Time varying connectedness and volatility spillover among Shariah compliant indices

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DECLARATION

I, *Zeenat Patel*, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university. I empower the university to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.
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Contents

Glossary

Term	Definition
Gharar	Arabic word for uncertainty
Hadith	Saying and Actions of the Prophet Muhammad
Ijarah	Shariah-compliant leasing
Ijtihad	Shariah law based on Quran and Hadith
Islam	The religion of the Muslims
Mudarabah	Partnership where one party provides the capital while the other provides labor and both share in the profits
Musharakah	Joint enterprise or partnership structure in Islamic finance
Muslim	A follower of the religion of Islam
Quran	Central religious text in Islam
Salam	Futures contract
Shariah	Islamic law
Sukuk	Shariah-compliant Bond

List of Abbreviations

Abbreviation	Full term
AAOIFI	Accounting and Auditing Organization for Islamic Financial institutions
ADCC	Asymmetric Dynamic Conditional Correlation
AGARCH	Asymmetric Generalized Autoregressive Conditional Heteroscedasticity
ALSI	Shariah All Share Index
ARCH	Autoregressive conditional heteroskedasticity
ARMA	Auto Regressive Moving Average
AUM	Assets Under Management
BEKK	Baba, Engle, Kraft and Kroner
Bofa	Bank of America
BRICS	Brazil, Russia, India, China and South Africa
CCC	Constant Conditional Correlation
CDS	credit default swap
CPI	Consumer price index
DCC	Dynamic conditional Correlation
DCC-MGARCH	Dynamic conditional correlation model of multivariate generalized autoregressive conditional heteroscedasticity
DJIM	Dow Jones Islamic Market Index
EPU	US - Economic Policy Uncertainty index
ESDC	European Sovereign Debt Crisis (2011)
ESG	Environmental Social and Governance
FNB	First National Bank
GARCH	generalized autoregressive conditional heteroskedasticity
GCC	Gulf Cooperation Council
GFC	Global Financial crisis (2007/2008)
ICD	Islamic Corporation for the Development of the Private Sector
ICE	Intercontinental Exchange
IFRS	International Financial Reporting Standards
IFSB	Islamic Financial Service Board
IIFM	International Islamic Financial market
ISIS	Islamic State of Iraq and Syria
J140	the Shariah Top 40 Index

JSE	Johannesburg Stock Exchange
MENA	Middle East and North Africa
PBUH	Peace Be Upon Him
PWC	Price Waterhouse Coopers
TGARCH	Threshold GARCH
TRI	Total Return Index
UAE	United Arab Emirates
US	United States
VAR	Vector autoregression
VARMA	Vector Auto Regressive Moving Average
VIX	Volatility index
WTI	West Texas Intermediate

Abstract

Shariah-compliant investing is a subset of the conventional financial market; it follows certain faith-based principles and is also seen as a subset of ESG investing. This study seeks to identify the net transmitters and receivers of volatility within the Shariah compliant equity markets of the US, Europe, Canada, Japan, the UK, Asia Pacific, and South Africa. Using several Shariah-compliant Dow Jones Islamic Market (DJIM) indices as well as the Shariah-compliant JSE Top 40 index, data is collected from Bloomberg for the period of 22 September 2003 to 31 March 2023. The study employs the dynamic connectedness approach to investigate time-varying interdependence and volatility spillover among the indices during periods of economic crises. The results show that during economic crises, the volatility spillover between the Shariah-compliant indices decreases significantly. Therefore, we conclude that Shariah compliant indices decouple from each other during economic crises. Additional results show that the DJIM US index is the dominant net transmitter of volatility, while the DJIM Japan index is the main receiver of volatility spillover within the network. This study contributes to the academic literature by including an index from the South African market, incorporating a new methodology, and finally extending the period to incorporate the Russia-Ukraine conflict. The results have implications for individual and institutional investors active in the ESG environment and for the development of Shariah-compliant investing.

1. Introduction

1.1. Outline of topic, background, and overview

Shariah-compliant investing is garnering increasing popularity as a means to achieve lower portfolio volatility and enhanced diversification, making it an attractive choice for risk-averse investors.

However, Modern Portfolio Theory (Markowitz, 1952) states that investors can optimise their investments by considering the trade-off between risk and return so that returns are maximised for a given level of risk.

It is on this basis that we explore Shariah-compliant indices, which have been found to have lower volatility than their conventional counterparts (Ahmed and Farooq, 2018). Low volatility stocks can lower a portfolio's sensitivity to overall movements in the market due to their beta, thereby reducing their overall volatility and enhancing long-term risk-adjusted returns. (Diamant and Zdzienicki, 2021) This is referred to as the low volatility anomaly and is defined as low volatility stocks outperforming high volatility stocks (Walkshäusl, 2013).

This is somewhat contradictory to the concept that higher risk equates to a higher return. Nevertheless, low volatility investing as a portfolio strategy is a prominent one. A low volatility investment strategy involves constructing a portfolio that selects and focuses on investments with lower price volatility. This strategy aims to minimise the potential of large negative swings and provide a more stable level of return (Diamant and Zdzienicki, 2021).

This strategy requires selecting stocks or assets that have historically exhibited lower price volatility relative to the broader market or their peers. Indications of volatility include measures such as beta (systematic risk), standard deviation, or historical price fluctuations. Within this strategy, sector allocations are often skewed towards sectors with historically lower volatility, such as defensive sectors like consumer staples, utilities, and real estate (Diamant and Zdzienicki, 2021).

While this strategy may have its merits, there are also potential downsides. Although low volatility stocks have historically shown the potential to outperform over the long run, it is imperative to admit that they are not fully immune to market downturns or other risk factors. The other important consideration of this type of strategy is that there may be periods when low volatility stocks underperform the broader market. This could be due to a lower beta, whereas high-growth or high-beta stocks tend to dominate during a bull market (Alam and Rajjaque, 2010).

Low volatility strategies occasionally fall under the umbrella of factor-based investing. Factor-based investing targets specific factors due to those factors historically generating excess returns. However, factor-based investing is a broader concept that focuses on additional factors such as size, momentum, value, and growth, not just low volatility.

The evidence for low volatility investing is compelling; notable studies in favour of low volatility strategies are done by Blitz and Vliet (2007), and Baker and Haugen (2012). Blitz and Vliet (2007) categorised stocks into ten different groups based on their volatility levels, measured by the standard deviation from 1986 to 2006, using global market data. The group with the lowest volatility had an alpha of 4%, while the group with the highest volatility had an alpha of -8%. The difference in this range was 12% (-8%–4%). They make the argument for investors to include low risk stocks as a separate asset class in the strategic asset allocation phase of their investment process (Blitz and Vliet, 2007).

Similarly, Baker and Haugen (2012) found compelling empirical evidence that stocks with low volatility earn higher risk-adjusted returns. The study examined 21 developed countries and 12 emerging markets from 1990 to 2011. It concluded that low volatility stocks perform better despite the common belief that higher risks lead to higher rewards. The study challenges the usual narrative and highlights the benefits of investing in low volatility stocks.

Other than the empirical evidence for low volatility stocks, an additional argument for pursuing a strategy of low volatility is that investors are generally risk averse. According to the Prospect theory (Kahneman et al., 1979), individuals are more sensitive to losing a specified amount than they are to gaining an equivalent amount. To illustrate, the pain of losing a R100 will be significantly greater than the joy of gaining a R100. Investors will therefore often prefer an outcome that is certain with lower expected utility over an outcome with a higher risk and higher expected utility. This theory indicates that simply maximising utility and return is not the sole purpose when making a decision but is only part of a broader framework of decision-making.

The concept of minimising risk and determining an investor's risk preference or profile has also been written into legislation in some instances. For example, in South Africa, pension funds are governed by the Regulation 28 framework, which seeks to ensure that members' retirement provisions are protected from exposure to large amounts of higher risk asset classes. According to the *Pension Funds Act* of 1956 Regulation 28, as amended in 2023, it is required by law that pension funds diversify their investment portfolios between multiple risk tier assets. The act or regulation seeks to limit the maximum exposure of risky asset classes, ensuring that no unnecessary financial risks are taken with retirement savings. (South African Pensions Fund Act Regulation 28, 2023)

Ethical investing, as an alternative asset class, has also been found to exhibit low volatility. Given the loss aversion theory and risk profiling of investors, this is a viable option for those who are seeking low volatility assets. This asset class incorporates an ethical component that is an additional measure for 'value', other than just looking at financial returns as a basis for worth.

Socially responsible or ethical investing takes cognisance of moral values and human well-being. Its origins can be traced back to attempts by religious institutions and charities to bar certain sin industries such as alcohol, tobacco, gambling, and weapons manufacturing. Like other forms of ethical investments, Shariah-compliant investing, a subset of ethical investing, targets low volatility returns by focusing on low debt and social-ethical business activities.

Von Wallis and Klein (2015) outline the relevance and familiarity of ethical screening and socially responsible investing by pointing out that since early biblical times, religious laws have outlined specific investment rules. They further note that some studies have shown a positive relationship between socially responsible investing activities and financial performance.

In the 1900s, the equity market began to give attention to the specific religious requirements of the Islamic community, for instance, by excluding specific sectors such as pork production from investment portfolios. (Renneboog et al., 2008)

Shariah-compliant funds first emerged in Malaysia in the late 1960's and in the Middle East in the mid-1970's. The rise of Shariah-compliant funds stemmed from the need to invest in line with religious beliefs and Islamic principles. Shariah-compliant investing is done in accordance with the principles of Shariah (Islamic law). (Price Waterhouse Coopers [PWC], 2009)

In 2017, the Shariah-compliant market was estimated to be worth $2 trillion and has had an estimated annualised growth rate of 10%–12% over the last decade (The World Bank, 2017). It should be further noted that Fitch estimated an annualised growth rate of 13% for Shariah-compliant funds, which surpasses the broader global mutual fund industry growth of 11% (Singh, 2022).

However, this sector is still in its infancy, and part of the growth expectation is driven by the rise in environmental, social, and governance (ESG) investing. The principles of Shariah-compliant investments are closely aligned with the environmental and social factors that contribute to sustainable investing. Further to this point, the Muslim population represents about a quarter of the world population, and Shariah-compliant financial assets only represents a marginal proportion of all financial assets. The market is therefore expected to expand to accommodate this large segment of

the population. Another strong driving force behind this growth is wealthy Muslim oil-producing countries, where wealth is both governmental and private. (PWC, 2009)

In addition to the large growth opportunity for this industry, there is an argument to be made about the riskiness of this particular asset class. For a stock or company (in the case of unlisted equities) to comply with Shariah law, there needs to be a maximum debt ratio of 33%; further to this, the business should not be involved in any activities that are deemed prohibited in Islam, and no excessive gambling or uncertainty is allowed. (Balcılar, Demirer and Hammoudeh, 2015)

Due to this embedded criterion for a stock to be compliant, there is a case for Shariah-compliant investments to be seen as a safer asset class that can be used to hedge against large and sudden losses during times of economic turbulence and uncertainty. It is therefore within reason that interest in Shariah-compliant funds comes from Muslim as well as non-Muslim investors who are seeking returns with lower volatility.

According to the Islamic Corporation for the Development of the Private Sector (ICD) (2022) the top ten countries for Islamic funds based on the number of funds are Malaysia, Saudi Arabia, Indonesia, Iran, South Africa, Pakistan, the United Kingdom (UK), Luxembourg, the United Arab Emirates (UAE), and the United States. This shows a broad demand for Shariah-compliant funds across multiple geographical locations, four of which are not eastern or predominately Muslim countries. The top five countries by assets under management (AUM) for Shariah-compliant funds are Other MENA (Middle East and North Africa, excluding the Gulf Cooperation Countries [GCC]) countries, the GCC, Southeast Asia, Europe, and North America, with North America managing US$7 billion in 2021. This shows a significant market, even across non-Islamic countries.

Given the shock of the Covid-19 pandemic, investors are interested in finding safe-haven asset classes to protect returns and effectively diversify their portfolios. The negative impact of Covid-19 could be seen in the sharp decline of the global market. The United States (US) stock market fell by 12%, with all 11 groups in the S&P 500 decreasing (Hajric and Herron, 2020). Share prices also declined in Asia, and Europe, both share prices and bond yields fell to levels last seen in the European Sovereign Debt Crisis (ESDC) of 2011 and 2012 (Bossman et al., 2022). In the context of the level of global risk, low volatility investing seems to be an attractive alternative.

Given the global reach of Covid-19 and previous economic crises, there is a need to assess if Shariah-compliant indices are immune to financial crises, as well as to understand the spillover effects between them. Knowledge of this is useful in portfolio construction and risk mitigation. Globalisation

has caused markets to become more interrelated, thereby decreasing the ability to properly diversify. It is therefore important that the spillover effects between Shariah-compliant markets are properly assessed and understood.

Various studies seek to understand this topic; however, very few of them use data from the South African financial market. Given that South Africa is one of the top ten countries for Islamic funds, as previously mentioned, it is important to incorporate South African data in these studies. As such, this study seeks to contribute to the existing literature by including South African data to fully understand the spillover effects with a more robust dataset for emerging markets.

The Islamic financial sector in South Africa took off in 2004 with Islamic banking entering the scene, and some banks followed suit, contributing to the growth of the sector. In 2021, there were an estimated 101 Shariah-compliant funds in South Africa, estimated to be worth R50 billion (ICD, 2022). The Johannesburg Stock Exchange (JSE) lists four Shariah-compliant indices for investors seeking to invest in Shariah-compliant listed equities. The increase in demand for Shariah-compliant products has triggered an increase in research and product development in this sector. The Shariah-compliant financial industry is growing in South Africa, as evidenced by a growth rate in uptake for Islamic banking and other Shariah-compliant products. According to the Banking Association for South Africa (Mahlaba, 2022), the deposits and advances for Islamic banking exceeded the conventional banking deposits and advances for the period December 2020 to June 2021. Islamic banking advances grew by as much as 49.71% from March 2019 to March 2021, compared to commercial banking loans and advances, which only grew by 7.86%. There is an expectation that this industry is still growing in South Africa. Despite its expansive growth and rising global demand, research into Islamic finance and Shariah-compliant products is still in its infancy, especially in emerging markets such as South Africa.

The ICD (2022) reports that 1,903 Shariah-compliant funds globally span across 29 countries, with assets under management of $238 billion in 2021. It further projects assets under management to grow to roughly $416 billion in 2026. Interestingly, the report lists South Africa in the top ten countries based on the number of funds, with South Africa ranking seventh with 101 Shariah-compliant funds. Despite Covid-19, Shariah-compliant funds grew by 34% in assets under management in 2021 and by 22% in 2020. (ICD, 2022). Additionally, Investco also reports a rise in interest for Shariah-compliant funds after the Covid-19 pandemic. (Lillywhite, 2022)

The significant growth of Shariah-compliant markets, together with the economic turmoil created by the Covid-19 pandemic, creates a strong case for interrogating the spillover effects within Shariah-compliant markets. Specifically, we seek to evaluate the volatility spillover between developed and

emerging Shariah-compliant indices, with a specific focus on the South African market. These indices span the US, Europe, Canada, Japan, the UK, the Asia Pacific, and finally South Africa. The timeframe for this study ranges from 22 September 2003 to 31 March 2023 and employs Gabauer's (2020) time-varying connectedness approach, which is based on the Diebold and Yilmaz (2012, 2014) spillover index.

1.2 Problem statement

This study evaluates the volatility spillover between developed and emerging Shariah-compliant indices. We start with the assumption that the Shariah-compliant indices are segmented and present no volatility spillover among them. We further postulate that they are not correlated and behave independently of each other during times of economic crises.

To examine this issue, we assess how volatility spillover impacts the different indices using the dynamic connectedness approach and if volatility spillover increases or decreases during times of economic crises. In addition, we further examine which of the indices are transmitting volatility shocks and which of them are receiving volatility shocks, if any. This will assist in understanding volatility spillover in more detail. We also examine how much of each Shariah-compliant index's volatility is contributed by own-volatility shocks as we decompose the forecast error variance decomposition for each index. Furthermore, we examine net pairwise connectedness.

The above concept is an important one to understand. This is due to investors increasingly looking to diversify and minimise risk. If assets are connected or correlated, then hedging becomes less effective. Furthermore, building a well-diversified portfolio requires an understanding of which assets can be grouped to ensure that portfolio volatility is managed.

1.3 Significance of the study and limitations/caveats

The significance of this study is its contribution to the existing literature on volatility spillover between Shariah-compliant indices, one of which is the JSE Shariah-compliant index. In the below literature review (section 3), there are only 2 studies (Hassan et al. 2020 and Kenourgios et al. 2016) that utilise South African data, and in both studies, the studies are a comparison between the conventional market and the Shariah-compliant equities market. There are no studies that assess the volatility spillover between Shariah-compliant indices that also include South Africa in their analysis.

This study also contributes to the literature by including the period of the Russia-Ukraine conflict, which started in late February 2022. Of all the academic articles cited below, the latest data incorporated in the studies are for 08 September 2021, which excludes this period. We therefore contribute to the literature by including a sample period that includes the onset of the Russia-Ukraine conflict.

Furthermore, we use a unique methodology to calculate the volatility spillover between the Shariah-compliant indices. This method is not used in any of the papers reviewed below. Methods used in the studies below include various multivariate generalised autoregressive conditional heteroskedasticity (GARCH) models and the Diebold and Yilmaz (2012, 2014) methodology, among others.

Some caveats and limitations of this study relate to the use of the JSE Shariah Top 40 Index. South Africa is an emerging market, and as a result, the number of constituents in the JSE Shariah Top 40 index is 17, whereas the number of constituents listed in the DJIM US index is 568. Similarly, the constituents in the DJIM Europe index are 332. The difference in the number of constituents between these indices is significant and reflects the differences in the size of the countries' economies. Furthermore, South Africa is a mineral and resource rich country, resulting in a significant representation of mining and resource companies within the JSE Top 40 index. Consequently, the JSE Shariah Top 40 index in this study may be concentrated in the resource sector.

In line with the sector concentration, we also note that, because of the nature of Shariah-compliant equities, certain sectors will dominate the indices chosen, and other sectors will be underrepresented or excluded in the chosen index. Due to these sectoral biases, there is a risk that the results may be skewed because the indices chosen are not an accurate reflection of the whole market. As an example, the financial sector will not be fully represented in the indices due to the screening requirements for Shariah compliant equities.

This paper is divided into seven sections and opens with an introduction that discusses the importance and context of volatility spillover among Shariah-compliant indices. The second section gives a background to Shariah-compliant finance within the global financial market as well as Shariah-compliant equities within South Africa. Thirdly, we consider the existing academic literature and highlight the similarities, differences, and gaps by discussing them under three different themes. These themes relate to spillover volatility, decoupling and risk transmission, and finally, hedging and safe-haven capabilities. The fourth section examines the data used in the study. The fifth section discusses the motivation and steps used for the dynamic connectedness approach. The seventh section of the paper analyses the results from the study and draws comparisons and differences to

the existing literature. Finally, the paper concludes with the importance and contributions of the study, as well as a highlight of the results and implications.

