Volatility spillover between Exchange-Traded Funds on the Johannesburg Stock Exchange

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STRCAL003

SUBMITTED TO THE UNIVERSITY OF CAPE TOWN

In fulfilment of the requirements for the degree

MASTER OF COMMERCE

Investment Management

Department of Finance and Tax

UNIVERSITY OF CAPE TOWN

Date: 8th August 2024

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12/01/2024

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Abstract

Growth in the Exchange-Traded Fund industry (ETF) has been exponential in the past decade. International research on this topic has been extensive, with less focus given to the local Johannesburg Stock Exchange (JSE). This research aims to extend the existing literature on the JSE, particularly focusing on the volatility spillover between domestic ETFs representing four major asset classes and four equity ETFs using the Diebold and Yilmaz (2012) Spillover Index. The equity ETF system includes the Satrix RESI 10 (STXRES), Satrix FINI 15 (STXFIN), and Satrix Capped INDI (STXIND). Four ETFs are selected as proxies for equities, bonds, commodities, and property. The ETFs representing the asset classes are the Satrix 40 (STX40), Satrix GOVI (STXGVI), ABSA NewGOLD (GLD), and 1Invest SA Property (ETFSAP), respectively. These two volatility systems are examined independently. The results show that the STX40 ETF is a net volatility transmitter in the alternate asset ETF system. Within the equity ETF system, the STXFIN and STXRES are net volatility receivers, and the STXIND fluctuates between receiver and transmitter of volatility over the period analysed. In the alternate asset system, ETFSAP and STXGVI are net volatility receivers, with the GLD ETF oscillating between being both a net receiver and transmitter. Furthermore, the Chicago Board Options Exchange Volatility Index (VIX) index is used to proxy foreign volatility shocks to South African financial assets. Approximately 12,5% of volatility for the full set of ETFs can be attributed to the VIX. Additionally, a regression analysis is employed to evaluate the VIX as a significant explanatory variable for measuring volatility propagation through the chosen ETFs, with the results confirming its significance solely in the equity ETF system. This study adds to the existing literature on portfolio allocation decisions by focusing on sector rotation and asset allocation strategies. Additionally, it provides insights into the diversification opportunities that JSE investors can benefit from using ETFs. The study includes periods of financial market volatility, driven by significant macroeconomic events, such as Britain's referendum vote on European Union participation, the COVID-19 pandemic, and the conflict between Russia and Ukraine.

Keywords: Volatility Spillover; ETF; JSE; Asset Allocation; Diversification; VIX

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1. Introduction

History has shown that due to the greater linkage between global supply chains and interconnected financial markets, financial contagion has become a major area of interest for market participants. A shock in one market can have serious consequences in another. Knowing the magnitude and direction of cross-market volatility spillovers benefit investors as this has implications for a given portfolio's risk (Mensi et al., 2018).

The current global geopolitical landscape is tumultuous. Following the onset of COVID-19, weaknesses in global supply chains have been exposed. Moreover, the major conflicts in Russia, Ukraine, and the Middle East have resulted in restrictions on aggregate global output leading to a highly inflationary environment. The macroeconomic trend for major economies has been deglobalisation as shown by the world's two largest economies, the United States and China (Yu and Wang, 2023). These superpowers have imposed more strict protectionist policies to insulate themselves from current global supply chain disruptions.

During periods of financial crises, contagion effects are amplified, and previously uncorrelated assets experience the same negative returns. Ahmad et al. (2013) studied the effects of the Euro-zone crisis financial contagion in emerging markets. They found that Brazil, Russia, China, and South Africa were all hit by a contagion shock. The implications of these findings provide insights for policymakers and international organisations in determining possible decoupling strategies and rescue measures to insulate vulnerable countries.

Additionally, an investor's understanding of volatility transmission is vital for asset allocation and risk management strategies. Most investors concentrate on diversification which is the negative correlation between assets to minimise portfolio risk. However, analysing whether identical significant shocks impact asset returns differently can aid investors in making informed portfolio allocation decisions (Tian & Hamori, 2016)

1.1 Background on ETFs

The South African stock market has seen major divestment for the past decade with foreign investment experiencing major outflows. For the average South African investor looking for exposure to various asset classes, the JSE ETF market has made great strides. This market now includes numerous ETFs catering to varying exposures for investors looking to diversify. An opportunity exists for both retail and institutional investors to access the market in a relatively liquid investment vehicle. Additionally, there exists an opportunity for diversification as South Africa's financial markets are heavily reliant on the commodities cycle (Boako et al., 2020). This could be viewed as counter-cyclical to the rest of the macro-economic global economy during a slowdown.

The rapid growth in the ETF industry globally has not been equally matched by research focusing on the JSE. This dissertation addresses this gap by investigating the volatility spillover effects between domestic ETFs on the JSE, specifically across four major asset classes and four equity ETFs. The primary problem addressed is understanding the dynamics of volatility transmission within ETF categories for different asset classes on the JSE. The research questions include: (1) What are the volatility spillover effects between equity ETFs and alternate asset ETFs on the JSE? (2) Which ETFs act as net transmitters or receivers of volatility within the equity and alternate asset systems? (3) How does foreign volatility, proxied by the Chicago Board Options Exchange Volatility Index (VIX), influence volatility within JSE-listed ETFs? The study employs the Diebold and Yilmaz (DY) (2012) Spillover Index to examine these questions and aims to provide insights into portfolio allocation and diversification strategies for JSE investors.

ETFs are investment vehicles that consist of an underlying group of assets that mimic the returns of a given benchmark of securities. ETFs provide investors with passive exposure to an index. These funds are traded on stock exchanges just like ordinary shares, providing an alternative to mutual funds that are managed by investment companies (Steyn, 2019). Furthermore, mutual funds are similar to unit trusts which replicate the performance of an index that market participants use as a benchmark. The liquidity and ease with which ETFs can be traded are what separates them from index mutual funds. Easley et al. (2021) propose that the rise of factor investing, and “smart” beta strategies have resulted in an explosion of new ETF products which require frequent constituent rebalancing, with security selections that are not constrained by any benchmark.

The distinction between unit trusts and ETFs arises from the fact that the former is only traded once a day at their Net Asset Value (NAV). ETFs in comparison are traded on exchanges and can be bought and sold at any time (Charteris, 2013). Charteris (2013) evaluated the price efficiency of ETFs in South Africa or rather, the deviation between the NAV of the constituent assets and the market price of an ETF and found that arbitrage opportunities existed for investors. If the ETF is undervalued, relative to the constituents, the shares can be bought in anticipation of the price appreciation.

At the same time, the constituent assets can be short-sold and then redeemed from the ETF fund manager to close out the short position. It is important to note that only authorised participants can transact with the ETF custodian as transactions in the primary market have to be in sufficiently large quantities. ETFs are attractive to both retail and institutional investors as they include a host of benefits including tax efficiency, minimisation of transaction fees, liquidity, and transparency. Charteris (2013) further elaborated on the difference in the ETF market between emerging and developed countries. She found markets differed in the composition of investors, with the latter being dominated by institutional investors. In comparison, developing stock markets were comprised primarily of retail investors.

1.2 ETFs in the South African context

The South African ETF market has seen great growth since the first ETF came into inception in late November 2000. The first Exchange-Traded Product (ETP) listed on the JSE was the Satrix 40 ETF. In the ensuing years, the number of ETPs experienced a proliferation. Exchange-Traded Notes were introduced, which is a type of unsecured debt that tracks an underlying index of securities. In the early stages of the ETP industry, an important development was the conversion of the

Satrix ETFs to new legislation (The Collective Investments Schemes Control Act 45 of 2002, 2002). The original Unit Trust Act did not suit the ETF structure, and the Collective Investment Schemes Act was more accommodative. The Unit Trust Act was too restrictive for ETF issuers as under the Unit Trust Act, a percentage of assets would always need to be held in cash by the issuer to allow for the daily purchase or sale of units. This in turn would always lead to a high tracking error for the ETF. Additionally, under this act trading for open-ended portfolios of assets was only allowed in the primary market which did not cater to the ETF's ability to be traded amongst retail investors in the secondary market (etfSA, 2020).

ETPs are known to be fully transparent, highly liquid, and fully accredited funds that are well-established in the South African financial market. In particular, retail investors have shown an affinity towards these products and have become more influential in terms of trading volumes in major equity markets. Evidence of this is shown through ETPs exerting an influence on asset price discovery and product innovation. Fund managers have thus established new ETFs that focus on thematic investment trends, abandoning the initial passive replication of benchmarks in early ETF products. Interestingly, many ETP issuers have tried and failed to gain significant traction in the local market. As such, there have been notable delistings of ETPs through the years which have targeted niche areas of the listed South African market (etfSA, 2020).

Some ETFs have been recently introduced on the JSE which provide investors with exposure to factor or style-based investing. These risk factors which all stocks are theoretically exposed to can be used to tilt portfolios in their favour, achieving a return in excess of what is predicted solely by the Capital Asset Pricing Model (Sharpe, 1964). Such examples of these Smart Beta ETFs include the Satrix momentum ETF, and Satrix RAFI 40 ETF which selects shares based on their fundamental value. Satrix Dividend Plus ETF tracks an index of shares that are expected to pay high future dividends and the NewFunds Low Volatility ETF tracks 20 highly liquid shares exhibiting low volatility and possessing low market beta (etfSA, 2020).

1.3 Active and passive ETFs

Easley et al. (2021) introduced a framework based on the form and function of the relative activeness of ETFs. Some ETFs are active in form, which means that the portfolio of assets tracked by the ETF is chosen to generate alpha. Moreover, certain ETFs are active in function, serving as components of actively managed portfolios. The authors proposed a new empirical metric to capture the activeness of an ETF, the Activeness Index. The transition of ETFs from purely passive large-scale index products to more “aggressive-passive” investment products had important implications for investors. Recently introduced ETFs allow investors to implement more complex factor and industry-focused strategies. These products provide new ways to hedge an investor’s exposure, thereby enhancing the risk-return trade-off for investors. The benefits of active ETFs have created a more competitive landscape and have challenged the established model of the active mutual fund industry. Furthermore, older passive ETF products are at risk of obsolescence as newer ETFs provide both a lower cost of passive investing and new avenues for alpha-seeking investment strategies.

Relative to actively managed mutual funds, actively managed ETFs combine the advantages of ETFs which include intraday liquidity, significantly lower expense ratios, and tax advantages (Sherril and Upton, 2017). Sherril and Upton (2017) highlight the threat of actively managed ETFs to investment companies that manage mutual funds. A detailed analysis of the actively managed investment product industry showed that ETFs are gaining market share at the expense of mutual funds. The outperformance of ETFs coupled with an investor’s propensity to chase successful past performance demonstrates that the industry is well-positioned to grow exponentially in the ensuing years.

Charteris and McCullough (2020) provide context on the rise of flows into passive equity funds in global markets. The proliferation of passive funds available to investors has been commensurate with this growth. The choices available to investors whose goals align with a passive investment strategy have increased significantly. The choice of which ETF to invest in comes down to how accurately the fund performs in replicating its benchmark.

1.4 ETF performance measurement

Charteris and McCullough (2020) further elaborated on the difference in fund tracking performance measurements used by fund managers (and academics) and what is presented to investors on minimum disclosure documents for ETFs. The two measurements were tracking error and tracking difference. The latter measurement is computed on the difference in cumulative returns on the fund and the benchmark. It indicates to potential investors the "performance gap" or relative return of the fund. In contrast, the main performance measurement figure practitioners use is the tracking error. This measures the volatility in return differences between the fund and its benchmark. Therefore, it is a measure of the relative risk of the fund. Due to the discrepancy in the performance measurement criterion, this was found to affect the implications of an investor's decision, leading to a sub-optimal outcome.

Given that ETFs attempt to track the performance of a given benchmark, intuitively, the ETF should generate returns identical to the underlying index it tracks (Kunjal et al., 2021). Blitz and Huji (2012) conclude that global emerging market ETFs exhibit high levels of tracking error during high levels of volatility, including increased tracking error during periods of high levels of dispersion among cross-sectional returns. Furthermore, emerging market funds exhibit a higher tracking error than developed market ETFs. Steyn (2019) examined the relative tracking ability of South African ETFs to their given benchmark. However, the study did not take into account the performance of ETFs during changing market conditions. Kunjal et al. (2021) extended this research by measuring ETF performance during both bull and bear market regimes. The motivation behind studying the performance during differing market regimes is that investors can suffer consequences by attempting to time the market and invest in the ETF industry at the wrong time. The results from the single index Markov switching model were that the average beta of ETFs was higher during bull markets than with bear markets. Furthermore, the tracking error was higher during bear market regimes. This suggests that South African ETFs more closely track their indices in bullish market conditions. However, this study only employed ETFs tracking the Top 40 index on the JSE and therefore its findings cannot be appropriated to other index-tracking ETF products.

1.5 Dynamic asset allocation strategies

Clifford et al. (2014) examined an ETFs ability to benefit from market timing activities in a highly liquid manner with minimal cost to the investor. The ability to time the market is in direct contradiction to the Efficient Market Hypothesis. A successful market timing strategy allows investors to minimise their downside risk exposure and therefore due to their variety, country risk components may have minimal or no effect on ETFs. Furthermore, the total volatility of ETFs with international benchmarks has exceeded that of domestic benchmarks since the 2008 Global Financial Crisis. Theoretically, this should not be the case as if markets are efficient, ETFs that replicate international benchmarks should only be influenced by risks in the country they trade-in. The findings suggest that investors can minimise their exposure to financial risk shocks in South Africa by using ETFs with international benchmarks, due to them not being significantly influenced by this factor. Lastly, while all country risk components impact the ETF industry, political risk has the most significant effect, suggesting that policymakers should focus on creating a stable political environment through regulation.

According to Alexiou and Tyagi (2020) dynamic asset allocation strategies have experienced a rise in prominence in both academic literature and by market practitioners. Sector rotation is one such discipline that is premised on the balance between passive indexing and active stock picking. ETFs provide a vehicle for such exposure as they assign asset allocation in accordance with the current stage of the business cycle. Investors can take a long position on sectors expected to perform well in the future and similarly take bets on sectors by going short when they are expected to perform poorly. The rationale behind sector rotation stems from the impact that economic cycles will have on various sectors of an economy. For example, depending on which stage of the business cycle the market is experiencing, specific sectors will perform better in relation to others due to the underlying business models among the different sectors. Furthermore, the influence of investor sentiment on the performance of one sector in comparison with another is an important psychological aspect of markets that influences fund flows towards a particular sector. Alexiou and Tyagi (2020) find that sector rotation strategies have the potential to earn excessive returns under certain circumstances and specific macroeconomic factors. The conclusions drawn use market data from the United States and Europe. As such, the ability of sector ETFs in emerging markets as an effective means for a sector rotation strategy is beyond the scope of their paper.

