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EXPLORING STOCK MARKET RISK USING A GENERALIZED BREACH INDICATOR: EVIDENCE FROM INTERNATIONAL FINANCIAL MARKETS

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Abstract

Stock market risk is of significant consideration in asset management, due to its direct link with valuation. Risk in stock markets mostly arises from macro and micro policies which influence the returns of an index. However, there is no real meaningful study that has estimated the extent to which the realized returns exceed or fall short of the expected return in international stock markets. The aim of this study was to explore market risk using breach indicators in the JSE, Nasdaq, CAC 40, DAX, Nikkei 224, and BIST100 indexes. Using a sample period from January 2, 2018, to January 2, 2023, the findings revealed a significantly lower breach of expected returns in the Nasdaq, DAX, and CAC 40 while the JSE was within range. This implies a significantly larger than normal uncompensated risk involved in the Nasdaq, DAX, and CAC 40. However, the Nikkei 225 and BIST100 displayed a significant positive breach of expected returns. The findings of this study strengthen the debate that stock markets in developed countries are more susceptible to risk and losses than stock markets in less developed countries. In essence, using long-term moving averages will be useful in mitigating absurd price swings in the Nasdaq, DAX, and CAC 40.

Keywords: Stock Markets, Risk, Generalized Breach Indicators, Value-at Risk, Heteroscedasticity, Total Loss

JEL Classifications: D53, G15, G32

1. Introduction

The term “risk” is one of the most common perceptions associated with investing in stock markets (Huber *et al.* 2019). Investment practitioners and market participants often talk about risky stock markets with little or no empirical evidence. It is always prudent to contextualize risk in stock markets before elaborating on the amount of risk. There are several ways to analyze risk, but depending on the nature and horizon of investing, uncompensated risk is fundamental (Campbell *et al.* 2010). At its core, uncompensated risk in stock markets results in potential loss in total value of an investment, the level of volatility, and skewness in returns of assets (Baek *et al.* 2020).

Although a well-diversified portfolio may still experience volatility, the risk of total loss is very minimal as long as capitalism continues to function. Fama and French (2018) constructed a statistical model to examine the probability of negative risk premiums over various time periods. Their findings revealed that there is a 36% chance of total loss in equity premiums over a one-

year period in stock markets which may be better to rather invest in risk-free treasury bills. This finding concurs with the historical one-year return figures across global stock markets, which are at times lower than the return on risk-free assets (Anspach, 2022). In the same paper, Fama and French (2018) also simulated the returns of 100.000 stocks in the United States (US) over a period of 30 years and found a 4.08% loss in equity risk premium which is substantially lower than the 36%. From the above analogy, analysis of the taxonomy of stock market risk should mainly focus on the amount of uncompensated risk involved as it is sensible to assume compensated risk. This is particularly true because uncompensated risks are attributed to specific stock markets which adversely affects investors and market participants due to higher margin losses. To date, it is almost impossible to estimate the level of uncompensated risk involved in stock markets (Vernazza, 2017). Academics have attempted to measure the extent to which this form of risk can be minimized in a well-diversified portfolio (Jayeola *et al.* 2017; Sunchalin *et al.* 2019). In so doing, the theory of equally weighted was proposed to overcome weighting biases which were not feasible in the real world due to optimal risk adjustment return targets (Layton *et al*. 2018). Also, investing in stock markets should not only be gauged through the lens of volatility but also the tail risk or expected losses which are low-probability outcomes with high impact events which may significantly reduce the value of an investment. In other words, analyzing the extent to which stock market returns breach an expected threshold should be considered seriously.

The studies of Shkolnyk *et al.* (2019), Chiang (2019), and Enow (2023) reveal that stock markets are integrated, and many risks affect stock markets but very little is known on generalized breach indicators of stock market risk. Therefore, the main research question for this study is; which stock markets are more likely to experience the greatest losses in cumulative value during periods of market calm and distress? This study extends Fama and French's (2018) paper by analyzing the level of uncompensated risk given by generalized breach indicator. The motivation for this study stems from the perspective of individual investors and financial institutions.

More specifically, understanding stock market risk may help investors make informed investment decisions by assessing the potential risks associated with different stocks or portfolios, hence investors can evaluate the potential returns and determine if the level of risk aligns with their investment goals and risk tolerance. Also, exploring stock market risk will enable financial institutions to diversify their portfolios effectively considering that stock markets have varying levels of risk and diversification helps mitigate the impact of individual market fluctuations on the overall portfolio.