2. Background to Shariah Compliant Investing

As previously mentioned, the Shariah-compliant market in South Africa has experienced growth, even under trying economic conditions. This is also true in the global context, as internationally, the demand for Shariah-compliant financial products is still growing. However, despite the thriving Shariah-compliant market, especially in the Islamic eastern regions of the world, this is still a relatively new field and continues to adapt and evolve within the conventional financial system. (PWC, 2009)

Before diving into the specifics around the Shariah-compliant requirements, it is worth noting the different types of product offerings available. In South Africa, Islamic banking first emerged on the scene in 1989 with Albaraka Bank. In 1992, the first Shariah-compliant unit trust was introduced, and between 1997 and 2004, the industry started gaining momentum. In 2004, the first conventional bank to incorporate Islamic banking was First National Bank (FNB); thereafter, a few other banks followed suit. The first dollar denominated Islamic bond, called a sukuk, was introduced in South Africa in 2014. In 2018, the first rand denominated corporate sukuk was issued by Albaraka Bank. A sukuk differs from a conventional bond in the sense that conventional bonds earn interest, but shareholders of sukuks are remunerated with a share of the income generated. Sukuks are also required to have underlying tangible assets or services (Mahlaba, 2021).

Other Shariah-compliant products include Salam, which is an alternative to conventional Futures contracts; Ijarah, an alternative to leasing; Musharakah, an alternative to shareholding; and Mudarabah, an alternative to venture capital and bank offered investment accounts. (Mahlaba, 2021) Some of these concepts will be further elaborated on as we delve into the requirements for Shariah compliance; however, the emphasis and depth of details will be reserved for Shariah-compliant equity funds or indices, since that is the focus of this research. Shariah-compliant equity funds are similar to conventional equity funds; however, they have the additional element of ensuring that all companies within the funds are Shariah compliant.

Although the services and products offered within Shariah-compliant finance are somewhat similar to conventional financial services and products, the framework for this is different. The Shariah-compliant framework is based on the Quran, Hadith, and Ijtihad. The Quran is a central religious text. It is believed to be the literal word of God, revealed to Prophet Muhammad (Peace Be Upon Him

[PBUH]). Hadith is a record of the sayings and actions of the Prophet (PBUH). Ijtihad is the formulation of Shariah law based on deductions from the Quran and the Hadith (Derigs & Marzban, 2009).

Some of the key features of Shariah-compliance are the prohibition of interest, the prohibition of uncertainty and excessive risk, asset-backed finance, ethical investment criteria, and specialised contracts. In addition, all Islamic finance institutions have the added layer of incorporating an Islamic regulatory body, including religious scholars, to provide guidance and resolve any uncertainty or ambiguity on the permissibility of certain issues (Derigs & Marzban, 2008).

One of the most important aspects of Islamic financing is the concept of asset-backed finance. Conventional financing involves activities where banks and financial institutions deal in money and monetary papers only; however, Islam does not recognise money as a subject matter of trade, except in some special cases. Money has no intrinsic value and is only a medium of exchange. Money therefore cannot be profited on because profit generation is for assets that have an intrinsic value. The profit earned through dealing in money or the papers representing them is interest, and interest is prohibited in Islam and Shariah law. Therefore, unlike conventional financial institutions, financing in Islam is always based on illiquid assets, which create real assets (Usmani, 1998: 17). Real assets can be defined as tangible assets that have intrinsic value due to their physical properties, which include real estate, infrastructure, natural resources, commodities, agriculture, midstream energy, precious metals, and timber, among other things (Corcoran, 2021). Ultimately, Islamic financing is a system that is backed by assets and is always matched with corresponding goods and services.

As mentioned, profit cannot be earned on money; therefore, in Islamic finance, there is a prohibition of interest. The reason for such a system is that Islam deems interest unjust in that it either disadvantages the borrower or the lender. If there are losses, it is unjust for the lender to still claim the interest while the borrower bears a loss, and if the business does well and flourishes, it is unfair for the lender to only get a portion of the profits while the borrower gets a larger proportion of the profits. Ultimately, according to Islam, the only just system is for all parties to share equally in the profits and losses (Usmani, 1998: 17).

An implication of asset-backed finance and the prohibition of interest is ‘Musharakah’, an Arabic word that translates to sharing (Usmani, 1998: 17). This means that profit and loss sharing is done in proportion to the capital invested in the venture. This is one of the specialised contracts in Shariah -compliant finance, and it is the one aspect that scholars unanimously agree on. Losses will always be shared in accordance with the ratio of capital invested. If contracts are not in compliance with this, then they are rendered void (Usmani, 1998: 25).

Another example of a specialised contract is called "Mudarabah". This is a similar concept to Musharakah; however, whereas Mushrakah is a joint venture where all the partners share in the labour and investing, Mudarabah can be seen as a silent partner. In this instance, the profit and loss sharing principle is predetermined and agreed upon by both parties, and the working partner is not entitled to a regular salary but only a profit share. (Usmani, 1998:30)

Islamic finance has the additional criteria of being ethically in line with Shariah. Therefore, all business activities of Shariah-compliant companies are in accordance with Islam. According to Islam, there are prohibitions on certain activities and vices. These are alcohol, tobacco, pork, any adult entertainment related activities, gambling, weapons, and arms dealing. These activities are seen as harmful to humans physically and spiritually and are forbidden from consumption, and hence income generation. These forbidden activities also include insurance companies, derivatives, and other interest bearing instruments (Balcilar et al., 2015). This requirement contributes to the sector bias previously discussed in relation to low volatility investing.

The prohibition on derivatives, insurance, hedging, and other speculative products further relates to the concept of excessive uncertainty and risk. The Arabic term for this is '*gharar',* which translates to uncertainty (Usmani, 1998: 62). The sale of derivatives and similar financial products involves selling uncertainty and selling that which is not in one's possession. This is considered harmful to the general interest and well-being of a society due to the possible creation of wealth for one party at the expense of another party. The presence of such uncertainties renders contracts void, according to Shariah. (Balcılar et al., 2015)

Other requirements for Shariah-compliant funds and institutions are Shariah boards and Shariah auditors. The purpose of a Shariah board is to guide management or investment managers regarding Shariah law and whether the proposed investments decisions of the institution are Shariah-compliant. Shariah-compliant institutions also must be audited on an annual basis to ensure that they are adhering to Shariah principles. It is best practice for this to be carried out by scholars who are outside parties to avoid any conflict of interest (PWC, 2009).

It can be said that if the principles of Shariah are strictly followed as they relate to interest and uncertainty, then the Shariah-compliant companies to invest in are basically nil (Balcilar et al., 2015). However, given the modern financial market setup, the scholars of Islam have provided guidance for the practical implications and practices around assessing Shariah-compliance. Due to the different interpretations and views of scholars, there are some differences in the screening methodology for assessing Shariah-compliance. These screens can be broadly categorised into two classifications. The

first is a qualitative screen that reviews business activities; the second is a quantitative screen that assesses debt and interest levels (Derigs & Marzban, 2008).

A study done by Derigs and Marzban (2008) highlights the differences in screening methodologies and shows how they can culminate in differences in portfolio construction. Tables 1 and 2 (Derigs & Marzban, 2008) show the differences in methodologies used for the quantitative and qualitative screens. These tables show the differences in Shariah guidelines used between the Shariah boards of the Dow Jones Islamic Index (DJIM) Group, the Financial Times Islamic Index Series (FTSE), Standard & Poor's Islamic Index Group (S&P), the Morgan Stanley Capital International Islamic Index Series (MSCI), the HSBC Amanah Fund (HSBC), the Amiri Capital Islamic Fund (Amiri), Dubai Islamic Bank (DIB), the Azzad Islamic Fund by Azzad Asset Management (Azzad), and finally the Meezan Islamic Fund (Meezan) (Derigs & Marzban, 2008).

Table 1 (Derigs & Marzban, 2008) below displays how the different Islamic funds and indices assess the ethical screens. As an example of the discrepancy, given that alcohol is one of the prohibited sectors, the Dow Jones Islamic Market (DJIM) index excludes companies that have any involvement in alcohol; however, the FTSE will invest in a company whose core operations are Shariah-compliant but have a negligible amount of income from alcohol. These discrepancies are across most of the sectors displayed in Table 1.

Table 2 (Derigs & Marzban, 2008) shows the differences in methodologies used for the quantitative screen. These screens assess the liquidity, debt levels, amount of interest bearing income, and non-permissible income levels within the company. The biggest difference between the methodologies is related to whether market capitalisation or total assets are used to value the worth of a company. This is then used as a divisor for the different financial screens. The argument for using market capitalisation is that it indicates the real worth of a company as valued by the market. (Derigs & Marzban, 2008)

Table 1 Shariah screens industry survey – qualitative (sector) screens (Source: Derig & Marzban, 2008

	DJIM	FTSE	S&P	MSCI	HSBC	Amiri	DIB*	Azzad	Meezan
Alcoholic Beverages	☒	•	☒	•	•	•	•	☒	•
Biotechnology (Genetic & Foetus)					•				
Broadcasting & Entertainment	☒	•	☒	•	•	•	•	☒	•
Conventional financial services	☒	•	☒	•	•	•	•	☒	•
Gambling	☒	•	☒	•	•	•	•	☒	•
Hotels	☒	•	☒	•		•	•	☒	
Insurance	☒	•	☒	•	•	•	•	☒	•
Meat Production								☒	
Media Agencies**	☒		☒		•			☒	•
Pork-related products	☒	•	☒	•	•	•	•	☒	•
Restaurants & Bars	☒	•	☒	•	•	•	•	☒	•
Tobacco	☒	•	☒	•	•	•	•	☒	•
Trading of Gold & Silver			☒						
Weapons & Defence	☒	•		•	•	•	•	☒	

• core business ☒ any involvement

* The sector screens of DIB is defined based on the best of our knowledge

** except newspapers

Table 2 Shariah screens industry survey – quantitative (financial) screens (Source: Derig & Marzban, 2008)

Eligibility if £	DJIM	FTSE	S&P	MSCI	HSBC	Amiri	DIB	Azzad	Meezan
Liquidity Ratios									
$\frac{AR_i(t) + CSI_i(t)}{TA_i(t)}$					50%				80%
$\frac{AR_i(t) + C_i(t)}{TA_i(t)}$		50%				70%			
$\frac{AR_i(t)}{TA_i(t)}$				70%					
$\frac{AR_i(t)}{MC_i(t)}$	33%		49%					45%	
$\frac{CA_i(t) - CL_i(t)}{TCS_i(t)}$									$P_i(t)$
Interest Ratios									
$\frac{TI_i(t)}{TR_i(t)}$		5%			5%				5%
$\frac{CSI_i(t)}{MC_i(t)}$	33%		33%						
$\frac{CSI_i(t)}{TA_i(t)}$		33%		33.33%		33%			
$\frac{SI_i(t) + LI_i(t)}{TA_i(t)}$							30%		33%
$\frac{SI_i(t) + LI_i(t)}{MC_i(t)}$							30%		
$\frac{C_i(t) + AR_i(t) + SI_i(t) + LI_i(t)}{TA_i(t)}$									30%
$\frac{C_i(t) + AR_i(t) + SI_i(t) + LI_i(t)}{MC_i(t)}$									30%
Debt Ratios									
$\frac{TD_i(t)}{TA_i(t)}$		33%		33.33%	30%	33%	30%		40%
$\frac{TD_i(t)}{MC_i(t)}$	33%		33%				30%	33%	
Non-Permissible Ratio									
$\frac{NPI_i(t)}{TR_i(t)}$		5%	5%						5%
$\frac{NPII_i(t)}{TR_i(t)}$						5%	5%		

Tables 1 and 2 demonstrate a lack of standardisation across institutions and, by extension, across global borders. This is the first issue relating to the governance and framework challenges within the Shariah-compliant finance space and further motivates the need to assess the level of interdependence and influence across different Shariah-compliant indices.

Due to the idiosyncratic nature of Islamic finance, there are some instances that produce unusual transactions that are not considered within the framework of the International Financial Reporting Standards (IFRS). There is also the need to standardise operations, reporting, and procedures to ensure that Shariah-compliant financial products are comparable. Additionally, this is important to ensure further growth and legitimacy for the industry, especially in the wake of the current growth trajectory of the industry. As a result, the need for authoritative bodies to set standards is required. These bodies include the Accounting and Auditing Organization for Islamic Financial Institution (AAOIFI), the Islamic Financial Service Board (IFSB), and the International Islamic Financial Market (IIFM) (Aliyu et al., 2019).

The three organisations mentioned above are all international organisations that provide standards, guidelines, technical notes, and regulations for the operations of Islamic financial institutions. They also adopt other international standards that are not in contradiction with Shariah and develop additional reporting standards that are required for Islamic financial institutions. AAOIFI's focus is on providing financial accounting standards, but it also produces guidelines on governance, Shariah, and ethical standards. The IFSB focuses on corporate governance standards as well as capital adequacy, market discipline, stress testing procedures, and core principles for regulating Islamic finance. IFSB has a stronger focus on institutional solvency and is not concerned with the socio-economic aspects of Islamic finance. Unfortunately, these standards and practices are not uniformly adopted across regions and institutions. Further to this point, it is noted that the lack of sovereign backing for these standards and bodies undermines their enforcement of some guiding regulations, and as a result, there will be a slower rate of adoption. (Aliyu et al., 2019)

Some other challenges facing this new and evolving industry are the harmonisation with international standards, lack of subject matter experts, and issues around regulatory capital and liquidity. Harmonisation with international standards refers to the current divergence due to domesticating international standards. It is recommended that a consolidated approach is required to converge accounting standards at an international level so that they suit the majority of countries. The lack of expertise challenge relates to the relatively low number of experts in the field, given the high growth rate of Shariah-compliance finance. Then there is the issue of regulatory capital, which is not clearly defined according to the IFSB and speaks to specifying accountable instruments related to additional Tier I and II capital. A possible solution is for the aforementioned bodies to collaborate on the treatment of investment accounts. (Aliyu et al., 2019)

According to a survey done by PWC (2009), further issues faced by Shariah-compliant institutions are the additional costs due to the Shariah board and audit requirements. These additional expenses increase the cost of running a fund. However, PWC claims that the impact of these costs should start to reduce as the average fund size increases and economies of scale are found across the industry. They further point out that the valuation of certain instruments is undermined due to the lack of liquidity in the industry. This lack of liquidity can be attributed to the lack of a secondary market for trading Shariah-compliant assets. They argue that the solution for this will eventually present itself as the market matures and becomes deeper. (PWC, 2009)

Embedded in the Islamic financial system is the concept of ESG, which is why Shariah-compliant investing is seen as a subset of ESG investing. "According to Islamic principles, business transactions can never be separated from the moral objectives of society." (Usmani, 1998: 167). Unlike the conventional financial system, where profits are the only motivation and objective for business, Islam ensures that there is consideration for society as well as the environment. The purification process that is also part of these funds creates a positive social impact simply by investing in the product. This purification process involves all non-compliant income received in the fund, i.e., income from forbidden sources such as interest or alcohol, as an example, to be donated to a charitable cause that is selected by the Shariah board (PWC, 2009).

It is for this reason that Muslims as well as non-Muslims find Shariah-compliant investing appealing. The need for moral and risk averse investing is a universal one. As a result, the popularity of these types of investment products have been on the rise.

In South Africa, multiple institutions offer Shariah-compliant equity funds. These are investment managers that take an active investing approach. However, there are also Shariah-compliant indices offered on the JSE. This is a passive investment approach and is usually cheaper than actively managed funds. All the Shariah-compliant indices are screened by Yasaar Limited, which acts as their independent Shariah audit board and advisers. Yasaar Limited is a UK-incorporated company. They provide services related to Shariah compliance consulting and auditing to financial services (JSE, 2023).

On the JSE, the Shariah-compliant indices available are: The Shariah All Share Index (ALSI), which reflects Shariah-compliant companies from the JSE All Share Index. Where the All Share Index represents 99% of the full market capitalisation value of all eligible securities listed on the Main Board of the JSE. The Shariah Top 40 Index, which reflects all the Shariah-compliant companies in the Top 40 Index, The Capped Shariah Top 40 Index comprises of Shariah-compliant companies that are capped at 10% of the index; constituents with a weight greater than 10% in the index will be capped at a level

of 10% at each quarterly review. An alternate index, which is derived from the Shariah Top 40 Index (J140), where the Total Return Index (TRI) is calculated using net dividend rates. Dividend withholding tax is deducted from the declared dividend with the resulting net dividend used in the Ex-dividend adjustment. (JSE, 2023) This study will incorporate data from the JSE Shariah Top 40 Index.[1]

To date, there are limited studies that include data for the Shariah-compliant South African Stock Exchange, the JSE. In this study, we seek to contribute to the existing literature by expanding the evidence for spillover as it relates to the Shariah-compliant South African stock market. This is an important gap to bridge as the demand for Shariah-compliant investments increases globally.

3. Literature Review

This section aims to comprehensively discuss existing academic literature related to volatility spillover among Shariah-compliant indices, as well as related concepts. Most of the literature that will be discussed here includes conventional equity indices. Consequently, the literature review articles are not always direct comparisons to the results of this study, but some useful insights can still be drawn. This section therefore discusses the available academic articles by grouping them into three different sections, namely: volatility spillover; decoupling and risk transmission; and finally, safe-haven and hedging capabilities of Shariah-compliant indices.

The volatility spillover articles seek to directly analyse the volatility spillover between Shariah-compliant indices and, often, their conventional counterparts. Further to this, some of these articles will identify the net transmitters and receivers of volatility. The decoupling hypothesis relates to the concept of asset price movements becoming less correlated in crisis periods. (Shahzad, Ferrer, Ballester and Umar, 2017) This topic is related to the concept of spillover indirectly; if indices are decoupled, then there would be little to no cross-volatility spillover among them. Thirdly, we review studies relating to the safe-haven and hedging capabilities of Shariah-compliant indices. Safe-haven assets are formally defined as assets that are negatively correlated or uncorrelated with another asset or portfolio in specific periods only, such as crisis times (Arif, Naeem, Hasan, Alawi, and Taghizadeh-Hesary, 2022). Similarly, this concept can also be tied to volatility spillover; if there is little to no correlation between indices then we do not expect a high volatility spillover effect.

[1] Some of the income generated by underlying companies will include some form of non-permissible income, such as interest. This non permissible income will be donated to charity, under the guidance of the shariah advisory board. This is the purification process and affects the Net asset value calculation, as the non-permissible portion is removed. This has an impact on the returns of the fund. (PWC, 2009)

3.1 Volatility Spillover:

The studies presented below examine volatility spillover to assess whether Shariah-compliant equities are able to provide a diversification strategy such that they limit downside risk and consider evidence from the global financial crisis of 2008, the European sovereign debt crisis of 2011 and 2012, and the more recent Covid-19 crisis. Some research also focuses on the contagion effect of economic crisis periods, all of which contribute to the overarching theory of Shariah-compliant stocks being less volatile or a viable hedging strategy during economic uncertainty. The empirical evidence presented by the various studies cited below is mixed; however, most of the studies demonstrate that volatility spillover increases during economic crises.

