study makes contributions to the existing literature. To the best of our knowledge, this is the first work in Islamic finance to quantify both returns and volatility spillovers between futures and Islamic stock indices. Moreover, unlike the studies by Antonakakis et al. (2016), where the instruments were operating in a well-established market, the Malaysian market is emerging. Because Islamic financial markets offer limited portfolio diversification benefits, as in the findings by Cevik and Bugan (2018) and Bugan et al. (2021), and limited opportunities for hedging using conventional futures due to their perceived non-Shariah compliance, the paper also adds valuable insights to the literature on financial risk management within the realm of Islamic finance in emerging markets. These findings have implications for investors and policymakers dealing in these markets.

As a result, this analysis is more appealing to policymakers in similar emerging countries. Moreover, Ahmed and Elsayed (2019) and Elsayed et al. (2023) studied Islamic stock and sukuk markets in Malaysia. However, they did not include futures instruments compared to Islamic stock indices. Besides that, our study provides new outputs based on the avenues of the recency of the Malaysian data.

Importantly, this work helps to identify dynamically the direction of the shock spillovers from and to the Islamic spot index regarding the volume and open interest of the futures index. Therefore, this research offers a new perspective for enhanced understanding of the linkages – bi-directional shock transmission –between the Islamic spot market and conventional futures market. This may convey a clear policy implication to regulators for a possible introduction of a new Islamic futures index in international capital markets.

The rest of the paper is organised as follows: Section 2 presents the literature review, while Section 3 describes the data and discusses the econometric methods used to examine shock spillovers between spot equity and futures markets. Section 4 presents and discusses the results. The final section provides concluding remarks.

## 2. Literature review

The information transmission between spot and futures in the capital market plays a crucial role in price determination, price change, and volatility, implying potential opportunities for arbitrage for traders and investors (Floros and Vougas, 2008). It may also constitute a prognostic sign for coming shocks and spillover transmission between different markets. Several studies have examined the empirical relationship between the spot and futures markets and found evidence that futures have a dominant role and incorporate market-wide information more efficiently than spot markets (Stoll and Whaley, 1990; Chan, 1992; Ghosh, 1993; Koutmos andTucker, 1996; Pizzi et al., 1998; Tse, 1999; Brooks et al., 2001; Chou and Chung, 2006; Bohl et al., 2011).

### 2.1. Futures versus spot volatility

Numerous studies have investigated volatility persistence from one market to another; empirical analysis on this issue commonly focuses on price change and both return and volatility spillovers.

Chen et al. (2006) examined volatility persistence across different volatility estimators for various types of futures contracts, with a critical objective of finding the best measure for identifying volatility persistence. All intra-day and inter-day data covered the period from January 1998 through December 2002. The study compared the results from three conceptually different types of volatility estimators, namely, the classical volatilities (close-to-close, squared and daily absolute changes) where the daily volatilities were restricted to closing prices, intraday realized volatility (the Garman & Klass range-based and 5- minute measures), inter-day conditional volatility (FIGARCH volatility from inter-day close-to-close returns). Their findings indicated that intraday realized volatility measures were more persistent than daily measures and realized volatility persistence was inconsistent with conditional volatility persistence.

Similarly, Vipul and Jacob (2007) examined the estimation and forecasting performance of range-based volatility estimators for stocks, with two- scales realized volatility as the benchmark. Overall, they found the Garman and Klass (1980) estimator, which indirectly adjusted for the drift, performed better for the high drift stock. The Rogers and Satchell (1991) estimator performed better for the low drift stock. This was explained by the higher efficiency of the Garman and Klass (1980) estimator. The Parkinson estimator performed well if the drift was insignificant.

Along the same line, Bali and Weinbaum (2005) compared the performance of various methods of estimating volatility (bias and efficiency) from daily data (opening, closing, high, and low prices). Extreme value volatility estimators properties that have appeared in the literature, such as Parkinson (1980), Garman and Klass (1980), Rogers and Satchell (1991), and Yang and Zhang (2000), were introduced. Furthermore, in the study, high-frequency data on very liquid and actively traded assets were used to construct measures of realized volatility as in Andersen et al. (2001), Andersen et al. (2001), and Barndorff-Nielsen and Shephard (2002). Bali and Weinbaum (2005) found strong support for using extreme value volatility estimators when estimating daily volatilities. Extreme value estimators were less biased and more efficient than the traditional estimators at the daily frequency. All extreme value volatility estimators outperformed the traditional estimator, and the Garman & Klass estimator outperformed the others across all data sets. Shu and Zhang (2006) examined the relative performance of various historical volatility estimators that incorporate daily trading ranges, such as Parkinson (1980), Garman and Klass (1980), Rogers and Satchell (1991), and Yang and Zhang (2000).

Bali and Weinbaum's (2005) test with Monte Carlo simulation showed that the accuracy of range estimators depended on the assumption of the asset return distribution. They found that if a stock price followed a geometric Brownian motion with a slight drift and with no opening jump, all four range estimators provided a reasonable estimation of the actual variance. However, if the drift term were large, the Parkinson and the Garman & Klass estimators would significantly overestimate the true variance, whereas the Rogers & Satchell and the Yang & Zhang estimators drifted independently. If there was a large opening jump, only the Yang & Zhang estimator could give an accurate estimation. The others were downward biased. Their result showed that the range estimators could capture the short-run dynamics of volatility variation.

Regarding episodic volatility (volatility during episodes), Fernandez (2006) analysed permanent volatility shifts in the world stock markets during the Asian crisis and September 11. She tested for structural breaks in volatility during 1997–2002 using the Iterative Cumulative Sum of Squares (ICSS) algorithm and wavelet-based variance analysis. Her findings revealed that the ICSS algorithm failed to detect any breakpoints, while a wavelet-based variance test detected breakpoints at the high-frequency components of the filtered data. The findings proved that the latter method tends to be more robust.

### 2.2. Volatility spillovers

Considering the growing interest in managing risk for portfolio managers (Pati and Rajib, 2011) and trading stock index futures for hedging purposes (Antonakakis et al., 2016), it is vital to address the issue of volatility spillover effects between futures returns-trading volume and futures returns-open interest. For example, Wu et al. (2005) examined short-run transmission between the US and the UK markets using 5–5-minute returns of the S&P 500 and FTSE 100 index futures for the whole year of 1995. They employed a generalized autoregressive conditionally heteroskedastic model (GARCH) to estimate the mean and volatility spillovers of intraday returns. They also used a Fourier flexible function to filter the intraday periodic patterns caused by serial correlation in return volatility. The results support a 'heatwave' hypothesis for returns but not a 'meteor shower' hypothesis for volatility across markets, which also shows that intraday periodicity can affect the estimates of short-run volatility persistence, especially for return intervals longer than 15 minutes. Furthermore, they also found that intraday periodicity also affects the measurement of the speed of information transmission. However, these effects vary across markets. It should be noted that volatility persistence can generally be estimated better using returns measured at a shorter time interval and a filtering technique to remove intraday periodicity. Based on intraday data, their findings showed evidence of volatility spillovers between the US and UK markets where information transmission was unidirectional from the US to other markets.

Following the spillover approach developed by Diebold and Yilmaz (2009), (2012), Antonakakis et al. (2016) examined the dynamic spillovers between spot and futures markets volatilities, the volume of futures trading and open interest in the UK and the US markets. Based on a dataset that covers both the global financial crisis and the Eurozone debt crisis, their findings reveal that spot and futures volatilities in the UK (the US) are net receivers (net transmitters) of shocks to the volume of futures trading and open interest, while shocks to the volume of futures trading significantly contribute to the forecast error variance of open interest. Specifically, they find that the spot and futures volatility spillovers between the UK and the US markets are bidirectional, sensitive to time and specific events such as the global financial and Eurozone debt crises. In addition, Aloui et al. (2018) also analysed volatility spillover of stock indices and stock index futures in emerging and developed markets from three geographical locations based on wavelets. They found that the intensity of the spot-futures relationship depends on the level of volatility of the markets, supporting the position by Ross (1989) that the volatility increases the information flow and transmission of information across markets. Finally, they suggest future research focus on the dynamics of spillovers between different asset classes.

Using the multivariate DECO-FIGARCH model and the spillover index method of Diebold and Yilmaz (2014), Kang and Lee (2019) analyse the dynamic volatility spillovers between global futures markets throughout the 2008–2009 global financial crisis and 2010–2012 European sovereign debt crisis. They find the highest level of spillover index during the 2008 global financial crisis. Their findings also reveal that FTSE 100 index futures are the largest transmitter of volatility spillover shocks. As the study on the UK and the US markets by Antonakakis et al. (2016) shows, the direction and intensity of network connectedness are sensitive to financial and economic events.

Fassas and Siriopoulos (2019) extend the study of price discovery and volatility spillover between the stock and futures price indices in the Athens Exchange using a new high-frequency dataset. Their findings suggest strong bi-directional dependence on the volatility of both markets, implying that information in price innovations originated in either the spot or the futures markets is transmitted to the volatility of the other market. Similarly, Martinez and Tse (2008) studied intraday volatility for the E-mini S&P 500 futures contracts traded on a continuous 23-hour schedule on the CME (Chicago Merchantile Exchange) Globex electronic platform. Their datasets consist of CME time and sales intra-day data from January 2004 through June 2007 for the E-mini S&P 500 futures contracts traded on the CME Globex and daily volume and open interest data from Commodity Systems Incorporated. In the study, open interest is considered the total number of futures contracts that are not closed out by the end of the same day. Martinez and Tse's (2008) study dealt, on the one hand, with daily volatility, where volatility plots for average absolute returns are obtained from one-minute intervals, and on the other hand, with volatility transmission, where the authors analyse volatility transmission for the bond, and stock markets using one-minute intervals. Data are divided into five sub-periods representing the active times of different markets worldwide. VAR model instead of GARCH is used to analyse volatility transmission across and within the region. In describing a region's volatility, the authors use its volatility as the dependent variable and lagged volatilities of the same region and other regions as independent variables. The left-hand side variables are the volatilities in each of the five regions, and the right-hand side variables are lagged volatilities for each market. Instead of the vector autoregressive (VAR) model, the Seemingly Unrelated Regression (SUR) model is used to analyse the relationship between volatility, open interest and volume since the lagged values are different for each equation. Martinez and Tse (2008) tested the impact of expected and unexpected changes in volume and open interest on the volatility of E-mini-S&P futures contracts, and, following Bessembinder and Seguin (1993), they estimated the conditional means and volatilities. Volatility transmission in a single market across different regions was explained mainly by intra-region volatility (heat waves). They found that inter-region volatility (meteor showers), although significant, plays a secondary role in volatility transmission. In their study, impulse response functions for stock markets show that heatwave volatility shocks have at least twice the impact of meteor shower shocks. Thus, the return volatility in the E-mini S&P futures is mainly driven by each region's own volatility.

