Anomaly Detection in Financial Market Indices in East African Stock Markets

By:

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Submitted in partial fulfilment of the requirements for the Degree of Bachelor of Business Science in Financial Engineering at Strathmore University

Strathmore Institute of Mathematical Sciences Strathmore University

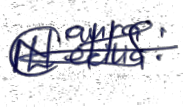
Nairobi, Kenya

February, 2025

DECLARATION

I declare that this work has not been previously submitted and approved for the award of degree by this or any other University. To the best of my knowledge and belief, the Research Work contains no material previously published or written by another person except where due reference is made in the Research Project itself.

Laura Cecilia Namata [Name of Candidate]

 [Signature]

19th February, 2025[Date]

This Research Project has been submitted for examination with my approval as the Supervisor.

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17th February 2025, Nairobi. [Date]

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ABSTRACT

This study investigated the detection and impact of anomalies in stock market indices within East African financial markets, focusing on the Nairobi Securities Exchange (NSE), Uganda Securities Exchange (USE), and Dar es Salaam Stock Exchange (DSE). Utilizing a descriptive and explanatory research design, the study integrates neural networks with statistical methods to identify and analyse anomalies such as market manipulation, insider trading, and reactions to macroeconomic events. By analysing both historical and real-time data, the research aimed to understand how these anomalies affect market behaviour, investor confidence, and overall market stability. The research was anchored on The Efficient Market Hypothesis. The population for this study encompassed the Nairobi Securities Exchange (NSE), Uganda Securities Exchange (USE), and Dar es Salaam Stock Exchange (DSE). The sampling frame for this study consisted of daily stock market index values from the NSE, USE, and DSE, along with annual inflation rates and GDP data for Kenya, Uganda, and Tanzania. This study utilized secondary data, spanning the period from 2013 to 2022. The primary sources of data included official publications and financial reports from the respective stock exchanges, such as annual reports and historical index data. Additional data was obtained from reputable databases and organizations, including the East African Community financial publications, Bloomberg, Reuters, and DataStream. Descriptive statistics such as mean, maximum, minimum, and standard deviation were employed to summarize and describe the key characteristics of the dataset. To evaluate the relationships between variables and detect patterns, the study employed multi-linear regression analysis using SPSS. Anomaly detection in the stock market indices was conducted using two complementary methods: Z-scores and a Multilayer Perceptron (MLP) Neural Network. The analysed data were interpreted and presented using graphs, tables, and charts generated from Microsoft Excel and SPSS. The study found that a unit change in inflation yields a 6.635 negative change on Stock Index. The p-value of 0.001 means that the inflation has positive and statistically significant effect on the Stock Index in East Africa. The study also found that a unit change in GDP yields a 4.443E-11 positive change on Stock Index in East Africa. The p-value of 0.000 means that the GDP has positive and statistically significant effect on the Stock Index in East Africa. The study concluded that while inflation has a negative impact, GDP exerts a positive and more substantial influence. Further, it was concluded that GDP had the greatest influence on the stock index values in East African markets, while inflation had the least effect on the stock index values in East African markets. The research suggested that policymakers address macroeconomic factors, such as inflation and GDP fluctuations, which significantly influence stock market anomalies. Effective monetary and fiscal policies were deemed necessary to control inflationary pressures and foster economic growth, which in turn could stabilize stock markets. The research also suggested that regional collaboration between stock exchanges—NSE, USE, and DSE—be strengthened to address shared economic and financial challenges. Establishing shared databases and analytical tools to monitor regional market trends and detect anomalies was recommended as a way to create a more integrated and stable financial ecosystem.

INTRODUCTION

1.1 Background

Anomaly detection refers to the finding of patterns in data that do not conform to expected behaviour(Chandola et al., 2009). According to (Hilal et al., 2022), the term anomaly detection is used interchangeably with outlier detection. These anomalies present differently in different domains and thus there has been a lot of research done in the area depending on the domain it relates. In financial markets, the anomalies that may be identified in the market indices could signal irregularities which include market manipulation, insider trading or even just reactions to macroeconomic events. Based on what these anomalies in the stock market indices signal, it is indeed tied to financial crime and hence their detection is important. The anomalies detected may not always indicate financial crime but may also indicate changes in the stock market that could prove useful to investors. This shows that anomalies do not always have a negative impact on the market but they may also have a positive impact. This detection of anomalies is crucial to maintain the integrity, stability and efficiency of financial markets.

Chandola et al. (2009) defined "anomalies as patterns in data that do not conform to a well-defined notion of normal behaviour." In financial market indices this would be the normal behaviour of market indices. These deviations can manifest as sudden price jumps, unusual trading volumes, or abnormal return distributions. Such anomalies are significant because they can indicate underlying issues such as market manipulation, insider trading, or external economic shocks. Detecting and analysing these anomalies is essential for understanding and mitigating risks in the financial markets.

Anomalies may also be referred to as outliers. These outliers in data are described as points in the data that differ from the norm or expected behaviour. Anomalies that occur in stock markets may be viewed as positive when they lead to positive outcomes for investors in the market. Some of the positive effects that may arise from outliers include investors using anomalies to indicate mispricing of stocks and using this information to trade in the market. The negative effects that arise are a major cause

for why anomalies need to be identified. Forecasting these anomalies in the market may also provide information for economic incidents that may greatly affect the market.

Market anomalies that arise in stock market indices challenge the Efficient Market Hypothesis (EMH) which posits that prices reflect all information available in the market (Fama, 1965). These market anomalies that exist including calendar anomalies and others have been otherwise explained by behavioural finance(Woo et al., 2020). Though market anomalies have been explained by behavioural finance, some anomalies that occur still greatly affect the economy and yet are not forecasted or known. A clear example of this would be the clear anomalous patterns that arose in the market due to Covid-19 in 2020. These patterns indicated an issue in the economies due to the outbreak that occurred in that period.

Financial markets play a vital role in the economic development of East Africa. The Nairobi Securities Exchange (NSE), Uganda Securities Exchange (USE), and Dar es Salaam Stock Exchange (DSE) have all experienced significant growth over the past few decades. These markets provide platforms for raising capital, trading securities, and facilitating investment, which are essential for economic growth and development. As these markets evolve, it is increasingly important to ensure their integrity and stability to foster investor confidence and attract both local and international investments.

The importance of avoiding financial crime in these markets cannot be overstated. Financial crimes such as market manipulation and insider trading undermine investor confidence and can lead to significant financial losses. Moreover, they distort market prices and impede the efficient allocation of resources, which is critical for economic development. By identifying and addressing anomalies in market indices, regulatory bodies and market participants can work towards creating a more transparent and fair-trading environment, which is vital for the sustainable growth of East African financial markets.

Since the market anomalies do not only portray negative effects, their detection in stock market indices comes as a great help to investors who would use this information to make better investment decisions. It is important to detect these anomalies in the

market using the stock market indices to enable investors to male informed investment decisions. They would also help government and regulators to understand how different economic conditions affect the stock markets.