Recently, Ghaemi Asl, Jabeur, Khalfaoui and Tavakkoli (2023) examined the dynamic volatility spillover connectedness among 20 sectoral S&P Global 1,200 indices. Sector indices include industrials, utilities, information technology, consumer discretionary, communication services, consumer staples, healthcare, financials, energy, and ESG sectors; these relate to both conventional and Shariah-compliant indices. Using a quantile vector autoregressive approach the authors examine the indices collected from the S&P Dow Jones Index website for the period 30 September 2010 to 28 October 2020. The quantile-based approach allows analysis to be done based on market conditions, i.e., bullish, bearish and normal market conditions. Quantiles were split into 5% (q=0.05), 25% (q=0.25), 50% (q=0.5), 75% (q=0.75%) and 95% (q=0.95%). The lower quantiles represented bearish market conditions and as the quantiles increased the market conditions become normal and bullish.

The authors analysed the volatility spillover based on the quantile vector autoregression to determine the static and net connectedness. The first set of results showed the volatility spillover effect from various sectoral indices to the ESG index. These were shown at a total level as well as in quantiles of 0.05, 0.25, 0.50, 0.75 and 0.95. The connectedness spillover coefficients were more than 87% for all cases, except for those from Shariah-compliant utilities to the ESG index. Here the coefficient was 63.16%, which indicated that the total connectedness spillover from Shariah-compliant utilities to the ESG index was less connected compared to the other sector indices.

This table was replicated for the spillover effect from the ESG index to other sectoral indices. The results showed that for the total level and the quantiles, the largest spillover receivers were energy, healthcare, information technology, industrials, as well as their Shariah-compliant counterparts. The financial and Shariah-compliant consumer discretionary sectors were also large receivers of volatility spillover. Once again, the lowest spillover contribution from the ESG index was to the Shariah-compliant utilities sector.

Analysing the net volatility spillover showed that Shariah-compliant industrials were the dominant net transmitters of volatility (25.96%) among the other indices. Conversely, Shariah-compliant communication services was the main net receiver of volatility (58.15%) from the other indices. Results further showed that Shariah-compliant utilities, consumer staples, financials, communication services, consumer discretionary, consumer staples and conventional utilities were net receivers of volatility. Whereas the remaining indices were all net transmitters of volatility.

Turning to the dynamic quantile based total connectedness of volatilities, it is observed that in all market conditions there were high degrees of connectedness. The connectedness coefficients ranged between 83% and 98% throughout the sample period. The spillover connectedness decreased slightly in 2018 but increased again post 2018.

Next, the authors examined the volatility spillover for pairwise indices. Based on the static connectedness of volatilities, it was observed that all pairs including Shariah-compliant industrials were relatively stronger compared to the other pairs. This indicated that the Shariah-compliant industrial sector was a dominant net transmitter.

When examining the pairs under negative market conditions (q=.05), it is noted that the volatility spillover increased in intensity. As market conditions improved from bearish to normal to bullish, volatility spillover effects for the pairs became less intense. It is further noted that in bearish market conditions, conventional financials, conventional industrials and Shariah-compliant consumer discretionary sectoral indices were weakly connected to the other indices.

The authors also plotted the dynamic net volatility spillover of the ESG index across all the quantiles. The results showed that the ESG index was sometimes a net receiver of spillovers and sometimes a net transmitter of spillovers. During negative market conditions (q=0.05) the ESG index appeared to be a net transmitter of volatility spillovers to other sector indices. This was also the case for q =0.25, q =0.50 and q =0.95. At the extreme upper quantile (q=0.95) the ESG index was a net receiver of spillovers, especially post-2017. The index was almost exclusively a net receiver of volatility spillover by remaining negative until the end of the sample period.

The article was concluded by suggesting that considering socially responsible investment in certain strategies could assist investors and policymakers in making more informed decisions. They further suggested that investors in Islamic finance might benefit from including ESG factors when managing their portfolios.

Sahabuddin, Islam, Tabash, Alam, Daniel & Mostafa (2023) also considered the dynamic correlation and spillover between conventional and Shariah-compliant markets. Daily closing prices from 26

October 2007 to 7 June 2018 were collected from the USA, UK, and Japan (developed markets); and Malaysia, Indonesia, and China (developing markets).

As a start to the study, Sahabuddin et al., (2023) plotted return movements of all the studied markets, both conventional and Shariah-compliant indices, and interestingly found that the markets move together and exhibit similar patterns.

Further investigations showed that volatility changes over certain time horizons for the different regions, but there was little evidence to suggest that there is no correlation and spillover effects between the conventional and Shariah-compliant indices. Using multivariate GARCH and wavelet transformations some of the findings showed that there is a large positive correlation between the UK Shariah- compliant and conventional index, and that the US Shariah-compliant market had a low correlation with the Chinese, Malaysian, and Japanese Shariah-compliant and conventional markets. However, the study concluded that in the long-run conventional and Shariah compliant indices moved together.

Bossman, Junior and Tiwari (2022) used the spillover index to examine the dynamic connectedness between Shariah-compliant markets and their conventional counterparts. Given that international financial markets are integrated, the diversification prospects for global portfolio managers and other investors have diminished. Shariah compliance, as the academic research suggests, provides an alternative strategy that provides diversification and is shown to outperform its conventional counterparts during crisis periods. The spillover index detailed the total and pairwise connectedness, as well as the direction of spillovers between the Shariah and conventional markets.

Bossman et al. (2022) sought to answer the following questions: i) Has the relationship between Shariah-compliant and conventional markets changed during the Covid-19 period? ii) What was the extent of connectedness between Shariah-compliant and conventional markets during stress periods iii) Did the connectedness between Shariah-compliant and conventional stocks differ across investment horizons? iv) Has connectedness evolved from interdependence or contagion, and v) Which markets transmitted and received shocks between Shariah-compliant and conventional markets.

The authors used the Banurik and Krehlik (2018) methodology, based on the 2012 Diebold and Yilmaz Spillover index, and applied it to the daily price of stock market indices from 23 November 2015 to 08 September 2021. Data from 17 predominantly Shariah-compliant markets (Egypt, Iraq, Jordan, Kuwait, Oman, Palestine, Qatar, Saudi Arabia, UAE, Bahrain, Bangladesh, India, Malaysia, Indonesia,

Kazakhstan, Pakistan, and Morocco) and G7 economies (Canada, Italy, Japan, UK, France, Germany, and the USA) were used in the study. EquityRT provided the daily stock indices denominated in US dollars.

Their findings assisted with answering the initial questions probed. The total connectedness index between conventional and Shariah-compliant indices has changed since the inception of the study in 2015 through 2021. The degree of interdependence between the conventional and Shariah-compliant indices went from below 60 to a high of about 70 from 2015 to 2016. Thereafter, the connectedness decreased steadily to about 50% until the inception of the Covid-19 pandemic, where it increased significantly to above 85%. In terms of the connectedness between Shariah-compliant and conventional stocks during economic turbulence, the evidence presented demonstrates that during the Covid-19 pandemic, the connectedness increased significantly, showing that spillover intensified during economic crisis periods. Further to this, the results showed that spillovers were more intense during the short term period for both conventional and Shariah-compliant markets compared to the medium and longer term investment horizons, i.e. Shariah-compliant and conventional indices studied were more responsive to market shocks in the short term, which means that diversification in the short term was not very effective compared to longer investment horizons. The intensity of spillover decreased as the time frame increases.

Additionally, the study showed that increases in spillover during the 2017/ 2018 and 2020/ 2021 periods could be explained by a delayed contagion effect, which is attributed to Brexit and the Covid-19 pandemic, respectively. Finally, the study revealed the net receivers and net transmitters of volatility and shocks. In the short term when comparing conventional and Shariah-compliant indices, the largest contributors to spillover were France, the UAE and Malaysia. In the long term, the largest contributors were Canada, Kuwait and Saudi Arabia. When isolating the G7 and Shariah-compliant markets, across all investment horizons, Germany and France were the largest contributors to spillover for the G7 markets. In the Shariah-compliant markets, the UAE and Malaysia were the largest contributors of spillover in the short-term, and Kuwait and Saudi Arabia were the largest contributors in the long term.

When looking at the receivers of volatility for both markets, Saudi Arabia received the highest spillover in the short-term and Bahrain received the highest spillover in the longer term. For the G7 markets, Germany received the highest spillover in the short term, and France received the highest in the longer term. The Shariah-compliant market receivers of spillover were the UAE in the short term and Bahrain in the long term.

The study showed that the spillovers were more observable for the G7 indices compared to the Shariah-compliant indices during the Covid-19 pandemic. Overall, the study provided evidence to support the premise that Shariah-compliant indices were less prone to volatility spillovers during economic crises.

Another study focusing on volatility spillover as it relates to Shariah-compliant equities is that of Yarovaya, Elsayed & Hammoudeh (2021). This article is broader than just Shariah-compliant equities and included Shariah compliant bonds in the study.

The study examined spillovers between conventional and Shariah-compliant equities and bond markets. It further analysed some determinants of spillovers; namely gold, oil, and Bitcoin prices, as well as risk measures such as the volatility index (VIX) and the US Economic Policy Uncertainty index (EPU). The study sought to understand how the Covid-19 pandemic affected all these relationships.

The authors employed a multivariate Asymmetric Generalised Autoregressive Conditional Heteroscedasticity (AGARCH) and an Asymmetric Dynamic Conditional Correlation (ADCC) GARCH to determine the development of the time varying correlations and spillovers between the markets. Daily observations for the Dow Jones World Stock Market Index, the Dow Jones Islamic Stock Market Index (DJIM), the Intercontinental Exchange Bank of America (ICE Bofa) world bond market index and the Dow Jones World Sukuk index were used over the period 1 April 2019 to 4 May 2020.

The results showed that there was a large volatility spillover from the conventional markets to the Shariah-compliant markets and that only gold and oil prices were reliable determinants of spillover.

Ultimately, the results of this study showed that only Sukuks (Shariah-compliant bonds) displayed hedging abilities during the Covid-19 pandemic and that the spillover effect between the conventional and Shariah-compliant stock markets intensified during this time.

Hassan, Hoque, Wali, and Gasbarro (2020) used threshold GARCH (TGARCH) and generalised forecast error variance decomposition to determine time and frequency domain volatility spillover. Weekly data for Morgan Stanley Capital International (MSCI) Shariah-compliant and conventional stock indices for the BRICS (Brazil, Russia, India, China, and South Africa) countries were collected from Datastream and ranges from the first week of June 2002 to the second week of March 2017. Weekly data was used instead of daily data because it bypassed the problems associated with daily data, such as the day-of-the-week effect or missing data for non-trading days.

The results of the study showed that there was moderate volatility spillover among Shariah-compliant stocks, conventional stocks and crude oil. For Brazil, it showed a total volatility spillover of 32.35%,

which is the highest volatility spillover. The lowest result was for India at 17.67%. The results for Russia, China and South Africa were 17.67%, 19.49% and 21.80% respectively. Focusing on the South African market, we note that the Shariah-compliant market received 77.62% of its volatility from itself, 14.70% from its conventional counterpart and 7.68% from West Texas Intermediate (WTI) crude oil. The Shariah-compliant market in South Africa transmitted 29.02% volatility to others, while it received 22.38% from others.

Although these results were static and were an average over the sample period, plotting the time-varying total spillover index revealed further insights. The time varying total volatility spillover index revealed a high connectedness during financial distress, namely the GFC in 2007 and 2008 and the European debt crisis periods of 2011 and 2012.

The authors further plotted the frequency domain analysis, which decomposed the total spillover into four frequency bands comprising up to one month, one month to one quarter, one quarter to six months and six months to one year. These results showed that volatility spillover in the first four weeks were minimal and as a result, was suitable for investors with high risk-aversion and short investment horizons. For Russia and India, the spillover magnitude was still relatively low in the 12 to 24 week frequency band compared to the other BRICS countries. These results are important because investors with a longer term investment horizon and an aversion to risk should hold these portfolios for longer than 48 weeks. After 48 weeks most of the spillover was realised.

Further analysis of the time domain total volatility index of the countries were broken down into pre-crisis, crisis and post-crisis periods. The most interesting result here is that all countries increased in connectedness post the crisis, except for India.

Net pairwise volatility spillover was also examined for the three periods: pre-crisis, crisis and post-crisis. Some of the notable observations here were that in the post-crisis period, Shariah-compliant stocks were the net receivers of volatility spillover in all countries, except South Africa. Alternatively, conventional stocks were the net transmitters of volatility to Shariah-compliant stocks in all countries except South Africa. This is in line with all the results of this study and supported the conclusion that Shariah-compliant stocks cannot be used as an alternative to conventional stocks.

Additional literature that focuses on the spillover index as it relates to Shariah-compliant investing is that of Balli, de Bruin and Chowdhury (2019). The focus of this study was on the spillover between Shariah-compliant equity markets. The study sought to investigate the scope and scale of volatility spillovers between the major Shariah-compliant markets, how the GCC region contributed to the

rest of the Shariah-compliant markets and lastly, if the bilateral and macroeconomic economic conditions of the countries could explain these spillovers.

The authors employed fifteen Shariah-compliant equity markets that are geographically dispersed. These countries include Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE, with Egypt, Jordan, Morocco, and Tunisia from the Middle East and North Africa (MENA countries); Turkey from Western Asia; Indonesia and Malaysia from Southeast Asia; and Bangladesh and Pakistan from South Asia. Data was collected for the period 16 July 2007 to 15 July 2017, which includes periods of economic distress such as the GFC of 2008 and the Islamic State of Iraq and Syria (ISIS) escalation threat, geopolitical conflicts in the Middle East and the Brexit referendum of 2015.

Using Forecasted Error Variance Decomposition (FEVD), the authors plotted the time varying volatility spillover and found that the intensity of spillovers vary over time. The results showed that spillovers increased from 2015 and remained relatively high until 2017, which can be attributed to the crisis of the ISIS escalation threat, geopolitical conflicts in the Middle East and the Brexit referendum. This suggests an increased interdependence between markets in crisis periods.

The study also broke down the net receivers and transmitters of volatility. To better understand the effects of the economic crisis, the authors plotted the network of directional pairwise volatility spillovers for the period during and after the GFC.

They identified Oman, Kuwait, the UAE, Malaysia, Bahrain, and Morocco as the net receivers of volatility during the GFC. After the GFC, the net receivers were Qatar, Oman, Kuwait, and Pakistan, with Oman and Kuwait remaining net receivers during the full sample period. Oman and Kuwait were net receivers of volatility for the full sample period.

During the GFC, the net transmitters identified were Indonesia, Qatar, Saudi Arabia, Turkey and Pakistan. The period after the GFC identifies Indonesia, Malaysia, Turkey, the UAE, Saudi Arabia, Bahrain and Morocco as net transmitters. Turkey, Indonesia and Saudi Arabia were net transmitters of volatility for the full sample period.

They found that during the GFC, in line with the rest of their findings, certain spillover effects intensified. This is the case for Turkey, where during the GFC, the net spillover to Indonesia and Malaysia was 18.17% and 14.35% respectively, i.e. Turkey was a net transmitter to Indonesia and Malaysia. After the GFC, Turkey had less of an impact on Indonesia and Malaysia. However, the relationship and transmission of volatility between these two countries intensified. Finally, Kuwait

remained the largest receiver of volatility both during and after the GFC. During the GFC, Kuwait received the most volatility spillover from Bahrain; after the GFC, the volatility spillover from Bahrain weakened.

Ultimately, using cross sectional regression, they found that the significant contributors to the spillover dynamics were total bilateral trade, the net outflow of direct investment equity and sharing borders.

The study concluded with the implication that holding a portfolio concentrated in the GCC region may be at risk of stronger spillover effects during economic distress. However, these results are dated and did not include the Covid-19 pandemic crisis or data from the G7 Shariah-compliant indices globally.

Ahmad, Rais and Shaik (2018) modelled the directional spillovers between the DJIM index and three conventional benchmark indices, namely Standard & Poor's (S&P) 500 USA, S&P Europe 350 and S&P Asia 50. Additionally, the study examined the spillover between the DJIM index and global risk factors, namely Europe and US interest rate benchmarks, and the volatility index (VIX), which was used to capture stock market risk and crude oil prices.

The methodology applied here is the dynamic conditional correlation (DCC) model of multivariate generalized autoregressive conditional heteroscedasticity (MGARCH), where the DCC is based on Engle (2002). The sample period ranged from the 01 March 2006 to 30 June 2015.

The authors plotted the volatility spillover index over the studied period of 2006 to 2015. This graph demonstrated that volatility spillover increased at the beginning of 2007 and remained high throughout the GFC. The index remained relatively high after the GFC and only started to decrease significantly post 2012.

Results showed that the S&P 500 USA was a net transmitter of shocks to the DJIM index throughout the sample period. Additionally, the DJIM index was the net receiver of volatility spillover during the GFC period from S&P Europe 350, and it was a net transmitter of volatility spillover to crude oil prices (WTI crude oil prices). The authors suggested that the high interdependence between these indices can be explained by the regional allocation and overlapping of stocks. These results also demonstrated that the DJIM index displays bidirectional interdependence with the conventional indices.

Finally, the authors also sought to understand the hedging properties of Shariah-compliant equity by computing time-varying hedge ratios from the DCC model. They found that the DJIM index appears to be the appropriate hedging instrument when combined with the S&P 500, S&P Europe 350 and S&P Asia 50. The study therefore concluded that the DJIM index can act as an effective hedging instrument during crisis periods.

Shahzad et al. (2017) analysed the volatility spillover between conventional and Shariah-compliant markets. Their results provided evidence against Shariah-compliant indices as a diversification avenue and they rejected the decoupling hypothesis of Shariah-compliant stocks. The authors assessed the returns and volatility spillovers across the global Shariah-compliant stock market and three conventional national stock markets, namely: the US, the UK and Japan.

The data set for this study included the daily closing prices for the DJIM index, the Dow Jones US stock index, the Dow Jones UK stock index, the Dow Jones Japan stock index , and a number of significant macroeconomic and financial risk factors over the period 15 July 1996 to 30 June 2016. Macroeconomic factors included the VIX index, the U.S. equity market related uncertainty index developed by Baker, Bloom, and Davis (2012), the U.S. 10-year treasury bond yield and the WTI crude oil price. This resulted in 5 027 daily observations.

The authors used a generalised vector autoregression (VAR) based spillover index approach, which is based on the methodology of Diebold and Yilmaz (2012). Plotting the total volatility spillover index showed that prior to the GFC the index lingered around 50%. The index increased after the GFC of 2007/ 2008 and reached a peak of 80% in October 2008 during the days following the Lehman Brothers collapse. Another significant increase in volatility occurred in May 2010 which coincides with the Greek bailout package financed by the European Union, the European Central Bank and the International Monetary Fund. Additional peaks occurred in May 2012 and September 2015, coinciding with two significant corrections in the U.S. stock market in the context of strong economic uncertainty. This showed that volatility spillover increased during times of economic crises, suggesting an increasing degree of integration between the global Shariah-compliant stock market and its conventional counterpart.

Next, the authors plotted time varying net directional volatility spillovers for all variables in the study. Here, it identified the net transmitters and receivers of volatility spillover. The indices and economic indicators that were shown to be the net transmitters of volatility are the DJIM index and VIX, with VIX being the strongest net transmitter. Conversely, the Dow Jones UK stock index, the Dow Jones Japan stock index, the U.S. equity market-related uncertainty index, change in U.S. 10-

year Treasury bond yields and crude oil price fluctuations were clearly identified as the net receivers of volatility spillovers from all other variables throughout the sample period.

Lastly, the paper concluded with the overarching point that Shariah-compliant markets are not independent of the conventional financial system and are susceptible to volatility transmission, especially during financial stress. However, this study was restricted to developed markets and only included three different country indicators. It is also an outdated study, with the sample period ending in 2016.