1.6 Implications of ETF volatility for market participants

The creation of these investment vehicles has resulted in an unintended consequence of increased volatility as its liquidity and diversification benefits have attracted high-frequency investors (Ben-David et al.,2018). Demand shocks caused by these investors translate into arbitrage activity which is then passed on to the ETFs underlying securities. Ben-David et al. (2018) elaborates that asset prices may deviate from their intrinsic value with greater volatility for stocks with more ETF ownership than similar securities. Lastly, the research highlights that the increase in stock volatility brought about by ETFs is partly non-diversifiable and as such represents a systematic risk for investors, especially ones with short-term holding periods. Therefore, the paper argues that ETF investors should be compensated for this risk premium.

In summary, the objective of this dissertation is to evaluate volatility spillover, and hence diversification, among JSE-listed ETFs which would have implications for an investor's portfolio allocation decisions. The sample period is from 14th February 2013 to 8th December 2023. These dates were chosen as it is the earliest trading history for each of the ETFs included in the study. Another objective of this dissertation is to determine the volatility spillover between the various ETFs as well as spillover from a foreign source of volatility. This study contributes to the existing literature in two ways. Firstly, previous literature has not covered the niche area of using ETFs as proxies for various equity sectors and asset classes on the JSE. Studying the spillover among these ETFs assists investors in portfolio allocation decisions and market timing strategies. The period included in the study has significant market shocks such as Brexit, the COVID-19 pandemic, and conflict in Russia and Ukraine. Moreover, the volatility transmission between ETFs representing four distinct asset classes available to investors on the JSE gives investors an insight into the possibility of diversification during market downturns. Secondly, the study is motivated by a large contingent of literature dedicated to the synchronisation of cross-market volatilities both internationally and between asset classes. This research extends that of Duncan and Kabundi (2013) in that sources of foreign shocks to volatility on domestic assets are investigated. An important restriction to be noted would be that spillovers are not permitted to flow in the opposite direction as South Africa is a small open economy that is highly sensitive to global shocks. Shocks originating in its domestic economy are relatively idiosyncratic to the global economy. The volatility spillover mechanism proposed by Diebold and Yilmaz (2012) is implemented.

The remainder of this paper is as follows: Section 2 provides a literature review while also outlining the motivation for analysing the volatility between various ETFs available to investors on the JSE. A discussion of the data, including an overview of the ETFs used in the study is found in Section 3. Section 4 describes the DY connectedness methodology as well as the regression analysis used in the analysis. Section 5 includes a preliminary data analysis as well as the main results of the spillover between ETFs and the VIX index. Section 6 contains the conclusion and provides recommendations for future studies.

2. Literature Review

The literature review outlines relevant seminal research on theoretical finance principles, including an overview of volatility spillover, a discussion of market efficiency through the lens of active and passive investing, and how diversification can benefit investors in portfolio allocation decisions.

2.1 Efficient Market Hypothesis

The Efficient Market Hypothesis (EMH) is the rationale that most academics use to describe stock price movements (Fama, 1970). The theory states that stock prices follow a random walk and are, therefore unpredictable. All new material information that would affect the stock's price is fully reflected immediately and known by all market participants. Hence, investors are unable to consistently earn abnormal returns, and the optimal investing strategy is to buy and hold a broad-based market index (Malkiel, 2005).

However, the EMH has also been criticised by academics for falling short in explaining pricing bubbles such as the internet stocks of the late 1990s and more recently the large-cap technology stocks in the US market. The Grossman-Stieglitz paradox (1980) is one such theory that argues against the EMH. The theory posits that market prices tend towards their true fair value through market participants actively competing to achieve this.

If this is viewed through a behavioural lens, we can see that some investors believe there are mispricings and benefit from exploiting them. This will encourage more investors to expend resources to find these mispricings, competing away the arbitrage opportunity, as prices tend towards their true value. If investors believe the market is efficient and buy broad-based index funds, the frequency of mispricings will likely increase, eventually leading to investors trying to beat the market once again. Therefore, for the market to be efficient there needs to be participants who believe it is inefficient.

2.2 Markowitz Efficient Frontier Framework

A great deal of praise is given to Markowitz (1952) for his seminal work in the study of financial economics and portfolio construction. The introduction of the efficient frontier framework is a milestone in the field. According to the framework, an optimal portfolio is defined as the specific combination of assets that provides the greatest expected return for each specified level of risk during portfolio construction at a given time horizon. Although the theory was sound, one only needed to input expected asset returns and the covariances between them and an optimal portfolio tailored to an investor's risk preferences would be produced (Flint et al., 2016). The model was sensitive to changes in the estimated mean returns and as such inefficient asset allocations would occur. Consequently, both academics and practitioners have shifted focus towards risk-based portfolio construction, improved risk estimates, and alternative diversification strategies. Furthermore, the increase in research on the underlying factors that influence expected returns has been an area of great interest. These factors have been demonstrated practically on the JSE through ETFs which attempt to capture risk premia, which fund managers use to tilt their portfolio to achieve returns in excess of the benchmark.

2.3 Active vs Passive Investing

There has been a paradigm shift in the debate of active vs passive investing shift. Easley et al. (2021) propose that the rise of factor investing, and "smart" beta strategies have resulted in an explosion of new ETF products that require frequent constituent rebalancing, with security selections that are not constrained by any benchmark. The paper elaborates on the balance between active and passive investing. Active investing is a strategy that strives to generate alpha via selective stock picking, using information to beat the overall market. A purely passive investing strategy involves holding a broad market index to generate the average return of the investable market, disregarding information.

Easley et al. (2021) build on the work of Gârleanu and Pedersen (2021) who use a model based on rational expectations to show that if the cost of information falls, the number of active managers increases, and overall market efficiency is improved. If the cost of passive investing falls, the number of active managers decreases, the cost of active fees falls by less than passive fees, and overall market efficiency decreases. Moreover, active managers may adapt in part by becoming closet indexers. The term describes a fund that claims to be actively managed but ends up with a stock selection, not too dissimilar to its benchmark. Similarly, this also reduces market efficiency (Cremers et al., 2016). What is evident from the literature is that the commitment of investor resources to alpha generation or active investing, is important in determining market efficiency.

Active investors capitalise on market inefficiencies across diverse assets. Grossman and Stiglitz (1980) delineate inefficiency as the uncertainty surrounding the fundamental value of a security, contingent upon solely knowing its price relative to the uncertainty when also privy to private information. In other words, a market is considered to be fully efficient if uncertainty about the fundamental value is the same whether one learns only from looking at the price or also from the signal. Contrastingly, the more of an advantage one gains from knowing the signal, the more inefficient the market (Gârleanu and Pedersen, 2021).

2.4 Volatility spillover between asset classes

Liow (2015) describes a volatility spillover index methodology that measures cross portfolio volatility linkages in asset pricing as the share of total return variability in one asset or market which can be attributed to a volatility surprise in another. Given the increasing size and sophistication of financial markets, implied volatility has become the predominant method for analysing volatility spillover (Yang and Zhou, 2017). Implied volatility is the ex-ante risk-neutral expectation of a specific asset or market's, future volatility. Yang and Zhou (2017) made a novel contribution to the existing literature on volatility in that they used the daily implied volatility spillovers to identify the network structure of volatility spillovers that link the US treasury bond market and major global stock and commodity indices. Additionally, the methodology used in their paper improves on the use of Vector Auto Regressive (VAR) analysis implemented by Diebold and Yilmaz (2012). This was achieved by uncovering the contemporaneous causal relationships among implied volatilities, thereby improving the ordering of variables. Through this novel method, they accurately detected and accounted for the network of global volatility spillovers. They found that global volatility spillover during the period 2008 to 2013 could be attributed to the US market.

Diebold and Yilmaz (2009) base their measurement of return and volatility spillovers on vector autoregressions (VAR) models, introduced by Engle et al. (1990). The paper implemented variance decomposition as it was widely used at the time and allowed the aggregation of spillover effects across multiple markets into a single spillover measure. Their methodology allows for the analysis of a broad set of global equity returns and volatilities. The shortcomings of this methodology were that the resulting variance decompositions were dependent on variable ordering through the Cholesky-factor identification of VARs. Moreover, the earlier iteration of the model, only considers the measurement of spillovers across identical assets (equities) in different countries and only the total spillovers from/to each market and to/from all other markets. This was then addressed in Diebold and Yilmaz (2012) in which the forecast-error variance decompositions are invariant to variable ordering and the measurement of directional spillovers (from/to a particular market). The study conducts an empirical analysis of daily volatility spillovers across the United States stock, bond, foreign exchange and commodity markets over ten years.

A novel contribution using the Diebold and Yilmaz methodology by Andrada-Félix et al. (2018) measures the connectedness among five implied volatility indices representative of different asset classes intending to explore expected future market volatility. The volatility indices were derivative markets and acted as gauges of uncertainty within each financial market. They were especially relevant for establishing the connections between uncertainty and the dynamics of economies, investor preferences, and asset pricing. The paper used a system-wide approach using a methodology proposed by Diebold and Yilmaz (2014). This is the first introduction of utilising a network framework and the realisation that the variance decomposition matrix or the connectedness table could be viewed as an adjacency matrix of a weighted directed network (Diebold and Yilmaz, 2023). The framework has been used to define connectedness in financial and macroeconomic environments whether it be between assets, countries, or markets. Andrada-Félix et al. (2018) find that the system-wide total connectedness value sits at 38,99%. It can also be interpreted that 38,99% of the total variance of forecast errors is explained by shocks across markets. This indicates that the remainder 61,01% of the variation is due to idiosyncratic shocks. Additionally, there is evidence of large variation in volatility connectedness with increases during unstable periods. Lastly, variables switched between net volatility transmitter and receiver roles over the period analysed.

Fleming et al. (1998) investigated the volatility linkages in stock, bond, and money markets. The paper describes two distinct phenomena known as common information which simultaneously affects expectations across markets as well as information spillover caused by cross-market hedging. The motivation for studying volatility linkages stems from its importance in risk management decisions. As mentioned earlier, common information, for example, the inflation rate will affect investor expectations in multiple markets. Cross-market hedging occurs when information in one market affects the expectations in that market, which results in traders adjusting their holdings across markets. Strong volatility linkages are found within the United States market which are influenced by macroeconomic information, in particular post the 1987 stock market crash. Fleming et al. (1998) found evidence of speculative trading techniques that considered the correlation in returns across markets as traders form their speculative demands. This led to traders diversifying their holdings across markets to reduce the variance in their speculative profits.

2.5 Diversification

There is a great deal of literature in finance that for the average equity investor, a broad exposure to a group of stocks is the ideal investment strategy. This provides diversification benefits to the investor. To remain invested during turbulent economic times has been shown to provide investors with greater returns over time than when compared with trying to “time” the market.

Constructing a multi-asset class (MAC) portfolio as shown by Agrrawal (2013) can be easily constructed with ETFs that perform well in a mean-variance space under varying market conditions, including the Global Financial Crisis of 2008. Moreover, the MAC portfolio when compared to an all-equity portfolio - which itself is diversified across various size, style, and country demarcations, exhibits cross-correlations that are lower with the variance-covariance matrix producing fewer overlaps and redundancies.

Boako et al. (2020) provide further evidence that African stock markets, specifically South Africa, can provide an uncorrelated return from commodity markets. South Africa holds the world's largest reported reserves of gold and platinum group metals and is therefore heavily exposed to risks in the demand for these exports. Furthermore, commodity markets experience periods of large fluctuations, and investors seek viable solutions to compensate for losses experienced from global shocks. Boako et al. (2020) find that equity markets are an alternative for investors to earn uncorrelated returns. The findings advocate for the enhancement of commodities financialisation which would aid in the flow of investment capital into their economies. The introduction of ETFs which track the spot price of the major exported commodities is evidence of this.

He et al. (2020) studied the asymmetric spillover effect of economic policy uncertainty (EPU) on the S&P 500 index. According to Amonlirdviman and Carvalho (2010), diversification gains are lower due to the correlations between assets increasing during market downturns. Moreover, if downside risk suffers more due to exogenous shocks and the connectedness between EPU and downside risk is higher, it means that EPU is more likely to cause a financial crash. This reduces investors' wealth and uproots financial stability. He et al. (2020) extends the existing literature on asymmetric pairwise directional spillovers and the decomposition into good and bad volatility. It examines this using several influential countries' EPU on the US stock market risk. Additionally, this study also captures the time-varying relationship between EPU and the stock market by using rolling windows, while also capturing significant market events such as Britain's referendum vote on European Union membership, the debt crisis, and escalating trade conflicts. The findings show that the asymmetric relationship between EPU and the stock market is important for risk management practices as well as building on the framework of EPU and the stock market by providing asymmetric effect characteristics.

Significant contributions to the existing literature include research on the effect of uncertainty on various South African asset classes, conducted by Muzindutsi and Obalade (2024), and a study by Muzindutsi et al. (2021) on the returns of the bond and property prices respectively. Muzindutsi et al. (2021) found that the property sector is heavily influenced by political risk. The uncertainty in the political climate and its impact on property prices is understandable as a politically uncertain environment leads to economic and financial risks. Furthermore, a long-run relationship was found between the housing market and the components of country risk. It is noted that the property market segments do react differently to shocks and as such, investors should treat each segment of the property market differently to hedge their exposures. The performance and stability of the bond market are measured through bond returns and yield spread using a Markov Switching Model (Muzindutsi and Obalade, 2024). The paper found that the bond market was particularly susceptible to country risk shocks which affect a government's ability to borrow and lend at favourable rates. It was found that country risk's effect on bond returns was only significant in a bear regime in which bond returns increase with a change in political and economic risk but decrease with financial risk. As such it was concluded that the South African bond market is influenced by market cycles.