In extending the empirical literature, Fung et al. (2010) investigated the effects of the US market on Asian markets, focusing on how Asian index futures markets overreacted to price movement in the US. They studied the active index futures trading markets in Asia, namely Singapore, Korea, Hong Kong, Taiwan and Japan. However, they excluded the index futures markets in Malaysia[3] and India due to low liquidity in their sampling period. They found that the more extreme the US market returns were, the higher the futures price reversals would be, and as markets matured and information flowed more freely, over-reaction did not disappear. Their findings contradicted the 'efficient market hypothesis',[4], stating that the price discovery process at the open market should not cause any systematic reversals after the market opened. Fung et al.'s (2010) findings were in line with many studies that found evidence of the dominant effects of the U.S. equity market on the Southeast Asian equity markets, including Malaysia (Ibrahim, 2006) and the significance of U.S. leadership over other markets (Boon and Wooi, 2005). Subsequent to Fung et al.'s (2010) study, the liquidity of the Malaysian futures market has improved due to its migration to the CME Globex electronic trading platform, which provides an

[3] On 20 September 2010, Bursa Malaysia Derivatives Berhad migrated its derivatives products onto CME Globex® electronic trading platform. This move enables global traders to access to Malaysian Futures market electronically, allowing for higher liquidity in the market.

[4] Developed by Fama, this theory suggests that all relevant information is already priced into any security. Based on the theory, according to Fung et al., (2010), the most recent performance of the US market is a piece of public information easily assessable to Asian investors.

opportunity for the current study.

The introduction of stock index futures in China in 2010 marked a significant development in the country's financial markets. Covering the period of the stock market crash in 2015, Miao et al. (2017) examined the intraday price discovery and volatility spillover relationship between the CSI 300 equity index and stock index futures in China. Contradicting regulatory claims that futures markets contributed to the stock market crash in 2015, results from the study show that volatility spillover documents significant return and volatility shocks transmitted from the stock market to the futures market. The context of China's unique institutional trading structure explains the evidence from their study.

Finally, Kang et al. (2013) provide empirical evidence of South Korea's volatility spillover relationship between spot and futures markets using high-frequency datasets of KOSPI 200 spot and futures contracts. The results indicate a strong bi-directional relationship between futures and spot markets, suggesting that return volatility in the spot market can influence that in the futures market and vice versa. Thus, the results indicate that new information is simultaneously reflected in futures and spot markets.

As regards the importance of open interest and trading volume as critical determinants of market volatility, according to Sutcliffe (2006), open interest is calculated as the sum of either the outstanding long positions or the outstanding short positions. It is considered an indicator of sentiment for market depth or a proxy of heterogeneous beliefs in futures markets (Watanabe, 2001; Aguenaou et al., 2011). Open interest can impact the end of major market moves Floros (2007) since open interest may be significantly related to trading volume and price volatility. Furthermore, the volume affects both futures volatility and changes in open interest (Bessembinder and Seguin, 1993).

Lucia and Pardo (2010) have found that futures speculative demand is driven by trading volume, while the latter is strongly correlated with open interest (Bessembinder et al., 1996; Mougoué and Aggarwal, 2011). Although volume tends to increase volatility, open interest does not affect it. In electronic markets, open interest does not seem to be a good proxy for liquidity. Instead, strategies of informed and uninformed investors, along with information on the limit order book, provide valuable information on the market's liquidity. These results may help policymakers understand better the causes and consequences of volatility transmission in different markets around the world and give them a better understanding of liquidity factors and the market dynamics that may affect them.

### 2.3. Islamic versus conventional spot index

Studies of Islamic investment performance in dealing with global financial market turmoil have received much attention in the literature. To examine the advantages of portfolio diversification and the safe haven characteristics of Islamic financial markets, Cevik and Bugan (2018) and Bugan et al. (2021) examine the interaction between Islamic and conventional financial markets under various market situations and regimes. Because of the two markets' comparable behaviours, both studies show that Islamic stock markets offer only partial benefits for portfolio diversification. In a similar vein, Yarovaya et al. (2021) reach a similar conclusion using global data for Islamic and conventional financial markets.

During the bear market, the Islamic equity indices underperform their conventional counterparts (Hussein and Omran, 2005). However, overall, Shear and Ashraf (2022), Hussein and Omran (2005) and Shamsuddin (2014) have found the returns of the Islamic equity indices outperform their conventional counterparts.

Besides the performance of Islamic investment, volatility spillover across different Islamic markets has also attracted many studies recently. For example, Majdoub and Mansour (2014) used the MSCI (Morgan Stanley Capital International) Islamic equity index and employed GARCH BEKK, CCC, and DCC models to study spillovers across the U.S. market and five Islamic emerging equity markets, namely Indonesia, Malaysia, Pakistan, Qatar and Turkey. Their findings indicate no precipitate evidence supporting the U.S. market spillovers into the Islamic emerging equity markets. Due to weak market transmission, they suggest that investors should take caution when investing in the Islamic emerging equity markets and diversifying their portfolios to minimize risk. Majdoub and Mansour (2014) highlighted some peculiar specificities of the Islamic finance industry, such as the imposition of certain restrictions and the admittance conditions to the MSCI Islamic equity index, contributing to explaining the weak market integration. Majdoub and Sassi (2017) employ the Bivariate VARMA-BEKK-AGARCH model to study the volatility spillover between China and Asian Islamic stock markets using a sample of six Islamic MSCI indexes from the Asian region, namely China, India, Malaysia, Indonesia, Korea and Thailand. They find a significant positive and negative return spillover from China to selected Asian Islamic stock markets and bidirectional volatility spillovers between China, Korea and Thailand Islamic markets. Although there is no short-term volatility persistence in India, Indonesia and Malaysia, their results provide evidence of the short-term predictability of Islamic Chinese stock market movements. In the long run, their results show no persistence in volatility spillover impact from Chinese to Indian, Indonesian and Korean Islamic stock markets.

Many empirical studies have examined the interlinkages between Islamic and conventional financial markets and assess the fact that both markets are highly interlinked with higher spillovers and increased linkages during stress periods (Ahmed and Elsayed, 2019; Billah et al., 2023; Aloui et al., 2015a, 2015b; Maghyereh and Awartani, 2016). The Covid-19 pandemic has prompted numerous research to look into the consequences of the pandemic on financial markets because it is the health epidemic that has had the most significant impact on the world financial market. Shear and Ashraf (2022) examined the performance of Islamic versus conventional equities during the Covid-19 pandemic, while Adekoya et al. (2021) investigated the dynamics of risk transmissions between the Islamic and conventional stock markets. They offer proof that Islamic stocks outperformed traditional ones in terms of resilience., Their findings are consistent with those of Akhtar and Jahromi (2017), who documented that Islamic financial markets are more stable than

**Table 1**
Descriptive statistics.

| | RKLCIF | RKLCIC | RKLCISH | KLCIFV | KLCIFOI |
|---|---|---|---|---|---|
| Mean | 8.60E-05 | 8.47E-05 | 0.00016 | 7.168 | 24.588 |
| Median | 0.000 | 0.000 | 0.000 | 6.181 | 24.866 |
| Maximum | 0.0483 | 0.0426 | 0.0454 | 31.156 | 56.090 |
| Minimum | -0.0756 | -0.0998 | -0.1109 | 0.098 | 0.000 |
| Std. Dev. | 0.0086 | 0.0071 | 0.0076 | 3.9780 | 8.8972 |
| Skewness | -0.66402 | -1.13751 | -1.10776 | 1.852675 | -0.17072 |
| Kurtosis | 10.6626 | 19.20273 | 21.13607 | 7.714045 | 2.783908 |
| JB | 6313.4*** | 33110*** | 41512*** | 4639.6*** | 25.874*** |
| ADF | -62.56*** | -52.66*** | -52.47*** | -28.34*** | -3.438*** |
| Q(20) | 29.486*** | 42.487*** | 47.117*** | 1623.085*** | 7949.506*** |
| $Q^2(20)$ | 153*** | 0.411 | 0.543 | 351*** | 13024*** |
| ARCH(20) | 446*** | 124*** | 101*** | 73.8*** | 238*** |

Notes: (1) This table reports the descriptive statistics of FTSE Bursa Malaysia KLCI return (RKLCIC), FTSE Bursa Malaysia Hijrah Shariah return (RKLCISH), FTSE Bursa Malaysia KLCI Futures return (RKLCIF) that are calculated as the first log-difference of the market index. In addition, both the trading volume and open interest in the FTSE Bursa Malaysia Futures market (KLCIFV & KLCIFOI) are expressed as thousands of contracts. JB is the Jarque-Bera test for Normality, and ADF is the Augmented Dickey-Fuller unit root test. Q(20) and $Q^2(20)$ are the Ljung-Box statistic for serial correlation in raw series and squared residuals, respectively. ARCH (20) testing Engle's ARCH effects up to 20 lags. (2) *** indicates significance at the 1 % level.