Majdoub and Sassi (2017) investigated the volatility spillover among Chinese and other major Asian Shariah compliant stock markets (China, India, Malaysia, Indonesia, Korea and Thailand). The purpose of this study was to examine the dynamics of international Asian assets linkages between China and other selected stock markets.

The study employed the Vector Auto Regressive Moving Average; Baba, Engle, Kraft and Kroner AGARCH (VARMA-BEKK-AGARCH) model developed by Ling and McAleer (2003) to study interdependence between the markets and uses Morgan Stanley Capital International (MSCI) Shariah compliant indices from the 3rd of September 2011 to 5th February 2016. This date range excluded the GFC and yielded 1 306 observations.

The results showed that the volatility transmissions were between the Chinese index, the Korean index and Thailand's index. The spillovers from the Chinese index were negative for the Korean and Thailand's index, and the only positive spillover was Thailand's index to the Chinese index. This means that the Chinese index was a net transmitter to Korea and Thailand's index, and the Chinese index received spillover from Thailand's index.

The results showed that volatility persistence was in the short term for the Chinese index, while it showed no short term volatility persistence in the Indian, Indonesian and Malaysian index. Results also showed no persistence in the volatility spillover effect in the long term from the Chinese index to the Indian, Indonesian and Korean index. The results suggested that Shariah-compliant financial markets reduce the transmission of shocks and in turn provide opportunities for long term portfolio diversification.

The Chinese Shariah-compliant stock market did not show long term volatility persistence in Indian, Indonesian and Korean indices and Chinese Shariah-compliant markets in Asia were relatively more integrated with conventional financial markets compared to other Shariah-compliant indices. Lastly,

there were long term diversification benefits from holding Shariah-compliant equities in the Chinese markets.

The final study in this subsection of the literature review was done by Majdoub and Mansour in 2014. They mapped the conditional correlations across the US market and five other Shariah-compliant emerging markets. These markets were Turkey, Indonesia, Pakistan, Qatar and Malaysia.

Daily data was utilised from January 2008 through January 2013. Indices used were provided by Morgan Stanley Capital International (MSCI) and expressed in US dollars for Indonesia, Malaysia, Pakistan, Qatar, Turkey and the US. This equated to 1 306 observations. The models used to estimate the dynamic conditional correlation were multivariate GARCH BEKK, constant conditional correlation (CCC) and DCC.

The key result from the study showed that the US and the Shariah-compliant emerging equity markets had significantly low conditional correlations. This meant that the US market was not a channel for the transmission of shocks and volatility spillover to Shariah-compliant emerging markets over the sample period.

Notably, the country pairs' daily moving correlations of returns were plotted, which showed that the strongest correlated pair over the sample period was that of the MSCI Turkey index and the MSCI US index. The remaining pairs' (US-Indonesia, US-Pakistan, US-Qatar, and US-Malaysia) correlations were weak and barely breached a correlation of 0.1. Additionally, MSCI Pakistan and MSCI Malaysia index showed a negative correlation during the GFC. Further estimations done using the multivariate GARCH BEKK (1,1) model indicated that all pairwise countries exhibited a weak correlation of volatility. They exhibited a statistically significant but low correlation, which suggested that the Shariah-compliant emerging markets and the US were weakly correlated, and the transmission of shocks and volatility spillover among these markets were not significant.

A similarity between the studies were that during crisis periods, there is an increase in the spillover index. Many of the articles presented above provided evidence against the theory that Shariah-compliant equity markets are less prone to shocks and volatility spillovers. Only four of the articles presented above provided evidence for the stability of Shariah-compliant markets in terms of volatility spillover, i.e. Bossman et al. (2022), Ahmad et al. (2018), Majdoub and Sassi (2017), and finally, Majdoub and Mansour (2014).

3.2 Decoupling and risk transmission articles:

The decoupling hypothesis relates to certain asset classes performing differently under certain circumstances. In relation to Shariah-compliant indices, the decoupling hypothesis states that Shariah-

compliant indices will be weakly correlated to the conventional equity market or other Shariah-compliant markets. (Shahzad et al., 2017)

Although this topic is somewhat different from the volatility spillover literature, this set of studies contributes to the overarching thesis that Shariah-compliant indices are less risky during economic crises relative to the conventional stock market.

The first article examined in this section is by Shahzad and Naifar (2022). Their findings provided evidence for the decoupling of Shariah-compliant equities from their conventional counterparts. Here, the authors examined the dynamic dependence within the Shariah-compliant and conventional equity sectors using network analysis. During the Covid-19 pandemic sector volatility increased. Additionally, Shariah-compliant and conventional investors both diversify their portfolios between Shariah-compliant and conventional sectors respectively. It is therefore imperative to understand the dependence or interrelatedness of these sectors.

Using daily closing price data of twenty sectoral Shariah-compliant and conventional indices for the period 01 August 2015 to 20 August 2020, the paper supported the idea that Shariah-compliant equities can provide safety during crisis periods, providing empirical evidence for the decoupling hypothesis.

The main points from this study showed that the financial sector mostly affected the other sectors for conventional equities, whereas the industrial sector was the main source of linkage to the other Shariah-compliant equity sectors. All Shariah-compliant and conventional sectors were both receivers and transmitters of volatility spillover during Covid-19. There were stronger dependency effects between the sectors for conventional equities than Shariah-compliant equities during Covid-19. And finally, the study showed that Shariah-compliant equities behaved differently than conventional equities during normal times and crisis periods, which implies the decoupling theory.

Likewise, Erdoğan, Gedikli and Çevik (2020) conducted a study using the Turkish financial market and presented evidence in favour of the decoupling theory. It is important to note that the Shariah-compliant financial market in Turkey is only a small portion of the conventional market in Turkey.

Daily prices from the Istanbul stock exchange were used for the period 10 February 2011 to 02 September 2020 and the DCC-GARCH method was applied in the analysis. Findings showed that the contagion effect was present in the Turkish stock market, and as a result, correlations between the stock markets and the S&P 500 3-month realised volatility index had significantly increased during the global Covid-19 pandemic. The results further suggested that the Shariah-compliant stock market is less susceptible to global shocks than conventional markets, suggesting that Shariah-compliant stocks

could be used as a hedging strategy during the Covid-19 pandemic. Although the Shariah-compliant financial market in Turkey is a small fraction of the financial market, the results from this study are still valid and mean that Turkish investors could use Shariah-compliant equities to hedge and diversify their portfolios. Turkey could also use the evidence of this study to promote and grow its Shariah-compliant financial market. This study is focused on the diversification properties of Shariah-compliant stocks, specifically for the Covid-19 period. The study is, however, limited in its time frame and geographical location.

Kenourgios, Naifar and Dimitriou (2016) examined the contagion effects of the global financial crisis and the European sovereign debt crisis on Shariah-compliant equity and bond (Sukuk) markets. The findings showed that the emerging BRICS Shariah-compliant indices are more effective for portfolio diversification compared to the developed markets.

Data used for this study consisted of daily closing prices over the period 1 June 2007 to 01 March 2015. This period covered the global financial crisis and the European sovereign debt crisis. Kenourgios et al. (2016) used the asymmetric dynamic conditional correlation, which is then applied to a multivariate asymmetric power autoregressive conditional heteroskedasticity (ARCH) framework.

There are three sources of contagion that were assessed: the MSCI World Stock Index for equity markets, the U.S. Treasury Bill (10 years) as a source of contagion for bond markets and the Euro benchmark bond (10 years) as an additional source of contagion. The study examined the contagion effects for the MSCI Shariah-compliant stock market indices of the G7 (Canada, France, Germany, Italy, Japan, UK and US), the Shariah-compliant stock index of Europe (excluding UK) and the European Economic and Monetary Union (EMU), the MSCI Islamic stock indices of the BRICS (Brazil, Russia, India, China and South Africa), the MSCI World Islamic stock index and the Dow Jones Sukuk index.

A pairwise conditional correlation was created between the Shariah-compliant BRICS stocks, the MSCI World Stock Index, the Dow Jones Sukuk and the aforementioned bond markets. Hypothesis testing evidence suggested that Shariah-compliant stocks and bonds were decoupled from their conventional counterparts, and further suggested that they were more profitable than their conventional counterparts.

Naifar (2016) attempted to understand if global risk factors and macroeconomic conditions affect global Shariah-compliant indices or if they were a viable diversification avenue. Using the Dow Jones Islamic Market (DJIM) index, the author collected monthly equity returns for the DJIM index and used quantile regression to investigate this. The quantile regression approach allowed the results to be

observed across bull, bear and normal market conditions. The data collected spans from January 2003 to October 2014; this period incorporated the GFC and the ESDC.

DJIM index returns were modelled on some exogenous independent variables; these included the S&P500 index, the crude oil price, the slope of the yield curve, the consumer price index (CPI) and finally investor sentiment (implied volatility index). The S&P500 index was a representation of the conventional market and the investor sentiment indicated the global investor sentiment. The first regression model was run for the full period of the study (2003–2014), whereas the second model was run only for the crisis period of 2008–2014 and had an additional independent variable, the five year credit default swap (CDS) index, which was an indication of global sovereign debt.

The results of the first model indicated that the DJIM index had a statistically significant relationship with the conventional market (S&P 500 Index), the volatility index and the slope of the yield curve for all quantiles. Investor sentiment and crude oil prices were only positively statistically significant for the lower quantiles. The second model focused on the period of the GFC and ESDC, and revealed that there was a positive relationship between the returns of the DJIM index and the sovereign credit crisis. Here, the possibility of large co-movements existed, and these undiversifiable risks meant that the theory of diversification is limited. To further support these results, an extension is required to include other Shariah-compliant developed and emerging markets.

Here evidence for the decoupling hypothesis was presented, with a total of four articles examined, three of which provide evidence for the decoupling hypothesis.

3.3 Safe-haven and Hedging abilities of Shariah compliant equities

The below articles relate to Shariah-compliant equities being used as safe-haven investments and their abilities to hedge against financial loss in times of economic turmoil. Safe-haven assets are formally defined as assets that are negatively correlated or uncorrelated with other assets for specific periods only, such as during crisis times or during heightened uncertainty. During these times equity investors typically resort to safe-haven assets like gold (Arif, Naeem, Hasan, Alawi, and Taghizadeh-Hesary, 2022). This ties into the topic of discussion due to the initial argument that Shariah-compliant equities, based on their reduced volatility, are less risky investments despite their returns not being significantly affected by this.

Arif et al. (2022) contemplated the safe-haven properties of G7 Shariah-compliant stocks, during the GFC and the Covid-19 pandemic. The study examined the time-varying cross-quantile correlation to observe the evolution of Shariah-compliant stocks' safe-haven potential. The benefit of this model was that it allowed for concentration on the lowest tails of the distribution rather than the whole

distribution. Therefore, the model helped make inferences about the safe-haven potential of an asset when stocks were in adverse market conditions and when they were in extreme conditions.

The study used DJIM data from the G7 countries, namely Canada, France, Germany, Italy, Japan, the UK and the US. The period for this study spanned from 02 January 1996 to 29 January 2021, which included the GFC and the Covid-19 pandemic.

The results from this study indicated that over the full sample period, 1996–2021, the DJIM for the G7 countries did not possess safe-haven properties. However, during the GFC sub-period, there was evidence for limited diversification. Further to this, the sub period for the Covid-19 pandemic displayed the strongest evidence for the G7 DJIM index's ability to provide a safe-haven during crisis periods. This was not the case for the Japanese equity market, which was the least affected by the Covid-19 pandemic compared to the other G7 markets. This result is limited to developed markets and requires an extension to emerging markets.

Salisu and Sikiru (2020) looked at the effects of the pandemic on Shariah compliant financial assets. The study made use of daily Asia Pacific data for the Dow Jones Composite Average stock index (DJCA) and the Asia Pacific Shariah-compliant stock price index, proxied by the DJIM Asia Pacific index. Data was extracted for the period 31 August 2010 to 15 September 2020, which incorporated the period of the Covid-19 pandemic. Specifically, the paper examined how efficient the Asia Pacific Shariah-compliant stock market was at hedging against the Uncertainty of Pandemics and Epidemics (UPE) by using a predictor series based on the recently developed measure of UPE by Baker et al. (2020).

The preliminary statistics computed from the data already showed higher returns and lower volatility in Shariah-compliant stocks relative to conventional stocks during the COVID-19 pandemic. Thereafter, a predictive model was constructed that quantified the response of the DJIM Asia Pacific index as well as the conventional market to UPE.

This predictor technique provided evidence for the hedging potential for Asia Pacific stocks during pandemics and epidemics, although the hedging benefit during the Covid-19 pandemic was shown to be lower.

As cited above, the evidence for Shariah compliance as an alternative investment strategy for diversification and hedging is mixed. The evidence presented incorporates different methodologies and time frames, with no method consistently resulting in the same conclusion. Given all the studies cited above, only two have included South African market data. The longest time frame based on the above studies for volatility spillover is 15 years, with some studies excluding certain important timeframes. In order to expand and rectify these gaps in the literature, this study seeks to incorporate

all these salient features. That is to incorporate data for the South African market and extend the time frame of the study to include multiple crisis periods, namely the GFC, Covid-19, the European sovereign debt crisis and the Russia-Ukraine conflict.

Additionally, the methodology used in this study is unique, with no other study on volatility spillover among Shariah-compliant indices adopting this approach, namely the time varying connectedness approach of Gabauer (2020), which is an enhancement of the Diebold and Yilmaz (2012, 2014) spillover index.

4. Data

4.1 Data set

The objective of this study is to evaluate the volatility spillover between developed and emerging Shariah-compliant indices.

This analysis uses daily index price data from 22 September 2003 to 31 March 2023 collected from Bloomberg. This comprises of 5 094 observations.

The indices used span across 7 geographical locations, that being: the US, Canada, Europe, the UK, Asia Pacific, Japan, and South Africa. All indices used are from developed markets, except for the South African index, which represents an emerging market, and the Asia Pacific index, which includes some emerging markets such as India, Malaysia, Pakistan, China, Indonesia, Singapore, the Philippines, Pakistan, and Sri Lanka. Table 1 summarises the indices used and is further expanded on below:

Table 3 Summary and brief description of Indices

Bloomberg Ticker	Index	Name	Currency	Region	Description
IMUS	US Islamic	Dow Jones Islamic Market US Index	USD	US	The Dow Jones Islamic Market US Index tracks American companies that meet Shariah compliant principles. The index is quoted in USD.
DJIEU	Europe Islamic	Dow Jones Islamic Market Europe Index	USD	Europe	The Dow Jones Islamic Market Europe Index was created for people who wish to invest in Shariah compliant companies in Europe. The index is quoted in

					USD and is disseminated by the Dow Jones and data feed of the Chicago Board of Trade.
DJIAP	Asia-Pacific Islamic	Dow Jones Islamic Market Pacific Stock Index	USD	Pacific Rim	The Dow Jones Islamic Market Asia-Pacific Index measures the performance of Shariah compliant equities, in the Asia-Pacific region. The index is in quoted in USD and is calculated and disseminated by the Dow Jones and data feed of the Chicago Board of Trade.
DJIUK	UK Islamic	Dow Jones Islamic Market UK Index	USD	UK	The Dow Jones Islamic Market UK Index was created to track Shariah compliant stocks in the United Kingdom. The index is disseminated by the Dow Jones and data feed of the Chicago Board of Trade.
DJIJP	Japan Islamic	Dow Jones Islamic Market Japan Index	USD	Japan	The Dow Jones Islamic Market Japan Index was created for people who wish to invest in Shariah compliant stocks in Japan. The index is quoted in USD and disseminated by the Dow Jones and data feed of the Chicago Board of Trade.
DJICA	Canada Islamic	Dow Jones Islamic Market Canada Index	USD	Canada	The Dow Jones Islamic Market Canada Index was created for people who wish to invest in Shariah compliant equities in Canada. The index is quoted in USD and is disseminated by the Dow Jones and data feed of the Chicago Board of Trade.

JSH40	South Africa Islamic	JSE Shariah Top 40 Index	USD	South Africa	The JSE Shariah Top 40 Index is derived from Shariah compliant stocks listed on the JSE and taken from the JSE Top 40 index in South Africa.

The DJIM US index was launched in February 2000. It has been designed to measure the performance of US equities that meet the Shariah investment guidelines. As of March 2023, the index had 568 constituents, 40% of which fall within the technological sector and 15.8% in healthcare. The high technological sector weighting for index reflects the growth and expansion in technological sector. The highest weighted stocks in this index were Apple incorporated and Microsoft corporation due to its large market capitalization and its compliance with Shariah principles. The remaining sectors include industrials, consumer services, consumer goods, financials, oil and gas, basic materials, and utilities, where percentage weightings are 11.2%, 10.1%, 9.4%, 5.4%, 5.1%, 2.6%, and 0.1%, respectively. The float-adjusted market capitalisation weighting method is used to rebalance the index quarterly in March, June, September, and December. For ease of refence, the sector weightings have been added as Appendix A. (S&P Global, 2023)

The Dow Jones Islamic Market Europe index was launched in May 1999 and tracks the Shariah compliant stock market in Europe. It consists of 332 equities, with the highest weighted sectors being healthcare, consumer goods, industrials, technology, and basic materials, with percentage weightings of 29.9%, 20.7%, 20.3%, 14.1%, and 7.9%, respectively. The float-adjusted market capitalisation weighting method is used to rebalance the index quarterly in March, June, September, and December. For ease of refence, the sector weightings have been added as Appendix A. (S&P Global, 2023)

The Dow Jones Islamic Asia Pacific index was launched in May 1999 and tracks the Pacific Rim stocks that are Shariah compliant. This index includes companies from 15 different countries, namely: Japan, China, Taiwan, India, Australia, South Korea, Thailand, Hong Kong SAR (China), Malaysia, Indonesia, New Zealand, Singapore, the Philippines, Pakistan, and Sri Lanka. The countries with the highest constituents are China, South Korea, Japan, Taiwan, and India. As of March 2023, the index had 2 444 constituents, with technology being the highest weighted sector, followed by industrials, healthcare, consumer goods, and basic materials; their weightings are 32.3%, 18.7%, 12.5%, 11.8%, and 11.1%, respectively. The float- adjusted market capitalisation weighting method is used to rebalance the index quarterly in March, June, September, and December. For ease of refence, the sector weightings have been added as Appendix A. (S&P Global, 2023)

The DJIM UK index was developed to track UK stocks that comply with sharia law based Islamic investment requirements. This index has had an annualised growth rate of 2.21% since its inception. (Bloomberg, 2023)

The DJIM Japan index was developed to track Japanese stocks that comply with Shariah-based Islamic investment requirements. This index has had an annualised growth rate of 6.17% since inception. (Bloomberg, 2023)

The DJIM Canada index was developed to track Canadian stocks that comply with Shariah-based Islamic investment requirements. This index has had an annualised growth rate of 13.78% since its inception. (Bloomberg, 2023)

The screening methodology used for the Dow Jones Islamic indices is twofold: the first is a business screen, and the second is an accounting-based leverage compliance screen. Business activities need to be in line with Shariah law. Non permissible business activities include all activities relating to alcohol, tobacco, electronic cigarettes, recreational cannabis products, pork-related products, conventional finance (excluding Islamic banks and Takaful insurance companies), financial services, and entertainment (hotels, casinos/gambling, cinema, pornography, music, etc.). Since businesses and companies have become more integrated and complex, revenues from non-compliant activities are tolerated, provided that these revenues are less than 5% of the business income. (S&P Global, 2023) This is calculated by:

$$\frac{Non\ Permissable\ Income}{Total\ revenue} \quad (1)$$

After removing companies with non-permissible primary business activities, companies are further excluded based on the amount of debt and interest bearing instruments. This is the accounting screen and should be limited to 33%, and is calculated according to the below:

$$\frac{Total\ Interest\ Bearing\ Debt}{Trailing\ 24\ month\ Average\ Market\ Capitalisation} \quad (2)$$

Note that the denominator could also be based on total assets and not market capitalisation. Stocks deemed compliant at the prior evaluation period that exceed the maximum at the current evaluation period remain compliant if the ratio is within two percentage points of the maximum allowed. However, if the maximum is breached for three consecutive evaluation periods the stock will be deemed non-compliant. If the ratio is above the two-percentage point buffer limit, the stock is deemed noncompliant immediately. (S&P Global, 2023)

Finally, the JSE Shariah Top 40 Index is derived from Shariah compliant stocks listed on the JSE and taken from the JSE Top 40 Index. The index tracks the performance of Shariah-compliant South African companies and comprises 17 constituents. As of March 2023, the highest weighted sector was basic materials, which accounts for 78.35% of the fund, followed by industrials, telecommunications, healthcare, and real estate, weighing 9.77%, 3.19%, 2.98%, and 2.11%, respectively. The high weighting of basic materials is a function of South Africa's economy, given that a significant portion of exports relate to mining and raw materials, which in turn creates a relatively larger basic materials sector.