Market indices are said to aggregate the performance of various stocks and serve as benchmarks for evaluating market performance. Investors rely on these market indices to understand how the market is working and to compare their portfolios to what the market has (Feeney & Hester, 1964). Each of the stock markets in East Africa NSE, USE, and DSE has unique characteristics and faces different challenges regarding anomalies.

Nairobi Securities Exchange (NSE): The NSE is the oldest and largest stock exchange in East Africa as it was founded in 1954('About NSE', n.d.). It lists a wide range of financial instruments, including equities, bonds, and derivatives, and plays a crucial role in the Kenyan economy. The NSE has three major indices that enable investors to understand better the performance of the market and these are: NSE All Share Index, NSE 25 Share Index and the NSE 20 Share Index.

Uganda Securities Exchange (USE): Founded in June 1997(*Milestones of the USE | Uganda Securities Exchange (USE)*, n.d.), the USE is relatively young but has grown steadily. It offers trading in equities and government bonds, providing a platform for Ugandan companies to raise capital. The indices that provide reference and performance metrics to investors for these securities exchange are the USE All Share Index and the USE Local Share Index.

Dar es Salaam Stock Exchange (DSE): The DSE has seen significant growth in listings and market capitalization since it became operational in April 1998(*Dar Es Salaam Stock Exchange*, n.d.). It serves as a key financial hub for Tanzania, facilitating the mobilization of long-term capital. The market indices that indicate the trends are Tanzania Share Index, DSE All Share Index, Banks, Finance & Investments Index and Industrial & Allied Index.

1.2 Problem Statement

The stock markets in East Africa, comprising key indices in Kenya, Uganda, and

Tanzania, have shown notable growth in recent years. However, these markets are also characterized by increased volatility and unexplained price movements, raising concerns about the overall stability of the financial system. Unlike more developed markets, where extensive research has been conducted to understand and mitigate such volatility, the East African markets remain underexplored. Existing studies largely focus on anomalies in developed markets, where economic conditions, market structures, and regulatory environments differ significantly from those in East Africa.

Despite their critical importance to economic development, the stock markets in East Africa are frequently disrupted by anomalies that undermine market efficiency and investor confidence. The core issue lies in the lack of effective methodologies tailored to detect and analyse these anomalies within the unique context of East African markets. Current detection methods, often imported from studies in developed markets, may not adequately address the region's distinct economic, political, and social factors, leading to gaps in market understanding and potential mismanagement of these anomalies.

While the literature on market anomalies is vast, it is predominantly centered on developed markets, leaving a gap in the understanding of these phenomena in emerging markets, particularly in East Africa. Existing methodologies, such as statistical anomaly detection and neural network- based models, have not been fully adapted or tested within this regional context. This gap presents an opportunity to develop and refine techniques that are more suited to the unique characteristics of East African stock markets.

This study was guided by the following research questions:

1. What specific types of anomalies are prevalent in East African stock markets?
2. How effective are current anomaly detection methods when applied to East African financial markets, and what modifications are necessary?
3. What are the impacts of identified anomalies on market stability, and how can they be mitigated through improved detection techniques?

The research focused on stock market indices from Kenya, Uganda, and Tanzania over a period spanning from 2013 to 2022. Key variables to be analysed include stock

indices, and selected macroeconomic indicators such as inflation rates and GDP growth. The study primarily employed a hybrid detection model that integrates neural networks with statistical methods, while also exploring the implications of detected anomalies on market stability. However, limitations might arise due to the availability of high-frequency data and potential changes in market conditions during the study period.

1.3 Research Objectives

The primary objectives of this research were:

1. To develop a hybrid methodology that combines neural networks and statistical methods for detecting anomalies in the stock market indices of East African financial markets.
2. To identify and classify common types of anomalies in the stock market indices of the Nairobi Securities Exchange (NSE), Uganda Securities Exchange (USE), and Dar es Salaam Stock Exchange (DSE).
3. To analyse the impact of detected anomalies on market performance, investor behaviour, and the overall integrity of East African financial markets.

1.4 Significance of the Study

This research was of importance for multiple stakeholders within the financial system of East Africa. Firstly, it addresses a significant gap in the academic literature by concentrating on financial market anomalies within a region that has not been extensively studied. While much of the existing research on market anomalies focused on developed economies, this study provided a crucial perspective on how these phenomena manifest in emerging markets, particularly in East Africa, where economic conditions, market structures, and investor behaviours differ markedly from those in more developed regions.

Secondly, the insights gained from this study was of great value to policymakers and regulatory authorities in East Africa. By uncovering the nature and impact of market

anomalies, the research can inform the development of more robust market surveillance systems and regulatory frameworks. Such frameworks would enable regulators to detect irregularities more effectively, respond to market disruptions promptly, and implement policies that enhance market transparency, liquidity and stability.

Thirdly, this study offered practical benefits to investors and market participants. By enhancing the understanding of how anomalies influence market dynamics, the research would equip investors with better tools for risk assessment and investment decision-making. Improved anomaly detection methodologies would enable market participants to anticipate potential disruptions and adapt their strategies accordingly, thereby minimizing risks and capitalizing on opportunities.

Ultimately, the broader impact of this research lied in its potential to contribute to the development of more resilient and transparent financial markets in East Africa. By fostering a deeper understanding of market anomalies and their effects, the study would help build investor confidence, attract both domestic and international investment, and support sustainable economic growth in the region. This research not only enriched the academic discourse but also has practical implications for the ongoing development and integration of East African financial markets into the global economy.

LITERATURE REVIEW

2.1 Introduction

This literature aimed to provide a comprehensive overview of existing literature on anomaly detection in stock market indices with a focus on East African stock markets. In the recent decades there has been a lot of research done on anomaly detection but most of the studies done have been surveys of the literature done on the techniques used in anomaly detection. This literature review aimed to explore the theoretical frameworks that govern market anomalies, the types of market anomalies that exist in financial markets, the techniques to be considered in anomaly detection and finally what significance these anomalies have in the context of East African stock markets.

2.2 Theoretical Framework

The Efficient Market Hypothesis posits that markets are efficient and thus reflect all information that is within the market (Fama, 1965). The most common market anomalies observed to be inconsistent with EMH according to Yalçın (2010) are volume, volatility, cash dividends, Equity Premium puzzle and predictability which includes the Winner-Loser Effect suggested by (De BONDT & Thaler, 1985).

The past decades have seen a lot of studies that have compared market anomalies with the Efficient market hypothesis. One of the most recent studies (Woo et al., 2020) , reviewed the studies that had been done on market efficiency and clearly explained it. They then went further to review and describe different market anomalies that have arose in stock markets and finally reviewed the different theories of behavioural finance that explained these anomalies. Various anomalies have challenged EMH and demonstrated instances where the asset prices have deviated from what is expected of them.