By analyzing risk, investors can identify stock markets that exhibit low correlation with each other, thereby reducing the overall risk exposure. Furthermore, in understanding the extent to which stock markets breach their expected thresholds, appropriate hedging mechanisms and portfolio diversification strategies may be used. In so doing, this study makes a noteworthy contribution not just to the academic literature on risk in stock markets but also to industry practitioners in mainly two ways. Firstly, this study may lead to the development of effective risk management strategies to help identify and evaluate different risk mitigation techniques, such as diversification, hedging, and portfolio rebalancing. Secondly, this study may provide valuable insights to policymakers and regulators in shaping financial policies and regulations. Hence, the development of regulatory frameworks that promote transparency, fairness, and stability in the financial industry.

This paper is structured as follows: Section 2 highlights the literature review followed by the research method in section 3. Data is given in Section 4. The results are discussed in Section 4. Finally, Section 5 concludes the paper.

2. Literature

Stock market risk involves uncertainty surrounding the expected value of an index arising from economic or country-specific factors. The idea of risk management is either to mitigate or reduce risk to an acceptable level. There are several risks associated with investing in stock markets. Some of these risks are, event risks, associated with activities within a market that affects the value of an index such as the COVID-19 pandemic. Obsolescence risk involves the use of disruptive technology to downsize the market share of previously successful firms (Pantano *et al.*

2013). Legislative risks involve adverse impacts on the value of an index due to country-specific rules and regulations while political risks relate to instability in a country. All the risks mentioned above are important considerations in investing due to their significant effect on the value of a security which makes hedging an important tool in curbing risk. A survey from Bloomberg (2022) indicates that inflation and recession are the two reoccurring risks that affect almost all stock markets together with a liquidity crunch. In a stability report by the US Central Bank, inflation and the Russian invasion of Ukraine are the prevailing risks that affect stock markets (Enow, 2023).

An understanding of the nature of risk and margin of safety involved in specific stock markets are of vital importance, which is necessary for moat and valuation purposes. Understanding stock market risk and its relevance is crucial for various stakeholders, including investors, financial institutions, regulators, and policymakers. These include investor protection, portfolio management, risk mitigation, financial stability, pricing and valuation, risk management for financial institutions, economic decision-making, investor confidence and market efficiency.

Stock market risk awareness is vital for protecting investors' interests. By understanding the potential risks associated with investing in stocks, investors can make informed decisions, set realistic expectations, and protect their portfolios from potential losses. It allows them to assess the risk-return trade-off and make appropriate investment choices.

Understanding stock market risk is essential for effective portfolio management (Liu *et al.* 2022). Investors aim to optimize their risk-return trade-off by diversifying their portfolios across different asset classes and securities. By understanding stock market risk, investors can identify potential risks, allocate assets appropriately, and manage their exposure to different risk factors.

Knowledge of stock market risk enables investors and financial institutions to implement risk mitigation strategies (Gong *et al.* 2022). This may involve diversification, hedging techniques, and the use of financial derivatives. By understanding stock market risk, market participants can proactively manage and mitigate their exposure to market volatility and downturns.

Stock market risk has implications for overall financial stability. Excessive volatility, systemic risks, or market crashes can have ripple effects on the broader economy, impacting businesses, employment, and consumer confidence. Understanding stock market risk helps policymakers and regulators identify potential vulnerabilities in the financial system, implement appropriate measures, and maintain stability.

Understanding stock market risk is crucial for accurate asset pricing and valuation. Investors and financial institutions need to assess the risk associated with a particular stock or investment to determine its fair value and potential returns. Accurate pricing ensures efficient capital allocation, fair market valuations, and the overall functioning of financial markets.

Financial institutions, such as banks, insurance companies, and asset management firms, are exposed to stock market risk through their investment portfolios and trading activities. Understanding stock market risk allows these institutions to implement effective risk management practices, ensure capital adequacy, and protect against potential losses that could impact their stability and solvency.

Stock market risk is closely tied to economic decision-making at both the individual and macroeconomic levels. Stock market fluctuations can impact consumer spending, business investment decisions, and overall economic growth. Understanding stock market risk helps policymakers make informed decisions on monetary policy, fiscal measures, and regulatory interventions to promote economic stability.