Here, the screening methodology is relatively similar to the methodology used by the Dow Jones Islamic Market Index, with the difference relating to the second part of the screen. The following financial ratios must be met for companies to be considered Shariah-compliant:

- Debt is less than 33.333% of total assets;
- Cash and interest-bearing items are less than 33.333% of total assets;
- Accounts receivable and cash are less than 50% of total assets;

Here, the accounting screens are based on total assets and not the 12-month trailing market capitalisation. This ensures companies do not pass the screening criteria due to market price fluctuations, allowing the methodology to be less speculative and more in keeping with Shariah. (JSE, 2023)

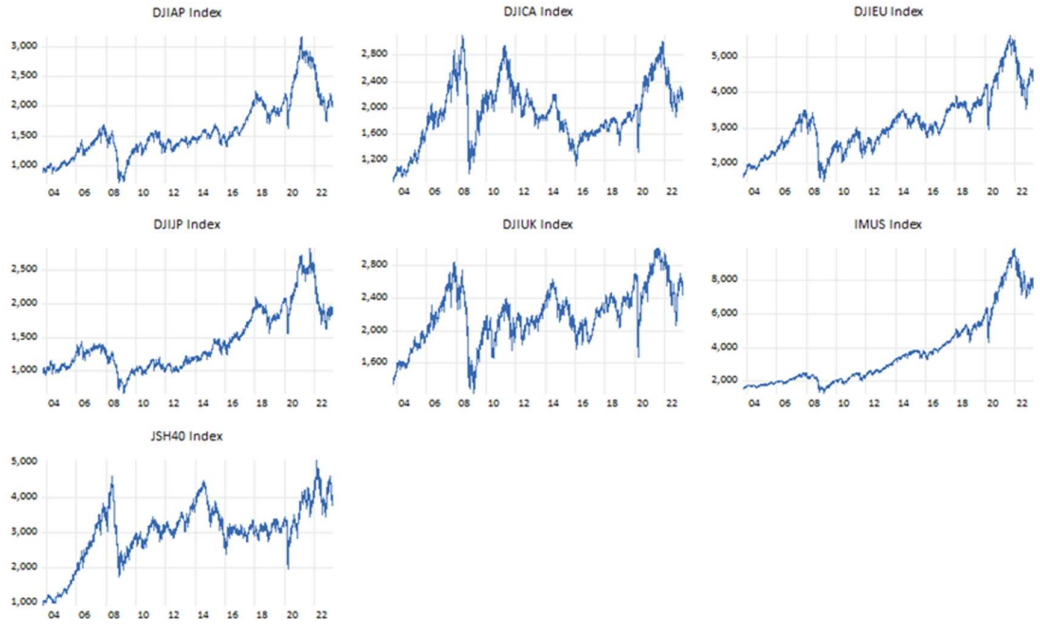

Figure 1 Daily prices of the different indices used, plotted from September 2003 to March 2023

Figure 1 displays the daily closing prices throughout the period of the study. The X-axis represents the chronological timeline, where "04" corresponds to the year 2004 and "22" corresponds to the year 2022. The Y-axis denotes the share price of the index. An immediate notable point to make is the significant decline in the daily prices of all the indices during economic global crisis periods. The first sharp decline can be seen in the GFC period of 2008; the sudden and notable decline in March 2020 is attributed to the Covid-19 pandemic, and finally, another decline in all Indices is shown in late February 2022 due to the Russia-Ukraine conflict.

The DJIM Canada index shows a notable downturn in prices starting late 2014 and reaches its lowest point, in line with GFC lows, at the end of 2015 and the beginning of 2016. There are multiple factors that have led to this decline; some of them include the global economic slowdown and concern over China's economic stability. Being a resource rich country, the sharp decline in the oil price also affected Canada's energy related stocks. (Government of Canada, 2023)

The JSE Shariah Top 40 Index shows a significant growth in prices until the GFC in 2008. The recovery of the index after the GFC is once again robust until the South African Finance minister was fired in December 2014 which led to political and economic instability in country. Even after the Covid-19 pandemic there is strong growth in the index price, all suggesting a strong increase in demand for Shariah-compliant investing in South Africa.

The US Shariah compliant index is conservative from 2004 up until 2020, with a noticeable increase from 2020. Similar increases are seen in all developed Islamic indices, however the JSE Shariah Top 40 Index displays relatively more volatility over this period.

4.2 Motivation for methodology

To determine if the GARCH model is a good fit for the data used, the daily closing prices are converted to daily returns. These returns are calculated as shown below:

Equations: $Rt = Yt = \ln (P_t/P_{t-1})$ (3)

Where P_t is the daily closing price on trading day *t* for each index.

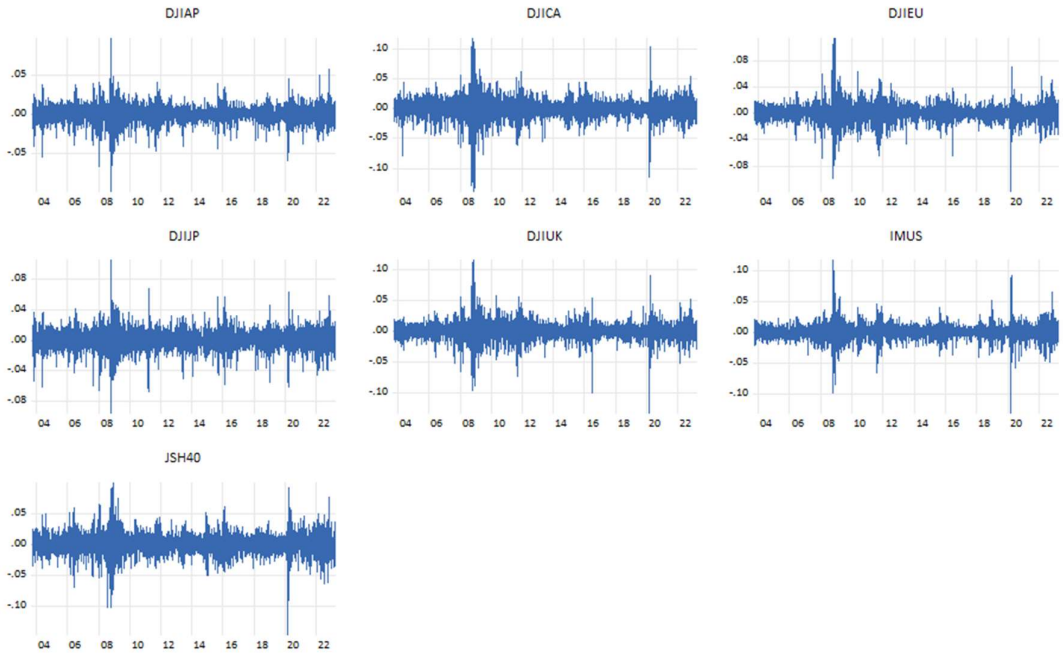

Figure 2 Daily returns of the Shariah compliant indices

In Figure 2 the X-axis represents the chronological timeline, where "04" corresponds to the year 2004 and "22" corresponds to the year 2022. The Y-axis denotes the daily returns of the index. Figure 2 demonstrates volatility clustering for all the indices; this can be defined as volatility that changes over time, and its degree shows a tendency to persist. To further elaborate, the graph of indices shows that there are periods of low volatility and periods where volatility is high. Significant volatility clustering is seen for each of the index returns; it can be confirmed that the data displays autoregressive conditional heteroskedasticity, and therefore the use of a GARCH model for volatility is appropriate.

Table 4 Summary statistics for the Shariah compliant indices returns

	DJIAP	DJICA	DJIEU	DJIJP	DJIUK	IMUS	JSH40
Mean	0.000166	0.000178	0.000209	0.000134	0.000129	0.000322	0.000271
Median	0.000727	0.000686	0.000491	0.000141	0.000383	0.000415	0.000000
Maximum	0.096905	0.118689	0.114505	0.106591	0.116768	0.117405	0.099737
Minimum	-0.096878	-0.137681	-0.117805	-0.095475	-0.131457	-0.128880	-0.143787
Std. Dev.	0.010904	0.016156	0.012690	0.012736	0.013453	0.011992	0.015812
Skewness	-0.450654	-0.738775	-0.216870	-0.222006	-0.349430	-0.399014	-0.279109
Kurtosis	9.733370	13.09504	12.58063	7.690597	12.78120	15.32675	8.562371
Jarque-Bera	9795.469	22093.72	19522.02	4711.706	20410.01	32386.32	6633.147
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ERS	-28.531***	-29.588***	-30.848***	-33.308***	-31.989***	-30.891***	-23.879***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Q(10)	99.747***	11.669**	39.444***	16.657***	42.455***	21.058***	14.097***
	(0.000)	(0.031)	(0.000)	(0.002)	(0.000)	(0.000)	(0.009)
Q2(10)	3356.882***	783.195***	1317.643***	932.807***	763.692***	1689.099***	803.431***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	5 094	5 094	5 094	5 094	5 094	5 094	5 094

Additionally, Table 4 shows summary statistics for all Shariah compliant index returns, where each of the means is close to zero, slight negative skewness is observed, and kurtosis figures are all larger than 3, indicating a leptokurtic distribution.

Further to this, the Jacque-Bera statistics have p-values less than 5%, indicating that the assumption of normality is rejected at the 1% level of significance.

The results from Figure 2 and Table 4 motivate further for the use of a GARCH model. According to Table 4, the ERS unit root test of Elliot et al. (1996) confirms that all return series are stationary. Significant autocorrelation is also observed, further motivating the use of the GARCH approach, as it shows that time varying variance co-variance structures would be more suitable (Engle, 2002).

The emerging market of South Africa has the second largest standard deviation in comparison to all other developed countries, as well as the lowest minimum statistic. This is in line with the expectation

that the emerging markets are riskier than the developed markets. South Africa also has the second lowest maximum statistic, with the Asia Pacific market exhibiting the lowest maximum statistic.

The Canadian market has both the highest maximum statistic and the highest standard deviation, implying that there is potential for higher returns but not without the associated risks.

5. Methodology

This study employs the methodology of Gabauer (2020), the dynamic connectedness approach. This model is an improvement of the Diebold and Yilmaz Spillover index (2012, 2014) which also incorporates Engle's 2002 DCC-GARCH Model.

The dynamic connectedness approach was developed by Diebold and Yilmaz (2009, 2012, 2014) to study volatility spillover. This procedure is based on the decomposition of forecast error variance using vector auto-regression (VAR). The first step in the process is to estimate the time varying volatility using a multivariate generalised autoregressive heteroskedasticity (GARCH) model, which is then used in the estimation of the rolling-window vector auto-regression estimation.

One of the notable downsides to this methodology is that if the first step is not correctly estimated, then the second step is based on an inaccurate estimate. Another disadvantage of this method is that the window sizes are often chosen arbitrarily, and using the rolling-window analysis leads to a loss of observations.

It is for this reason that Gabauer (2020) introduces the Volatility Impulse Response Function (VIRF) as an alternative method for measuring volatility spillover. For this method, the author seeks to provide VIRFS for the DCC-GARCH model, which is based on Engel (2002).

The DCC GARCH (1,1) model is defined as:

$$\boldsymbol{y}_t = \boldsymbol{\mu}_t + \epsilon_t \quad \text{, where} \quad \epsilon_t \mid \boldsymbol{F}_{t-1} \sim N(\boldsymbol{0}, \boldsymbol{H}_t) \tag{4}$$

$$\epsilon = \boldsymbol{H}_t^{1/2} \boldsymbol{u}_t \quad \boldsymbol{u}_t \sim N(\boldsymbol{0}, \boldsymbol{I}) \tag{5}$$

$$\boldsymbol{H}_t = \boldsymbol{D}_t \boldsymbol{R}_t \boldsymbol{D}_t \tag{6}$$

Where yt, μt, ϵt, and ut represents the conditional mean, error term, and standardized error term, respectively. They are all N×1-dimensional vectors representing the analysed time series.

F_{t-1} represents all information available up to t-1. R_t, H_t, and Dt are N × N-dimensional matrices, illustrating the dynamic conditional correlations, time-varying conditional variance–covariance matrices, and the time-varying conditional variances; with D_t = diag(h1⁄2 11t , … , h1⁄2 NNt)

For the first stage, D_t is initially created by estimating a Bollerslev (1986) GARCH model for each series. One shock and one persistency parameter are based on Hansen and Lunde (2005) and are written below:

$$h_{ii,t} = \omega + \alpha\epsilon_{i,t-1}^2 + \beta h_{ii,t-1} \quad (7)$$

The second stage computes the dynamic conditional correlation, shown below:

$$\boldsymbol{R}_t = \operatorname{diag}\left(q_{iit}^{-1/2}, \ldots, q_{NNt}^{-1/2}\right) \boldsymbol{Q}_t \operatorname{diag}\left(q_{iit}^{-1/2}, \ldots, q_{NNt}^{-1/2}\right) \quad (8)$$

$$\boldsymbol{Q}_t = (1 - a - b)\overline{\boldsymbol{Q}} + a\boldsymbol{u}_{t-1}\boldsymbol{u}_{t-1}' + b\boldsymbol{Q}_{t-1} \quad (9)$$

Where Q_t, and $\bar{Q}$ are N × N-dimensional positive-definite matrices, they represent the conditional and unconditional standardised residuals variance covariance matrices respectively.

a (α) and b (β) are nonnegative shock and persistency parameters, which has to satisfy the condition a + b < 1 ($\alpha + \beta \leq 1$).

If a + b < 1, Qt and hence Rt are varying over time. If this condition is not fulfilled then this model would converge to the CCC-GARCH model, where Rt is constant over time.

The Volatility Impulse Response Function represents the impact of a shock in variable *I* on variable *j*'s conditional volatilities, and the equation is defined below:

$\boldsymbol{\Psi}_g$ = VIRF(J, $\boldsymbol{\delta}_{j,t}$, $\boldsymbol{F}_{t-1}$) = $E(\boldsymbol{H}_{t+J} \mid \epsilon_{j,t} = \boldsymbol{\delta}_{j,t}, \boldsymbol{F}_{t-1}) - E(\boldsymbol{H}_{t+J} \mid \epsilon_{j,t} = \boldsymbol{0}, \boldsymbol{F}_{t-1})$, (10)

Where, $\eth j,t$ represents a selection vector with a one at the j^{th} position and zero otherwise.
VIRF can be calculated iteratively with three steps, those steps are:

1) Calculate the conditional volatilities ($D_{t+h}|F_t$) using univariate GARCH(1, 1):

$$E(h_{ii,t+1} \mid \boldsymbol{F}_t) = \omega + \alpha\delta_{1,t}^2 + \beta h_{ii,t} h = 1, \quad (11)$$

$$E(h_{ii,t+h} \mid \boldsymbol{F}_t) = \sum_{i=0}^{h-1} \omega(\alpha + \beta)^i + (\alpha + \beta)^{h-1} E(h_{ii,t+h-1} \mid \boldsymbol{F}_t) h > 1, \quad (12)$$

2) The second step relates to predicting E ($Q_{t+h}|F_t$) and uses the below formulae,

$$E(\boldsymbol{Q}_{t+1} \mid \boldsymbol{F}_t) = (1-a-b)\overline{\boldsymbol{Q}} + a\boldsymbol{u}_t\boldsymbol{u}_t' + b\boldsymbol{Q}_t h = 1, \tag{13}$$

$$\begin{aligned} E(\boldsymbol{Q}_{t+h} \mid \boldsymbol{F}_t) =& (1-a-b)\overline{\boldsymbol{Q}} + aE\left(\boldsymbol{u}_{t+h-1}\boldsymbol{u}_{t+h-1}' \mid \boldsymbol{F}_t\right) \\ &+ bE(\boldsymbol{Q}_{t+h-1} \mid \boldsymbol{F}_t)h > 1, \end{aligned} \tag{14}$$

Where $E\,(\boldsymbol{u}t+h-1\boldsymbol{u}'t+h-1 \mid \boldsymbol{F}t) \approx E(\boldsymbol{Q}t+h-1 \mid \boldsymbol{F}t)$

3) The third step derives the conditional variance–covariances:

$$\begin{aligned} E(\boldsymbol{R}_{t+h} \mid \boldsymbol{F}_t) \approx \operatorname{diag}\left[E\left(q_{\mathrm{iil}+h}^{-1/2} \mid \boldsymbol{F}_t\right), \ldots, E\left(q_{\mathrm{NN}t+h}^{-1/2} \mid \boldsymbol{F}_t\right)\right] \\ E(\boldsymbol{Q}_{t+h}) \operatorname{diag}\left[E\left(q_{iit+h}^{-1/2} \mid \boldsymbol{F}_t\right), \ldots, E\left(q_{\mathrm{NN}t+h}^{-1/2} \mid \boldsymbol{F}_t\right),\right. \end{aligned} \tag{15}$$

$$E\left(\boldsymbol{H}_{t+h} \mid \boldsymbol{F}_t\right) \approx E\left(\boldsymbol{D}_{t+h} \mid \boldsymbol{F}_t\right) E\left(\boldsymbol{R}_{t+h} \mid \boldsymbol{F}_t\right) E\left(\boldsymbol{D}_{t+h} \mid \boldsymbol{F}_t\right). \tag{16}$$

Based on the Volatility Impulse Response Function, the generalised forecast error variance decomposition (GFEVD) is shown below: This is interpreted as the variance share of one variable that explains the others. These variance shares are normalised ensuring that each row sums up to one. In other words, all variables together explain 100% of variable i's forecast error variance.

$$\tilde{\phi}_{i,t}^{g}(J) = \frac{\sum_{i=1}^{J-1} \Psi_{i,1,}^{2,g}}{\sum_{j=1}^{N} \sum_{i=1}^{J-1} \Psi_{i,j,t}^{2,g}}, \tag{17}$$

Where, $\sum_{j=1}^{N} \tilde{\phi}_{ij,t}^{\mathrm{g}}(J) = 1$ and $\sum_{i,j=1}^{N} \tilde{\phi}_{ij,t}^{g}(J) = N$

The numerator indicates the cumulative effect of the i[th] shock and the denominator indicates the aggregate cumulative effect of all the shocks.