Woo et al.(2020) describes “Behavioural Finance as a new approach to financial markets that has emerged, at least in part, in response to the difficulties faced by the traditional paradigm.” Behavioural finance thus explains the behaviours of investors in the stock market that are not rational and further supports EMH when its assumptions do not hold.

2.3 Market Anomalies

According to Kahneman & Tversky (1986)"an anomaly is a deviation from the presently accepted paradigms that is too widespread to be ignored, too systematic to be dismissed as random error, and too fundamental to be accommodated by relaxing the normative system". This translates to any behaviour in the stock market that cannot be explained by normal market conditions. The first stage of anomaly detection would be to define the anomalies that may occur and anomalous behaviour in regard to the stock market and various stock market indices.

In Thaler, (1999) study "The End of Behavioural Finance", five areas are discussed in which anomalous behaviour in stock markets is believed to pivot. Yalçın (2010) supported these and called them the most commonly seen anomalies in the market. These areas are as follows: volume, volatility, cash dividends, the equity premium puzzle and predictability.

a. Volume

According to Yalçın, (2010), Investors only trade in big volumes when they need liquidity and desire to re-balance their portfolios. This implies that any sudden changes in volumes traded by investors without reason would turn out to be anomalies. In the case of market indices, it indicates that any sudden increments in the market index value without any known market causes would be an anomaly in the index.

b. Volatility

Yalçın's, (2010) study establishes that security prices only change when there is dividend expectation or with arrival of new information to the market from an efficient market point of view. This has been observed not to hold by some studies done in 1981. This may come across as an anomaly but as shown is the behaviour of stock indices and prices since they have changing volatility.

c. Cash dividends

According to (Yalçın, 2010), shareholders would still prefer cash dividends despite the higher tax rates that come with them as compared to capital gains and thus leading to

an increase in stock prices after the announcement of dividends. This would mean that even though investors have a high cost from receiving dividends they prefer them to capital gain and thus would lead to anomalous behaviour in the market once dividends are announced.

d. The equity premium puzzle

Mehra & Prescott, (1985) introduced the "Equity Premium Puzzle" which is a phenomenon that stocks historically offer higher returns than Treasury Bills. The anomaly however comes in when investors still do not invest more in stocks than Treasury bills since they assume the latter are less risky and thus deem them a more worthy investment.

e. Predictability

Yalçın, (2010) mentions several anomalies that arise from predictability of stock returns in the market. These include:

Dividend yield anomaly (D/P Ratio)

Studies by Rozeff (1984) and Fama & French (1988) showed that higher dividend yields (the ratio of dividends to price) are associated with higher future stock returns. This challenges the EMH as it suggests that future returns can be predicted using current dividend yields.

Earnings-Price ratio anomaly (E/P Ratio)

Campbell & Shiller (1988) found that the earnings-price ratio, especially when averaged over a decade, is a powerful predictor of future stock returns. Higher E/P ratios are linked to higher expected returns, challenging the assumption that stock prices fully reflect all available information.

Price-Earnings ratio anomaly (P/E Ratio)

Basu, (1977) observed that stocks with low price-earnings ratios tend to outperform those with high P/E ratios. This anomaly suggests that investors can achieve higher returns by selecting stocks based on their P/E ratios, which contradicts market efficiency.

Price-to-Book ratio anomaly (P/B Ratio)

Lakonishok et al., (1994) found that stocks with low price-to-book ratios generally provide higher returns than those with high P/B ratios. This indicates that undervalued stocks, as measured by P/B ratios, tend to outperform overvalued ones.

Post-Earnings-Announcement drift

Ball & Brown (2013) and studies that came after noted that stock prices tend to underreact to earnings announcements, leading to a gradual adjustment over time. This drift results in abnormal returns that can be predicted based on recent earnings announcements, violating market efficiency.

Size effect

Banz (1981) and Reinganum (1981) demonstrated that smaller firms tend to have higher average stock returns compared to larger firms. This "size effect" suggests that firm size can be a predictor of future returns, which is inconsistent with the efficient market hypothesis.

Neglected firm effect

Arbel & Strebel (1982) proposed that smaller, lesser-known firms ("neglected firms") tend to offer higher returns due to their lower liquidity and reduced coverage by analysts. This effect is related to the size effect and indicates that lack of attention can lead to higher returns.

Liquidity effect

Amihud & Mendelson (1986) found that less liquid stocks (those that are harder to trade) tend to have higher expected returns. This suggests that liquidity, or the ease of buying and selling a stock, is a predictor of future returns, challenging market efficiency.

Initial Public Offering (IPO) underperformance

Ritter (1991) and Loughran & Ritter (1995) observed that IPOs tend to underperform in the long run compared to matching firms. This anomaly indicates that newly public companies often deliver lower returns over time, despite initial market optimism.

Overreaction Hypothesis

De BONDT & Thaler (1985, 1987) found that stocks that were extreme past losers tend to outperform extreme past winners over subsequent years. This "overreaction" implies that investors overreact to news, causing mispricing that later corrects itself, leading to predictable returns.

Finally, Yalçın (2010) mentioned seasonal anomalies which include calendar anomalies like January effect, Day-of-the-week effect and others.

2.4 Impact of Anomaly Detection

There have been several studies done on the impact of anomaly detection in different stock markets. Even though this is the case, most of the studies that have been done in developed markets focus on impacts like market manipulation and insider trading. They also focus mainly on particular market anomalies. While this is advised, this study focused on first identifying the major anomalies that are experienced in East African stock markets and how these anomalies impact market stability.

Sawitri & Astuty (2018) studied the impact of the month of the year effect on market returns using major world stock indices and those in Indonesia. The study employed Ordinary least squares and Generalized Autoregressive Conditional Heteroskedasticity to analyse the data and observed that the effect exists in some periods of the data while it does not in others(Sawitri & Astuty, 2018). The study focused on the Indonesia Stock Exchange and indices in the world while also focusing on one market anomaly being the month of the year effect. This study differs by analysing what major market anomalies are experienced in East African financial markets while also considering their impacts on market stability.

Some studies were done to detect market manipulation using contextual anomaly detection techniques (K. Golmohammadi & Zaiane, 2017; S. K. Golmohammadi, 2016). These studies emphasized the use of contextual anomaly detection for time series data and worked to improve on the way anomalies are detected in securities. This study intends to use a hybrid methodology to test its effectiveness in detection of anomalies in stock market indices that differs from there use of information on stocks

to detect market manipulation as an effect of anomalies detected.

A study that was carried out in the Egyptian stock market assessed the impact of size effect, momentum effect and value effects on investment decision. The study concluded that value effect and momentum effect do have a significant effect by testing hypotheses, on investment decision (El-Soud & Mostafa, 2021). This study investigated these effects existence in East African stock markets and thus differs in this way from the previous study. It also further assesses the impact on market stability and transparency thus focusing on different effects in the stock markets.