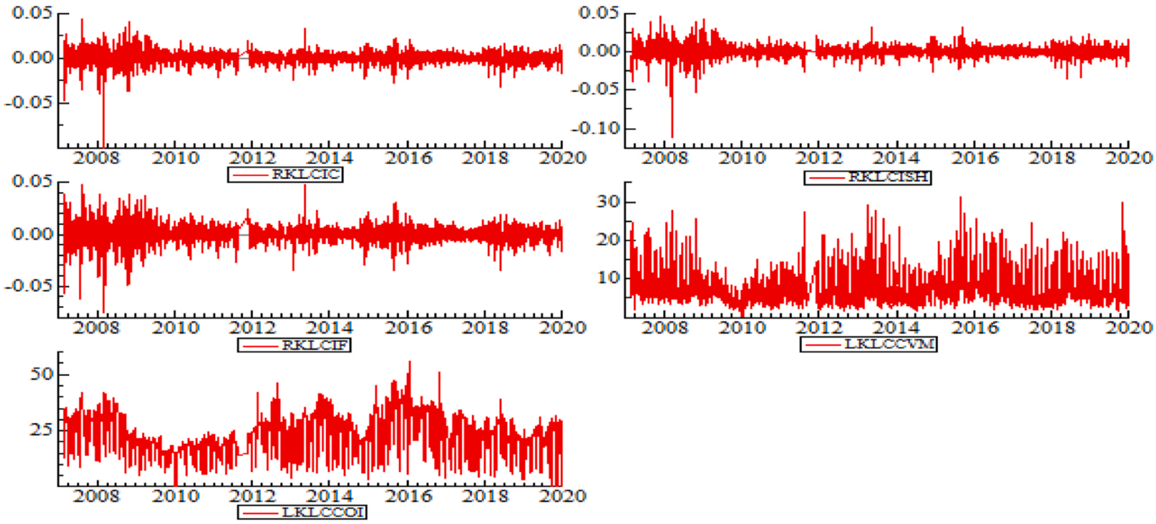



**Fig. 1.** Market returns, trading volume and open interest, Notes: This figure portrays the variation of FTSE Bursa Malaysia KLCI return index (RKLCIC), FTSE Bursa Malaysia HijrahShariah return index (RKLCISH), FTSE Bursa Malaysia KLCI Futures return index (LKLCIF) as well as the trading volume (LKLCIFV) and open interest (KLCIFOI) in FTSE Bursa Malaysia Futures market over the sample period starting from 28 February 2007 to December 31, 2019.

their conventional counterparts, especially during financial turbulence. This may be explained by prohibiting risky activities such as derivative products. In addition, Karabiyik et al. (2016), (2018) have evidenced that the spot market dominates the price discovery process in most of their sampled countries. Specifically, in some countries, the futures market seems to dominate price discovery, but in most countries, the spot market dominates price discovery.

## 3. Data and methodology

### 3.1. Data sources and descriptive statistics

Daily spot prices for both conventional and Islamic stock markets, as well as Malaysian futures market for this study, are obtained from DataStream, namely, FTSE Bursa Malaysia KLCI price index, FTSE Bursa Malaysia Hijrah Shariah price index and FTSE Bursa Malaysia KLCI Futures price index. In addition to the three stock price indices, data on the total trading volume and open interest in the Malaysian futures market are collected and scrutinised. The daily trading volume represents the total number of futures contracts traded on that particular date. On the other hand, daily open interest reflects the total number of outstanding futures contracts that have not been settled by the end of the day. The sample spans from 28 February 2007–31 December 2019, with 3350 observations. The sample period is determined by data availability.

Table 1 provides the descriptive statistics for the returns series of conventional, Islamic and futures markets, along with total trading volume and open interest in the futures market. In addition, it shows the first four statistical moments for each series along with tests statistics of normality, autocorrelation, heteroscedasticity and stationarity. These results confirm stylized facts of the financial data, such as asymmetry, fat tails and volatility clustering. In addition, the Augmented Dickey-Fuller unit root test (ADF) indicates that all underlying series are stationary at levels, which motivates the use of the VAR model. We observe high correlations[5]between futures and spot indices, opening a way for portfolio hedging instead of diversification opportunities.

As shown in Fig. 1, when the futures contract approaches its maturity date, traders and investors tend to close tier positions and open a new position in the next nearest contract. Kim (2006) confirmed that futures contracts should be seasonally adjusted as they are heavily traded close to their maturity date. Following Antonakakis et al. (2016), both the trading volume and opening interest series are adjusted against the seasonal effects by estimating the following equation:

$$\mathrm{KLCIFV}_t = \beta_0 + \beta_1 D_{jan} + \beta_2 D_{feb} + \beta_3 D_{mar} + \ldots.. + \beta_{11} D_{Nov} + \gamma_t \tag{1}$$

$$\mathrm{KLCIFOI}_t = \beta_0 + \beta_1 D_{jan} + \beta_2 D_{feb} + \beta_3 D_{mar} + \ldots.. + \beta_{11} D_{Nov} + \delta_t \tag{2}$$

where$D_{jan},\ D_{feb},\ D_{mar},\ \ldots, D_{Nov}$ are monthly dummy variables that take the value of one for the relevant month and zero otherwise. The obtained residuals, $\gamma_t and \delta_t$, are the seasonally adjusted trading volume and seasonally adjusted open interest in the futures market, respectively, that have been used to run the empirical analysis in the next section.

### 3.2. Econometric method

The return and volatility spillover transmission patterns are analysed using the spillover approach introduced by Diebold and Yilmaz (2009) and developed further in Diebold and Yilmaz, 2012; Diebold and Yılmaz, 2014. The spillover approach is mainly based on the notion of variance decomposition function based on the Cholesky-factor identification of a VAR model, which is very sensitive to ordering variables in the VAR model. To overcome this limitation, Diebold and Yilmaz, 2012; Diebold and Yılmaz, 2014 estimated the forecast error variance decomposition matrix from a generalized VAR framework of Koopn et al. (1996) and Pesaran and Shin (1998) that is invariant to the VAR ordering.

Assuming covariance stationary, the N-variable VAR model of order (p) can be given by:

$$y_t = \sum_{i=1}^{p} \Phi_i y_{t-i} + \varepsilon_t \tag{3}$$

where$y_t = (y_{1t}, y_{2t}, \ldots y_{Nt})$ denotes a vector of N endogenous variables. $\Phi_i$are$N \times N$ coefficients matrices where $i = 1, 2, \ldots p$ and $\varepsilon_t$ is a vector of identically and independently distributed errors with zero mean and $\Sigma$ variance-covariance matrix, that is, $\varepsilon_t \sim \mathrm{i.i.d}(0, \Sigma)$.

Following on from the stationary VAR model in Eq. (3), the infinite moving average representation of this model could be written as follows:

$$y_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i} \tag{4}$$

where the parameter matrices $A_i$ are of dimension $N \times N$ and recursively defined as$A_i = \Phi_1 A_{i-1} + \Phi_2 A_{i-2} + \ldots + \Phi_p A_{i-p}$, where $A_0$ represents the identity matrix and $A_i = 0$ for all $i < 0$. Building on the work of Koop et al. (1996) and Pesaran and Shin (1998), a variance decomposition function from a generalized VAR framework is estimated, which permits correlation between shocks but accounts for them proportionally. Hence, the H-step-ahead forecast error variance decomposition attributable to each of the underlying variables can be defined as:

$$\phi_{ij}(h) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (\acute{e}_i A_h \sum e_j)^2}{\sum_{h=0}^{H-1} (\acute{e}_i A_h \sum \acute{A}_h e_i)} \tag{5}$$

where $\sum$ represents the variance matrix of the error vector $\varepsilon$ in the non-orthogonalized VAR model, $\sigma_{jj}$is the $j-th$ diagonal component of the standard deviation of the error term and $e_i$ denotes the selection vector with one for $i-th$ elements and zero otherwise.

The resultant H-step-ahead forecast error variance decomposition,$\phi_{ij}$, is a square matrix of order $N \times N$ that shows the contribution of a shock invariable $j$ to the H-step-ahead forecast error variance in the variable $i$. Hence, the main diagonal elements of this matrix show the own-variance shares, which represent the contributions of shocks to the variable $i$ to its own forecast error variance, whereas

[5] We do not report the results in this study. However, the correlation matrix is available upon request.

the off-diagonal elements indicate cross-variance shares that are contributions of the other variables to the forecast error variance of variable *i* (spillover hereafter).

Finally, each entry in the above-generalized variance decomposition matrix should be normalised by the raw sum since both own-variance and the cross-variance contributions for each variable do not add to unity, as follows:

$$\widetilde{\phi}_{ij}(h) = \frac{\phi_{ij}(h)}{\sum_{j=1}^{N}\phi_{ij}(h)} \tag{6}$$

The previous representation is extremely useful as it allows us to calculate total, directional as well as pairwise spillovers between the underlying variables. For instance, the directional spillovers received by variable *i* from all other variables *j* are given by:

$$DS_{i\leftarrow j}(h) = \frac{\sum_{j=1,j\neq i}^{N}\widetilde{\phi}_{ij}(h)}{N} \times 100 \tag{7}$$

Whereas the volatility spillover effects transmitted from variable *ito* all other markets *j* is calculated as:

$$DS_{i\rightarrow j}(h) = \frac{\sum_{j=1,j\neq i}^{N}\widetilde{\phi}_{ji}(h)}{N} \times 100 \tag{8}$$

Following on from the directional volatility spillovers indices defined in Eqs. 7 and 8, the net spillover for market *i*-$NS_i$- could be estimated as the difference between volatility spillovers transmitted by market *i* and those received from all other markets where positive (negative) values of the index indicate whether market *i* is a net transmitter (receiver) of spillover to (from) all other markets.

$$NS_i(h) = DS_{i\rightarrow j}(h) - DS_{i\leftarrow j}(h) \tag{9}$$

Similarly, net pairwise spillovers -NPS- between variable *i* and *j* is calculated as the difference between total volatility spillovers from market *i* to market *j* and those spread from j to *i*:

$$NPS_{i\rightarrow j}(h) = \left(\frac{\widetilde{\phi}_{ji}(h) - \widetilde{\phi}_{ij}(h)}{N}\right) \times 100 \tag{10}$$

Finally, the Total Spillover Index (TSI) measures the ratio of the total contribution of shocks transmitted across all variables in the variance decomposition matrix (off-diagonal entries or cross-variance contributions) to the total forecast error variance (both own-variance and cross-variance) as follows:

$$TSI(h) = \frac{\sum_{i,j=1,i\neq j}^{N}\widetilde{\phi}_{ij}(h)}{N} \times 100 \tag{11}$$

The main advantages of the spillover approach lie in its ability to declare the magnitude and direction of return and volatility spillover effects across variables under consideration over time. Furthermore, using a generalised VAR model provides a more accurate estimation of the variance decomposition function that is independent of the ordering of variables in the VAR model. Finally, the spillover methodology fits our study's objectives as it is data-driven and does not require any prior theoretical background and/or restrictions on the model parameters (Diebold and Yilmaz, 2012; Antonakakis et al., 2016; Ahmed and Elsayed, 2019).