2.6 Empirical studies of ETFs in South Africa

Strydom et al. (2015) empirically test whether ETFs provide a better tracking instrument compared to index funds for investors seeking to replicate the returns of the market or a particular sector. Their findings indicate that JSE-listed ETFs, particularly ones that track the FTSE/JSE Top 40 index are superior to the index mutual funds. Matarutse (2014) analysed the volatility of JSE-listed ETFs, in particular the Satrix Top 40 and its effect on volatility spillover between its component stocks. The findings of the paper assert that understanding volatility persistence is crucial for long-term investment decisions. Furthermore, increased ETF trading is an important source of information flow and affects the volatility characteristics of its underlying shares.

Kunjal et al. (2022) investigated the country-specific, political, economic, and financial risks and their effect on volatility in the South African ETF industry. They found that due to the increased growth in the ETF industry, sentiment-driven noise trading contributed to excess volatility. Due to the increased market uncertainty, the volatility of financial markets had various implications on asset allocation, capital pricing, derivative pricing, and risk management. The motivation for Kunjal et al. (2022) stems from the rising influence of the above factors and their potential to influence market volatility further. As such, the need to explore the direction and magnitude of the risk components that affect the volatility of ETFs is a key area of interest for researchers.

Assessments of country risk can reflect the probability of delays or even defaults of a country's debt service obligation to foreign borrowers due to financial, political, or economic conditions (Kunjal et al., 2022). Due to its influence on key decision-making processes, research has shown that country risk intuitively has a significant effect on the investment flows to equity and bonds asset classes (Lee et al., 2013).

Additionally, the degree of financial development, the occurrence of financial crisis, and the overall volatility within financial markets are all factors that are affected by country risk (Lee et al., 2016). Kunjal et al. (2022) also examined whether ETFs can be used as an alternative investment strategy to diversify an investor’s exposure to country risk components, thereby reducing a portfolio’s overall risk. The wide range of ETFs available to investors means that they behave similarly to stocks in that their response to a particular country’s risk may vary in response.

The investigation into volatility spillover among ETFs is crucial, particularly when these funds are used as proxies for different asset classes. Understanding the dynamics of volatility transmission between various ETFs can provide invaluable insights for investors looking to optimise their portfolio allocation strategies and manage risk more effectively. Despite the significant growth and increasing prominence of ETFs on the JSE, there has been a notable lack of research focused on volatility spillover within this market.

This dissertation addresses this gap by examining the volatility interactions between domestic ETFs representing key asset classes and equity ETFs listed on the JSE. By doing so, it aims to contribute to the existing literature and provide practical insights for investors. The primary objective of this study is to enhance the understanding of volatility spillover effects among JSE-listed ETFs, thereby aiding investors in making more informed decisions regarding sector rotation and asset allocation. This research will fill an important void in the literature and offer a new perspective on the interconnectedness and behaviour of ETFs in the South African financial market.

3. Data

Sector indices are a common benchmark when allocating portfolio exposure into the stock market. The diversification effect that an investor is exposed to through sector allocation is a large proponent of its use as an asset allocation strategy (Briere and Szafarz, 2021). Van Rensburg and Slaney (1997) showed that a two-factor Arbitrage pricing theory model was superior at explaining returns on the JSE, with the JSE All-Gold index and the JSE Industrial Index used as observable proxies. Later reclassification of the indices saw this change to the JSE Financial-Industrial (CI21) and Resources (CI11) Indices (Van Rensburg, 2002). This demonstrates the inherent market segmentation on the JSE and is further motivation for the equity ETFs to be included in the analysis.

The equity ETFs included are the Satrix RESI ETF, Satrix FINI ETF, Satrix INDI ETF as well as the Satrix Top 40 ETF. The Top 40 ETF comprises the largest market capitalisation-weighted shares on the JSE. As such, it is the most accurate out of the available ETFs as a proxy for what the average investor is expected to return on the JSE within the sample period. The remaining three ETFs track the largest indices of the JSE which provide investors with an option to diversify their portfolio, differing from the broad market exposure of the Top 40.

The bond ETF to be included is the Satrix GOVI ETF, which tracks an index comprising bonds issued by the South African Government. These bond yields and returns are dependent on monetary policy decisions and the perceived riskiness of sovereign debt for investors. The commodity ETF is the NewGold ETF. Gold is a significant component of South Africa’s raw material exports and a traditional safe haven asset for investors during crisis periods. The 1Invest property ETF will proxy the property asset class and consists of the top 20 listed property companies on the JSE. Property is an alternative asset class and due to the possibilities of international investing, having a portion of a portfolio dedicated to real estate as part of a diversified strategy has gained traction in the global investment landscape (Newell and Worzala, 1995).

The aforementioned ETFs have all been in existence from the beginning of the analysis period. As such ETFs that only possess more recent trading history are excluded from the study. Table 1 provides a description of the ETFs used in this study together with their top constituents as at 31 March 2024. The daily closing price of each ETF was collected from Bloomberg. The logarithmic (log) returns for 14th February 2013 to 8th December 2023 were calculated which resulted in 2 704 total observations. The market return for each ETF proxy was calculated as the log difference between time *t* and *t-1,* formally defined as:

$$ETFReturn = \ln(ETFClosingPrice_t) - \ln(ETFClosingPrice_{t-1}) \quad (1)$$

Similar to Duncan and Kabundi (2013), squared return measures are used as proxies for financial volatility (Andersen and Bollerslev, 1998). As such, the closing price of each ETF is squared with the result being a proxy for financial volatility in the market. A well-known stylised feature of financial asset returns is volatility clustering. Ning et al. (2015) describe volatility clustering as the tendency of high volatility movements to be followed by further high volatility movements, with the same being true during tranquil periods. Modelling this phenomenon is important as the volatility of asset returns can directly impact prices of options and the riskiness of stocks in portfolio construction. Additionally, the Chicago Board Options Exchange Volatility Index (VIX) is used to proxy foreign volatility shocks in line with Duncan and Kabundi (2013), Szczygielski et al. (2022), and Wang (2019) as it reflects global market uncertainty. This period includes recent market shocks such as the Russia-Ukraine conflict, trade sanctions imposed by the world's two biggest economies, the global fallout due to the COVID-19 pandemic, and Britain's exit from the European Union in 2016.

Table 1: Description of ETFs and top 10 constituents

Panel A: Description of Equity ETFs

ETF	Top 10 Holdings as at 31 March 2024
Satrix 40 ETF (STX40)	Naspers Ltd, Firstrand Ltd, Gold Fields Ltd, Standard Bank Group Ltd, Prosus Nv, Anglo American Plc, Compagnie Fin Richemont, Capitec Bank Holdings Ltd, Mtn Group Ltd, British Am. Tobacco Plc
Satrix RESI 10 ETF (STXRES)	Gold Fields Ltd, Anglo American Plc, Anglogold Ashanti Plc, Bhp Group Limited, Harmony Gold Mining Company Ltd, Sasol Ltd, Glencore Plc, Impala Platinum Holdings Ltd, Sibanye Still Water Limited, Exxaro Resources Ltd
Satrix FINI 15 ETF (STXFIN)	Firstrand ltd, Standard Bank Group Ltd, Capitec Bank Holdings Ltd, Absa Group Limited, Sanlam Ltd, Investec Ltd, Nedbank Group Ltd, Nepi Rockcastle N.v., Remgro Ltd, Discovery Limited
Satrix Capped INDI ETF (STXIND)	Naspers Ltd, Prosus Nv, Compagnie Fin Richemont, Mtn Group Ltd, British Am. Tobacco Plc, Bid Corporation Limited, Shoprite Holdings Ltd, Anheuser-busch Inbev Sa Nv, Aspen Pharmacare Holdings Ltd, Bidvest Ltd

Panel B: Description of Alternate Asset ETFs

ETF	Top 10 Holdings as at 31 March 2024
Satrix GOVI ETF (STXGVI)	R186, R2030, R2048, R2032, R2035, R2037, R2044, R2040, R213, R209
ABSA NewGOLD ETF (GLD)	Physical Gold Bullion
1Invest SA Property ETF (ETFSAP)	NEPI Rockcastle NV, Growthpoint Properties Ltd, Redefine Properties Ltd, Fortress REIT Ltd B, Vukile Property Fund Ltd, Reselient REIT Ltd, Hyprop Investments Ltd, Equities Property Fund Ltd, Sirius Real Estate, Lighthouse Properties plc

4. Methodology

In this analysis, the squared log returns for each ETF will proxy the volatility for each equity sector or asset class. Unlike previous academic literature, this research uses ETFs as a proxy for exposure to various asset classes and measures the spillover between them as well as spillovers between ETFs tracking different equity indices on the JSE. The implications of these findings are important for investors as it assists in portfolio allocation decisions. The statistical package used in the analysis is the "Spillover" package or the Connectedness Index based on VAR Modelling in RStudio.

In their seminal work, Diebold and Yilmaz (2009) pioneered a methodology to measure volatility spillover through a simple quantitative measure of independence, which they coined as the spillover index. Later, Diebold and Yilmaz (2012) introduced a measure of both total and directional volatility spillovers. Despite its versatility in capturing cross-market volatility linkages, it did not account for the potential asymmetry that originates due to bad and good uncertainty. This methodology proposes measures of total and directional volatility spillovers using a generalised vector autoregressive framework in which the forecast error variance decompositions are invariant to the variable ordering. These volatility spillover measures are based on error variance decompositions from vector autoregressions (VARs). They can be used to measure the spillover in returns as well as the volatility in returns across asset classes. In summary, the DY methodology is a robust tool for analysing the complex spillovers in financial markets, contributing valuable insights for academics and investors on the JSE.

Initially, the domestic equity ETFs and alternate asset ETFs will be analysed in isolation with the contribution to and from each ETF to total volatility being calculated. Following on from this, the contribution of VIX to volatility within each ETF is measured. The rationale for the addition of the VIX to the system is to test the effect on volatility on asset classes in South Africa from a global proxy for uncertainty. The annualised volatility on a rolling 252-day basis for each ETF is presented and the results are discussed. Thereafter, a regression analysis is conducted to determine whether VIX volatility is a significant explanatory variable in determining the total connectedness among each ETF system. Lastly, each ETF is analysed over the full sample period to determine whether they are a net transmitter or receiver of volatility.

The Diebold Yilmaz Spillover Index is defined next.

4.1 Variance Shares

Own variance shares are defined as the fraction of the H-step-ahead variances in forecasting x_i, for i = 1,2,…N and cross variance shares as the fractions of the H-step-ahead error variances in forecasting x_i that is due to shocks to x_j, for i,j = 1,2,…,N, such that i≠j. Denoting the Koop, Pesaran, and Potter (1996) (KPPS) and Pesaran and Shin (1998), the H-step-ahead forecast error variance decompositions by θ_{ij}^{g} (H), for H =1,2,…, is presented below:

$$\theta_{ij}^{g}\,(\mathrm{H}) = \frac{\sigma_{jj}^{-1}\sum_{h=0}^{H-1}(e_i' A_h \sum e_j)^2}{\sum_{h=0}^{H-1}(e_i' A_h \sum A_h' e_i)} \tag{2}$$

The H-step ahead variance is set to a standardised 10. Where Σ is the variance matrix for the error vector ε, σ_{jj} is the standard deviation of the error term for the *j th* equation and e_i is the selection vector with ith element and zeros otherwise. The sum of the elements in each row of the variance decomposition table is not equal to one. : $\sum_{j=1}^{N}\theta_{ij}^{g}(H) \neq 1$. For the information to be used, each entry in the variance decomposition matrix must be normalised while calculating the spillover index. As shown by:

$$\tilde{\theta}_{ij}^{g}(H) = \frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{N}\theta_{ij}^{g}(H)} \tag{3}$$

Note that, $\sum_{j=1}^{N}\tilde{\theta}_{ij}^{g}(H) = 1$ and $\sum_{i,j=1}^{N}\tilde{\theta}_{ij}^{g}(H) = N$. The calculation of variance decompositions requires orthogonal innovations whereas the VAR innovations are generally contemporaneously correlated. Identification schemes such as those based on Cholesky factorisation, achieve orthogonality but the variance decompositions are then dependent on the ordering of the variables. The generalised VAR framework of KPPS produces variance decompositions that are independent of the order of the variables.

4.2 Total spillovers

Using the volatility contributions from KPPS variance decomposition, the total volatility spillover index is constructed.

$$S^g(H) = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}^g(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^g(H)} \cdot 100 = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}^g(H)}{N} \cdot 100 \tag{4}$$

This is the KPPS analogue of the Cholesky factor-based measure used by Diebold and Yilmaz (2009). The total spillover index measures the contribution of spillovers of volatility shocks across four asset classes and equity sectors to the total forecast error variance.

4.3 Directional spillovers

The total volatility spillover index allows us to understand how the shocks to the volatility spillover across major asset classes or equity sectors. The generalised VAR approach demonstrates the direction of volatility spillover across the major asset classes. As the generalised impulse responses and variance decompositions are invariant to the ordering of variables, the directional spillovers, using the normalised elements of the variance decomposition matrix are calculated. The directional volatility received by ETF *i* from all other ETFs *j* is defined as:

$$S_{i\cdot}^g(H) = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ij}^g(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^g(H)} \cdot 100 = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ij}^g(H)}{N} \cdot 100 \tag{5}$$

Similarly, the directional volatility spillovers transmitted by ETF *i* to all other ETFs *j* is defined as:

$$S_{\cdot i}^{g}(H) = \frac{\sum_{\substack{j=1\\ j\neq i}}^{N} \tilde{\theta}_{ij}^{g}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{g}(H)} \cdot 100 = \frac{\sum_{\substack{j=1\\ j\neq i}}^{N} \tilde{\theta}_{ij}^{g}(H)}{N} \cdot 100 \tag{6}$$

By using the generalised VAR framework there is a crucial improvement in that directional spillovers can be identified. For example, the total spillover coming from and to each observed ETF can be separated (Diebold and Yilmaz, 2012).

4.4 Net spillovers

The net volatility is the difference between gross volatility shocks to and those received from all other markets (Barunik et al., 2016), or in this case ETFs. As such the net volatility from ETF *i* to ETF *j* is defined by:

$$\mathcal{S}_{i}^{g}(H) = \mathcal{S}_{\cdot i}^{g}(H) - \mathcal{S}_{i\cdot}^{g}(H) \tag{7}$$

For example, the spillovers from (to) the STX40 ETF to (from) the rest of the ETFs within the system are captured in the equation. The net contribution is calculated and if it is positive, the ETF is a net volatility transmitter, and if negative, a net volatility receiver.