2.5 Anomaly Detection Techniques

Anomaly detection techniques have been the object of many surveys in the past decades. All forms of techniques have been reviewed via different studies that have led to more efficient techniques of detecting anomalies. One of the greatest things that happened to anomaly detection was machine learning which introduced a diversity of techniques to the field and made the process more efficient and effective to do as well as to simplify it. These techniques have been used in various domains to detect different anomalies such as in credit card fraud, cyber-security as well as detection in stock markets.

The techniques that have been used to detect anomalies in markets have been mainly grouped into statistical methods and machine learning algorithms as discussed below. Hilal et al. (2022) grouped the techniques into supervised, semi-supervised and unsupervised techniques. All the anomaly detection techniques can fall in either of these whether they are statistical or machine learning algorithms.

Statistical methods: Markou & Singh (2003) state that statistical methods are those that model data based on its statistical properties and then finally use the information to infer that a test sample comes from the same distribution. The study goes on to identify the different kind of parametric and non-parametric approaches that are used to determine novelties. A survey that was conducted by Chandola et al. (2009) further discusses these techniques in section 7 and also describes what domains have applied different techniques.

Machine learning algorithms: Some of the machine learning algorithms including neural networks, decision trees and others have been reviewed by Hilal et al. (2022) in the context of financial fraud. Markou & Singh (2003b) did a review of the neural network approaches as did Chandola et al. (2009) who surveyed the study alongside other studies.

In Albu & Lupu (2020), the study focused on anomaly detection in stock market indices using neural networks. Though this study is similar their subject was major stock indices and exchanges which may have different factors affecting them than the emerging markets in East Africa. The study solely focused on detecting anomalies using recurrent neural network algorithms with no reference to how they affect the markets as well as how they challenge the EMH (Albu & Lupu, 2020). This study differs by considering the possible consequences these anomalies have in the stock markets as well as their challenges of the Efficient Market Hypothesis (EMH). It further taps into the gap that has been identified with lack of literature covering emerging markets like the ones in East Africa.

In conclusion, this literature review provided an understanding of the anomalies faced in the stock market and thus the importance that comes with anomaly detection. While there has been significant research conducted in developed markets, East African markets remain understudied, and this comes as a challenge when techniques used do not apply to emerging markets such as these. This study looks to contribute to this field by providing a detailed analysis of anomalies and their detection in stock market indices in East Africa while understanding their impact on the operations of the stock market.

METHODOLOGY

3.1 Introduction

This chapter discussed the study's research methodology. It provided a general summary of the research design, target population, sample size and design, data collection techniques, data validity and reliability, and data analysis and presentation procedures for the current study. Finally, the research discussed the ethical considerations that were made.

3.2 Research Design

A research design refers to a structured framework or blueprint for conducting a study while ensuring that the findings are valid and reliable (Snyder, 2019). This study employed a descriptive and explanatory research design, which is appropriate for understanding the "what," "how," and "why" of market anomalies in East African stock indices. Descriptive research aimed to provide an accurate profile of phenomena by identifying key characteristics, behaviours, and trends, while explanatory research focused on uncovering causal relationships and underlying patterns (Ranjit, 2020).

The descriptive design was selected to analyse historical data, such as stock indices (NSE, DSE, USE), inflation rates, and GDP, to identify anomalies and examine their relationships with economic factors. The explanatory component allowed the study to evaluate the effects of macroeconomic variables (e.g., inflation, GDP) on the frequency and nature of anomalies in East African financial markets.

This approach was suitable for the study because it: provided a clear understanding of the prevalence and patterns of anomalies within the data, helped establish the impact of macroeconomic variables on stock market stability and performance, and ensured the flexibility required for both statistical analysis and anomaly detection models, including the integration of neural networks and regression analysis.

Moreover, the chosen design aligns with prior research in financial markets, which frequently utilizes descriptive and explanatory methodologies to analyse stock indices and macroeconomic indicators (Ørngreen & Levinsen, 2017). By adopting this design,

the study facilitated a comprehensive exploration of anomalies in East African stock markets and their implications for market stability and investor behaviour.

3.3 Population and Sampling

The population for this study encompassed the Nairobi Securities Exchange (NSE), Uganda Securities Exchange (USE), and Dar es Salaam Stock Exchange (DSE). These indices represent the key performance metrics of the financial markets in Kenya, Uganda, and Tanzania, respectively, over the ten-year period from 2013 to 2022. The choice of this population was informed by the significance of stock market indices as benchmarks for market performance and their role in reflecting investor behaviour and macroeconomic trends within each country. By focusing on these three major stock exchanges, the study aimed to comprehensively analyse and detect anomalies within East African financial markets and evaluate their impacts on market stability.

To ensure the study achieved its objectives, a census sampling approach was adopted. This method involved analysing all available data points from the three stock markets and macroeconomic indicators over the specified ten-year period. A census approach was deemed appropriate as it provided a complete dataset, ensuring that all relevant trends and potential anomalies were captured without introducing bias or limiting the scope of analysis. Additionally, the manageable size of the population, which included daily index values and yearly macroeconomic indicators for the three countries, supported the feasibility of the census method.

The sampling frame for this study consisted of daily stock market index values from the NSE, USE, and DSE, along with annual inflation rates and GDP data for Kenya, Uganda, and Tanzania. These data were sourced from publicly available and reliable resources, including official stock exchange websites, financial reports, central bank publications, and other reputable financial databases.

3.4 Data Collection Methods

This study utilized secondary data to investigate anomalies in the stock market indices of the Nairobi Securities Exchange (NSE), Uganda Securities Exchange (USE), and Dar es Salaam Stock Exchange (DSE). The data collected encompassed trading

volumes, inflation rates, and GDP growth rates for Kenya, Uganda, and Tanzania, spanning the period from 2013 to 2022. These variables were chosen due to their significance in capturing the dynamics of stock market performance and their correlation with macroeconomic indicators, which are critical for analysing anomalies.

The primary sources of data included official publications and financial reports from the respective stock exchanges, such as annual reports and historical index data. Additional data was obtained from reputable databases and organizations, including the East African Community financial publications, Bloomberg, Reuters, and DataStream. These sources ensured the reliability and credibility of the data used in the study.

Data collection methods included a combination of desk research and data retrieval from financial APIs. Desk research involved manually extracting historical data from official stock exchange websites and central bank reports. Data retrieval through APIs, such as Bloomberg API, facilitated the acquisition of large datasets and ensured the accuracy of the data collected. To organize and analyse the data, Microsoft Excel was used for preprocessing, structuring, and conducting preliminary analyses such as percentage calculations and ratio derivations.

3.5 Data Analysis

Data analysis refers to the systematic process of organizing, transforming, and interpreting data to extract meaningful insights and address the research objectives (Popenoe et al., 2021). This study utilized a combination of Microsoft Excel and SPSS (Statistical Package for the Social Sciences) for descriptive and inferential analysis, enabling comprehensive exploration of the relationships among the study variables and detection of anomalies.