Understanding stock market risk contributes to investor confidence and enhances market efficiency (Baek *et al.* 2020). Transparent and well-regulated markets, supported by robust risk management practices, attract investors and foster liquidity. When investors have confidence in the risk management framework, it reduces information asymmetry, promotes fair price discovery, and contributes to efficient market operations. By comprehending stock market risk, stakeholders can navigate the complexities of financial markets, protect investments, and contribute to the efficient functioning of the overall economy. Hence, this study makes a significant contribution to empirically analyzing stock market risk through generalized breach indicators. The section below highlights the blueprint.

3. Methodology

This study adopted a Generalized Breach Indicator (GBI) and Breusch-Pagan-Godfrey Heteroscedasticity Test to explore stock market risk in selected financial markets which is a different approach from that of prior studies. It is well documented that conventional Value-at-Risk (VAR) models still experience many limitations (Krause, 2003; Chen, 2018) which has given rise to the use of expected shortfall models as substitutes for risk measurements. However, expected shortfall models in themselves also suffer some limitations such as the incapability back testing conditional VAR due to difficulties in measuring the severity of its violations (Chen, 2018). A GBI was used to substitute the violation counts of expected shortfall model in relation to the standard VAR model. In so doing, the values of GBI provide a clear indication of the extent to which stock markets violate their expected threshold. A significantly higher than expected GBI value indicates risk and vice versa. A conditional VAR and GBI is given by Equations 2, 3, 4, and 5.

$$CVAR = \mu - \sigma \frac{\varphi(VAR(\alpha))}{\omega(VAR(\alpha))} \tag{1}$$

$$GBI = \sum_{i=1}^{N} (r_t \leq VAR(\alpha))\ (1 - \frac{\omega(r_t)}{\alpha}) \tag{2}$$

$$\mu GBI = \frac{1}{2}\alpha N \tag{3}$$

$$\sigma GBI = \frac{\alpha(4 - 3\alpha)}{12} \tag{4}$$

where μ is the mean return, σ is the standard deviation, α is the confidence interval, ω is the cumulative distribution function, and N is the number of observations.

4. Data

A sample of six international stock markets was used which are the Johannesburg stock exchange (JSE), the Nasdaq Index, the French Stock Market index (CAC 40), and the German blue-chip companies trading on the Frankfurt Stock Exchange (DAX), the Tokyo Stock Index (Nikkei 225) and the Borsa Istanbul 100 index (BIST100) which represents financial markets across the continents. A five-year sample period was used from January 2, 2020, to January 2, 2023, including the COVID-19 pandemic era. The main data consisted of daily share prices retrieved from Yahoo Finance. Descriptive statistics were also used to provide a summary of the stylized facts for the stock market returns. The section below highlights the findings of the data analysis.

5. Results and discussion

Table 1 and Table 2 highlight the descriptive statistics and Heteroscedasticity test results. The standard deviation in Table 1 ranges from 1.2% to 5.63%. Most importantly, the Kurtosis statistics values which indicate heavy tail distribution are skewed to the left for all the financial markets under consideration except for the BIST100. This finding implies that there have been many negative price fluctuations in the JSE, Nasdaq, DAX, CAC 40, and Nikkei 225 in the recent 5 years, contrary to the BIST100 where it rather experiences many positive price fluctuations.

Table 1. Descriptive statistics

	Std. Dev.	Kurtosis	Skewness	Minimum	Maximum
JSE	1.6%	2.8	-10.9%	-9.5%	6.2%
Nasdaq	1.60%	6.23	-42.33%	-12.32%	9.34%
CAC-40	1.29%	12.04	-73.50%	-12.27%	8.38%
DAX	1.34%	11.83	-36.93%	-12.23%	10.97%
Nikkei 225	1.91%	408.27	-1527%	-51.07%	8.03%
BIST100	5.63%	644.07	1519%	-98.99%	163.72%

Also, Table 2 indicates that the volatility of the index price movement varies significantly in the JSE, Nasdaq, CAC 40 and the DAX gleaned from the significant observed R-square values and scaled scores. However, the variance in the Nikkei 225 and BIST100 seemed to be constant suggesting a linear market risk. Table 2 also presents some interesting findings on the level of market risk experienced in these stock markets.