4.5 Foreign shocks on domestic asset volatility

Similarly to Duncan and Kabundi (2013), the foreign spillovers are defined by letting $i \in \{1, \dots, m\}$ and $j \in \{m+1, \dots, n\}$. The spillover received by ETF *i* and from shocks to the foreign volatility source *j* is normalised through the following process:

$$\tilde{\theta}_{ij}^{f} = 100 \cdot \frac{\theta_{ij}}{\sum_{\ell=1}^{n} \theta_{i\ell}} \tag{8}$$

A total foreign volatility spillover of between zero and 100% is received by the domestic financial system as calculated in the following index:

$$\mathcal{S}^f = \frac{\sum_{i=1}^{m}\sum_{j=m+1}^{n}\tilde{\theta}_{ij}^{f}}{\sum_{i,\ell}^{m}\tilde{\theta}_{i,\ell}^{g}} = \frac{1}{100N}\cdot\sum_{i=1}^{m}\sum_{j=m+1}^{n}\tilde{\theta}_{ij}^{f} \quad (9)$$

In this model, the foreign source of volatility is the VIX index. It is often used as a gauge of market sentiment. The VIX level for the analysis period is captured and the squared returns of the index are used to proxy its volatility.

4.6 Total Connectedness Index (TCI)

Antonakakis et al. (2020) presented a TVP-VAR connectedness methodology based on Diebold and Yilmaz (2014) connectedness approach. This approach can be regarded as an improvement over the standard rolling-window VAR connectedness approach. It is an improvement over its predecessor in that it allows for capturing parameters more accurately, it is not as outlier sensitive, there is no need to arbitrarily set the rolling window size and there is no loss of observations in the calculation of dynamic measures. It is defined below as:

$$C_t(H) = \frac{\sum_{i,j=1,i\neq j}^{m}\widetilde{\Phi}_{ij,t}(H)}{\sum_{i,j=1}^{m}\widetilde{\Phi}_{ij,t}(H)} * 100 = \frac{\sum_{i,j=1,i\neq j}^{m}\widetilde{\Phi}_{ij,t}(H)}{m} * 100 \quad (10)$$

Using the generalised forecast error variance decompositions the TCI is constructed. The denominator represents the cumulative effect of all shocks while the numerator illustrates the cumulative effect of a shock in variable *i*. The TCI for each ETF system is used as the response variable in a linear regression equation with the squared returns of the VIX being used as the explanatory variable in the following equation:

$$C_t(H) = \beta 0 + \beta 1 \times VIX_{Volatility} + \varepsilon \quad (11)$$

An analysis of the relationship between the TCI and VIX is conducted, to test financial market interconnectedness and systemic risk. The results of the regression will indicate whether the VIX variable is significant in explaining shocks to each system. Furthermore, the regression is run to test the determinants of connectedness among ETFs and add robustness to the results.

5. Results

5.1 Preliminary data analysis

Table 2 displays the descriptive statistics for the return series (calculated as the difference in the natural log of the closing price) for each ETF. Additionally, the daily change in the VIX level is also captured. The VIX is included only on the days on which trading takes place on the JSE. The Augmented Dickey-Fuller (1979) (ADF) test is employed to confirm the stationarity of each return series. For each series, the ADF test was significant, therefore we can reject the null hypothesis that a unit root is present in the series. This indicates that the logarithmic return series are all stationary. As such, the series can be analysed, and the VAR model can be implemented. The VAR model allows for the dynamic relationships between variables to be adequately modelled. Additionally, Table 2 displays the average daily return achieved by each ETF. Almost all average returns are positive indicating that these price series have increased over the sample period. The ETFSAP (property) displays a negative average return, meaning a decreased price series. The STX40, STXFIN, STXIND STXRES, and STXGVI all exhibit a slightly negative skew. In particular, the STXGVI and STXFIN have a significant negative skew.

Table 2: ETF descriptive statistics for log returns of each ETF and VIX

	STX40 SJ Equity	**STXFIN SJ Equity**	**STXIND SJ Equity**	**STXRES SJ Equity**	**STXGVI SJ Equity**	**GLD SJ Equity**	**ETFSAP SJ Equity**	**VIX**
Mean	0,0002	0,0001	0,0003	0,0000	0,0002	0,0003	-0,0002	*0,00001*
Std. Dev.	0,0117	0,0147	0,0116	0,0177	0,0145	0,0114	0,0308	*0,0792*
Min	-0,1011	-0,1150	-0,0844	-0,1167	-0,3983	-0,0781	-0,7596	*-0,2998*
Max	0,0847	0,0774	0,0682	0,1205	0,3855	0,0676	0,8378	*0,7682*
Skewness	-0,2624	-0,5909	-0,2043	-0,0799	-0,8772	0,2968	0,8318	*1,2347*
Kurtosis	7,6070	9,8308	6,3208	6,1510	410,48	6,7923	363,4052	*6,7737*
Jarque-Bera	2422,30	5414,10	1261,20	1121,50	19012033	1660,00	14634801	*5742,7*
Probability	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Observations	2704,00	2704,00	2704,00	2704,00	2704,00	2704,00	2704,00	2646,00

This indicates that investors may experience frequent small gains and a few large losses. All series exhibit kurtosis that is greater than three, indicating that each series shows heavier tails than the standard normal distribution. This implies that the leptokurtic tails contain a greater chance of extreme positive or negative movements occurring in the distribution of returns. Furthermore, the significant Jarque-Bera statistics mean that the null hypothesis of normality in the series can be rejected, and the series departs from the standard normal distribution. The VIX return series has a slight positive mean return. There is a significantly greater distribution in the returns of the VIX level, compared to the ETFs, as evidenced by the standard deviation of 0,0792 (7,92%). It has a positive skew and displays leptokurtosis. Due to the large Jarque-Bera test score, its returns are not normally distributed.

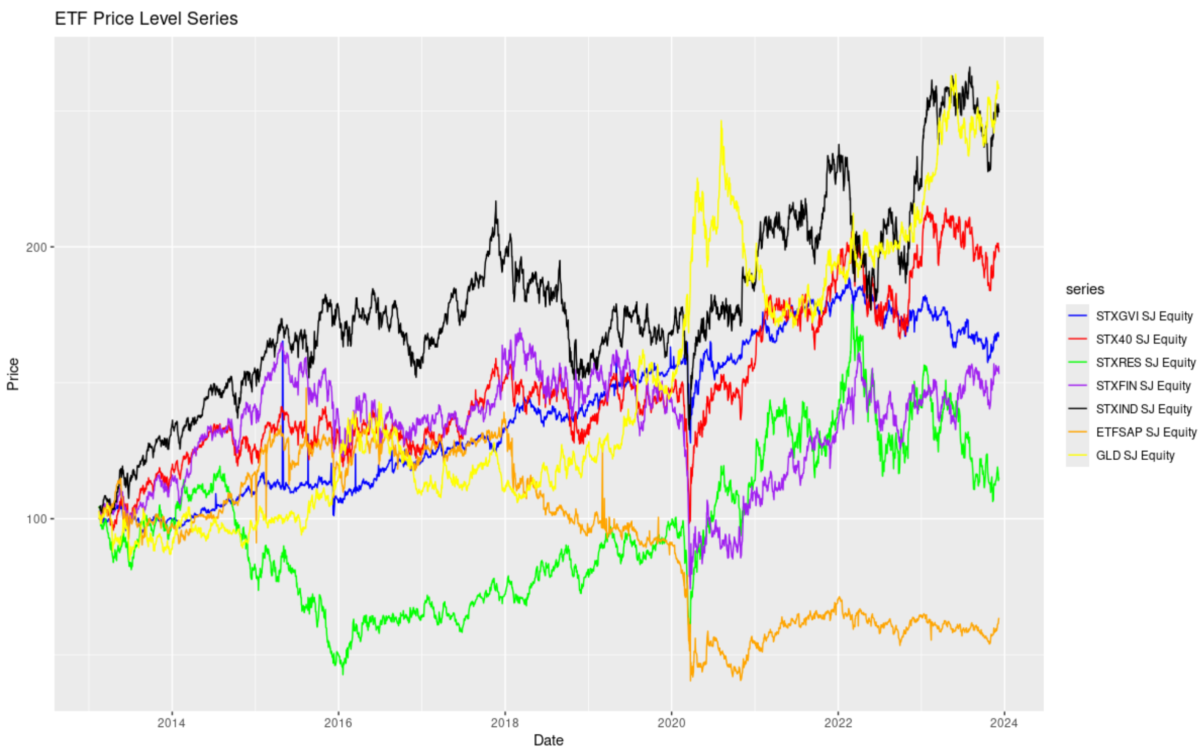


Figure 1: Price level for various ETFs

The series above displays each ETF price level for the analysis period. The GLD and the STXIND equity price level are noticeably higher than every other ETF over the sample period. Through visual inspection, the GLD ETF has a significant spike in price during the pandemic affected 2020. Similarly, the performance of the STXIND also demonstrates great price fluctuations both positive and negative. During 2020 the STXIND falls dramatically before recovering with the same pattern repeating in 2022. The STXGVI and STX40 have similar price movements which is interesting considering the ETFs track indices that represent South African Government bonds and South African equity, respectively. The STXRES experiences great fluctuations over the period but ultimately ends at a level similar to where the series starts. The STXFIN has a relatively flat performance over the entire period with minimal price fluctuations. The ETFSAP has performed the worst of all ETFs included and has not managed to recover to its pre-pandemic levels at the end of the sample period.

The static correlation heat map in Figure 2 shows that the Gold (Commodity) ETF has a negative correlation with every other asset class except that of the STXRES. Smirnova (2016) documents the use of gold and other commodities as an important addition to any diversified market portfolio to protect investors from tail risk events. Gold holdings tend to have low correlations with many other asset classes, arguing in favour of its role as a diversifying tool. Furthermore, this relationship extends to the use of gold ETFs. The returns of these products have a positive beta in relation to the market factor providing limited diversification benefits to the investor. The inclusion of gold ETFs in an investor’s portfolio can reduce systematic risk during a market downturn and is a good substitute for holding physical gold. The STXRES is comprised of companies that deal primarily in commodities mining and trading and as such there should be some inherent correlation between the GLD and STXRES. The STXRES, STXGVI, and STXFIN all display high correlations with STX40. This demonstrates the concentration within the JSE of a few large stocks dominating the capitalisation-weighted indices on the stock market (Van Rensburg and Robertson, 2003). It is interesting to note that over the analysis period, the returns of the STXIND have the highest correlation with the STX40.

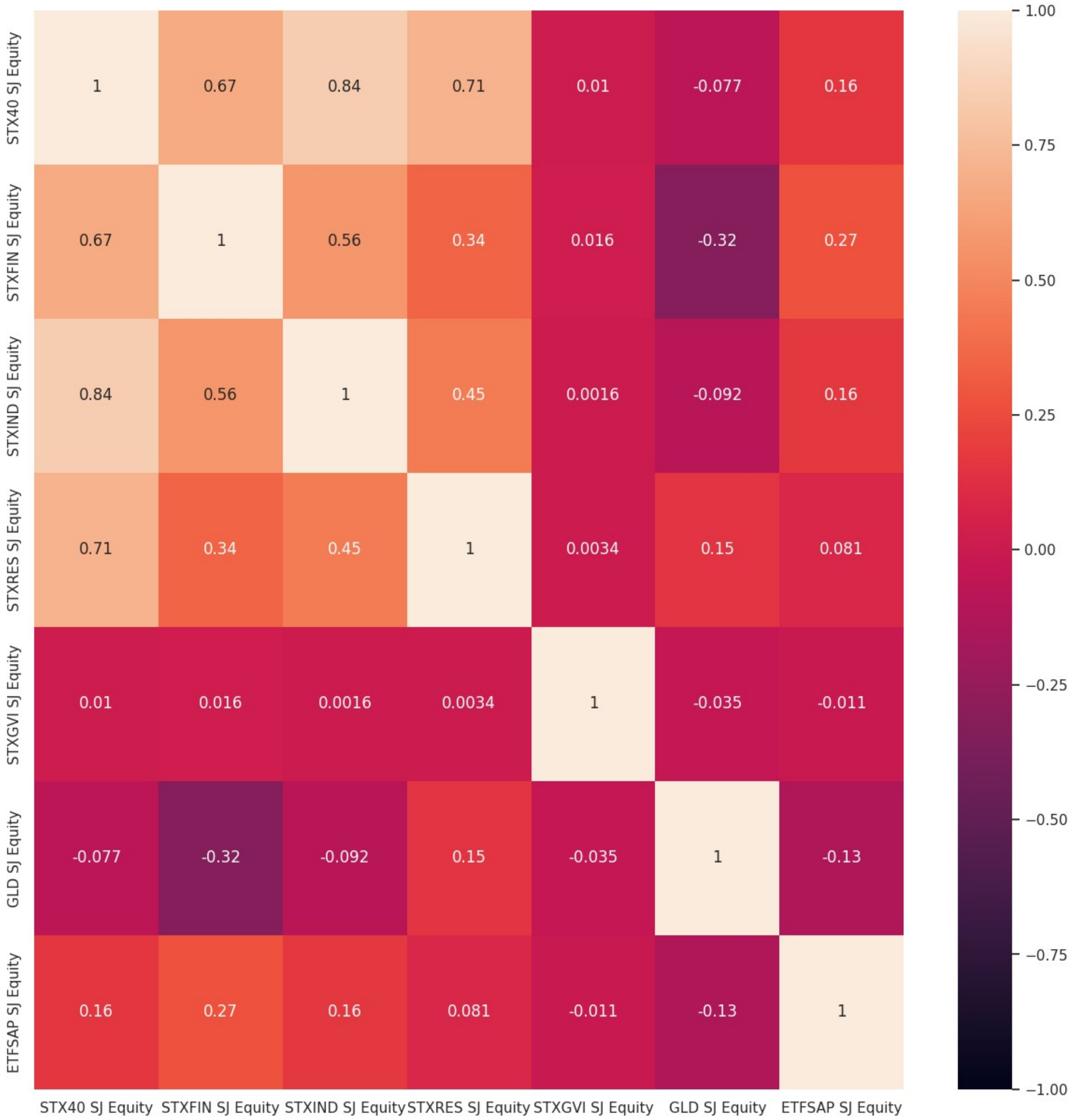


Figure 2: Correlation matrix for the ETF proxies

Figure 2 presents the correlation matrix between the ETFs included in the analysis. The results are as expected with low and even negative correlations, in the case of GLD between the equity ETFs and the bond and property ETFs. The period after the implementation of the Commodity Futures Modernisation Act (CFMA) is generally regarded as the beginning of the financialisation of commodities. The financialisation phenomenon is associated with institutional investors taking up greater positions in energy and other commodity markets (Liu et al., 2020). Liu et al. (2020) use conditional correlations between crude oil and sector ETFs to test the relationship between these variables. The paper found the correlation between crude oil and industry sectors has remained high since the Global Financial Crisis in 2008, indicating a long-lasting effect on how different asset classes move together. The post-recession period included monetary policies that increased money supply and kept interest rates low. This resulted in an increased demand for alternative assets such as commodities. Overall, the findings suggest that energy and commodities still offer diversification benefits for sector-style investing albeit to a lesser extent than in the early 2000s, during the financialisation of commodity markets.