Descriptive statistics were employed to summarize and describe the key characteristics of the dataset. Measures such as mean, maximum, minimum, and standard deviation were computed to capture the central tendency and variability of inflation rates, GDP growth, and stock market indices across Kenya, Uganda, and Tanzania over the period 2013–2022. These metrics were calculated using Microsoft Excel, which also

provided a platform for preliminary data visualization, such as trend graphs and tables. SPSS was further used to enhance data profiling and provide insights into potential anomalies in the dataset.

To evaluate the relationships between variables and detect patterns, the study employed multi-linear regression analysis using SPSS. Regression analysis enabled the investigation of how macroeconomic indicators, such as inflation and GDP growth, influenced anomalies in stock market performance. This analysis provided insights into the causal relationships and interdependencies among the variables. The regression model applied in the study is as follows:

$$Anomaly_t = \beta_0 + \beta_1 Inf_t + \beta_2 GDP_t + \epsilon_t$$

Where:

$Anomaly_t$ refers to anomalies detected in the market at time t.

Inf_t is the inflation rate at time t

GDP_t is the Gross domestic Product growth rate at time t.

β0,β1,β2: Coefficients of the model indicating the impact of each variable on anomalies.

ϵ_t : Error term accounting for unexplained variations.

Anomaly detection in the stock market indices was conducted using two complementary methods: Z-scores and a Multilayer Perceptron (MLP) Neural Network. Z-scores were calculated for inflation, GDP, and stock indices to identify outliers. A data point with a Z-score above 3 or below -3 was flagged as a potential anomaly. This statistical method ensured that significant deviations in the data were highlighted for further investigation. Z-scores were particularly useful for detecting linear deviations and providing a baseline understanding of potential anomalies across the dataset. A neural network model was used to uncover complex, non-linear relationships between the variables. The neural network, implemented through SPSS, consisted of two input variables (Inflation and GDP), one hidden layer, and an output layer representing the Stock Index. The network used a hyperbolic tangent activation

function in the hidden layer and an identity activation function in the output layer, allowing for the prediction of Stock Index values based on input variables. The neural network effectively captured interactions and trends in the data, complementing the insights gained from the Z-scores.

The model's performance was assessed using relative error metrics for training and testing datasets, with low relative errors indicating high accuracy and strong generalizability. The neural network identified patterns in the relationships between Inflation, GDP, and Stock Index while highlighting subtle deviations that Z-scores alone might not capture.

The analyzed data were interpreted and presented using graphs, tables, and charts generated from Microsoft Excel and SPSS. Z-score analysis highlighted deviations and outliers in the data, while the neural network captured non-linear trends and interactions among variables. Together, these approaches provided a robust framework for detecting anomalies and understanding stock market performance in the East African region over the study period. The dual-method approach ensured a comprehensive examination of the data, supporting the study's objectives and contributing to insights into financial market behaviour in East Africa.

3.6 Research Quality

The quality of this research project was evaluated based on its reliability, validity, and objectivity. These criteria were adhered to in order to ensure the study was robust, credible, and capable of producing findings that are replicable and unbiased.

3.6.1 Reliability

Reliability refers to the consistency and dependability of research findings, ensuring they are unaffected by biases or random events and can be replicated in subsequent studies (Chetwynd, 2022). In this study, reliability was upheld through the use of robust data collection and analysis methods. Secondary data was sourced from reputable and widely recognized financial databases and official publications, such as those from the Nairobi Securities Exchange (NSE), Uganda Securities Exchange (USE), Dar es Salaam Stock Exchange (DSE), and central banks. This ensured that

the data was accurate and consistent across the stock markets examined.

To enhance reliability, the study employed a census approach, analyzing all stock market indices, inflation rates, and GDP growth rates over the 2013–2022 period. This approach minimized sampling bias by ensuring that the entire population of interest was considered. Furthermore, the application of standardized analytical tools, including Microsoft Excel and SPSS, ensured the consistency of computations and statistical outputs, making the findings dependable and replicable.

3.6.2 Validity

Validity refers to the accuracy and appropriateness of the methods and measures used in a study to achieve its objectives (Shah Kumar et al., 2018). This study ensured validity through rigorous statistical testing and data analysis.

3.6.2.1 Heteroscedasticity Test

To avoid the issue of heteroscedasticity, which occurs when the variance of the error term is not constant, the study conducted a heteroscedasticity test using SPSS. The assumption of homoscedasticity, or constant error term variance, is critical for accurate regression analysis. A p-value greater than 0.05 for the Observed R-squared indicated the absence of heteroscedasticity, ensuring the reliability of the regression model used to analyse anomalies in the stock markets.

3.6.2.2 Test of Significance

The statistical significance of the regression results was assessed at a 95% confidence level. This ensured that the relationships identified between inflation, GDP growth, and stock market indices were robust and representative of the study population. Analysis of variance (ANOVA) was employed to determine the relevance and explanatory power of the regression model. A high level of significance confirmed that the observed trends in the data were accurate reflections of the underlying population.

3.6.3 Objectivity

Objectivity in research refers to being truthful to the facts, free from bias, and detached

from personal opinions or moral judgments (van Dongen and Sikorski, 2021). This study maintained objectivity by employing a structured and transparent approach to data collection and analysis.

First, the research questions were carefully aligned with the study objectives to eliminate any ambiguity or potential for biased interpretations. By clearly defining the study scope, the analysis was focused and free from personal influences. Second, the study relied exclusively on secondary data obtained from credible and publicly accessible sources, such as financial reports and official stock exchange records, ensuring that the data selection process was unbiased. Lastly, the analysis was conducted on a well-defined and representative dataset covering the key financial markets in East Africa, which was chosen based on objective criteria rather than personal preferences. By adhering to these principles, the study achieved a high level of neutrality and fairness, ensuring that its findings are reliable, valid, and free from bias.

3.7 Ethical Issues in Research

Ethical considerations form the guiding principles of a study, ensuring that the research process is conducted with integrity and transparency (Drolet et al., 2021). Ethical issues can arise during various stages of research, including research design, data collection, analysis, and dissemination of results. Observing ethical standards not only enhances the credibility and reliability of the research but also fosters responsibility and professionalism throughout the research process.

All data used in this study was sourced from publicly available and reputable sources, such as the Nairobi Securities Exchange (NSE), Uganda Securities Exchange (USE), Dar es Salaam Stock Exchange (DSE), and official publications from central banks and financial authorities. This ensured that the data collection process was transparent and did not involve unauthorized access to sensitive or confidential information.

The data collected was used in its original form, with no manipulation or alteration to fit preconceived conclusions. This ensured that the findings were accurate, unbiased,

and reflective of the actual trends and anomalies observed in the financial markets. Proper citations and references were provided for all data and literature used in the study, ensuring that intellectual property rights were respected and that the contributions of previous researchers were acknowledged.