## 4. Empirical results

Our empirical analysis employs daily return and volatility data of the conventional stock price index (FTSE Bursa Malaysia KLCI), Islamic stock price index (FTSE Bursa Malaysia Hijrah Shariah) and futures price index (FTSE Bursa Malaysia KLCI Futures). The analysis is enriched by adding data on the total trading volume and open interest in the Malaysian futures market.

The empirical results are presented in the form of two sub-sections, starting with the Spot–futures spillovers analysis in Section 4.1, followed by the futures volume and open interest spillovers analysis in Section 4.2. In each analysis, we first examine the static spillovers (*see*: Sections 4.1.1 and 4.2.1), followed by the dynamic spillovers transmission (*see*: 4.1.2 and 4.2.2).

Following Tao and Green (2012) and Antonakakis et al. (2016), the conditional volatilities of the spot Islamic, spot conventional and futures returns of the Malaysian financial market are calculated based on a three-variate Dynamic Conditional Correlation GARCH (DCC-GARCH) model introduced by Engle (2002) that takes into account possible interdependencies among the three markets.

As previously mentioned, empirical results of return and volatility spillover analyses between futures, Islamic and conventional financial markets in Malaysia are examined using the spillover approach developed by Diebold and Yilmaz (2012). This approach allows us to examine both static as well as time-varying spillover patterns among the underlying markets. Following Diebold and Yilmaz, 2012; Diebold and Yılmaz, 2014, dynamic spillover indices are estimated based on a rolling window of 200-day and a forecast horizon of 10 days. Furthermore, the Schwarz Bayesian Information Criterion (BIC) is used to determine the optimal lag specification of each generalized VAR model.

**Table 2**
Spillovers across spot and futures markets.

| **Panel A - Returns** | **RKLCIF** | **RKLCIC** | **RKLCISH** | ***From Others*** |
|---|---|---|---|---|
| RKLCIF | 42.90 | 31.39 | 25.71 | 57.10 |
| RKLCIC | 29.06 | 38.46 | 32.49 | 61.55 |
| RKLCISH | 25.37 | 34.24 | 40.39 | 59.61 |
| Contribution to others | 54.43 | 65.62 | 58.20 | Total spillover |
| Contribution including own | 97.33 | 104.08 | 98.59 | Index (TSI)= |
| **Net Return spillovers** | **-2.67** | **4.08** | **-1.41** | **59.42** |
| **Panel B - Volatilities** | **CVKLCIF** | **CVKLCIC** | **CVKLCISH** | ***From Others*** |
| CVKLCIF | 47.83 | 27.72 | 24.45 | 52.17 |
| CVKLCIC | 27.48 | 37.44 | 35.08 | 62.56 |
| CVKLCISH | 24.96 | 35.53 | 39.51 | 60.49 |
| Contribution to others | 52.44 | 63.25 | 59.54 | Total spillover |
| Contribution including own | 100.27 | 100.69 | 99.05 | Index (TSI)= |
| **Net Volatility spillovers** | **0.27** | **0.69** | **-0.95** | **58.41** |

***Notes***: Panel A summarises empirical results of the total, directional and pairwise spillovers from the static analysis. RKLCIF, RKLCIC and RKLCISH denote returns of the FTSE Bursa Malaysia KLCI Futures index, FTSE Bursa Malaysia KLCI index and FTSE Bursa Malaysia Hijrah Shariah Index, respectively. Total Return Spillover Index (TSI) demonstrates that 59.4 % of the forecast error variance comes from spillovers between the three markets. The underlying variance decomposition matrix is calculated based on a Tri-variate VAR model of order 2 and 10-step-ahead forecasts. While the diagonal elements present the own-variance shares, the off-diagonal elements show the cross contributions (spillovers).
*Panel B* shows empirical results of total, directional and pairwise volatility spillovers from the static analysis. CVKLCIF, CVKLCIC and CVKLCISH denote conditional volatilities of FTSE Bursa Malaysia KLCI Futures index, FTSE Bursa Malaysia KLCI index and FTSE Bursa Malaysia Hijrah Shariah Index that are estimated from the DCC-GARCH model. Total Volatility Spillover Index (TSI) demonstrates that 58.4 % of the forecast error variance comes from volatility spillovers among the three markets. The underlying variance decomposition matrix is calculated based on a Tri-variate VAR model of order 7 and 10-step-ahead forecasts.

### *4.1. Spot–futures returns and volatility spillovers*

This sub-section presents the breakdown results of the return and volatility spillovers indices, respectively, for static and dynamic decomposition among spot and futures returns in the Malaysian markets.

Before delving into detailed interpretations, it is essential to highlight a few broad and preliminary results. First, as can be seen in Table 2, the magnitude of total return and volatility spillovers between spots and futures indices expressed through the TSI – without considering in the analysis the volume and the open interest variables - is relatively high and respectively equal to 59.42 % and 58.41 % with a difference between return and volatility spillovers around l.7 %. This suggests that, in response to the market information and news, spot and futures markets do not adjust with a similar intensity regarding return and volatility shocks.

At this initial stage, it is worth mentioning that the results for the Malaysian markets do not reveal any significant asymmetry between returns and volatility spillovers for both Islamic and conventional spot indices versus futures index because the intensity of transmission of both types of shocks demonstrates a quasi-equally informative variability in the spot and futures markets.

#### *4.1.1. Static analysis for return and volatility spillovers*

Table 2 presents the breakdown results of the return and volatility spillover indices for static decomposition in Malaysian markets. As can be seen, directional TSIs between spot and futures markets are 59.4 % for return and 58.4 % for volatility, suggesting that both return and volatility spillovers are quasi-equally informative about the variability in the spot and futures markets as their relative difference is around l.7 %. Therefore, the return and volatility shocks are quasi-acting with similar intensity in response to the market information and news flowing into spot and futures markets. This result aligns with Diebold and Yilmaz (2009), who reported that return and volatility spillovers are of the same magnitude.

The return and volatility shocks to spot and futures indices, however, present different behaviour in terms of the direction of the transmission. For the return, the shocks are transmitted from the conventional spot index to both futures and Islamic spot indices, while both futures and conventional spot indices transmit volatility shocks to the Islamic spot index with a superior contribution in favour of the conventional index compared to the futures index.

As mentioned in the methodology section, each $ij^{th}$ entry in Table 2 shows the contribution to *i* market's forecast error variance generated by shocks to market *j*. Accordingly, the value of return and volatility spillovers received by both the Islamic spot and futures indices from the conventional spot index is relatively high, with 32.5 % and 29.1 %, respectively. In the case of volatility spillovers, the Islamic spot index receives shocks from both conventional and futures indices with a value of 35.1 % and 24.5 %. For instance, the finding suggests that the conventional spot market has a greater forecasting ability than both Islamic spot and futures indices. This can be used by professional investors and traders to improve the accuracy of their forecasts. However, the lowest value of return spillovers is directed from the futures index to the Islamic index, with a 25.7 % return and 24.5 % volatility.

The last column ('From Others') provides the aggregated off-diagonal row sums that are the total contribution from other markets to market *i*, representing the average contribution of spillovers from shocks to all (other) markets to the total forecast error variance of

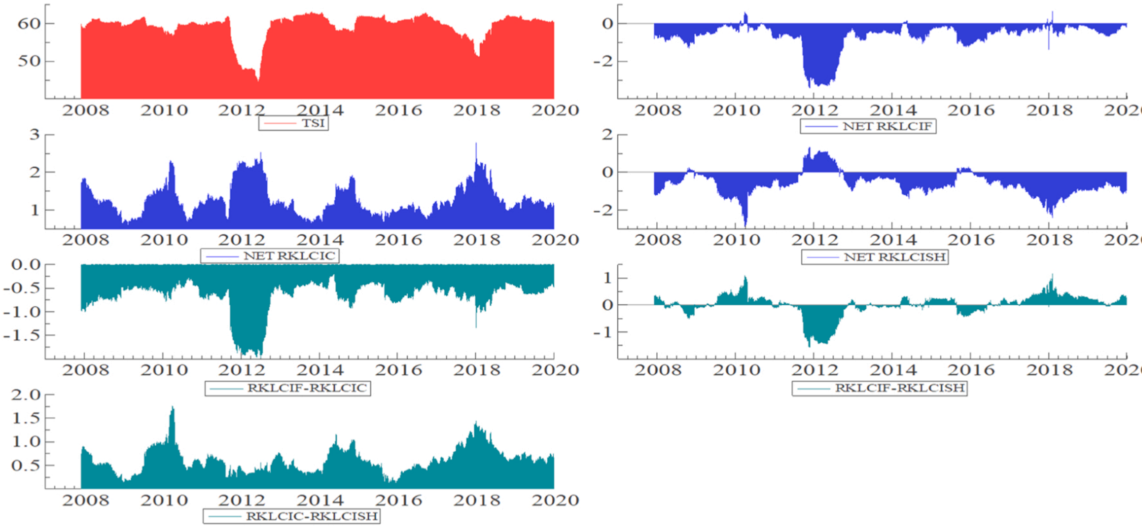



**Fig. 2.** Total, net and pairwise return spillover indices *Notes*: This graph displays the time-varying behaviour of the total return spillover index (red) between futures, conventional and Islamic financial markets in Malaysia from 6 December 2007–31 December 2019. Net directional return spillover indices for each of the three markets are presented in blue, where positive (negative) values of the index indicate whether the market is a net transmitter (receiver) of return spillover to (from) all other markets. In addition, dynamic pairwise spillovers among all possible pairs of the three markets are presented in green. These indices are estimated based on a Tri-variate VAR model of order 2 with 10-step-ahead forecasts and a 200-day rolling window.

market *i*. It can be used to show which market is the most sensitive to inter-market shocks. On the other hand, the off-diagonal column sums, namely the 'Contribution to Others' row, demonstrate the reverse direction of spillover: the spillover from shocks to market *i* to all other markets.