5.2 Volatility spillover between equity ETFs

Table 3: Volatility spillover between equity ETFs

	STXFIN,SJ,Equity	**STXIND,SJ,Equity**	**STXRES,SJ,Equity**	**C, from others**
STXFIN,SJ,Equity	94,91	0,88	4,21	5,09
STXIND,SJ,Equity	0,88	98,21	0,91	1,79
STXRES,SJ,Equity	2,06	0,36	97,58	2,42
C, to others (spillover)	2,94	1,24	5,11	3,10
C, to others including own	97,85	99,45	102,70	300,00

Table 3 shows the volatility spillover between the equity ETFs. An approximation of the "input-output" decomposition of the total volatility spillover index is provided in the spillover table. The *ij* th entry is the estimated contribution to the forecast error variance of market *i* coming from innovations to market *j.* The STXFIN has a contribution of 2,94% to the other ETFs, and a contribution from of 5,09% meaning it is a net receiver of volatility. This can be interpreted as shocks in the STXFIN are relatively insulated within the financial sector.

The STXIND has a contribution to others of 1,24% which is the least of all the ETF's and a contribution from other ETFs at 1,79%. The STXRES has a contribution of 5,11% to the total system-wide volatility spillover and a contribution from other ETFs spillover at 2,42%. The STXRES can be identified, to a slight extent, as a net volatility receiver. Additionally, the total spillover index is equal to

[(5,09%+1,79%+2,42%)/300]:3,1%. This indicates on average that across the entire sample period, 3,1% of the volatility forecast error variance for these markets can be attributed to spillovers.

5.3 Volatility spillover between alt. asset class ETFs

Table 4: Volatility spillover between alternate asset class ETFs

	STX40.SJ.Equity	**STXGVI.SJ.Equity**	**GLD.SJ.Equity**	**ETFSAP.SJ.Equity**	**C. from others**
STX40.SJ.Equity	97,54	0,10	2,03	0,33	2,46
STXGVI.SJ.Equity	0,04	99,94	0,01	0,01	0,06
GLD.SJ.Equity	2,53	0,04	96,61	0,83	3,39
ETFSAP.SJ.Equity	1,01	0,01	0,73	98,25	1,75
C. to others (spillover)	3,58	0,14	2,77	1,17	1,92
C. to others including own	101,12	100,08	99,38	99,42	400,00

Table 4 displays the volatility spillover between the STX40 (Equity), STXGVI(Bonds), GLD (Commodities), and ETFSAP (Property). The STX40 ETF contributes the highest volatility spillover towards the other asset class ETFs at 3,58%. It has a net directional volatility of (3,58–- 2,46 = 1,12%). The ETFSAP has a net directional volatility of (1,17 – 1,75 = -0,58%). The GLD ETF figure is (2,77 – 3,39 = -0,62%) and lastly, the STXGVI ETF is (0,14 – 0,06 = 0,08%). Additionally, the total spillover index is equal to [(3,58+0,14+2,77+1,17)/400]:1,92%. This indicates on average that across the entire sample period, 1,92% of the volatility forecast error variance for these markets can be attributed to spillovers.

Table 4 indicates that nearly all variance in each ETF can be attributed to the ETF itself. This suggests that shocks in each asset class are largely idiosyncratic. Consequently, in the ETF market, bonds, commodities, and property continue to be suitable options for hedging equity market risk. When applying the DY methodology, the low level of connection among the four markets implies that there are diversification options during periods of high market uncertainty (Tiwari et al., 2018).

5.4 Volatility spillover of VIX returns on ETFs

Table 5: Volatility spillover for VIX

	VIX.Vol
VIX.Vol	96,71
STX40.SJ.Equity.ETF	2,49
STXFIN.SJ.Equity.ETF	3,04
STXIND.SJ.Equity.ETF	2,60
STXRES.SJ.Equity.ETF	1,23
STXGVI.SJ.Equity.ETF	0,04
GLD.SJ.Equity.ETF	2,96
ETFSAP.SJ.Equity.ETF	0,11
C. to others (spillover)	12,47
C. to others including own	109,18

Table 5 displays the total volatility spillovers transmitted from the VIX index to the financial asset ETFs in South Africa in line with Duncan and Kabundi (2013). The VIX spillover contribution is the highest for STXFIN ETF at 3,04%. In comparison to the spillovers between domestic ETFs, the VIX is well below the average level. The entire contribution spillover of the VIX sits at a low of 12,47%. This indicates that global volatility shocks generally have limited influence on the variability of South African asset classes in the context of ETFs. It is important to note that the VIX is not the only source of foreign volatility as it only takes into account, the cost to investors for hedging against short-term, downside risk in the United States S&P 500 index. It is essentially, the amount that risk-averse investors are willing to pay to avoid downside risk in foreign markets (Duncan and Kabundi, 2013). According to Umar et al. (2022), the VIX was the second largest transmitter of spillovers to other variables at 65,2% in their study of spillovers during the Russia- Ukraine conflict. The variables in the paper included Russian, European, and United States bonds and equities. In the analysis, European equities turned out to be the largest transmitter and receiver of shocks on returns at 69,31% and 49,23%, respectively.

5.5 Annualised volatility plots for ETFs

Figure 3 plots the annualised daily volatility measures for each ETF. The plots are calculated using the logarithmic squared returns of 252-day rolling average for each ETF.

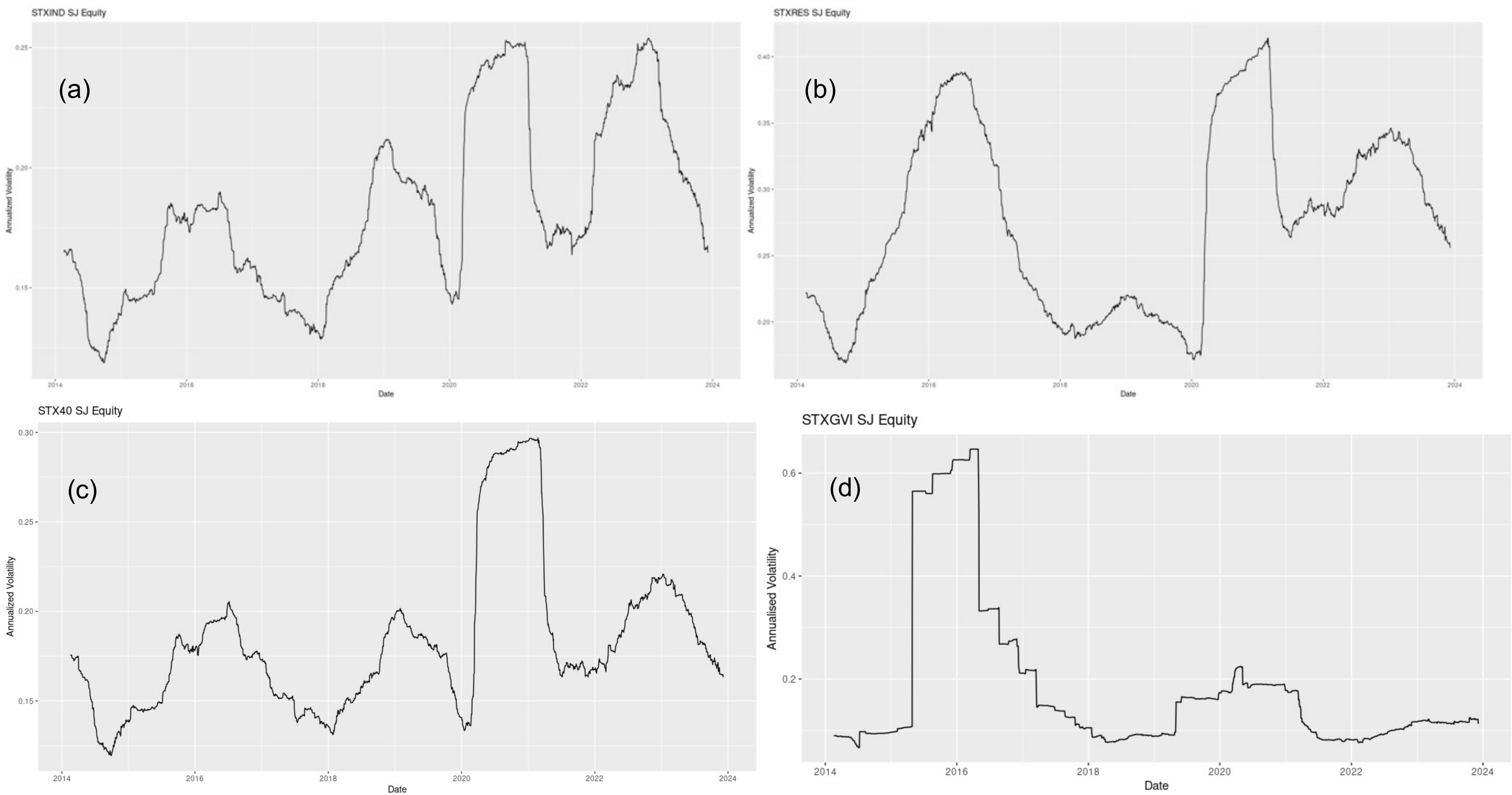


Figure 3: Annualised volatility plots (a – d)

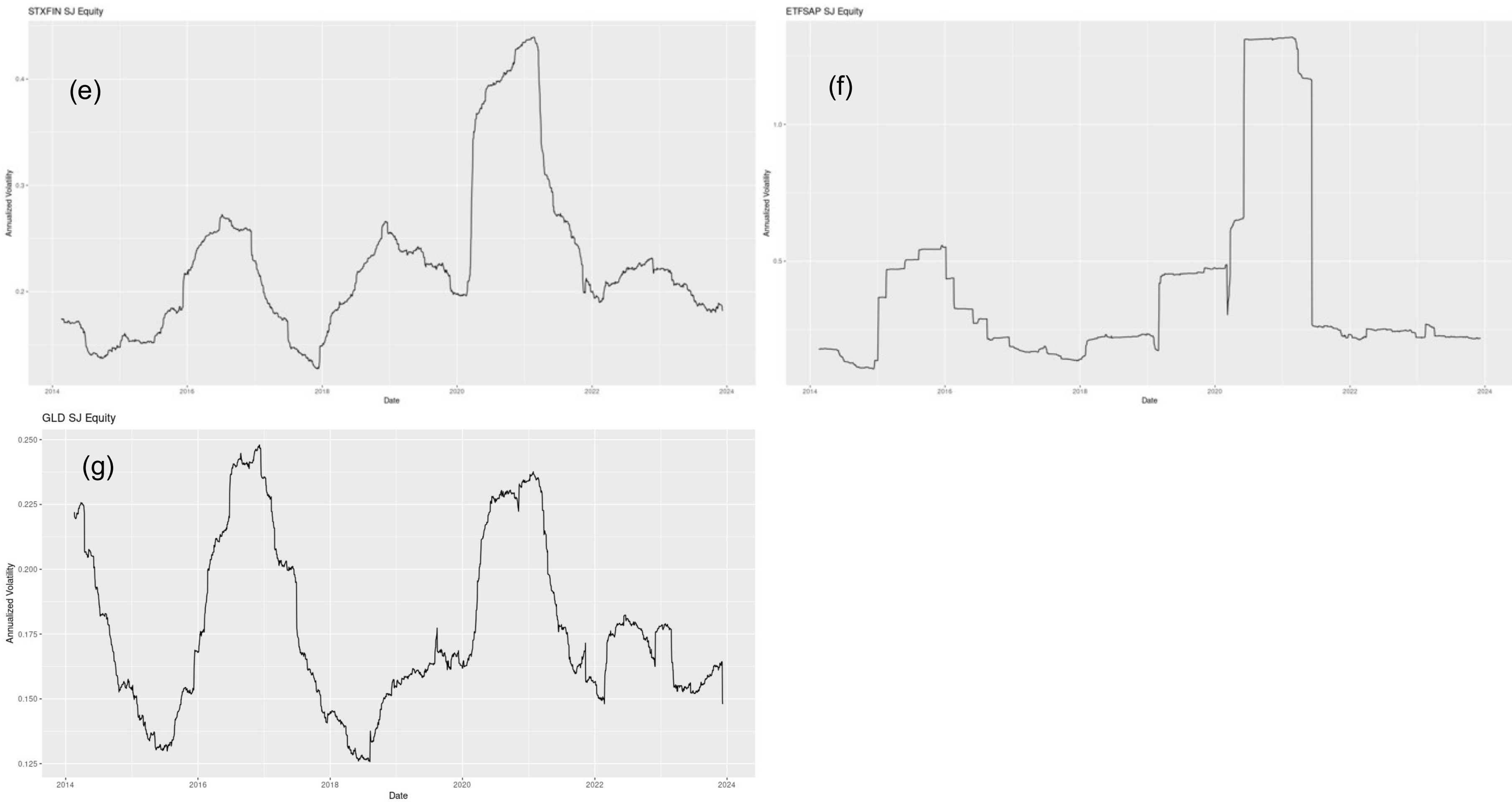


Figure 3: Annualised volatility Plots–- continued (e – g)

As indicated in the plots, it is noted that the feature of volatility clustering in financial time series is present, particularly in the equity and commodity ETFs. The STXFIN (e) and STX40 (c) volatility plot peaks and troughs seem to mirror each other well. However, the former's average volatility level is higher than that of the STX40. The STXFIN includes fewer shares than that of the STX40 and therefore it does not benefit as much from diversification.