The total connectedness index (TCI) can be constructed using the GFEVD, shown below:

$$C_t^{\mathrm{g}}(J) = \frac{\sum_{i,j=1, i \neq j}^{N} \tilde{\phi}_{ij,t}^{\mathrm{g}}(J)}{N} \tag{18}$$

To calculate the **total directional connectedness TO others, we calculate the below**

$$C_{i \rightarrow j,t}^{\mathrm{g}}(J) = \frac{\sum_{j=1, i \neq j}^{N} \tilde{\phi}_{ji,t}^{\mathrm{g}}(J)}{\sum_{j=1}^{N} \tilde{\phi}_{ji,t}^{\mathrm{g}}(J)} \tag{19}$$

To calculate the **total directional connectedness FROM others,** the below equation is used. This represents the spillovers variable i receives from variables *j*, and is represented below:

$$C^{g}_{i\leftarrow j,t}(J) = \frac{\sum_{j=1,i\neq j}^{N} \tilde{\phi}^{g}_{ij,t}(J)}{\sum_{i=1}^{N} \tilde{\phi}^{g}_{ij,t}(J)} \quad (20)$$

In order to ascertain the net total directional connectedness, we subtract the two aforementioned measures from each other, and interpret the result as the influence variable *i* has on the analysed network. This is shown below:

$$C^{g}_{i,t} = C^{g}_{i\rightarrow j,t}(J) - C^{g}_{i\leftarrow j,t}(J) \quad (21)$$

A positive net total directional connectedness result indicates that *i* is a net transmitter, and a negative net total directional connectedness result indicates that *i* is a net receiver of shocks.

Finally, the determination of the net pairwise directional connectedness (NPDC) is shown below:

$$\mathrm{NPDC}_{i,j}(J) = \tilde{\phi}^{g}_{Ji,t}(J) - \tilde{\phi}^{g}_{i,t}(J) \quad (22)$$

Here a positive NPDC_{ij} means that variable *i* dominates variable *j*. Alternatively, a negative NPDC_{ij} means that *j* dominates *i*.

6. Results

6.1 Net receivers and transmitters of volatility and Total Connectedness index

Table 5 Dynamic Connectedness Approach Matrix

	IMUS Index	DJIEU Index	DJIAP Index	DJIUK Index	DJIJP Index	DJICA Index	JSH40 Index	FROM
IMUS Index	52.33	11.24	2.30	10.60	0.44	18.82	4.27	47.67
DJIEU Index	13.08	42.43	5.94	21.28	1.94	7.59	7.73	57.57
DJIAP Index	3.48	7.96	52.71	6.18	21.31	3.25	5.11	47.29
DJIUK Index	14.82	25.26	5.45	37.89	1.60	6.64	8.35	62.11
DJIJP Index	0.83	3.34	28.35	2.32	62.30	1.21	1.66	37.70
DJICA Index	27.99	10.04	3.23	7.56	0.95	45.29	4.95	54.71
JSH40 Index	8.02	12.41	6.04	11.45	1.50	5.99	54.58	45.42
TO	68.23	70.25	51.31	59.38	27.73	43.50	32.06	352.48
Inc Own	120.56	112.68	104.02	97.27	90.03	88.79	86.64	TCI
NET	20.56	12.68	4.02	-2.73	-9.97	-11.21	-13.36	50.35
NPT	6.00	5.00	2.00	4.00	0.00	3.00	1.00	

Table 5 is a matrix of the total connectedness for all the indices in this study. Each row displays the generalised forecast error variance decomposition and is used to explain 100% of the volatility for the index. This relates to equation (17). The row entitled "Net" relates to the net volatility transmitted or received from the other indices, where an index below zero is associated with a net receiver of volatility. This relates to equation (21).

There is an average influence of a shock of above 50%. The average total connectedness of 50% indicates a high interdependence among the Shariah-compliant indices examined. This measure does not show the time varying connectedness; to examine this, we refer to the below graph:

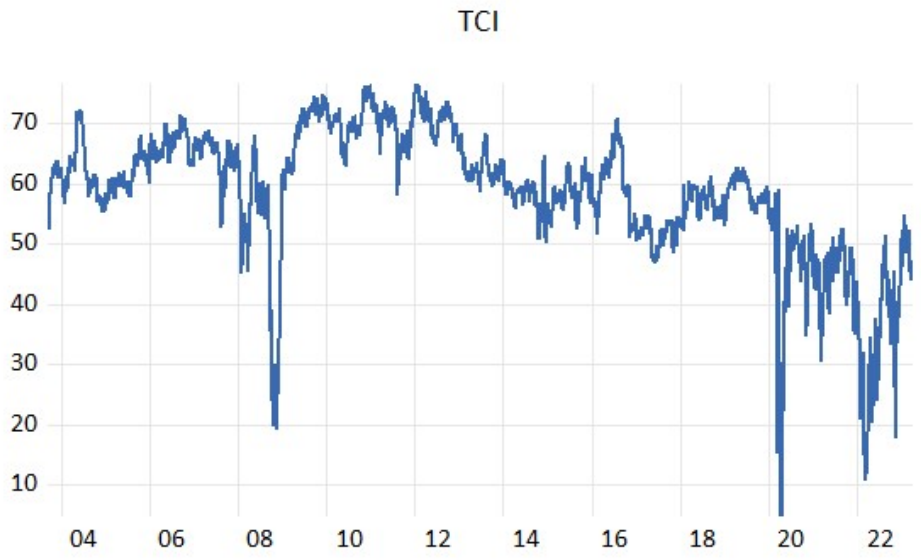

Figure 3 Total Connectedness Index (TCI)

In figure 3 the X-axis represents the chronological timeline, where "04" corresponds to the year 2004 and "22" corresponds to the year 2022. The Y-axis denotes the total connectedness index. The total connectedness index, relating to equation (18), and illustrated in Figure 3, shows that the range of the total connectedness index is between 5% and 75% over the years 2003 to 2023. The lowest index is observed in April 2020, followed by March 2022 and November 2008. These time periods coincide with the Covid-19 Pandemic, the Russia Ukraine conflict and the global financial crisis, respectively.

The low index of the economic crisis indicates that during this time the Shariah compliant indices were not highly correlated. This implies the decoupling of Shariah compliant indices during periods of economic crisis.

High interconnectedness was observed from 2004 to 2007; in this period, the index ranged between 50% and 70%. During the GFC the index decreased significantly and dropped to a low of about 20%. Post the GFC period the index returns to a range of 50% to 70% until the Covid-19 pandemic, where it drops to below 10%. In March 2022 we again observe a sudden decrease in the total connectedness index, this coincides with the Russia-Ukraine conflict. Following the Russia-Ukraine conflict total connectedness decreased and has not yet breached the 55% level.

The result in this study, based on Figure 3, is contrary to the results shown by multiple previous studies. These studies done by Ghaemi Asl et al. (2023), Bossman et al. (2022), Yarovaya et al. (2021), Hassan et al. (2020), Balli et al. (2019), Ahmad et al. (2018) and Shahzad et al. (2017), as mentioned

in the literature review, demonstrate that during periods of economic turmoil, volatility spillover intensifies.

Although various studies discussed in the literature review section did not exclusively study Shariah-compliant equities and included conventional equities, we still would like to highlight some comparisons.

Figure 4 below graphs the volatility spillover index on the Y- axis, whereas the X-axis represents the chronological timeline, from 2016 to 2021. Figure 4 is extracted from Bossman et al. (2022) and shows that Shariah compliant markets are more stable during crisis periods than their conventional counterparts. These crisis periods relate to the Chinese market crash in January 2016, the Brexit effect in 2016, and the announcement of the first confirmed case of COVID-19 infection in China on 7 January 2020. The increase in intensity is not as pronounced within the Shariah compliant indices as it is in the G7 indices, however it does increase slightly during crisis periods.

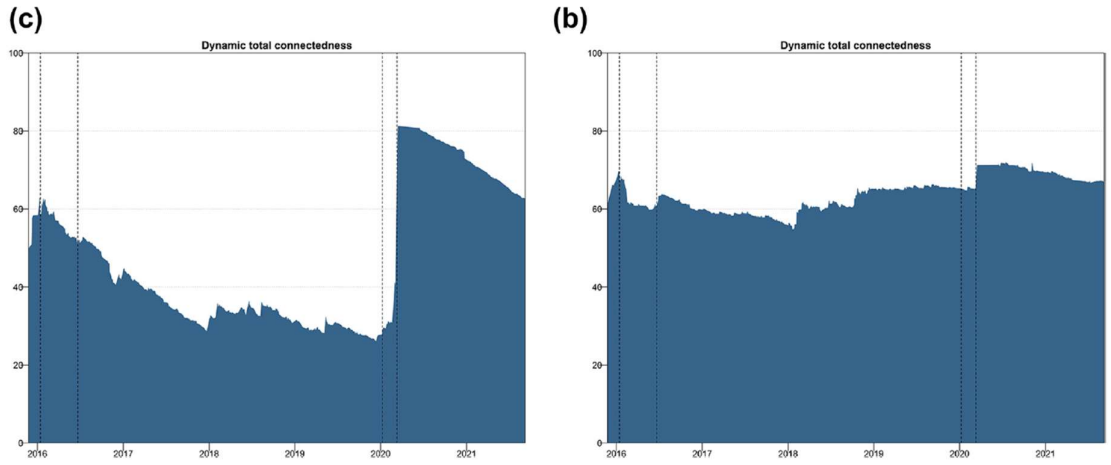

Figure 4. Total connectedness index. (a) – between Islamic and G7 markets; (b) – between Islamic markets only; (c) – between G7 markets only.

Figure 4 Source **:** Bossman et al. (2022)

Balli et al. (2019) also demonstrates that the spillover index intensifies during economic crisis periods. This is shown in figure 5, where volatility index spillover is shown on the Y- axis. The X-axis corresponds to the timeline, where "12" corresponds to the year 2012 and "18" corresponds to the year 2018. The volatility index is shown by the black line. The volatility index intensified during the period of 2015 to 2017. This period represents the economic instability of the Middle East caused by the crisis of the ISIS escalation threat, geopolitical conflicts in the Middle East and the Brexit referendum.

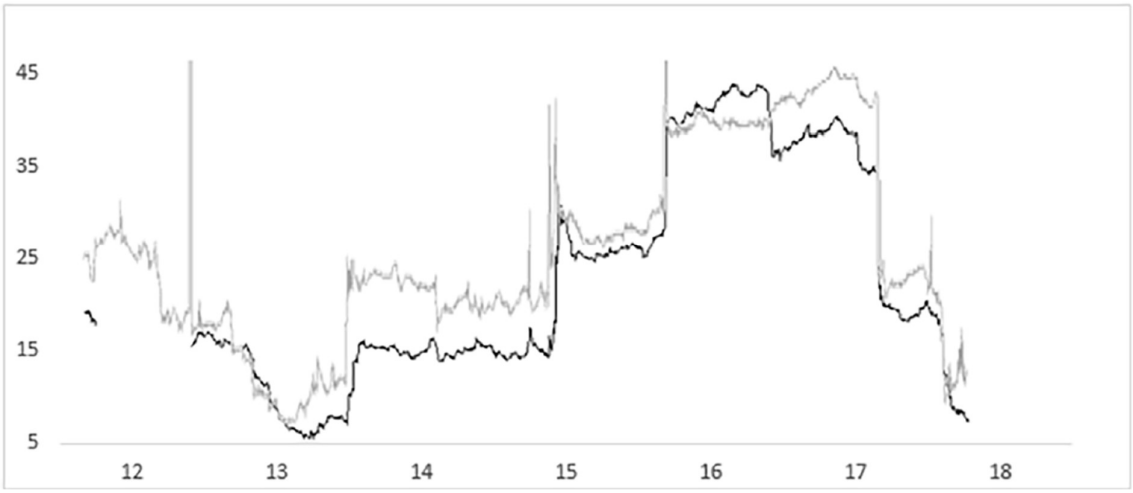

Figure 5 Source: Balli et al. (2019)

The contradictory results from this study compared to previous research could be due to the differences in methodology used to derive the spillover index. Further to this, the countries used in the study by Balli et al. (2019) are all concentrated around the Middle East, whereas this study used countries that are predominantly located in the West and have developed economies, except for the South African data from the JSE. The different sample periods across the studies could also explain the difference in results. Balli et al. (2019) used an index with an inception date of 2011, which excludes the GFC, a significant economic crisis.

Returning to Table 5, and in line with our objective to contribute to the existing literature by increasing the empirical evidence on South African Shariah-compliant equities, we will start by discussing in detail the results of the JSE Shariah Top 40 Index. The volatility transmission for the JSE Shariah Top 40 Index is shown in the seventh row of Table 5. These results show that 54.58% of the JSE Shariah Top 40 Index FEVD is explained by its own volatility, with the balance of 45.42% transmitted from the other six indices. Interestingly, the main contributors of volatility to the JSE Shariah Top 40 Index are from the DJIM EU index and DJIM UK index, contributing 12.41% and 11.45% respectively. The next biggest contributors are DJIM US index and DJIM Asia Pacific, with 8.2% and 6.04%, respectively. Finally, the least significant index in terms of volatility transmission is the DJIM Canada index, contributing 5.99% and the DJIM Japan index contributing 1.50%.

The DJIM US index receives 52.33% of its volatility from itself. The biggest contributor to the remaining 47.67% is predominantly comprised of 18.82% from the DJIM Canada index, 11.24% from the DJIM Europe index, and 10.60% from the DJIM UK index. The remaining contributions are relatively insignificant, at 4.27% from the JSE Shariah Top 40 Index, 2.3% from the DJIM Japan index, and 0.44% from DJIM Asia Pacific. As expected, the DJIM US Index receives most of its volatility from its close

neighbour, the DJIM Canada index, and from the other developed market indices. We also expect that the indices from the smaller and developing economies will have less of an impact on the US index.

The DJIM Europe Index receives 42.43% of its volatility from itself. The DJIM UK index is the biggest contributor to volatility spillover, contributing 21.82%. The DJIM US index contributes 13.08%, the JSE Shariah Top 40 Index contributes 7.73%, the DJIM Asia Pacific index contributes 5.94% and the smallest contribution is 1.94% from the DJIM Japan index.

The DJIM Asia Pacific index receives 52.71% of its own volatility, with the next biggest contributor coming from the DJIM Japan index, which contributes 21.28%. 7.96% of the volatility is contributed by the DJIM Europe index, with 6.18% contributed by the DJIM UK index, 5.11% contributed by the JSE Shariah Top 40 index, 3.48% contributed by the DJIM US index and lastly, 3.25% contributed by the DJIM Canada index. An interesting observation is that the DJIM US index and the DJIM Canada index have the least impact on the DJIM Asia Pacific index, this could be due to the geographical proximity of the countries.

The DJIM UK index receives 37.89% of its volatility from itself; the next biggest contributor is the DJIM Europe index, which contributes 25.26%. 14.82% is contributed by the DJIM US index, 8.35% is contributed by the JSE Shariah Top 40 Index, 6.64% is contributed by the DJIM Canda index and 5.45% is contributed by the DJIM Asia Pacific index. The smallest contribution is by the DJIM Japan index, which contributes only 1.60%. An interesting observation about this index is that it has the lowest own volatility contribution. All other indices contribute above 40% to their own volatility.

The DJIM Japan index received 62.30% of its volatility from itself. The remaining 37.7% of its volatility comes from the DJIM Asia Pacific, which contributes 28.35%. The remaining 9.35% comes from the five other indices, with each index contributing less than 3.5% each. An interesting observation from this index is that it has the highest own volatility contribution of 62.30%, with the majority of the remaining volatility coming from the DJIM Asia Pacific index.

Lastly, the DJIM Canada index received 45.29% of its volatility from itself, as expected, the next biggest contributor to volatility is the DJIM US index at 27.99%. It received 10.04% of its volatility from the DJIM Europe index and 7.56% of its volatility from the DJIM UK index. The smallest contributors to this index are the JSE Shariah Top 40 Index, the DJIM Asia Pacific Index, and the DJIM Japan index, contributing 4.95%, 3.23% and 0.95% respectively.

Next, we assess the impact from the JSE Shariah Top 40 Index to other indices. The highest transmission to other countries is seen on the DJIM UK index, where it contributes 8.53% to the DJIM UK index. It is the fourth largest contributor out of the seven indices (including own); with DJIM Canada, DJIM Pacific,

and DJIM Japan indices having smaller contributions to the volatility of the DJIM UK index. Given the 11.45% impact that DJIM UK index has on the JSE Shariah Top 40 Index, we can conclude that the DJIM UK index is a net transmitter of volatility to the JSE Shariah Top 40 Index.

The second largest impact the Shariah Top 40 JSE index has on another index is 7.73%, and it is on the DJIM Europe index. Here it is also the fourth largest contributor out of the seven indices (including own), with the DJIM Canada index, the DJIM Asia Pacific index, and the DJIM Japan index transmitting all contributing less to the DJIM Europe index, contributing 7.59%, 5.94%, and 1.94%, respectively. Given the 12.41% contribution of the DJIM Europe index to the JSE Shariah Top 40 Index, it can be concluded that DJIM Europe is a net contributor to the volatility of the JSE Shariah Top 40 Index.

The third largest contribution of the JSE Shariah Top 40 Index is 5.11% to the DJIM Asia Pacific index. Here, it is the fifth largest contributor to the DJIM Asia Pacific index. Based on the 6.04% contribution of the DJIM Asia Pacific index to the JSE Shariah Top 40 Index, it can be concluded that the DJIM Asia Pacific is a net transmitter of volatility to the JSE Shariah Top 40 index. For the DJIM Asia Pacific index, the DJIM US index and DJIM Canada index both contribute less than the JSE Shariah Top 40 index.

The fourth largest impact that the JSE Shariah Top 40 Index has on other indices relates to the DJIM Canada index, at 4.95%. Comparing this to the 5.99% that the DJIM Canada index has on the JSE Shariah Top 40 Index, it can be concluded that DJIM Canada index is a net transmitter of volatility to the JSE Shariah Top 40 Index.

The JSE Shariah Top 40 Index contributes 4.27% of all volatility to the DJIM US index; this is the fifth largest contribution from the JSE Shariah Top 40 Index to the other indices. The DJIM US contributes 8.02% to the volatility of the JSE Shariah Top 40 Index; this means that the DJIM US index is a net transmitter of volatility to the JSE Shariah Top 40 Index.

Lastly, the smallest contribution by the JSE Shariah Top 40 index is 1.66% is to the DJIM Japan index. This means that the DJIM Japan index received minimal volatility spillover from the JSE Shariah Top 40 index. The converse is also true which means the that the two indices do not significantly affect each other. The DJIM Japan index contributes slightly less to the JSE Shariah Top 40 Index, at 1.50%, making the JSE Shariah Top 40 Index a net transmitter of volatility to the DJIM Japan index.