The study maintained a neutral stance throughout the research process. Data was analysed objectively, without any influence from personal opinions, financial incentives, or external pressures, ensuring the findings were unbiased and credible. Also, the research findings were presented transparently and truthfully, without exaggeration or misrepresentation. This commitment to ethical reporting ensures that the study contributes meaningfully to the academic and professional understanding of stock market anomalies in East Africa.

PRESENTATION OF RESEARCH FINDINGS

4.1 Introduction

This chapter explores data analysis, presentation, interpretation and discussions of the research findings using descriptive and inferential statistics. Secondary data was collected through data collection sheet. The data was afterwards scrutinized based on the objectives of the study and the findings were presented in tables and graphs.

4.2 Descriptive Statistical Analysis

The descriptive statistical analysis provided an overview of the key characteristics of the variables under investigation: inflation rates, GDP, and stock market indices across Kenya, Uganda, and Tanzania over the period 2013–2022. This analysis identifies central tendencies, dispersion, and the distribution of data, offering insights into the underlying dynamics of the East African economies and their financial markets in Table 4.1.

Table 4. 1: Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Inflation	3.29	124.16	67.597	46.6811	-0.537	0.427	-1.55	0.833
GDP	0	3.53606E+13	1.88655E+13	1.36271E+13	-0.38	0.427	-1.714	0.833
NSE	121.6	169.57	149.5774	14.06224	-0.412	0.687	0.73	1.334
USE	1278.5	1987.81	1622.9577	219.51549	0.272	0.687	-0.302	1.334
DSE	1619.89	2614.6	2104.1952	303.65988	0.178	0.687	-0.582	1.334

The inflation across the three countries exhibited significant variability, with a

minimum value of 3.29 and a maximum of 124.16. The average inflation rate over the study period was 67.5970, with a standard deviation of 46.68110, indicating substantial fluctuations in price levels within the region. The slightly negative skewness (-0.537) suggests that lower inflation rates were more frequent, although there were a few years marked by extremely high inflation. Furthermore, the negative kurtosis (-1.550) indicates a platykurtic distribution, with fewer extreme inflationary events than might be expected in a normal distribution. This variability underscores the diverse economic challenges faced by the region, including periods of hyperinflation likely driven by external shocks or policy mismanagement.

GDP figures also revealed considerable disparities across the region, with values ranging from 0.00 to 35.36 trillion (in local currency). The average GDP was 18.87 trillion, with a standard deviation of 13.63 trillion, reflecting the economic disparity between smaller and larger economies within East Africa. The slight negative skewness (-0.380) indicates that lower GDP values were more common, while the negative kurtosis (-1.714) suggests a flatter distribution, with fewer extreme values than expected in a normal distribution. The minimum GDP value of zero likely reflects missing data or unrecorded economic activity, particularly in Uganda. These results highlight the significant differences in economic output among the three countries, which may contribute to varying stock market performance.

The NSE index fluctuated between 121.60 and 169.57, with an average of 149.58 and a standard deviation of 14.06. This relatively narrow range compared to other markets suggests moderate volatility in Kenya's stock market, though the index showed consistent growth over the years. The negative skewness (-0.412) and moderate kurtosis (0.73) point to a distribution that leans slightly toward lower index values but with occasional higher peaks. This behaviour could indicate investor caution or response to macroeconomic conditions such as inflation or external market pressures.

The USE index, with a range from 1,278.50 to 1,987.81, had an average value of 1,622.96 and a standard deviation of 219.52. The positive skewness (0.272) suggests that years with higher index values were more common, possibly due to favourable economic events or investor sentiment. However, the negative kurtosis (-0.302)

implies that extreme values (both high and low) were less frequent than expected, indicating a more stable market with fewer large swings.

The DSE index exhibited a range between 1,619.89 and 2,614.60, with an average of 2,104.20 and a standard deviation of 303.66. The slight positive skewness (0.178) shows that the market tended to see more frequent lower values, but with occasional increases in the index. The negative kurtosis (-0.582) indicates a market with fewer extreme fluctuations. Like the USE, DSE experienced relatively stable performance but still encountered substantial variability during the observed period.

The high variability in inflation rates suggests that periods of hyperinflation or extreme price stability could have influenced stock market performance, either through dampened investor confidence or favourable economic conditions. Similarly, the disparity in GDP highlights the economic dominance of larger markets, such as Kenya, and their likely contribution to higher stock index values. However, the variability in stock indices suggests that external factors, such as political events or global economic trends, may also play a significant role in influencing market behaviour.

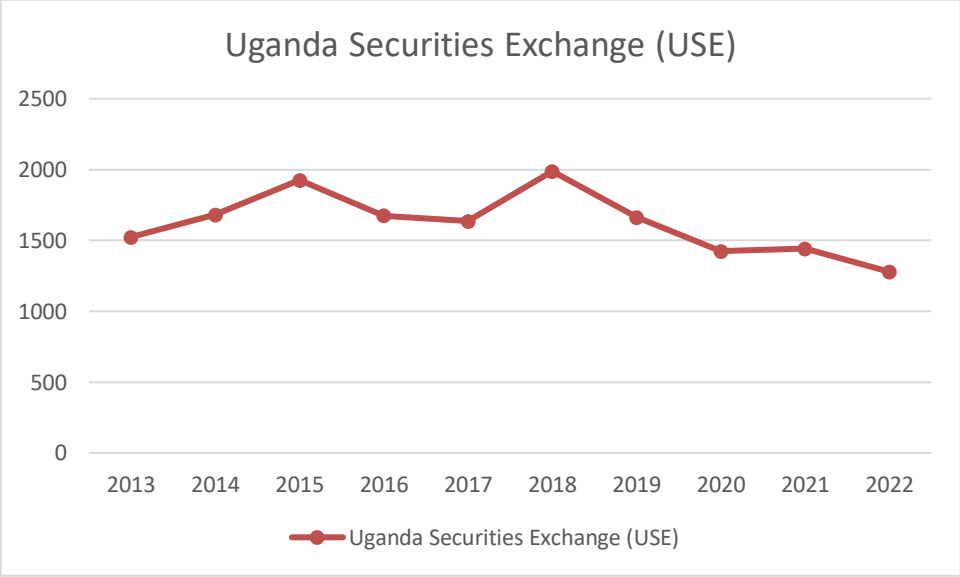

Figure 4. 1: Uganda Securities Exchange (USE) Index

The performance of the Uganda Securities Exchange (USE) stock index from 2013 to 2022 highlights significant variability, reflecting the dynamic nature of the Ugandan financial market and the broader macroeconomic environment. Over this ten-year

period, the USE index ranged from a high of 1,987.81 in 2018 to a low of 1,278.50 in 2022, with an average value of 1,644.96. These fluctuations suggest a market that is both volatile and sensitive to external and internal economic influences, making it a critical case for analysing anomalies and identifying key drivers of performance.