The STXIND (a) experiences four major volatility spikes the most prominent of which are in 2020 and 2022. During the pandemic, the Monetary Policy Committee policy rate was at an all-time low of 3,50%in July 2020 to stimulate economic activity. Industrial companies that primarily focus on manufacturing goods struggled greatly with a slowdown in consumer demand and supply constraints due to mandatory lockdown. Again supply was affected in 2022 when due to the invasion, two global producers of wheat and oil stopped supply, creating a shortage in global markets. Inflation subsequently set in due to the supply constraints as well as an overspending during the pandemic area. This created artificially inflated financial asset prices around the world. As a net receiver of volatility spillover, South African financial markets had to absorb these foreign shocks. It is interesting to note there is an increase in volatility during the global interest rate hiking cycle which began in 2022.

The STXRES (b) mirrors the peaks and troughs of the GLD equity ETF. The large mining companies that comprise the STXRES are reasons for this. This poses an interesting question of whether to invest in direct commodity exposure through an ETF or indirectly through investing in gold mining companies. There is a difference in the cash flow profile as mining shares tend to do better as the gold price rallies. Their profits increase by inflation as gold remains a good inflationary hedge. As such, profits increase, and more cash is returned to shareholders as dividends. Profit margins for miners are squeezed during commodity cycle downturns as operational costs outweigh revenue and dividends may be suspended leading to poor performance for investors (Blose and Shieh, 1995). Smirnova (2016) describes the difference in performance between gold ETFs and gold mining companies as diversification tools in portfolio allocation decisions. Gold mining companies show a high correlation with the market portfolio and comparatively provide fewer diversification benefits than ETFs or physical gold.

The STXGVI (d) volatility drops slightly through 2021 and then remains relatively flat from 2022, onwards. Looking further back, from 2015 till mid-2016, the STXGVI experienced a major spike in volatility. This coincides with a period of great political and economic instability for the country. It culminated in the ratings agency, Standard and Poor's downgrading South African sovereign debt. During this tumultuous period, Jacob Zuma underwent a cabinet reshuffle which included the departure of then Finance Minister, Pravin Gordhan. Investors were uneasy about the country's ability to finance their existing debt obligations due to the poor economic growth and high levels of corruption and as such cut South Africa's rating to BB+, its highest noninvestment grade mark. Muzindutsi and Obalade (2024) mirror the sentiment observed in the analysis by confirming that political risk has a significant effect on the financial flows within the sovereign bond market. Janus (2021) provides context on the immediate impact of sovereign bonds in emerging market economies during times of crisis.

The flight to safety due to the worsening prospects of global economic growth and the downturn in international trade is evident during the first quarter of 2020. Emerging market economies were more susceptible to capital outflows than advanced economies. The STXGVI plot shows a slight increase in volatility during 2020, and this echoes the findings of Janus (2021). During extreme global market events, pre-existing vulnerabilities are amplified by emerging market economies.

Furthermore, riskier emerging markets still face challenges such as their inability to provide safe and secure investments that would reassure foreign investors during times of uncertainty. Comparatively, South Africa's sovereign bond market is well-developed and regulated compared to other riskier emerging economies, which could explain only the slight increase in volatility during 2020.

The STXFIN (e) ETF, tracks as closely as possible, the value of the FTSE/JSE Financial 15 index. All of these companies are in the banking and other related financial services industry. There seems to be a peak in volatility approximately every two years on the graph with a major spike during 2020. The resilience of South African banks during COVID-19 is evident in Figure 1. The STXFIN had the best relative performance compared to the other ETFs. The sector remained relatively flat over the analysis period, with little fluctuations in price. Moyo (2018) elaborates on the banking sector in South Africa. The paper describes a well-developed and effectively regulated industry with the South African Reserve Bank ensuring financial stability and acting as a lender of last resort. South Africa ranks among the highest in the world with regards to financial market development and bank soundness according to the Global Competitiveness Report.

The banking sector in South Africa has strict lending terms and the majority of the largest banks are all well capitalised. The resilience of the South African banking sector was also observed during the Global Financial Crisis (GFC) of 2008 as many of the banks were highly efficient and put them in good stead to deal with the crisis (Erasmus, 2014). The banking sector in a country is vital in stimulating economic activity by mobilising individuals' savings and channelling them into productive sectors. The fragility within the banking sector was brought to light by the collapse of Silicon Valley Bank (SVB) and other regional banks in the United States (Akhtaruzzaman et al., 2023). The paper attributes the bank's collapse to a change in the regulatory framework. This limited the heightened risk monitoring practices to only the largest banks and coupled with a slow response from the Federal Reserve, allowed a hoarding of bad news of SVB which spread to the rest of the banking sector.

The results show that there has been a pronounced elevation of contagion globally within the banking industry as evidenced by the takeover of Credit Suisse in Switzerland and First Republic in the United States. Unlike in 2008 during the GFC, the banking crisis in 2023, was confined within the banking industry and its effect was negligible in other market sectors. Mbatha and Alovokpinhou (2022) find that information spreads quicker to other industries, via the finance industry. A negative impact on the finance industry could potentially collapse the economy. The

identification of which sectors impact each other is pivotal for policymakers to ensure the stability of the stock market during times of crisis.
The ETFSAP (f) has a major spike in volatility during the COVID-19 pandemic. This ETF aims to track the South African listed Property Index (SAPY) as closely as possible. This index consists of the 20 largest market-capitalisation-weighted property companies on the JSE. It is important to note that this ETF is only a proxy for the property asset class and is the most easily accessible investment vehicle for investors to gain exposure to the South African property sector without physically owning the asset. Milcheva (2021) describes the effect of how market expectations have changed, and risk was re-assessed in the property sector as a result of COVID-19 among US and Asian property companies. Real estate was among the poorest performing sectors in various countries around the world with strict lockdowns imposed on citizens. All service-related businesses suffered massively as leisure activities were ceased and social distancing practices were enforced by law. In general, real estate companies have low exposure to market shocks, experiencing mostly idiosyncratic shocks and having a low correlation with equity indices during normal economic times.

Intuitively, when the economy slows down and the majority of these real estate companies derive profits from rental income on the properties they own, investors change their assessment of the inherent riskiness of real estate shares. The discount rate to which investors apply to the current valuation of the stock will increase due to the increased uncertainty of future cash flows of the company. This sentiment is mirrored in the South African property sector throughout 2020 and most of 2021. A R500bn social and economic relief support was announced shortly after the lockdown was imposed. These funds were mainly allocated to credit guarantee schemes as well as job creation and support for small and medium enterprises. Although these measures did assist the economy in functioning during the hardest parts of the pandemic, it was at the cost of reducing spending on the very projects that were aimed at improving society's development and well-being in the long term (de Villiers et al., 2020).

The GLD ETF (g) has two pronounced peaks, with a long bull run from mid-2015 and most of 2016 and again a dramatic increase in 2020. This argues in favour of gold being the safe haven asset in times of economic uncertainty (Akhtaruzzaman et al., 2021), as the GLD SJ equity ETF, similarly experiences a sudden increase in volatility. Gold does not behave in a similar way to traditional commodities such as oil and platinum group metals. These commodities are critical inputs in the manufacturing process of various goods in contrast to gold which has limited use in these processes (Fassas, 2012). Geopolitical risk plays a major role in the demand and hence the volatility of gold. Black Swan events that create turmoil in global financial markets such as the COVID-19 pandemic and the Russian invasion of Ukraine are key drivers of gold returns for investors. The ability of gold to be a store of value with geopolitical tensions rising is demonstrated in the volatility plot as investors flock to the commodity. Further evidence of this is the large bull run in 2016 which coincides with the United Kingdom referendum on membership within the European Union.

5.6 VIX comparison and linear regression on TCI of equity ETFs

Figure 4 shows the system-wide domestic volatility spillovers for the equity ETFs with the VIX level superimposed.

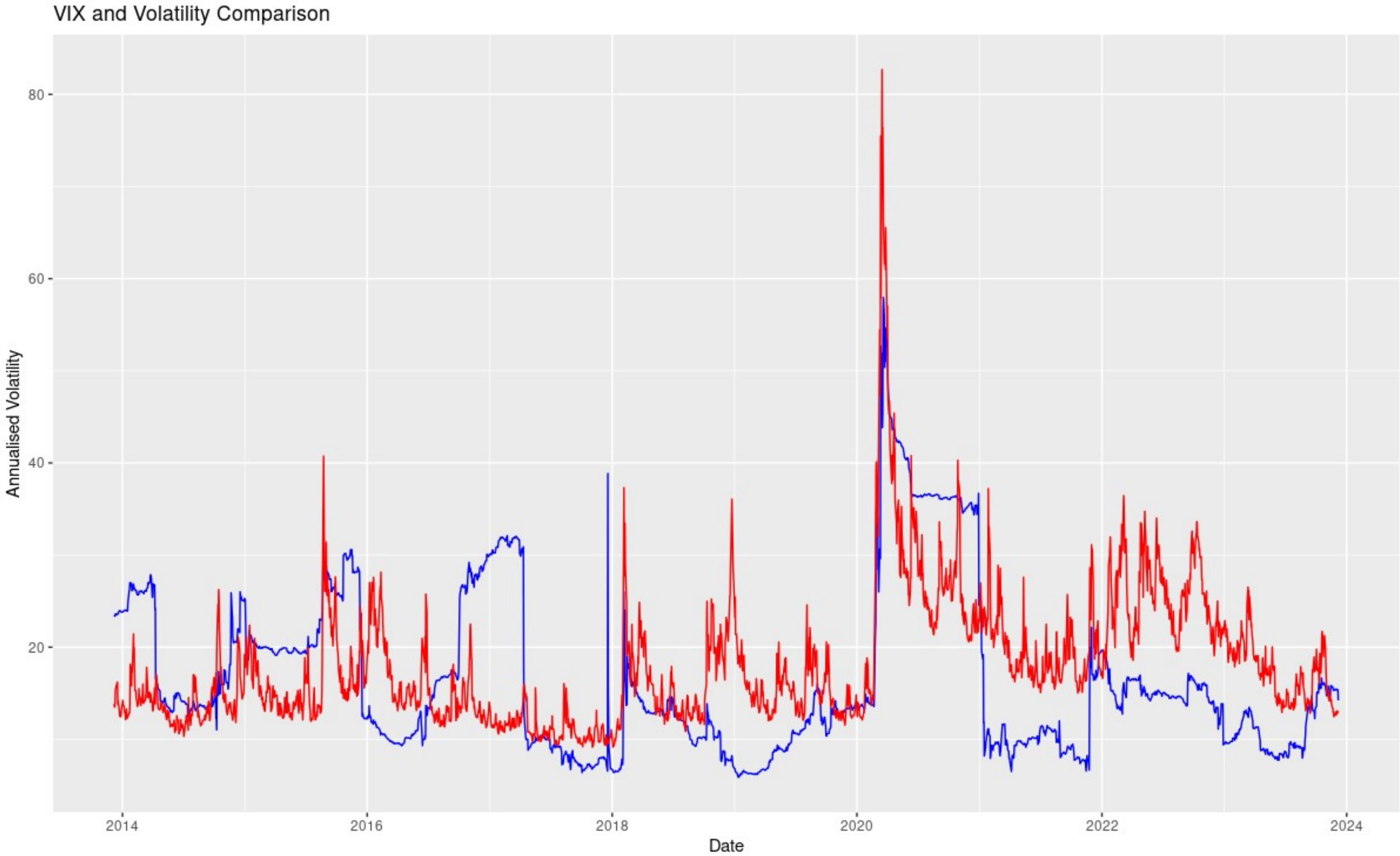


Figure 4: Total volatility spillover for equity ETFs with VIX

The contagion among the equity ETFs does not show much correlation with the VIX level. However, during COVID-19 there is a clear relationship as the VIX level increases so does the spillover between equity ETFs. The equity system spillover coincides with times of uncertainty in financial markets. During 2016, Britain's referendum vote on whether to stay in the European Union seemed to coincide with increased spillovers.

Global markets lost more than two trillion dollars' worth of value on the 24th of June 2016 upon the news of the referendum result. At the time it was the largest single-day loss ever experienced in global markets (Burdekin et al.,2018). This drove global economic policy uncertainty and did affect Brazil, Russia, India, China, and South Africa (BRICS) as these markets fell but at a level, significantly less than the average global benchmark at -4,7%, the day after the referendum. Burdekin et al. (2018) elaborate on the fact that BRICS has become a more unified economic group, establishing formal ties through the New Development Bank and Contingent Reserve Arrangement. For the BRICS nations, a weakened European Union can be likened to the decline of a competitor. As such, these nations stock market performance fared much better than the United Kingdom or European markets.

However, South Africa was the only member country that did not experience significantly positive abnormal returns immediately after the referendum result. Similarly, the VIX level which proxies uncertainty in the United States market did not experience a level increase. The spillover graph peaks again in 2020, which can be attributed to the COVID-19 pandemic. The Russia-Ukraine conflict seems to have a muted effect on the South African equity market as shown by a relatively small increase in spillovers during this period. Within the South African equity market, the allocation towards the different sector ETFs does not seem to result in significant diversification for investors. The simultaneous negative movement of all sectors on the JSE is evidence of this during 2016 and 2020, especially. South African investors see the opportunities that offshore investing brings as attractive due to the diversification benefits as well as the opportunity to hedge against currency risk.

During the current economic climate, emerging markets are most vulnerable to macroeconomic shocks. The high inflation and interest rates around the world mean that the South African Reserve Bank is forced to maintain the current high Repo rate level to prevent further depreciation of the Rand. Ultimately, all market participants suffer as businesses have high debt burdens, consumers see their purchasing power depreciate due to inflation and investors suffer due to the detrimental performance of JSE shares. Bekaert et al. (2014) studied the effect of contagion among equity markets during the GFC. They found that factors related to banking sector links and information flow cannot explain all the variations in contagion across portfolios during a financial crisis. Furthermore, countries with high political risk, large unemployment, and high government deficits experience a high degree of contagion. The findings of this research are similar to those of Bekaert et al. (2014) in that South Africa as a country, possesses high political risk and large unemployment, therefore it is more likely to experience a high level of contagion between sectors.