As shown in Table 2, volatility and return spillovers 'From Others' directed to the futures index are around 57.1 % and 52.2 %, respectively. The shocks from volatility are less intense than those from return (with a value lower by 9.4 %), which means that the futures market is more sensitive to shocks coming from volatility than the return.

The lowest magnitude of shocks spillovers is from the futures index to other markets, with 42.9 % and 47.8 %, respectively, for return and volatility, the contribution from its own market innovations and 54.4 % (return) and 52.4 % (volatility) contributions to other markets indicated. The futures index is the highest contributor to its own market information and the lowest contributor to other market innovations. In contrast, the highest magnitude of shocks spillovers is found across conventional spot markets directed to Islamic spot and futures markets with values of 'Contribution to others' around 65.6 % and 63.3 %, respectively, for return and volatility spillovers and values of 38.5 % (return) and 37.4 % (volatility) as a contribution to its own shocks.

Our focus on the internal net pairwise directional connectedness shows that RKLCIC transmits 31.2 % to RKLCIF and receives 29.1 % from RKLCIF, implying an almost equivalent transmission and receipt. Further analyses of the other indexes confirm this equivalence. This is consistent with the very low net return and volatility spillovers for the respective indexes. Table 2 confirms that spot (conventional and Islamic) and futures markets respond to market-wide news. Interestingly, the values in Malaysia are around 60 % compared to 50 % for the U.S. and UK markets, as reported by Antonakakis et al. (2016).

### *4.1.2. Dynamic analysis for return and volatility spillovers*

Fig. 2 depicts the time-varying results of the total, net and pairwise, respectively, for return and volatility spillover indices in the Malaysian markets over the entire sample period. The TSI is presented in red, net directional return and volatility spillover between indices are presented in blue, where values (which could be either positive or negative) of the index indicate whether the market is a net transmitter (receiver) of return or volatility spillovers to (from) all other markets. In addition, dynamic pairwise spillovers (return in Fig. 2 and volatility in Fig. 3) among all possible pairs of the three markets are presented in green.

As can be seen from Fig. 2, directional TSIs between spot and futures markets move slightly around 59–58.4 % for both return and volatility (*see* the red coloured panels in Fig. 2 and Fig. 3), suggesting that both return and volatility spillovers are equally informative about the variability in the spot and futures markets.

A striking point can be observed during the last quarter of 2012, where the TSI reached the lowest value of around 25 %, whereas spot and futures indices have the maximum values of shocks as net transmitters and net receivers, respectively. This event happened during the European debt crisis, during which the Asian financial markets were also affected by European turbulence.

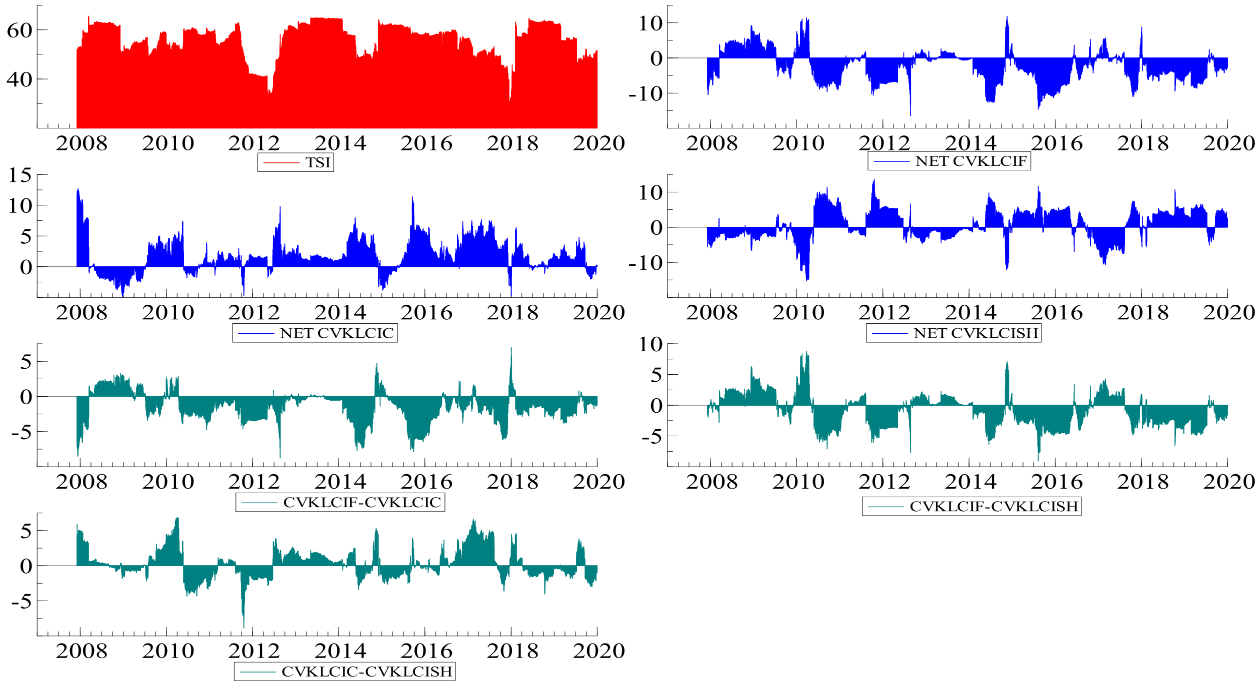



**Fig. 3.** Total, net and pairwise volatility spillover indices, *Notes*: This graph displays the time-varying behaviour of the total volatility spillover index (red) between futures, conventional and Islamic financial markets in Malaysia from 6 December 2007–31 December 2019. Net directional volatility spillover indices for each of the three markets are presented in blue, where positive (negative) values of the index indicate whether the market is a net transmitter (receiver) of volatility spillover to (from) all other markets. In addition, dynamic pairwise spillovers among all possible pairs of the three markets are presented in green. These indices are estimated based on a Tri-variate VAR model of order 7 with 10-step-ahead forecasts and a 200-day rolling window.

**Table 3**
Spillovers across futures volume, open interest and spot-futures markets.

| **Panel A - Return** | **RKLCIF** | **RKLCIC** | **RKLCISH** | **KLCIFV** | **KLCIFOI** | ***From Others*** |
|---|---|---|---|---|---|---|
| RKLCIC | 30.36 | **37.48** | 31.47 | 0.66 | 0.03 | 62.52 |
| RKLCISH | 26.53 | 33.27 | **39.47** | 0.68 | 0.04 | 60.53 |
| RKLCIF | **41.01** | 32.03 | 26.17 | 0.73 | 0.07 | 58.99 |
| KLCIFV | 2.74 | 2.73 | 2.67 | **78.57** | 13.29 | 21.43 |
| KLCIFOI | 1.21 | 0.58 | 0.50 | 18.24 | **79.48** | 20.52 |
| Contribution To others | 60.84 | 68.61 | 60.79 | 20.31 | 13.43 | Total spillover |
| Contribution including own | 101.85 | 106.10 | 100.26 | 98.89 | 92.90 | Index (TSI)= |
| **Net spillovers** | **1.853** | **6.10** | **0.26** | **-1.11** | **-7.10** | **44.80** |
| **Panel B - Volatility** | **CVKLCIF** | **CVKLCIC** | **CVKLCISH** | **KLCIFV** | **KLCIFOI** | ***From Others*** |
| CVKLCIC | 26.15 | **37.05** | 34.42 | 1.81 | 0.58 | 62.96 |
| CVKLCISH | 23.41 | 35.09 | **39.31** | 1.64 | 0.54 | 60.69 |
| CVKLCIF | **45.95** | 26.43 | 23.21 | 3.45 | 0.98 | 54.05 |
| KLCIFV | 1.07 | 0.35 | 0.44 | **84.15** | 13.99 | 15.86 |
| KLCIFOI | 0.86 | 0.73 | 0.70 | 18.19 | **79.52** | 20.48 |
| Contribution To others | 51.5 | 62.60 | 58.76 | 25.07 | 16.09 | Total spillover |
| Contribution including own | 97.45 | 99.64 | 98.08 | 109.22 | 95.62 | Index (TSI)= |
| **Net spillovers** | **-2.55** | **-0.36** | **-1.93** | **9.22** | **-4.38** | **42.81** |