From 2013 to 2015, the USE index exhibited steady growth, increasing from 1,522.64 to 1,925.23. This period of positive market performance likely coincided with macroeconomic stability and favourable investor sentiment in Uganda, potentially driven by policy initiatives or increased foreign direct investment. The index reached its first peak in 2015, reflecting strong market activity and a bullish outlook during this time.

However, this upward trend was interrupted in 2016, as the index declined sharply to 1,673.31, marking the beginning of a prolonged period of weaker performance. The subsequent years saw continued declines, with the index reaching 1,422.90 in 2020. This downturn may be attributed to several factors, including internal economic challenges, reduced investor confidence, and external shocks such as the global economic impacts of the COVID-19 pandemic. The pandemic likely exacerbated existing structural weaknesses within the Ugandan economy, including low market liquidity and limited diversification in the stock exchange.

By 2022, the USE index had declined to 1,278.50, its lowest value in the ten-year period. This continued drop reflects persistent challenges in Uganda's financial markets, potentially including inflationary pressures, reduced foreign and domestic investment, and the lingering effects of the COVID-19 pandemic on economic recovery. The decline in 2022 underscores the structural vulnerabilities of the Ugandan stock market, such as low market participation and sensitivity to external economic shocks.

The overall performance of the USE during this period highlights its volatility, which is indicative of a relatively small and underdeveloped market. The significant peaks and troughs in the index suggest that the market is highly responsive to macroeconomic conditions and investor sentiment.

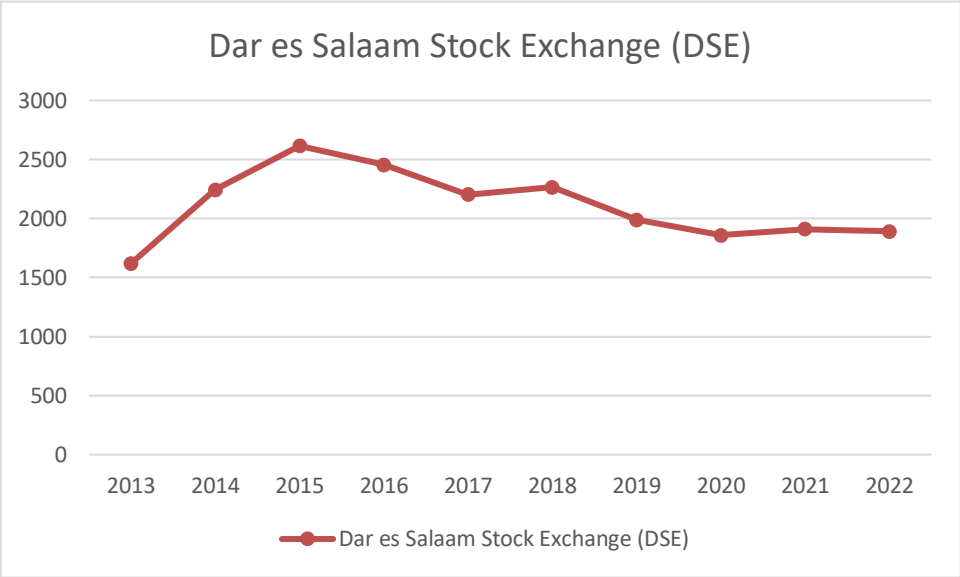

Figure 4. 2: Dar es Salaam Stock Exchange (DSE) Index

The performance of the Dar es Salaam Stock Exchange (DSE) index from 2013 to 2022 reflects the evolving dynamics of Tanzania's financial market, characterized by periods of significant growth, occasional declines, and moderate recovery. Over the ten-year period, the DSE index fluctuated between a low of 1,619.89 in 2013 and a high of 2,614.60 in 2015, with an average index value of approximately 2,104.41. From 2013 to 2015, the DSE index experienced a strong upward trajectory, increasing from 1,619.89 in 2013 to its peak of 2,614.60 in 2015. This marked a period of robust market performance, likely fuelled by favourable economic conditions, including steady GDP growth and relatively low inflation. During this time, increased investor confidence and possibly improved regulatory frameworks contributed to heightened market activity, positioning the DSE as a growing regional financial hub.

The upward momentum, however, began to wane in 2016, with the index declining to 2,453.65. This downward adjustment suggests a correction phase following the market's rapid growth, as well as potential external influences such as global market volatility or internal factors like reduced investor activity. The decline continued into 2017, when the index fell further to 2,202.54. This two-year period of contraction indicates a more cautious investment climate, potentially linked to political

uncertainties, regional economic challenges, or shifts in market fundamentals.

In 2018, the DSE index saw a modest rebound, increasing to 2,263.93. This recovery was short-lived, however, as the index began a gradual decline over the next several years, reaching 1,857.47 in 2020. The impact of the COVID-19 pandemic likely exacerbated this decline, as global and regional markets grappled with economic disruptions, supply chain issues, and diminished investor confidence. Tanzania's relatively smaller and less liquid stock market may have been particularly vulnerable to these external shocks.

Post-pandemic recovery efforts are reflected in the slight uptick in the index from 1,857.47 in 2020 to 1,909.24 in 2021. However, the market failed to sustain significant growth, as the index dropped marginally to 1,889.72 in 2022. This suggests that while there was some stabilization in the market, structural challenges such as limited market depth, low levels of investor participation, and dependence on a few key sectors may have hindered more robust recovery.

Overall, the DSE exhibited moderate volatility over the ten years, with noticeable peaks and troughs reflecting shifts in economic conditions and external influences. The high in 2015 and the lows in 2020 and 2022 emphasize the importance of investigating macroeconomic and market-specific drivers to better understand the factors shaping Tanzania's financial market performance. This analysis provided valuable insights into the DSE's potential for growth and the structural adjustments needed to bolster its resilience in the face of future economic shocks.