Table 6: Linear regression output of VIX level on TCI of equity ETFs

```
Call:
lm(formula = TCI_data ~ `VIX Vol`)

Residuals:
      Min          1Q       Median        3Q         Max
-0.0038279 -0.0006318 -0.0004162  0.0000910  0.0301372

Coefficients:
              Estimate    Std. Error  t value   Pr(>|t|)
(Intercept)  7.710e-04   3.248e-05  23.735  < 2e-16 ***
`VIX Vol`    5.959e-03   1.657e-03   3.596    0.000329 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.001583 on 2644 degrees of freedom
Multiple R-squared:  0.004867, Adjusted R-squared:  0.004491
F-statistic: 12.93 on 1 and 2644 DF,  p-value: 0.0003291
```

The output above shows the linear regression of the Total Connectedness Index (TCI) which represents the impact of one variable (VIX) on all other variables (volatility of equity ETF returns). The TCI is used in the analysis of financial networks to quantify the interconnectedness among various financial assets. If this measure is high it implies that the interconnectedness of the system and in other words, market risk is high. A low value implies that the variables are independent of one another and hence a shock in one variable will not result in a change in any of the other variables (Bouri et al., 2021).

The p-value for the coefficient of VIX volatility is 0,000329, which is less than the conventional significance level of 0,05. This means that the coefficient is statistically significant. In other words, for every one-unit increase in VIX Volatility, the TCI is expected to increase by 0,005959, holding all other variables constant. The residuals represent the difference between the observed variables of the TCI and the values predicted by the model. It bodes well for the model that they have a mean close to zero.

The adjusted R-squared value is 0,004491 which means that a small portion of variance in the TCI is explained by the VIX volatility. Moreover, the overall fit of the model, indicated by the F-statistic (12,93) and its associated p-value (0,0003291) is statistically significant in explaining the relationship. Although there is a statistically significant positive relationship between VIX and the TCI, the overall explanatory power of the model is limited. In contrast, Kang et al. (2021) found that the VIX volatility has the strongest effects on US sector ETF prices and returns, followed by Oil price uncertainty (OVX).

To assess, important secular and cyclical movements, a 252-day rolling sample is also used to estimate volatility spillovers. The total spillover plot captures the nature of the spillover indices through a time series. The COVID-19 pandemic resulted in a simultaneous negative movement in all markets (Mbatha and Alovokpinhou, 2022). This followed a significant decrease in spillovers as markets began to stabilise after the initial shock of global supply change slowdowns and lockdowns. Financial flows between countries were significantly slowed, with capital and trade halting as well. Another uptick in spillovers occurred after 2022 which coincides with the Russian invasion of Ukraine and increased geopolitical tensions between Western and Eastern aligned countries.

5.7 VIX comparison and linear regression on TCI of alt. asset class ETFs

Figure 5 shows the system-wide domestic volatility spillovers for the alternate asset ETFs with the VIX level superimposed.

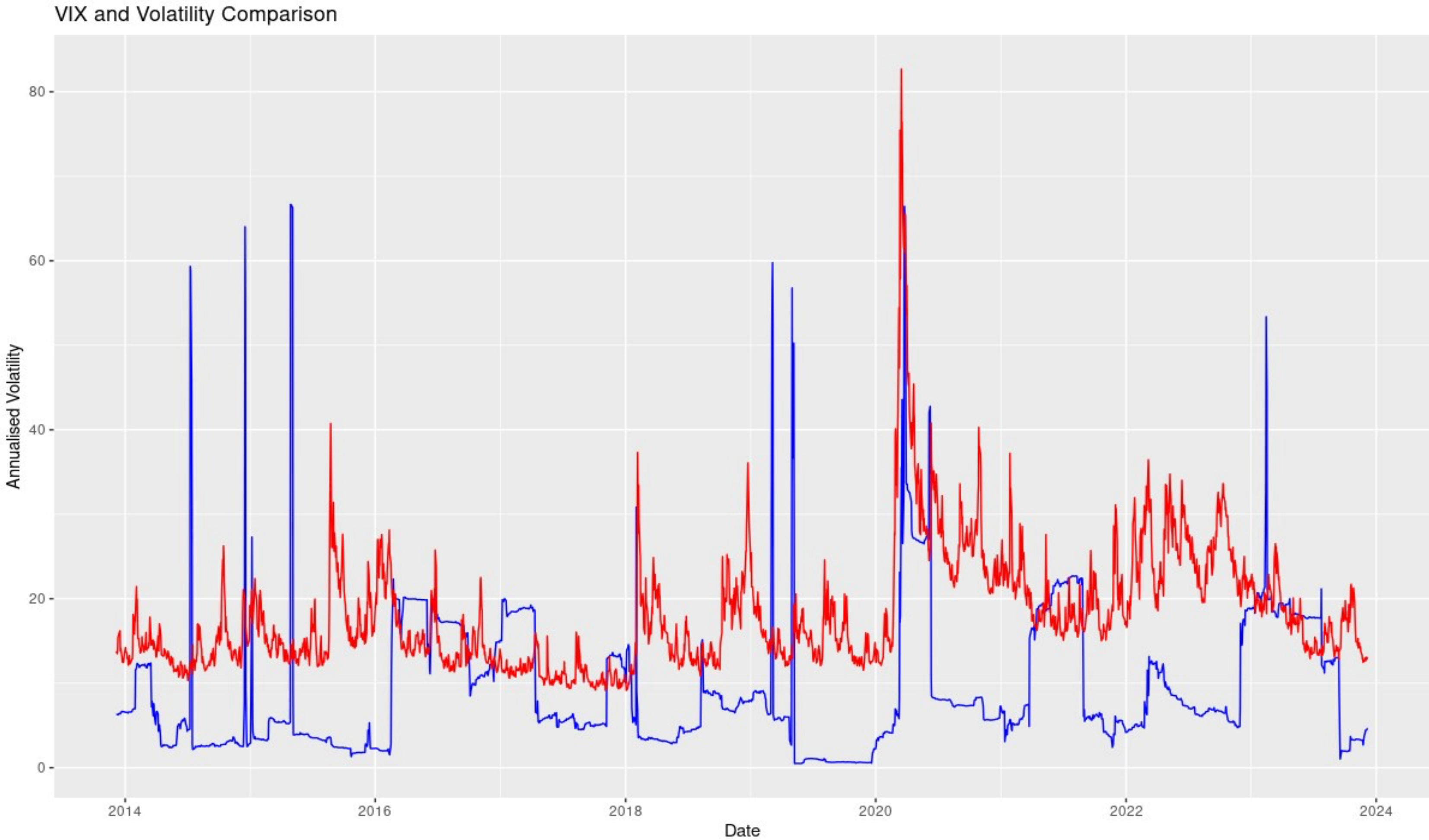


Figure 5: Total volatility spillover plots for alternate asset class ETFs with VIX

Umar et al. (2022) highlights the effect of the Russia-Ukraine conflict on global equity and bond and commodity markets. They found that the uncertainty caused by geopolitical risk resulted in a surge in demand for assets that preserve wealth with spillovers becoming increasingly pronounced. Importantly, their paper highlighted that the Russian invasion mainly affected the short-term relationship between financial asset returns and the long-term connectedness among their volatilities. This reinforces the rhetoric that the relationship between financial markets has changed, and investors need to construct strategies that hedge against geopolitical risk and undertake appropriate risk monitoring practices. This is in line with the conclusions proposed by Diebold and Yilmaz (2012) as well as Fleming et al. (1998) in which strong linkages in volatility are found between asset classes during periods of high market uncertainty such as the 1987 stock market crash and in this case, COVID-19 and the Russian invasion of Ukraine.

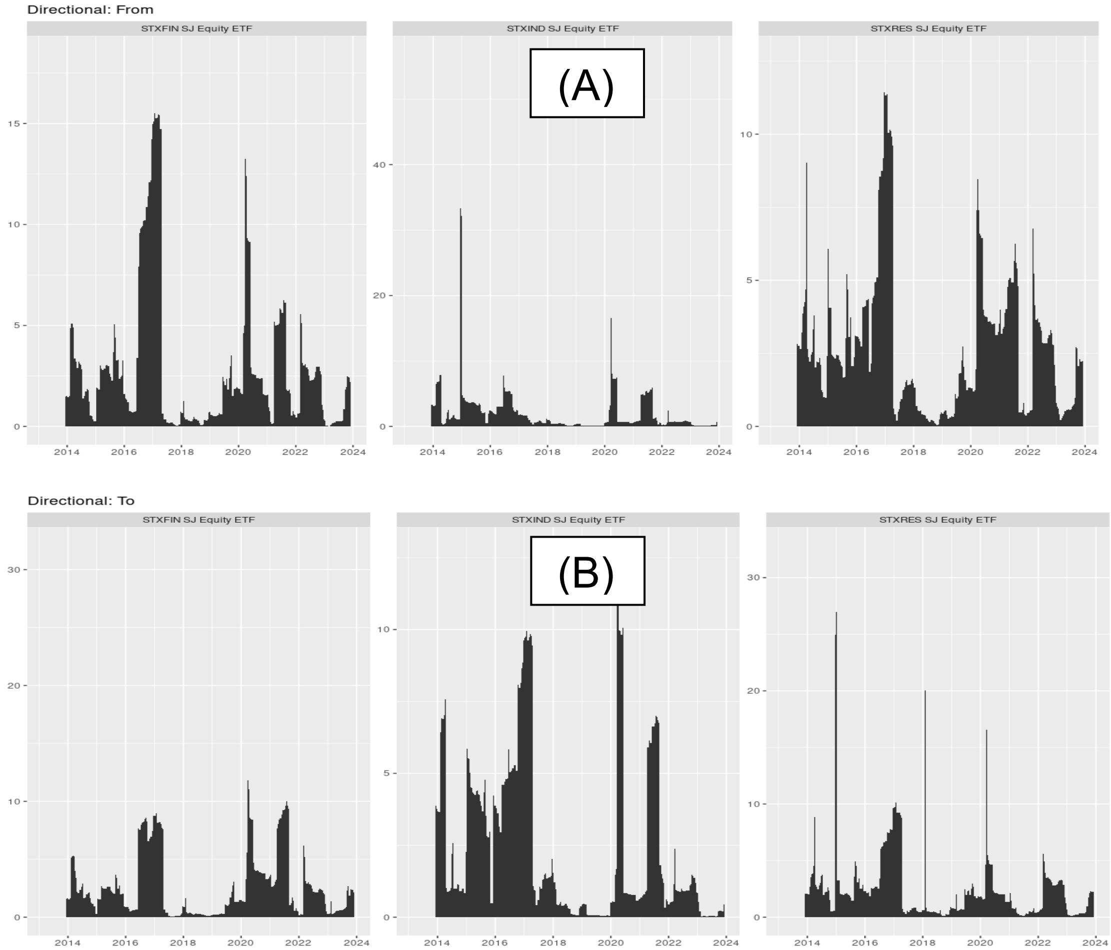
Table 7: Linear regression output of VIX level on TCI of alternate asset ETFs

```
Call:
lm(formula = TCI_data ~ `VIX Vol`)

Residuals:
    Min        1Q      Median     3Q        Max
-0.00429 -0.00131 -0.00118 -0.00089  0.70145

Coefficients:
             Estimate   Std. Error  t value    Pr(>|t|)
(Intercept)  0.0014119  0.0003857   3.661     0.000256 ***
`VIX Vol`    0.0060647  0.0196749   0.308     0.757920
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.0188 on 2644 degrees of freedom
Multiple R-squared:  3.593e-05, Adjusted R-squared:  -0.0003423
F-statistic: 0.09502 on 1 and 2644 DF,  p-value: 0.7579
```

Based on the output of this regression analysis, the p-value suggests that the coefficient of VIX volatility on the TCI among alternate asset class ETFs is not significant. The adjusted R-squared is -0,0003423 which is minuscule and explains almost no variance in the TCI of alternate asset class ETFs. In summary, based on the regression analysis, there is no significant relationship between VIX volatility and the TCI between ETFs representing different asset classes in South Africa. This argues in favour of the diversification benefit for investors allocating portions of their portfolio to multiple asset classes. The understanding of dynamic spillover across financial assets provides efficient risk hedging and diversification strategies during periods of turmoil (Bouri et al., 2021).

5.8 Directional equity ETF spillovers

Figure 6 (A) and (B) display the ETF spillovers from each ETF to the rest of the system and spillovers to each ETF from the system, respectively.



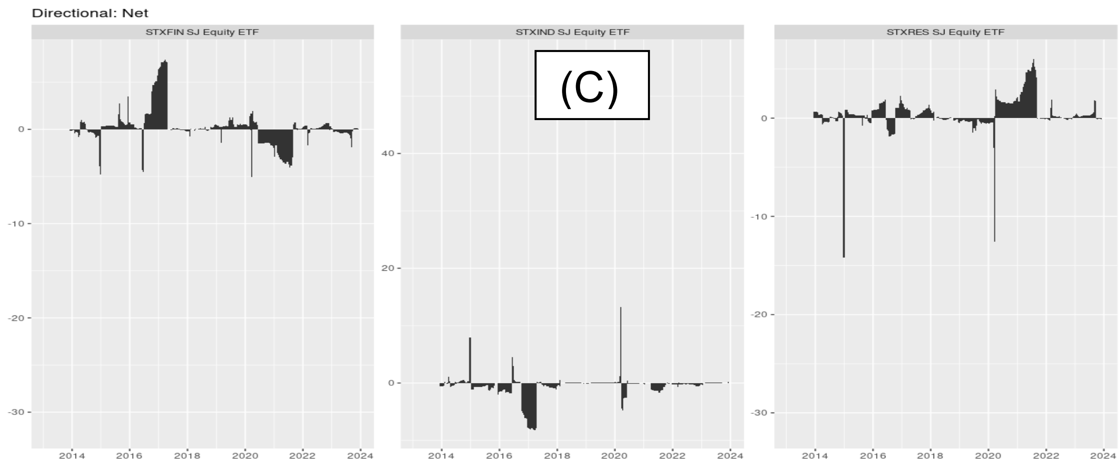


Figure 6: Net domestic equity spillovers (Clusters A, B and C)

Figure 6 (C) plots the net directional spillover index between each equity ETF over the analysis period. One can think of a set of directional spillovers as decomposing the total spillovers to those coming from (or to) a particular source. The plots show a great variation in spillovers over the period. Both the STXRES and STXFIN ETF fluctuate between being net receivers and transmitters of volatility at different periods. However, there are periods where the STXRES becomes a net volatility exporter, possibly due to the large fluctuations in the shares of mining companies which are particularly susceptible to the stages of the commodities cycle.