*Note*: *Panel A* summarises the empirical results of the total, directional and pairwise spillovers from the static analysis. RKLCIF, RKLCIC, RKLCISH, KLCIFV and KLCIFOI denote returns of FTSE Bursa Malaysia KLCI Futures index, FTSE Bursa Malaysia KLCI index, FTSE Bursa Malaysia HijrahShariah Index, seasonally adjusted trading volume in FTSE Bursa Malaysia KLCI Futures market and seasonally adjusted open interest in FTSE Bursa Malaysia KLCI Futures respectively. Total Return Spillover Index (TSI) demonstrates that 44.79 % of the forecast error variance comes from spillovers between these markets. The underlying variance decomposition matrix is calculated based on a Five-variate VAR model of order 4 and 10-step-ahead forecasts. *Panel B* shows the empirical results of the total, directional and pairwise volatility spillovers from the static analysis. CVKLCIF, CVKLCIC and CVKLCISH, KLCIFV and KLCIFOI denote conditional volatilities of FTSE Bursa Malaysia KLCI Futures index, FTSE Bursa Malaysia KLCI index, FTSE Bursa Malaysia Hijrah Shariah Index as well as seasonally adjusted trading volume in FTSE Bursa Malaysia KLCI Futures market and seasonally adjusted open interest in FTSE Bursa Malaysia KLCI Futures respectively. Volatilities are estimated by the conditional variance obtained from the DCC-GARCH model. Total Volatility Spillover Index (TSI) indicates that 42.8 % of the forecast error variance comes from volatility spillovers among markets. The underlying variance decomposition matrix is calculated based on a Five-variate VAR model of order 4 and 10-step-ahead forecasts

### *4.2. Futures volume and open interest for returns and volatility spillovers*

This sub-section presents the breakdown results of the return and volatility spillover indices, respectively, for static and dynamic decomposition among spot and futures return volatilities, futures volume and open interest in the Malaysian markets. According to Table 2, the TSI between spot and futures markets are 59.4 % for return and 58.4 % for volatility. Similar results are obtained with lesser impact and a slightly higher difference between return and volatility spillovers when we include both the volume and the open interest variables in the analysis - with a difference between return and volatility spillovers of around 2 % (TSI returns = 44.8 % and TSI volatility = 42.8 %.) as provided in Table 3.

Interestingly, in the presence of all variables, both spot and futures indices are net transmitters of returns spillovers to the volume and open interest of the futures index, while the futures volume is the only net transmitter of volatility spillovers to all other variables. Specifically, the Islamic spot index is a net transmitter of returns spillovers to the futures volume but a receiver of volatility shock spillovers from the futures volume.

#### *4.2.1. Static analysis for futures volume and open interest spillovers*

Table 3 reports the breakdown results of the return and volatility spillover indices for static decomposition among spot and futures return volatilities, futures volume and open interest in the Malaysian markets. As can be seen, the TSI between spot and futures markets are around 44.8 % for return and 42.8 % for volatility, suggesting that both return and volatility spillovers are quasi-equally informative about the variability in the spot and futures markets as their relative difference is around 2 %. This result, indicating that the magnitude of return spillovers is higher than volatility spillovers, is slightly different from our precedent finding. We may suggest that, in response to the market information and news, spot and futures markets adjust with a quasi-similar intensity regarding return and volatility shocks.

An accurate picture of cross-markets and markets specific information transmission is provided through both ‘Contribution to Others’ and ‘From Others’, together with other entries in Table 3. As can be seen, the strongest return and volatility spillovers transmitter and receiver (‘Contribution to Others’ and ‘From Others’) for all variables come from the conventional spot index, followed by the Islamic spot index. This could be explained by the fact that the Islamic spot market is well integrated into the Malaysian financial markets compared to the futures market. On the other hand, open interest is characterized by a lower level of spillovers in terms of ‘Contribution to Others’ with values around 13.4 % for the return and 16.1 % for the volatility. Consequently, the intensity of intra-market spillovers is higher than the intensity of inter-market spillovers. As can be seen, all the variables have the highest reaction to their own shocks; for example, the trading volume record 84.2 % and the open interest 79.5 % of their own forecast error variance, respectively, for the volatility and the return spillovers.

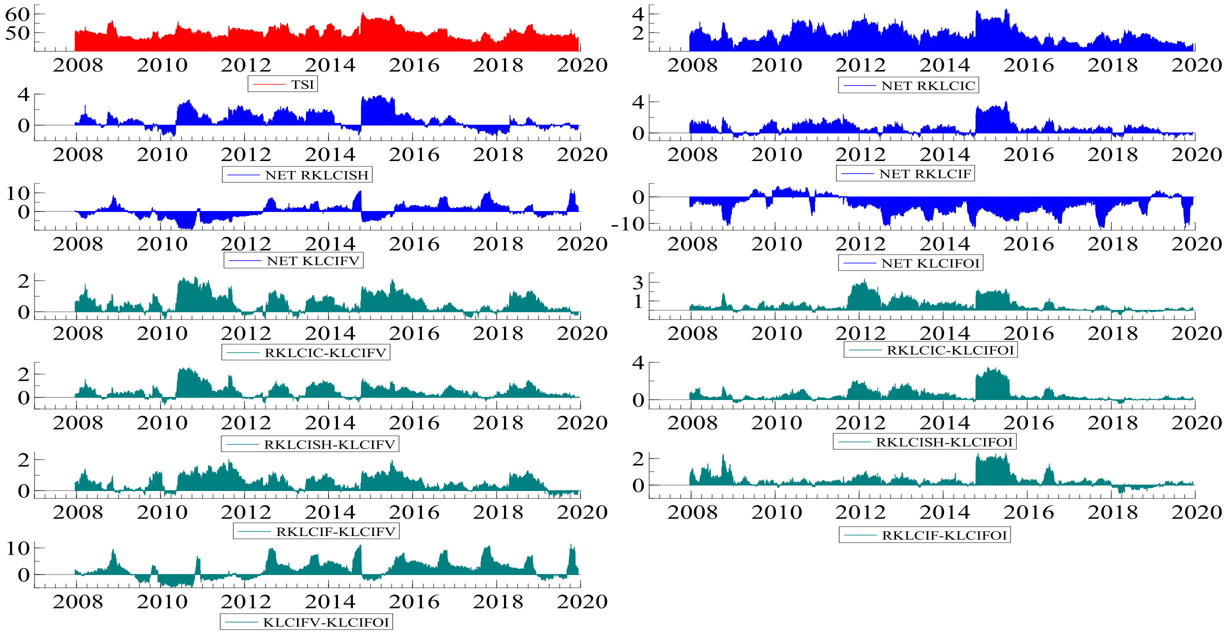



**Fig. 4.** Total, net and pairwise return spillover indices, *Notes*: This graph displays the time-varying behaviour of the total return spillover index (red) between futures, conventional, and Islamic financial markets, seasonally adjusted trading volume in the futures market and seasonally adjusted open interest in the futures market in Malaysia over the period from 6 December 2007–31 December 2019. Net directional return spillover indices are presented in blue, where positive (negative) values of the index indicate whether the market is a net transmitter (receiver) of return spillover to (from) all other markets. In addition, dynamic pairwise spillovers among all possible pairs are presented in green. These indices are estimated based on a Five-variate VAR model of order 4 with 10-step-ahead forecasts and a 200-day rolling window.

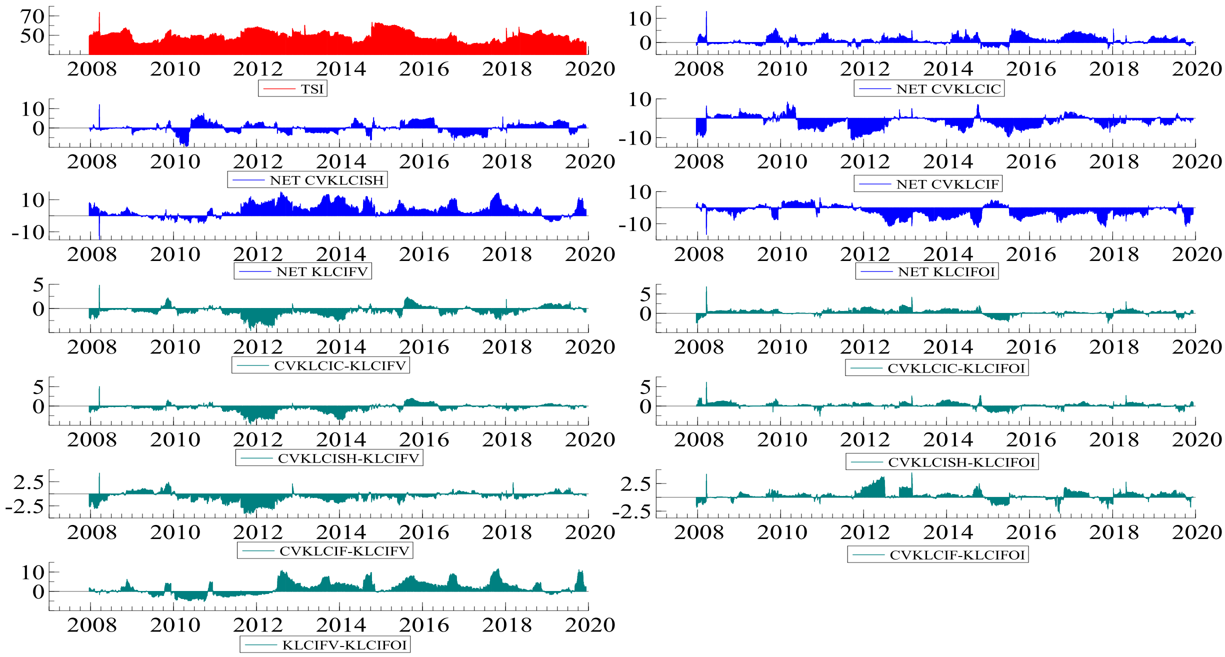



**Fig. 5.** Total, net and pairwise volatility spillover indices, *Notes*: This graph displays the time-varying behaviour of the total volatility spillover index (red) between futures, conventional, and Islamic financial markets, seasonally adjusted trading volume in the futures market and seasonally adjusted open interest in the futures market in Malaysia over the period from 6 December 2007–31 December 2019. Net directional volatility spillover indices are presented in blue, where positive (negative) values of the index indicate whether the market is a net transmitter (receiver) of volatility spillover to (from) all other markets. In addition, dynamic pairwise volatility spillovers among all possible pairs are presented in green. These indices are estimated based on a Five-variate VAR model of order 4 with 10-step-ahead forecasts and a 200-day rolling window.