Table 2. Breusch-Pagan-Godfrey heteroscedasticity test

	F-statistics	Observed R-square	Scaled Score
JSE	10.43 (0.0013)*	10.36 (0.0013)*	24.06 (0.000)*
Nasdaq	3.73 (0.053)	3.734 (0.05)*	13.02 (0.003)*
CAC-40	5.26 (0.0219)*	5.25 (0.0219)*	36.69 (0.000)*
DAX	4.50 (0.034)*	4.49 (0.034)*	30.85 (0.000)*
Nikkei 225	0.14 (0.701)	0.14 (0.7008)	0.40 (0.5221)
BIST100	0.00 (0.987)	0.00 (0.987)	0.086 (0.7681)

From Table 3, the conditional VAR is lower than the realized VAR for all the markets under consideration with the lowest value in the DAX. In worst-case scenarios, the BIST100 will experience the highest market drop than the other financial markets. This may be attributed to the heavy positive tail returns that the index has experienced in the past as shown in Table 3.

Table 3. GBI Test results

	VAR	**Conditional (VAR)**	**Realized GBI**	**Expected GBI**	**P-value**	**Z-statistics**
JSE	-2.77%	-3.5%	31.96	31.25	0.00*	5.68
Nasdaq	-2.66%	-3.33%	40.37	31.25	0.00*	72.06
CAC-40	-2.13%	-2.68%	32.15	31.25	0.00*	7.17
DAX	-2.21%	-2.77%	33.90	31.25	0.00*	20.96
Nikkei 225	-3%	-3.94%	10.73	31.25	0.00*	-161.99
BIST100	-9%	-11.62%	1.17	31.25	0.00*	-237.44

Note: * significance at 5%.

The findings in Table 3 also highlight the results of the realized and expected GBIs which were the main indicator of stock market risk applied in this study. Firstly, the difference between the realized values and the expected values are all significant at 5%. The expected and the realized GBI in the JSE are almost equal indicating a “within range” stock market risk. Also, a much higher positive difference was observed in the Nasdaq, CAC 40, and the DAX. One factor that might have contributed to the higher realized GBI in these developed stock markets may have been the COVID-19 and the Russian-Ukraine war since the United States, France, and

Germany are directly involved in the war and experienced record high COVID-19 cases. On the contrary, the Nikkei 225 and BIST100 had a significantly much lower realized and expected GBI. A vivid presentation of the above results can be seen in the Z-score values which are highest in the Nasdaq indicating the highest deviation per risk from the mean followed by the DAX, CAC 40, and JSE. From these findings, developed stock markets tend to be riskier and are more likely to experience the greatest loss in cumulative value during periods of distress.

These findings also suggest that investors in developed stock markets reduce their exposure to equities, leading to a decrease in demand and potentially lower stock prices. This loss of confidence triggers a bearish sentiment and further exacerbates market instability. These equity exposure reductions may be reinvested in developing markets like JSE and BIST100 hence, the lower GBIs. These results contradict Shkolnyk *et al.* (2019), which rather propose that developing stock markets are riskier than those of developed markets. It may be possible that investors' preferences change during periods of financial distress, and they rather shift their focus to developing stock markets.

6. Conclusion

The purpose of this study was to explore the stock market risk using the GBI model and Breusch-Pagan-Godfrey heteroscedasticity test. The primary aim was to investigate which international stock markets may experience the greatest losses if one or more adverse events occurred. The findings indicate that stock markets in developed countries are more susceptible to losses than stock markets in less developed countries. This was evident in a significantly positive higher GBI values in Nasdaq, DAX, and CAC 40. Conditional prediction of returns can be easily made in the JSE, CAC 40, and the DAX. Knowledge of past returns in JSE, CAC 40, and the DAX can be used as a guide to specify return distribution because the level of risk is close to an expected threshold. On the contrary, stock market risk varies non-linearly in the Nasdaq, Nikkei 225, and BIST100. The findings of this study also reveal the significant deviation per risk in the Nasdaq, DAX, and CAC 40 so the use of long-term moving averages will be useful in mitigating absurd price swings. Therefore, the use of call and put options should be prioritized in the Nasdaq, DAX, and CAC 40 for hedging. Further studies should conduct a comparative analysis between the GBI and other established market risk indicators to provide insight into their correlation and effectiveness in predicting stock market risks.

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