The STXIND ETF is mostly a net volatility receiver although punctuated with periods where it is a net transmitter. This ETF owns the top 25 industrial shares (manufacturing, construction, and retail). Industrial companies in South Africa were affected in multiple ways during the pandemic. Lockdown restrictions meant that sales suffered dramatic declines and as such investors perceived there to be risks to these firm's ability to remain profitable. Furthermore, the liquidity and solvency of these firms were questioned as many companies had to restructure their debt obligations so as not to default. The low-interest rate environment at the time allowed these companies to do so. The announcement of the R500bn social support and economic relief fund did provide some reprieve for businesses to continue operating in 2020 (de Villiers et al., 2020).

5.9 Directional alt. asset class ETF spillovers

Figure 7 (A) and (B) display the ETF spillovers from each ETF to the rest of the system and spillovers to each ETF from the system, respectively.

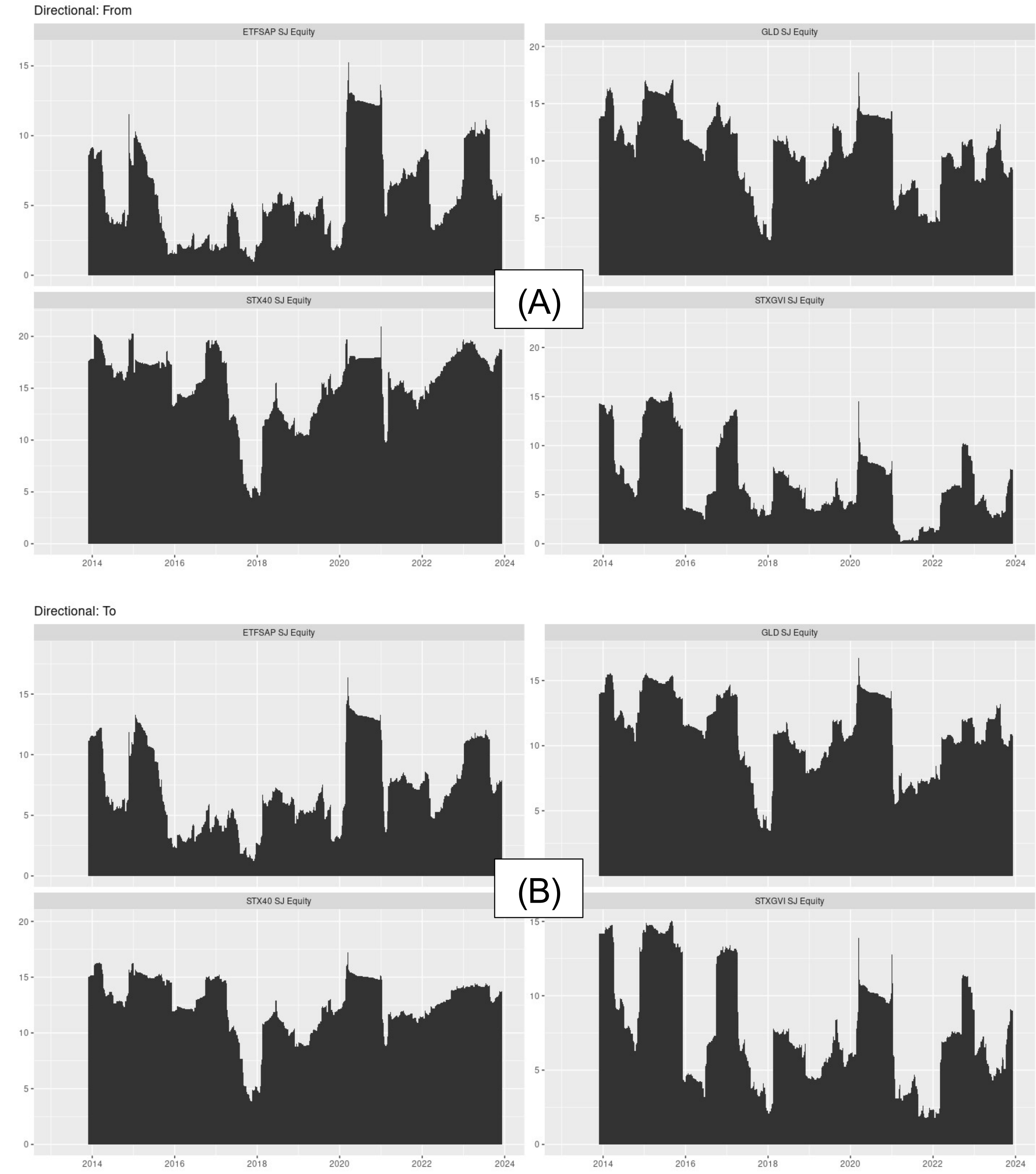


Figure 7: Net alt. asset class spillover (Clusters A and B)

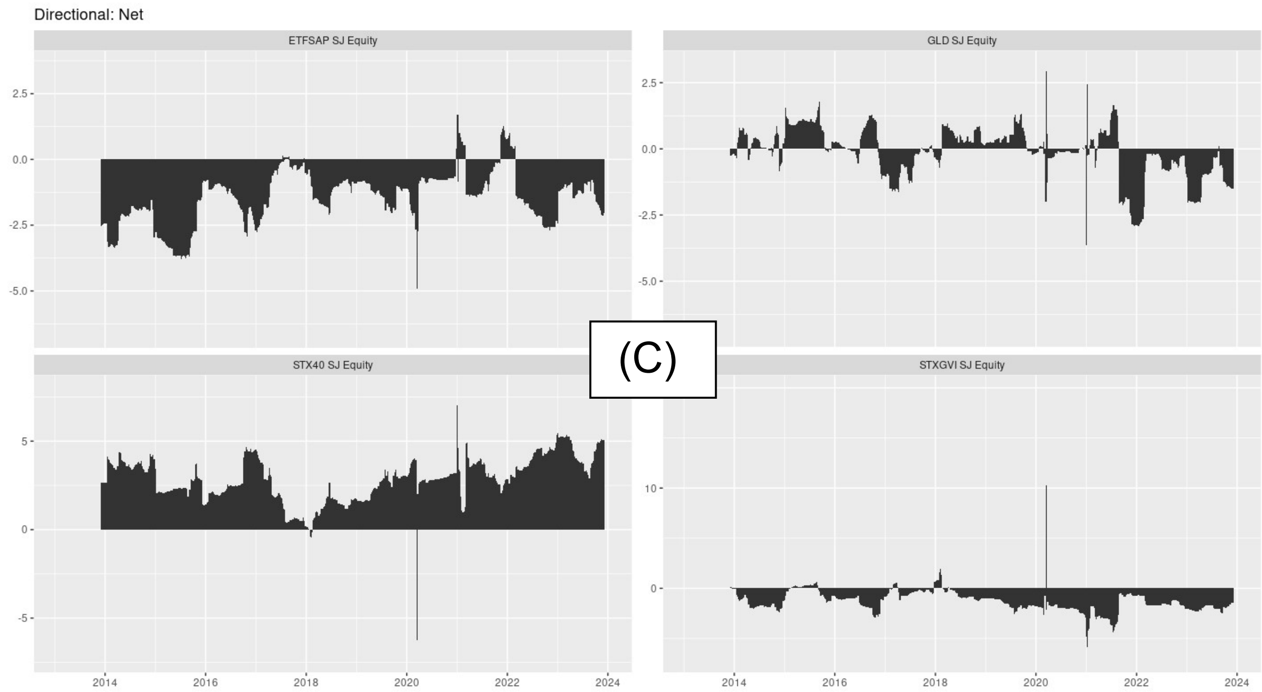


Figure 7: Net alternate asset class spillover – continued (Cluster C)

Figure 7 (C) shows the net volatility spillover between ETFs representing distinct asset classes. The STX40 is a net volatility transmitter to the rest of the system, for most of the sample period. During periods of crisis, seemingly uncorrelated markets experience simultaneous downturns. Volatility propagates through the entire financial system as uncertainty among investors creates an environment where financial flows between various asset classes increase. The ETFSAP is a significant importer of volatility from the rest of the system, peaking in 2020. It is punctuated with small infrequent periods when it is a net volatility transmitter. During the lockdown, investors had a negative sentiment towards the property sector. Milcheva (2021) constructed a COVID-19 Risk Factors model to assess the real estate stock market pricing behaviour. The findings underline the nuanced and varied impacts of the pandemic on real estate companies across regions. In particular US real estate companies experienced a sharp decline during this period with the retail sector being the worst performer. Asian-based companies, however, were less affected with less sector based divergence. Due to the ease for investors to move in and out of ETFs, the volatility spillover gives a good measure of investors’ sentiment towards a particular asset class. The GLD ETF experiences the greatest fluctuations between being a net volatility receiver and a transmitter. Commodities are especially susceptible to demand and supply factors as well as an inflation hedge for investors. Constable (2020) reported that many investors sought out ETFs holding precious metals, indicating that industries such as mining were more resilient to the COVID-19 pandemic, given the expectations of high future cash flows.

Between 2018 and 2020, the gold ETF was a net volatility transmitter and then switched to a net receiver from 2022 for the rest of the analysis period. In line with that of Duncan and Kabundi (2013), the STXGVI (Bond) ETF is a net volatility receiver for the majority of the analysis period. Meyer and Hassan (2020) attribute the continued volatility of exchange rates as the major contributor, adversely affecting African government bond yields. The stability and confidence of exchange rates are a reflection of how global markets view local governments and their economies. As such a negative global outlook brought about by a pandemic or increased geopolitical risk results in the performance of emerging market economies being very susceptible to shocks and hence the bond market being a net receiver of volatility.

6. Conclusion

After the COVID-19 pandemic, it became apparent that the integrated success of globalisation has now become a threat to the resilience of global supply chains. A comprehensive investigation into the spillover dynamics of various ETFs available to investors on the JSE was conducted in this analysis using the DY methodology of measuring spillovers. A wide range of ETFs that represented different asset classes including bonds, commodities, property, and equity were included. The analysis was separated into two parts - the first of which focused on spillovers only among the equity ETFs and the second, focusing on spillover amongst four asset classes (equities, bonds, commodities, and property). ETFs were chosen as they are liquid investment vehicles that are easily accessible to retail investors and are a good indication of sentiment amongst market participants. It was found that the contagion amongst the three equity ETFs included was higher at 3,1% with contagion amongst alternate asset classes at 1,92%.

During crisis periods especially, contagion among the different equity sectors was marginally higher, in comparison to the ETFs representing different asset classes. This argues in favour of diversification among multiple asset classes. The findings of this research are similar to those of Bouri et al. (2021) in that the understanding of the dynamics of spillovers among financial assets may provide efficient risk hedging models and diversification strategies during periods of market turmoil through the identification of which variables are net receivers and net transmitters of information across the system. The results show that the property and bond asset classes are susceptible to shocks in other asset classes. Equities seem to be the main contributor of volatility to the rest of the system for the entirety of the analysis period with gold fluctuating between being a net receiver and transmitter. In the equity ETF system, the STXFIN becomes a net receiver of volatility at the beginning of 2020 for two years. Contrastingly, the STXRES becomes a net volatility transmitter for the same period.

According to the analysis, a passive investor looking to diversify their holdings on the JSE should allocate a majority of their portfolio to the STX40 ETF as it is the least susceptible to shocks in other ETFs. It is unclear whether an investor is able to perfectly time switching between investment vehicles to mitigate losses due to volatility in financial markets.

Furthermore, the individual volatility for each ETF over the period was discussed in an attempt to understand how major macroeconomic shocks could affect volatility in these markets. Additionally, the effect of foreign shocks such as the VIX was included to test if there was a similar significant impact on South African asset classes. A regression analysis was conducted to determine whether the TCI for each equity and alternative asset system was explained by volatility in the VIX index. It was found that for equity-based ETFs there is a small significant effect on spillovers between the ETFs. This is in contrast to the small and non-significant effect on contagion among ETFs representing different asset classes. Lastly, the VIX contribution to each asset class was measured with its total contribution to system-wide volatility determined to be at 12,47% across all ETFs in the study.

Understanding volatility transmission between components within a portfolio is essential in preserving an investor's wealth. It is observed that certain variables switch between being net transmitters and receivers depending on either market-wide or asset-specific effects. Analysing the volatility connectedness suggests that there exists common information that both directly and indirectly affects uncertainty about the future development of the segments of the market included in the study. Furthermore, the findings prove insightful for volatility forecasting and hedging strategies to insulate the effects of macroeconomic shocks on investors in South African capital markets. For investors, diversification across asset classes and to a lesser extent, equity sectors is vital in ensuring the long-term preservation of one's wealth.

Future recommendations for research could be expanded to study the asymmetric effects of good and bad volatility spillovers. Bad uncertainty as defined by Segal et al. (2015) is the volatility that is associated with negative innovations to output returns. Intuitively, good uncertainty is associated with positive shocks to these variables. Numerous researchers have noted that volatility is higher during crisis periods in comparison to tranquil market conditions. This phenomenon is described as the asymmetry in volatility spillovers. Furthermore, the need for more high-frequency South African data to measure the asymmetric nature of volatility and how it propagates between different asset classes is an area of interest. A major obstacle in the research is the lack of historical ETF data. The introduction of ETFs that track international benchmarks and their spillover towards ETFs that track domestic benchmarks is an area for future studies to explore.

The amendments to regulation 28 of the Pension Funds Act stipulating how people should invest their retirement savings have resulted in investors being able to allocate a maximum of 45% to international assets in their investment portfolio. This motivates future literature to study the effect of the JSE-listed ETFs that track foreign assets and their spillover to domestic assets. This would include foreign exchange risk as an added element to an investor's portfolio allocation decisions.

Lastly, Bouri et al. (2016) implemented an alternate source of volatility shocks on financial assets. The research used a newspaper-based index of uncertainty in financial markets to capture the impact of an infectious global disease during the COVID-19 pandemic. Using a foreign source of volatility other than the VIX could see a different effect on volatility within financial markets.

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