**Table 4**
Summary of return and volatility spillover results.

| Net spillovers | CVKLCIC | CVKLCISH | CVKLCIF | KLCIFV | KLCIFOI | TSI |
|---|---|---|---|---|---|---|
| Returns | +6.10 | +0.26 | +1.85 | **-1.11** | **-7.10** | **44.8 %** |
| Volatility | **-0.36** | **-1.93** | **-2.55** | +9.22 | **-4.38** | **42.8 %** |

In addition, considering the volume and open interest, return, and volatility shocks to spot and futures indices present different behaviours regarding the transmission direction. For the return, the shocks are transmitted from both spot (conventional and Islamic) and futures returns to both volume and open interest of futures, while for volatility, futures' volume is only the net shock transmitter to conventional and Islamic spot volatilities, futures volatility and futures open interest. The latter is the higher net receiver of shocks from the volume compared to the three indices, spot conventional and Islamic and futures indices.

Panel B in Table 3 shows that futures' volume contributes to the forecast error variance of other markets by 25.1 %. By contrast, open interest only transmits 16.1 % to the forecast error variance of the other variables. Conversely, 62.9 % and 60.7 %of the variability in both conventional and Islamic spot volatility shocks is captured by other markets. Taken together, the results imply that, contrary to return spillovers, the trading volume is a net transmitter of spillovers to all the other variables.

It also appears clearly that returns of the conventional spot index are the primary transmitter of shocks to other markets, with a net spillovers rate of 6.1 %, affecting, in particular, both futures open interest as well as the futures trading volume - with a net spillovers rate of −1.1 % and −7.1 %, where the latter, at its turn, ricocheting-off, with higher intensity of transmission of 9.2 %, in the form of volatility spillovers to all other markets with different levels of intensities and vice-versa. These findings confirm that futures, Islamic and conventional indices are well integrated among themselves and within the Malaysian stock market.

For volatility spillovers, our results suggest that the SAIH is weakly characterising the Malaysian stock markets as the trading volume explains, at best 3.5 % of the 'forecast error variance' of the futures volatility shocks. However, in the case of return spillovers, the trading volume contributes, at best, 0.7 % of the 'forecast error variance' of the spot (conventional and Islamic) and futures returns.

Regarding the pairwise shock interactions, the net volatility spillovers indicate that the trading volume is the leading spot (conventional and Islamic) and futures indices, respectively by 1.45 %, 1.2 % and 2.37 %, in the Malaysian markets. This is consistent with the empirical literature (Telser & Higinbotham, 1977) regarding the information transmission channelled from futures trading volume to futures index, which may be explained by microstructure, public information and/or inventory control effects (Daigler & Wiley, 1999, Xu et al., 2006). On the other hand, contrary results are found by Merrick (1987), Bryant et al. (2006), and Chen and Daigler (2008), supporting the proposition that futures volatility can significantly cause trading volume.

The analysis of pairwise volatility (returns) spillover between futures' trading volume and open interest further suggests that the impact of trading volume on the variability in open interest is around 18.1 % (18.2 %), whereas shocks to open interest contribute about 14 % (13.3 %), to the 'forecast error variance' of the trading volume. This shows a quasi-equal intensity of transmission of both types of shocks (volatility and return), inferring a quasi-equally informative variability between trading volume and open interest in the futures markets.

However, it is apparent that including the futures volume and open interest has not made a substantial difference. The indexes spillover analyses show that the impact is negligible, and the spillover is between futures volume and open interest. Interestingly, the values in Malaysia are around 40 % compared to 50 % for the U.S. and U.K. markets.

#### *4.2.2. Dynamic analysis for futures volume and open interest spillovers*

Figs. 4 and 5 report the results of the dynamic return and volatility spillovers, respectively, among spot and futures indices by including futures volume and open interest in the Malaysian markets over the sample period. Similar to the previous analysis, the total volatility spillover index (TSI) is presented in red, net directional spillovers in blue, and pairwise spillovers in green (return in Fig. 4 and volatility in Fig. 5). However, in contrast with the case of returns spillovers (see Fig. 4), where the trading volume is a net receiver of shocks, and consistently with the results reported in Fig. 5, trading volume is clearly a net transmitter of spillovers throughout the sample period. Therefore, both spot (conventional and Islamic) and futures indices tend to receive volatility (transmit returns) spillovers from (to) the trading volume (and open interest).

A quick examination of Figs. 4 and 5 reveals which market is the most sensitive to inter-intra-markets shocks. Accordingly, the conventional spot index (blue on the right-hand side of Fig. 4) and the trading volume index (blue on the left-hand side of Fig. 5) show, respectively, the highest positive changes in return and volatility spillovers compared to the other variables.

The findings are indicative of net unidirectional spillovers from the volume of trading to futures volatility, which is also supported by the negative net pairwise spillovers between futures volatility and open interest and futures volume in Fig. 5 – as the net transmission from the volume of trading to open interest is net positive in favour of the former with a net value of 4.9 % and 4.1 %, respectively, for return and volatility. Thus, trading volume can significantly contribute to the forecasting ability of spot and futures indices volatilities. This is consistent with the SAIH (Copeland, 1976) in terms of trading volume's explanatory power for futures volatility and reacting to futures market information.

While it is observed that futures volume and open interest are interconnected, the spillover to KLCIC and KLCISH is limited. This information is available in Table 4. In contrast with our previous finding on the effects on return and volatility (see Table 2), the European sovereign debt crisis has minimal impact on the volume and open interest (see Figs. 4 and 5). This can be explained by the lower liquidity in the market during the crisis.

In reflection, these results have several important implications. Firstly, as per the theory, they reveal hedging opportunities between spot stock markets and the futures market depending on which market is less affected by external shocks. Secondly, the SAIH suggesting that futures total trading volume can predict futures price volatility has brought a theoretical base to our analyses, where the total futures trading volume is acting as a new information channel that flows sequentially and gradually into the market and through which the shocks are transmitted to different markets variables. (Copeland, 1976; Morse, 1981; Jennings et al., 1981; Jennings and Barry, 1983; Lamoureux and Lastrapes, 1990). For instance, the finding that the total volume of futures trading has a greater forecasting ability than all other variables can be used by professional investors and traders to improve the accuracy of their forecasts.

Overall, there is strong evidence of intra-market and inter-cross markets returns and volatility spillovers in the Malaysian stock markets, while the volatility shocks have a lesser impact compared to returns spillovers. The values of pairwise intra-market spillovers are much higher than between different markets (inter-cross markets). Furthermore, the magnitude of return spillovers between all variables is higher than that of volatility, providing professional investors and traders with more forecasting opportunities for their portfolio hedging. Finally, the futures and both Islamic and conventional spot volatilities are net receivers of shocks coming only from the trading volume and not from the open interest of the futures market. As a result, the futures market seems to be an attractive option for an Islamic portfolio hedging strategy if the investors are not considering observing the Islamic finance rules.

## 5. Robustness test

The robustness of the empirical results presented so far has been examined using several tests. In particular, the total spillover indices for both return and volatility are re-estimated using several lag lengths for the generalised VAR models. Furthermore, alternative H-step-ahead forecast error variance decomposition has been applied to check the sensitivity of the spillover analysis against the selection of H-step-ahead forecast error variance decomposition. In addition, the sensitivity of the spillover results is tested against the selection of the rolling window. Finally, we checked the robustness of our empirical results against the econometric technique applied using the Time-varying Parameter Vector Autoregressive (TVP-VAR) model recently developed by Antonakakis et al. (2020). Figure ‘d’ in Appendix 1 displays the total spillover indices using the two approaches, the traditional VAR and the TVP-VAR models. Empirical estimation of the aforementioned models indicates that our empirical results are robust and insensitive to the econometric technique, changes in the lag length of the VAR model, H-step-ahead forecast error variance decomposition, and the choice of the rolling window, as depicted in Fig. 4 (in Appendix 1).[6]

As a summary, the results reveal a spin-off shocks effect between returns and volatility spillovers; hence, the spot and futures returns affect the futures volume, which, in its turn, ricocheting-off, with consequential and non-negligible transmission magnitude in the form of volatility spillovers to the three indices and vice-versa.

This tends to support the widespread idea that trading volume is inherently more linked to speculative demand and that an increase in speculative activity can destabilize financial markets, as indicated by Antonakakis et al. (2016) in the case of the UK market. Conversely, open interest is more dedicated to hedging activities in the futures market, which is evidenced by spillovers received for any new information transmitted from either the three indices (in the case of return spillovers) or the volume in the case of volatility shocks (Bessembinder and Seguin, 1993; Donaldson and Kamstra, 2005; Le and Zurbruegg, 2010; Antonakakis et al., 2016). Traders and investors can use this information to forecast futures spot returns and volatilities to better hedge against unexpected changes in market conditions.

Specifically, the Islamic spot index is a net transmitter of returns spillovers to the futures volume and open interests, but it is also a net receiver of volatility shocks from the trading volume in the futures market. This may convey a clear message to the Malaysian regulators before devising a new *Shari'ah*-compliant futures index.

The bidirectional interdependence in shocks transmission is confirmed as summarized in Table 4, which provides evidence for time- and event-specific bidirectional interdependence between spot and futures markets. This finding suggests that Islamic investors and traders may push for devising a new futures compliant index in the Malaysian financial markets to better hedge their risky positions.