The results for the JSE Shariah Top 40 Index spillover can be used to better understand how to mitigate risk and diversify a South African Shariah-compliant portfolio. This study will also discuss, later, the time varying net pairwise connectedness and network analysis for a deeper understanding of the above discussion.

Turning attention to the row entitled ‘Net’ relates to the net volatility transmitted or received from the other indices and reveals further important results. Table 5 identifies the DJIM US index as the main net transmitter of volatility, with a net total directional connectedness of 20.56%. Figure 6 reiterates the dominant influence of the IMUS over the full sample period, as the net total directional connectedness for the DJIM US index never falls below zero.

The results also show that the second and third largest transmitters of volatility are the DJIM Europe index and DJIM Asia Pacific index, which have been net transmitters of volatility with net total directional connectedness figures of 12.68% and 4.02%, respectively.

In contrast, the net receivers of volatility were the JSE Shariah Top 40 Index, the DJIM Canada index, the DJIM Japan index, and the DJIM UK index with net total connected values of -13.36%, -11.21%, -9.97% and -2.27% respectively. The JSE Shariah Top 40 Index is the largest receiver of volatility, which could be due to the fact that emerging markets are usually at risk of any contagion effects from developed markets. South Africa, being an emerging market, is usually influenced by the more developed economies, which is generally why risk and instability transmission from their economies is commonplace. This is true for the relationship between the DJIM US index and the JSE Shariah Top 40 index, as can be seen from the volatility index matrix.

Nonetheless, the above results are static. To understand how these dynamics change through the period for each index, Figure 6 is plotted. Figure 6 displays the time-varying net total directional connectedness for the Shariah compliant indices on the Y-axis and the X- axis represents the chronological timeline, where "04" corresponds to the year 2004 and "22" corresponds to the year 2022. In this graph, the connectedness figure that is above zero is a net transmitter, and below zero is a net receiver.

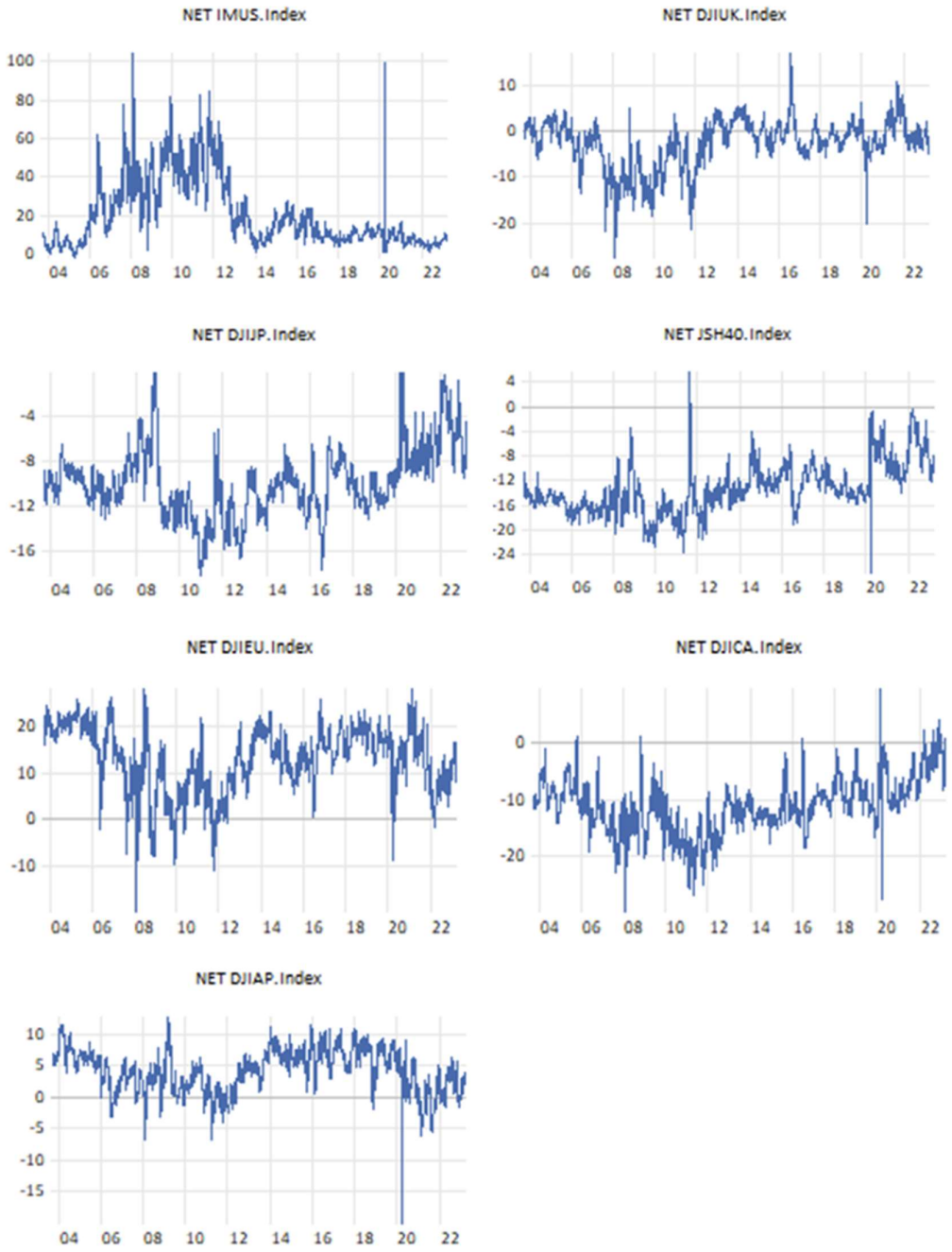

Figure 6 Time-varying net total directional connectedness among the Shariah compliant indices.

Focusing on the JSE Shariah Top 40 Index, we observe that, as per the initial results, the index is a net receiver of volatility and generally ranges from 0 to -24 throughout the sample period. The exceptions to this are in 2011 and 2020. In 2011, the index became a net transmitter of volatility, and this coincided with a strong commodity boom for the country in 2011. Allan Gray notes that in 2011, South Africa experienced a decade long commodity price boom, and that the South African economy managed to escape unscathed by the crushing austerity measures affecting Europe. (Liddle, 2012)

The other exception for the JSE Shariah Top 40 Index is in 2020, where the range decreased to below -24. This point coincides with the peak of the Covid-19 pandemic, where the economic disruptions were at their highest. We further note a decrease in the index in late February 2022, which causes the intensity of total directional connectedness to decrease for the JSE Shariah Top 40 index. This coincides with the Russia-Ukraine conflict.

Figure 6 also displays that the DJIM US index transmission of volatility peaks around the major economic crisis. The first of these relates to the GFC, around late 2007 and early 2008, where we see a significant increase in the volatility transmission. The transmission rate remains relatively high compared to 2004 and up until 2013. The second peak of transmission occurs around the beginning of the Covid-19 pandemic, however, this quickly subsides and remains lower than 20 for the remainder of the period. For the DJIM US index, there is no significant change in patterns or directions for the Russia-Ukraine conflict.

The DJIM UK index is predominantly a net receiver for most of the period, with some periods being a net transmitter. The general band of this index ranges from 10 to -20. The first period outside of this band can be seen at the beginning of 2008, which coincides with the GFC; here the index falls to below -20. In July 2016, the DJIM UK index becomes a net transmitter of volatility, with a significant increase in volatility that peaks at around 20. This period of transmission coincides with the Brexit vote. During this time, the UK was in political and economic turmoil, which caused a lot of uncertainty and volatility in the market. From mid-2020, as the Covid-19 pandemic and lockdowns intensified, we can also see a sharp increase in the extent of receiving volatility; however, this is not more significant than the period of the GFC. For the DJIM UK index there are no significant and persistent changes in patterns or directions for the Russia-Ukraine conflict.

The DJIM Japan index is a net receiver throughout the sample period, and the connectedness amount never goes above zero. The volatility transmission decreases (by becoming less positive) around the GFC and the Covid-19 pandemic. Interestingly, this is in line with the findings of Shahzad et al. (2017), where Japan is shown to be a net receiver of volatility over the long run, despite this study including the conventional markets. Notably, in February 2022, there is an increase (by becoming more negative)

in the intensity of volatility spillover to the DJIM Japan index. This coincides with the Russia-Ukraine conflict.

The DJIM Europe index is mainly a net transmitter of volatility ranging from 0 to 30 predominantly. During extreme market conditions we observe that the index becomes a receiver of volatility. These periods include the GFC of 2008, and some points thereafter. Notably, we see the index drop in the period of the ESDC in 2012, and finally, we see similar behaviour at the onset of the Covid-19 pandemic. In February 2022, there is a noticeable increase in the DJIM Europe index that goes from negative to positive. This increase coincides with the Russia-Ukraine conflict but does not significantly breach the general band.

The DJIM Canada index is also predominantly a net receiver of volatility and ranges between 0 and -20. We see extreme changes in the direction and magnitude of the graph during economic crisis periods. These include the GFC of 2008, headwinds faced by the Canadian economy in 2015 and 2016 (as previously mentioned) and the Covid-19 pandemic of 2020. During the recent Covid-19 pandemic, the Canadian index became a net transmitter of volatility. In February 2022, there seems to be a sharp increase, causing the DJIM Canada index to become a net receiver, but this increase is not persistent as the index becomes a net receiver of volatility shortly thereafter. The index continues to fluctuate after this point.

The DJIM Asia Pacific index has generally been a net transmitter of volatility, ranging mainly between 0 and 10. The index occasionally becomes a net receiver of volatility between 2006 and 2012. The DJIM Asia Pacific index then becomes a significant net receiver of volatility in early 2020 during the Covid-19 pandemic and reaches a low of -15; the index remains as a receiver of volatility during the remainder of 2020 until early 2022. The period around the Russia-Ukraine conflict shows a noticeable increase in the index, where it goes from negative to positive. This causes the DJIM Aisa Pacific index to go from being a net receiver of volatility to a net transmitter of volatility, however, this does not breach the general bands of the index.

The aforementioned literature reviews have all included the conventional market in their studies, and where studies are limited to only Shariah compliant equities (like this study), the country indices used are significantly different from the country indices used in this study.

As a result, we cannot make direct comparisons, but we can draw some similarities despite the differences in the data used. Based on Shahzad et al. (2017), the time varying net total directional connectedness derived in their study confirms some of the findings above. These similarities are, considering the inclusion of conventional financial markets in Shahzad et al. (2017), that the DJIM US

index is a net transmitter for the whole sample period, and the DJIM Japanese index is the net receiver of volatility for the whole sample period.

The results from Table 5 and Figure 6, coupled with previous evidence from some of the literature review articles, reiterate the US is a dominant transmitter of volatility to other markets. This result is to be expected given that the US is the largest contributor to the global market, based on stock market capitalisation, the dollar being the dominant reserve currency, foreign directs investment and global trade.

6.2 Net Pairwise Connectedness and Network Analysis

The below section discusses the net pairwise connectedness between two indices (the pair) in Figure 7.1 to 7.3, and then further plots this graphically in Figure 8 to visualise the relationships. In Figure 7.1 to 7.3, if the index remains above zero it means that the first index is a net transmitter of volatility to the second index, and if the index falls below zero it means that the first index is net receiver of volatility from the second index. This relates to equation (21) in the methodology section of this paper.

In Figure 8, a thicker line between the pairs represents a stronger relationship, conversely, a thinner line between the pairs represents a weaker relationship. Net receivers of volatility are shaded in yellow, whereas net transmitters are shaded in blue.