## 6. Conclusion

This paper investigates the dynamic spillover effects of returns and volatility shocks between spot conventional and Islamic stock and futures markets - including trading volume and open interest–in the Malaysian stock markets. Our study sheds light on the interconnectedness and interdependencies between the conventional stock and futures markets, as well as the Islamic stock market, emphasising how crucial it is to comprehend these relationships in an emerging market.

To our knowledge, no previous study has investigated risk transmission and return spillovers between conventional, Islamic and future markets. The main objective of this paper is, therefore, to examine the direction and magnitude of returns and volatility spillovers among the above-mentioned Malaysian markets using Diebold and Yilmaz, 2012; Diebold and Yılmaz, 2014 models. This

[6] The detailed empirical findings are omitted for the sake of brevity but are available upon request from the authors.

allows to identify and measure the predictive power of the underlying variables.

To this end, three research questions have been considered: whether there exist any differences in patterns of returns and volatility spillovers across spot and futures markets and which type of shock spillover (return or volatility) has more impact on those markets; whether any asymmetric patterns exist in returns and volatility spillovers across Islamic and conventional versus futures markets, and which market dominates the shocks transmission process; and whether the SAIH hold or help to forecast the return of stock index futures in an emerging economy such as the Malaysian market.

Results suggest the existence of differences in information transmission patterns, identified by a comparison of return and volatility spillovers across spot stock indices with futures index, concerning the market responsible for shocks transmission, but not significantly concerning the magnitude of returns and volatility spillovers as the intensity of shocks is at quasi-equality for spot and futures markets. Specifically, we find that the values in Malaysia for return and volatility spillovers are around 60 % compared to 50 % for the US and UK markets reported in Antonakakis et al. (2016). Moreover, for all variables, the magnitude spillovers of return are slightly higher than that of the volatility. For example, the TSI for returns (44.8 %) is higher than the estimated TSI for volatility (42.8 %), and it is pronounced specially for the conventional spot index since the value of 'Contribution to Others' in terms of shocks transmission is around 68.6 % for returns and only 62.6 % for volatility.

The empirical findings show that spot markets are the net donors to the futures market regarding returns shocks transmission and net receivers from futures volume, while futures open interest is the net receiver of returns and volatility shocks from all the other variables. Specifically, shocks to the volume of futures trading contribute significantly to the FEV (Forecast Error Variance) of futures index return and its open interest. Even if the two markets (Islamic and conventional versus futures markets) are highly interconnected, the transmission of shocks is still significant.

Interestingly, in the presence of all variables, both spot and futures indices are net transmitters of returns spillovers to the volume and open interest of the futures index, while the futures volume is the only net transmitter of volatility spillovers to all other variables.

The supporting evidence for the SAIH regarding inter-market information transmission holds partially in the case of the volume but not in the case of open interest, as the latter poorly explains the transmission of shocks for both spot stock indices and futures indexes in Malaysian markets. This implies that, when looking into an emerging economy, such as the Malaysian market, the volume is superior to open interest in forecasting the return of stock index futures.

Overall, the results for the Malaysian markets do not reveal any asymmetry in return spillovers compared to volatility spillovers because the intensity of transmission of both types of shocks is quasi-equal and relatively high. Moreover, our findings can provide insights to investors and traders to improve their forecasting for futures and spot volatilities. The results are rich and significant for theory and hence contribute to enhancing the existing knowledge. In addition, its implications should be considered valuable and informative for practitioners in providing practical insights to help develop better hedging strategies.

## Credit author statement

All authors have contributed equally.

## CRediT authorship contribution statement

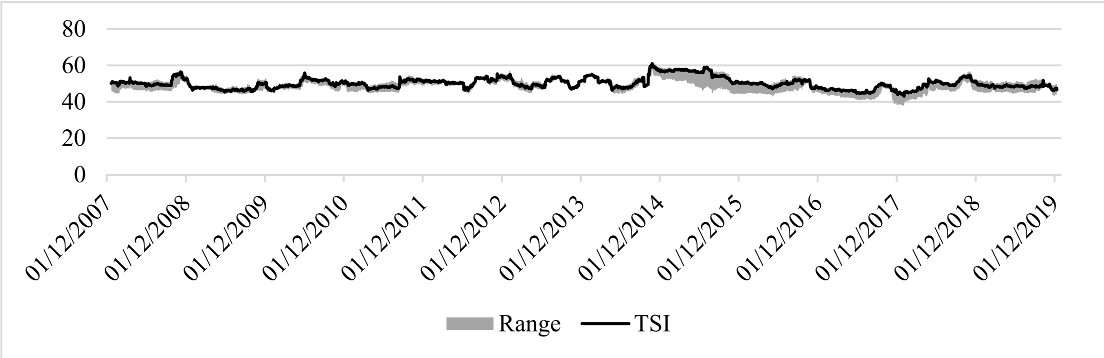
**Hashim Bin Jusoh:** Conceptualization, Data curation, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Abdelkader ElAlaoui:** Conceptualization, Data curation, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Mehmet Asutay:** Conceptualization, Investigation, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Ahmed Elsayed:** Conceptualization, Data curation, Formal analysis, Software, Supervision, Writing – original draft.

## Data availability

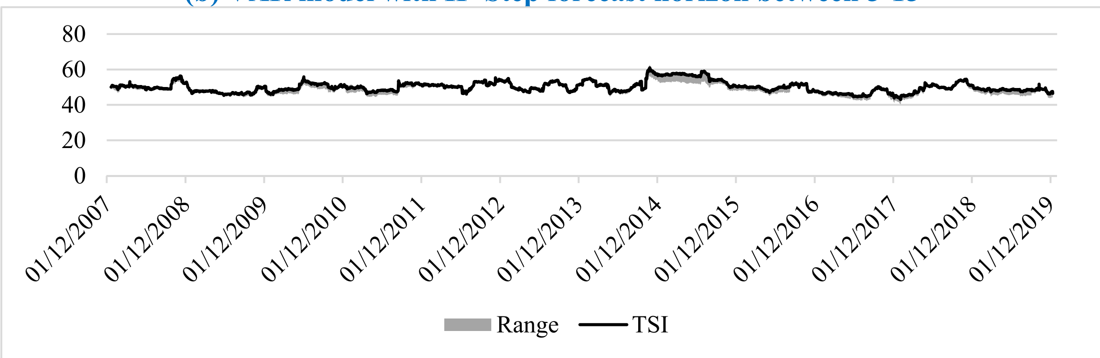
Data will be made available on request.

## Appendix 1. : Robustness tests for spillover analysis

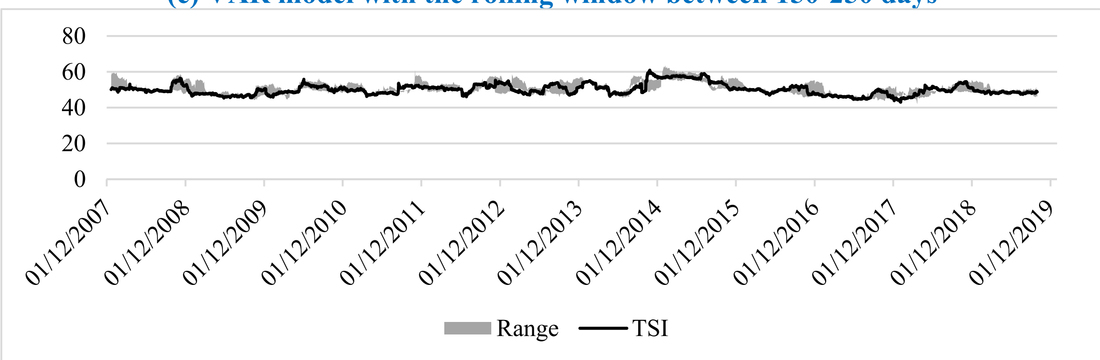
**(a) VAR model with lags from 2 to 6**



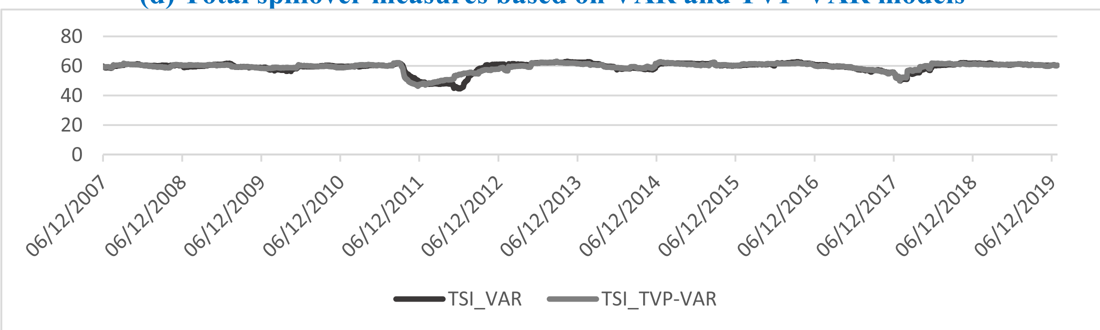

**(b) VAR model with H- Step forecast horizon between 5-15**




**(c) VAR model with the rolling window between 150-250 days**




**(d) Total spillover measures based on VAR and TVP-VAR models**



(a) VAR model with lags from 2 to 6, (b) VAR model with H- Step forecast horizon between 5 and 15, (c) VAR model with the rolling window between 150 and 250 days, (d) Total spillover measures based on VAR and TVP-VAR models, Notes: Panel 'a' presents the sensitivity of the total spillover index to the VAR lag structure (max, min and median values of the spillover index for VAR orders of 2–6). Panel 'b' illustrates the response of the total spillover index to the H-step forecast error variance horizon (min, max and median values over 5- to 15-day forecast horizons). Figure 'c' shows the sensitivity of the total spillover index to the rolling window (max, min and median values of the spillover index for VAR orders using a rolling window between 150 and 250 days). Finally, Figure 'd' shows the total spillover indices based on traditional VAR and TVP-VAR approaches to test the sensitivity of the total spillover measures to the underlying econometric technique.

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