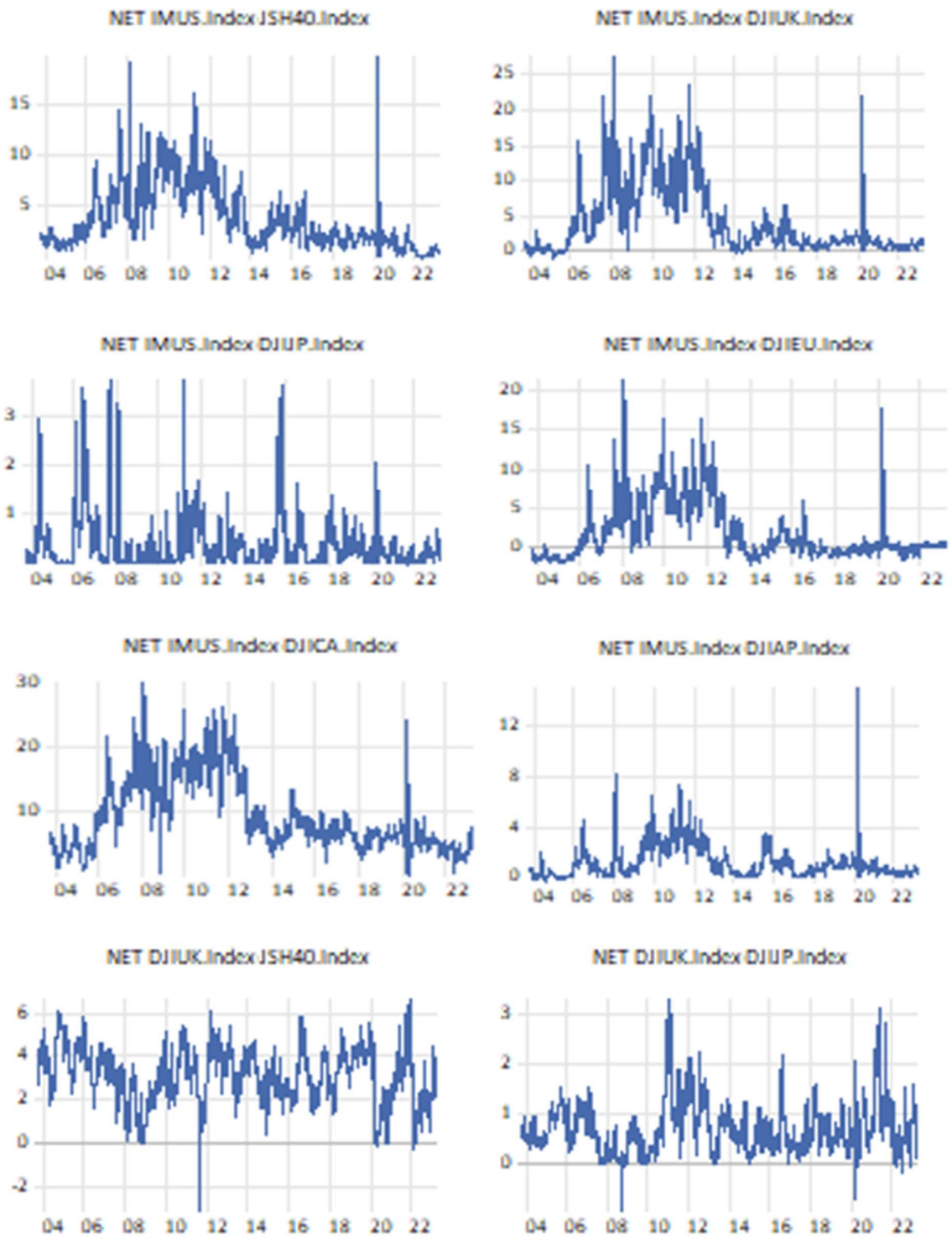

Figure 7.1 Net Pairwise Connectedness

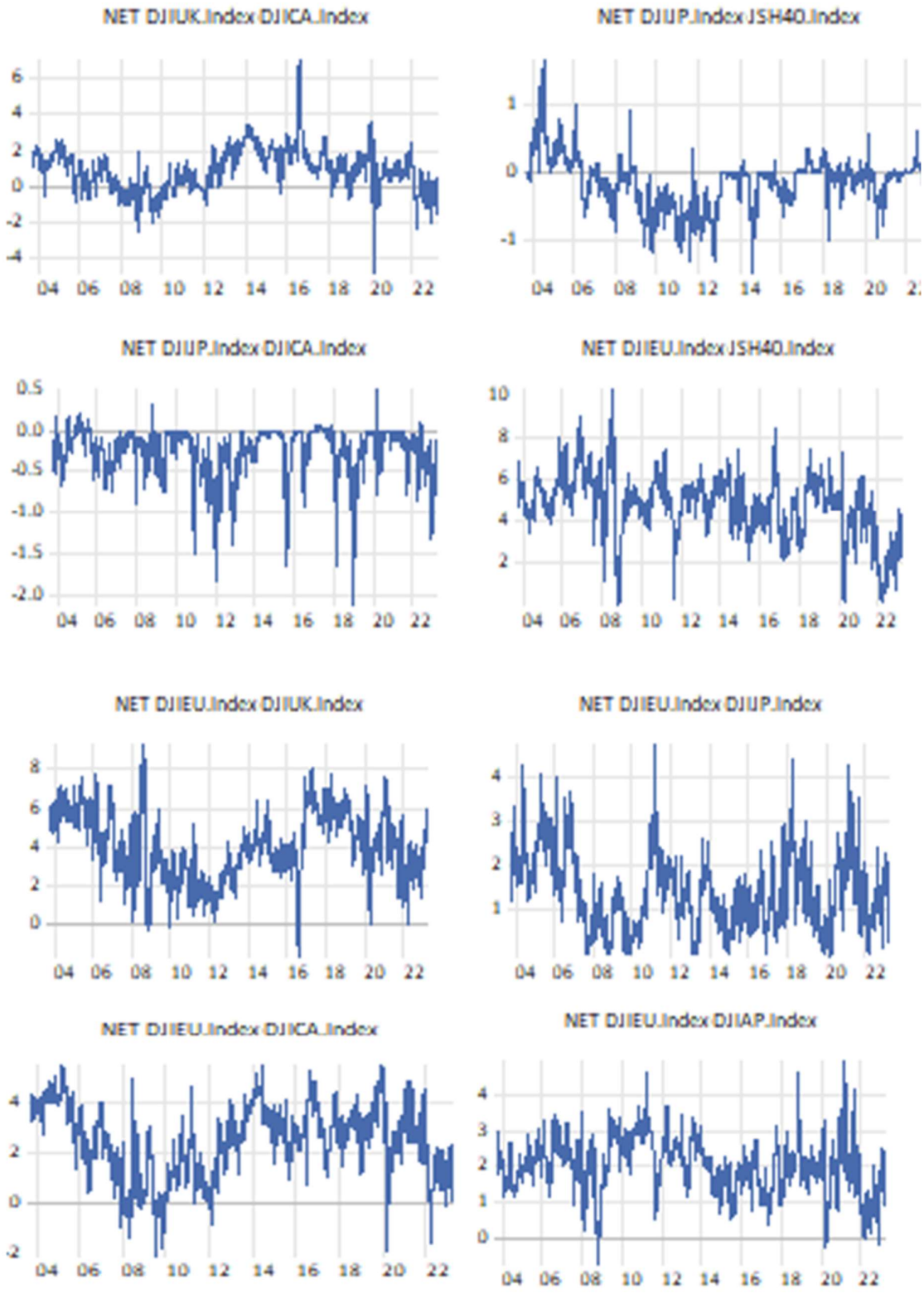

Figure 7.2 Net Pairwise Connectedness

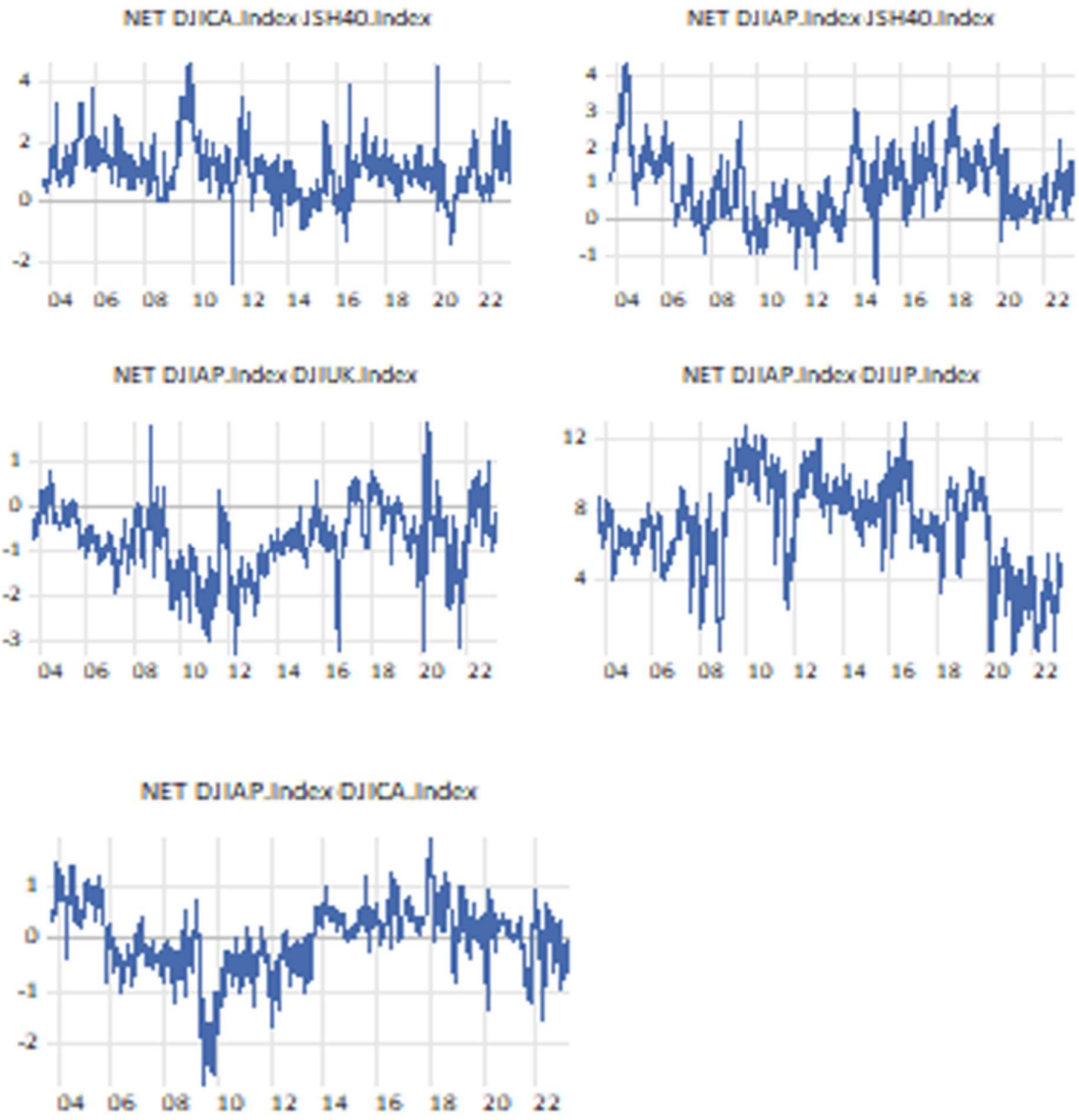

Figure 7.3 Net Pairwise Connectedness

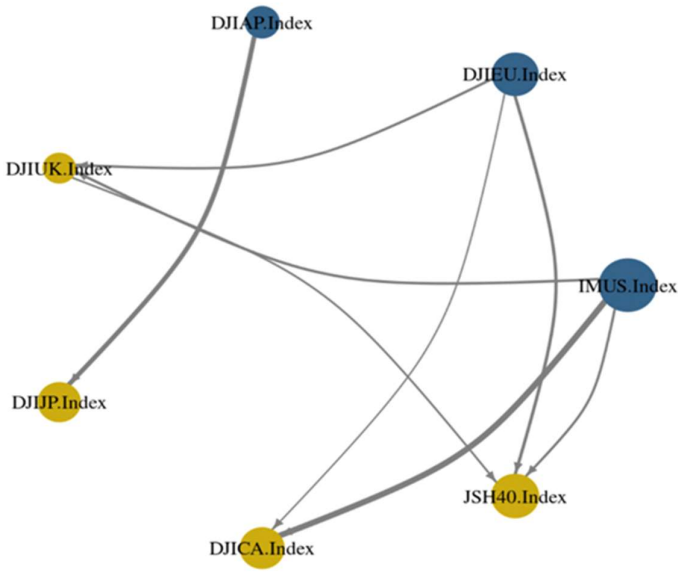

Figure 8 Network analysis Diagram

The relationship between the DJIM US Index and the JSE Shariah Top 40 index is displayed in the first graph in Figure 7.1. From this we can see that the DJIM US index transmits volatility to the JSE Shariah Top 40 index for the entire period, as the graph never falls below zero. This relationship is also shown in Figure 8. Figure 7.1 further displays that during times of economic crisis the DJIM US index transmits a significantly increased amount of volatility to JSE Shariah Top 40 index. The most notable of these increases relate to the GFC of 2007/2008 and the Covid-19 pandemic in 2020. The impact of the Russia-Ukraine conflict on this pair is negligible, as there is no significant increase or decrease in the spillover.

A similar relationship is seen with the DJIM US index, the DJIM UK index and the DJIM Japan index. Where the DJIM US index is a net transmitter of volatility to the DJIM UK and DJIM Japan index for the full sample period and occasionally the graphs hover around zero. In both relationships we note that during the crisis periods (GFC, ESDC and Covid-19 pandemic), there is a higher degree of volatility transmission to these indices. The impact of the Russia-Ukraine conflict on these pairs are also negligible as there is no significant increase or decrease in the spillover.

The relationship between the DJIM US index and the DJIM Europe index is more dynamic. Here, the DJIM US index is transmitting volatility and receiving volatility, albeit in a relatively smaller amount. During some periods the graph hovers around the zero line (2012-2022), other times the index is very high (2008–2012). From 2004 to 2006 the DJIM US index receives volatility, but the index did not fall

very far below zero, meaning that this effect was not as strong. From late 2007 to 2012 the DJIM US index transmitted a large degree of volatility to the DJIM Europe index, between 0 and 15, with a peak of 20 during the GFC. From 2012 to 2014 the index hovers around zero with the only significant outlier of 18 being in 2020, which coincides with the Covid-19 pandemic. The impact of the Russia-Ukraine conflict on this pair is negligible as there is no significant increase or decrease in the spillover.

The DJIM US index is a net transmitter of volatility to both the DJIM Canada index and the DJIM Asia Pacific index. Both indices remain higher than zero throughout the sample period. Once again, there seems to have been a significant increase in volatility transmission during the economic crisis periods, those being the GFC of 2007/ 2008, the European debt crisis of 2011 /2012 and the Covid-19 pandemic of 2020. The impact of the Russia-Ukraine conflict on this pair is negligible as there is no significant increase or decrease in the spillover.

Figure 7.1 shows that the relationship between the DJIM US index and the DJIM Canada index is the strongest, with the DJIM US index dominating the DJIM Canada index in terms of volatility spillover.

The above findings reinforce the previous results that the DJIM US index dominates as the net volatility transmitter for the full sample period, especially during economic crises. Even when the DJIM US index receives volatility spillover from the DJIM Europe index, the extent of this is slight, as the graph does not breach the -1 threshold. As previously discussed, the DJIM US index being a net transmitter to the other indices is not an unexpected result, it is logical given that the US is the largest contributor to global market capitalization.

The next relationship to examine is that of the DJIM UK index and the JSE Shariah Top 40 index. For most of the period the DJIM UK index is a net transmitter of volatility to the JSE Shariah Top 40 index. The range varies from 0 to 6 generally except in 2011 when the JSE Shariah-compliant index becomes a net transmitter of volatility to the DJIM UK index. As previously mentioned, the period of the JSE Shariah Top 40 index being a net transmitter of volatility coincides with a commodity price boom for South Africa. In late February 2022, there is a noticeable increase in transmission from the DJIM UK index which coincides with the Russia-Ukraine conflict; however, this increase in transmission does not breach 4.

The DJIM UK index is also a net transmitter of volatility to the DJIM Japan index except in the year 2008 and 2020. These periods coincide with the GFC and the Covid-19 pandemic respectively. Like the previous pair, in late February 2022, the DJIM UK index increased its transmission post the Russia-Ukraine conflict; however, this is minor and does not create an outlier.

In Figure 7.2 the relationship between the DJIM UK index and the DJIM Canada index is a more dynamic one, and generally ranges between 3 and -2. The DJIM UK index is mainly a net transmitter from 2004 to mid-2006. During the GFC of 2007 and 2008 the DJIM UK index became mostly a net receiver of volatility. From 2012 to 2020 the DJIM UK index becomes mostly a net transmitter of volatility to the DJIM Canada index, peaking at 6 in 2016, which coincides with the Brexit vote. In early 2020 the graph swiftly and significantly falls below zero to -4 making the DJIM UK index a net receiver of volatility. This coincides with the Covid-19 pandemic. Post Covid-19 the DJIM UK index swiftly returns to being mostly a net transmitter of volatility. In late February 2022 there is a relatively small increase in the transmission of volatility from the DJIM UK index, which coincides with the Russia-Ukraine conflict; however, the relationship after this date makes the DJIM UK index predominantly a receiver of volatility from the DJIM Canada index.

The next graph shows that the DJIM Japanese index was only a net transmitter of volatility from 2004 to 2006. Thereafter, DJIM Japan is mostly a net receiver of volatility from the JSE Shariah Top 40 index, except in 2008, 2011, 2020, and 2022. These periods relate to the GFC, the commodity boom in South Africa, Covid-19 and the Russia-Ukraine conflict in late February 2022.

The DJIM Japanese Index is a net receiver of volatility from the DJIM Canada index for the vast majority of the period. Some exceptions to this are in 2008, 2020 and very slightly in 2022, however, the DJIM Japan index returns swiftly to being a net receiver of volatility. These periods coincide with the GFC, the Covid-19 pandemic, and the Russia-Ukraine conflict.

The DJIM Europe index is a net transmitter of volatility to the JSE Shariah Top 40 index for the entire period. This is in line with the idea that there is a strong influence of developed markets over emerging markets. The most notable peak here is shown in 2008 during the GFC where the degree of volatility transmission is seen to be at its highest at 10. Another notable peak is in 2016 which coincides with Brexit. We further note that the impact of the Russia-Ukraine war in February 2022 is minimal. Based on Figure 8, we note that the influence of the DJIM Europe index over the JSE Shariah compliant index is the third strongest relationship.

The DJIM Europe index is a net transmitter of volatility to the DJIM UK index; however, there are periods of significant change in the index in 2008, 2016, 2020 and 2022. The decrease in 2008 relates to the GFC. In 2016 the DJIM Europe index was a net receiver of volatility from the DJIM UK index, this coincided with the start of Brexit in June 2016. The decrease in 2020 and 2022 coincides with the Covid-19 pandemic and the Russia-Ukraine conflict, both events cause the index to reach zero but do not breach it.

In line with all previous evidence, the DJIM Europe index is a net transmitter to the DJIM Japan index for the whole sample period. The index ranges between 0 and 4 and never breaches zero. We note no significant changes in patterns for the Russia-Ukraine conflict in February 2022.

The DJIM European index and the DJIM Canada index pair show that the DJIM Europe index is a net transmitter of volatility and ranges from 0 to 4 predominantly. Significant changes in the index can be seen in 2008, 2020 and 2022. The 2008 sudden increase in volatility spillover coincides with the GFC. Other notable changes include the Covid-19 pandemic in 2020 and the Russia-Ukraine conflict in early 2022.

The relationship between the DJIM Europe index and the DJIM Asia Pacific index ranges predominantly between 0 and 4. Here the DJIM European index is a net transmitter to the DJIM Asia Pacific index, except on a few occasions. In 2008 the DJIM European index was a net receiver of volatility from the DJIM Asia Pacific index. This coincides with the GFC. The DJIM Europe index also briefly becomes a net receiver of volatility at the beginning of 2020 at the onset of the Covid-19 pandemic. Further observations reveal that the transmissions dropped to zero in early 2022, around the time of the Russia-Ukraine conflict.

In Figure 7.3 the DJIM Canada index is predominantly a net transmitter of volatility to the JSE Shariah Top 40 index. This graph shows that after 2011 the DJIM Canada index occasionally became a net receiver of volatility. The instances where the DJIM Canada index is the net receiver of volatility relate to the periods in South Africa with a strong commodity price boom in 2011, between late 2013 and mid-2016 when the Canadian market faced certain headwinds (as previously mentioned) and during the height of the Covid-19 pandemic in 2020. There is a slight change in the direction of the graph during the Russia-Ukraine conflict, however, the DJIM Canada index remains a net transmitter during this period.

The DJIM Asia Pacific index is predominantly a net transmitter of volatility to the JSE Shariah Top 40 index; however, the DJIM Asia Pacific index becomes a net receiver of volatility often between 2008 and 2016 and then again during the Covid-19 pandemic of 2020. It is further noted that during the Russia-Ukraine conflict of February 2022 there is a slight change the graph, but this did not significantly change the relationship between the two indices.

The DJIM Asia Pacific index is a net receiver of volatility from the DJIM UK index. The most significant changes to this were in 2008, 2011, 2016, 2020 and 2022. These coincide with the GFC, the ESDC of 2011, Brexit in 2016, Covid-19 in 2020 and the Russia Ukraine conflict in early 2022.

The DJIM Asia Pacific index is a net transmitter of volatility to the DJIM Japan index. We note significant periods of change in the degree of volatility spillover between the two. These points are observed in 2008, 2011, 2020 and 2022. All four of these points coincide with economic crises, the first being the GFC, the EDSC, the Covid-19 pandemic and the Russia-Ukraine conflict. Based on Figure 8, we note that this is the second strongest relationship between the pairs.

Finally, the last pairwise connectedness graph shows the relationship between the DJIM Asia Pacific index and the DJIM Canada index. This relationship is not consistent. The DJIM Asia Pacific index starts off as a net transmitter of volatility up until 2006; thereafter, it becomes predominantly a net receiver of volatility up until 2014. From 2014 to 2018 the DJIM Canada index again becomes a net transmitter of volatility to the DJIM Canada index. From 2018 onwards the relationship becomes inconsistent, ranging between 1 and -1. However, we note a significant change in the graph in 2008, coinciding with the GFC. Other notable changes in the graph relate to the Covid-19 pandemic in 2020 and the Russia-Ukraine conflict in February 2022.

7. Conclusion

Shariah-compliant investing is a subset of the conventional financial market; it follows certain faith-based principles and is also seen as a subset of ESG investing. This dissertation aimed to study the volatility spillover among Shariah compliant indices from both developing and emerging markets. This is done by investigating how volatility spillover affects various indices using a dynamic connectedness approach, focusing on whether it intensifies during economic crises. We identify which indices transmit or receive volatility shocks to ascertain which indices are the dominant net transmitter and receivers of volatility. Additionally, we explore net pairwise connectedness to gain a deeper understanding of volatility spillover.

Based on modern portfolio theory, an increase in risk should result in an increased return; however, it has been shown previously that Shariah-compliant investing has lower volatility than its conventional counterparts but still offers portfolio diversification and optimised returns for their commensurate risk levels.

We, therefore, seek to further assess this claim and contribute to some of the gaps identified in the literature review. One of these gaps included a lack of empirical studies that incorporate the South African Shariah-complaint stock exchange (JSE). We further seek to cover a longer sample period by including the Russia -Ukraine conflict. This study utilised a unique methodology to assess the volatility spillover by using the Dow Jones Islamic indices from seven countries as well as the JSE Shariah Top 40 index from South Africa ranging from 22 September 2003 to 31 March 2023.

The Dynamic Connectedness Approach by Gabauer (2020) was used, which is based on the Spillover Index of Diebold and Yilmaz (2012,2014). The dynamic connectedness approach is an improvement on the Diebold and Yilmaz (2012, 2014) approach, and instead of using generalised impulse response functions, the method uses volatility impulse response functions. Using this approach we investigated the time varying connectedness between several developed and emerging indices and identified which of the indices studied were net transmitters and net receivers of volatility.

Based on the Total Connectedness Index, we observed that during economic crises, total connectedness decreased significantly. This result provided evidence for Shariah-compliant equities being a lower volatility investment, as the volatility spillover during crisis periods was reduced. This result cannot be confirmed by the previous academic articles discussed in the literature review section. Ghaemi Asl et al. (2023), Bossman et al. (2022), Yarovaya et al. (2021), Hassan et al. (2020), Balli et al. (2019), Ahmad et al. (2018) and Shahzad et al. (2017) all provide evidence for an increase in spillover volatility or connectedness between indices during economic crisis, but it is important to note that these studies were not done for Shariah complaint indices only, they included conventional indices.

Additional results from the study showed that the DJIM US index was the dominant net transmitter of volatility during the whole sample period and that the DJIM Japan index was the main net receiver of volatility over the whole sample period. The dominance and volatility spillover of the US market over the remaining economies is one that is supported by the findings of Ahmad et al. (2018) and Shahzad et al. (2017). This result has been discussed in detail, but it is also an expected result given the size and influence of the USA. The Japanese market being a net receiver of volatility for the full sample period is supported by the results of Shahzad et al. (2017).

The outcomes of this study are relevant to global investors and portfolio managers alike, who can implement the findings to better structure portfolios to ensure enhanced risk management. The information in this study can also be used to understand how to avoid large simultaneous losses and to diversify across different geographical locations.

Although this study has contributed to the research on volatility spillover for the South African market, there are some limitations and improvements that should be disclosed. The limitation is that the South African market is rather different from the developing markets, this culminates in the differences in the sizes and dominance of certain sectors. Since South Africa is a resource rich country, most exports are raw materials, and hence, the largest constituent in the South Africa Index is basic materials. There is also a difference in the size of the stock exchange, with South Africa having significantly fewer companies listed than the developed countries. An improvement to the study could be to incorporate additional locations, especially from emerging markets, such as the Middle East and northern Africa.

The Middle East is a large contributor to Shariah compliant equities, hence future studies will benefit from their inclusion.

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Appendix A

		Sector Weightings									
Index	Constituents	Technology	Healthcare	Industrials	Consumer Services	Consumer Goods	Financials	Oil and Gas	Basic Materials	Utilities	Tele-communications
IMUS	568	40%	15,80%	11,20%	10,10%	9,40%	5,40%	5,10%	2,60%	0,10%	0,00%
DJIEU	332	14,10%	29,90%	20,30%	5,70%	20,70%	0,00%	1,10%	7,90%	0,00%	0,00%
DJIAP	2 444	32,30%	12,50%	18,70%	7,40%	11,80%	1,00%	2,80%	11,10%	1,20%	1,30%