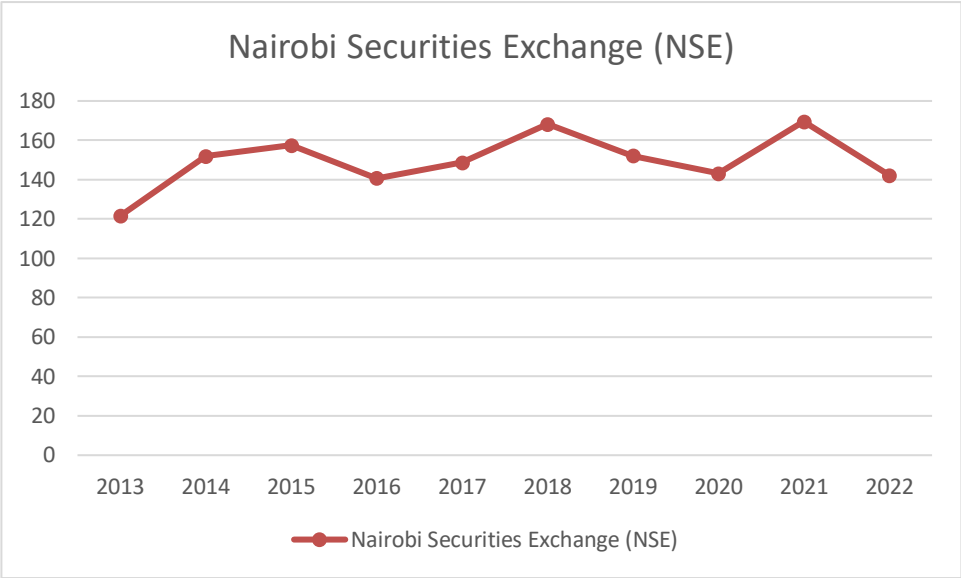

Figure 4. 3: Nairobi Securities Exchange (NSE) Index

The performance of the Nairobi Securities Exchange (NSE) index from 2013 to 2022 reveals a dynamic yet moderately volatile stock market. Over this ten-year period, the NSE index fluctuated between a low of 121.60 in 2013 and a high of 169.57 in 2021, with an average value of approximately 149.58. From 2013 to 2015, the NSE index experienced steady growth, rising from 121.60 in 2013 to 157.47 in 2015. This increase indicates a period of strong market performance, potentially driven by favourable economic conditions, including robust GDP growth, political stability, and increased foreign investment. However, this upward trend was interrupted in 2016, when the index declined to 140.69, marking a significant downturn. This decline may have been influenced by a mix of internal and external factors, including macroeconomic pressures such as currency fluctuations, rising inflation, or global economic trends that affected investor behaviour. The recovery in 2017, where the index rose slightly to 148.63, reflects a period of cautious optimism as market conditions began to stabilize.

In 2018, the NSE index climbed to 168.23, marking one of the highest values recorded during the study period. This surge likely reflects increased investor confidence, buoyed by improved macroeconomic conditions and positive market developments. However, this strong performance was not sustained, as the index began a gradual

decline over the next two years, dropping to 143.21 in 2020. The global economic disruptions caused by the COVID-19 pandemic likely contributed to this downturn, as investor confidence waned and market activity slowed.

The post-pandemic period saw a brief resurgence in 2021, with the NSE index reaching 169.57, the highest value recorded during the ten-year period. This rebound indicates a recovery phase, driven by improved economic activity and renewed investor optimism. However, the market once again experienced a decline in 2022, with the index falling to 142.22. This drop underscores the challenges of sustaining growth in the face of persistent structural issues, including market inefficiencies, low liquidity, and regional economic pressures.

The NSE's performance over the decade highlights its relative resilience and importance as a regional financial hub, despite periods of volatility. The steady growth in the early years and the rebound in 2021 demonstrate the market's potential when macroeconomic conditions are favourable. However, the fluctuations and declines in other periods underscore the need for continued reforms to enhance market stability and attract long-term investment. Efforts to improve market liquidity, diversify financial products, and strengthen investor protections would be critical in mitigating volatility and fostering sustainable growth.

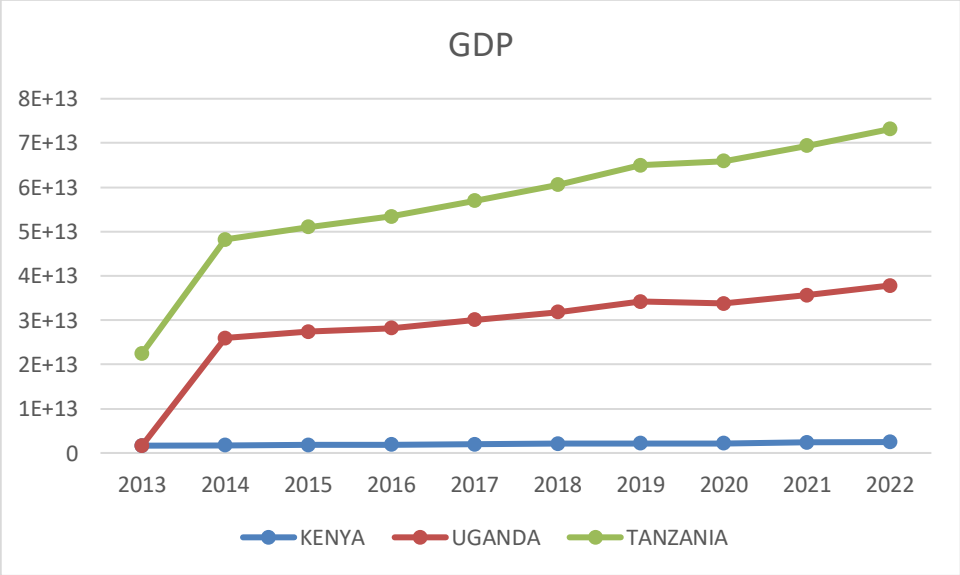

Figure 4. 4: GDP Performance of Kenya, Uganda, and Tanzania (2013 to 2022)

The GDP performance of Kenya, Uganda, and Tanzania from 2013 to 2022 reveals consistent economic growth across the three countries, albeit with variations in scale and pace. Kenya's GDP grew steadily from 1.65 trillion Kenyan shillings in 2013 to 2.46 trillion in 2022, reflecting a compound annual growth rate of approximately 4.5%. This sustained growth was driven by key sectors such as agriculture, services, and manufacturing, alongside major infrastructure investments and regional trade integration. The period between 2013 and 2018 saw consistent GDP increases, culminating in 2.08 trillion in 2018, signalling strong economic performance. However, Kenya experienced a slight stagnation in 2020, with GDP falling marginally to 2.18 trillion, likely due to the COVID-19 pandemic and its associated disruptions to trade, tourism, and domestic economic activity. By 2021 and 2022, Kenya's GDP recovered, reaching 2.46 trillion, underscoring the country's resilience and its position as a regional economic leader.

Uganda's GDP exhibited significant growth over the period, starting at 24.23 trillion Ugandan shillings in 2014 (data for 2013 is unavailable) and reaching 35.36 trillion in 2022. This growth, averaging approximately 5.3% annually, reflects robust economic expansion supported by infrastructure projects, agriculture, and natural resource development. Between 2014 and 2019, GDP grew steadily, peaking at 31.99 trillion in 2019. However, the pandemic caused a slight contraction in 2020, with GDP declining to 31.54 trillion, reflecting reduced trade activity, constrained government spending, and disruptions in key economic sectors. Uganda's recovery was swift, with GDP rebounding to 33.26 trillion in 2021 and 35.36 trillion in 2022. This resilience highlights the effectiveness of post-pandemic recovery measures and the adaptability of Uganda's economy despite external shocks.

Tanzania's GDP performance was characterized by consistent and significant growth, rising from 20.82 trillion Tanzanian shillings in 2013 to 35.31 trillion in 2022, with a compound annual growth rate of approximately 6.1%. This makes Tanzania the fastest-growing economy among the three countries during the study period. The country's GDP grew steadily from 2013 to 2018, reaching 28.79 trillion, driven by

agriculture, mining, construction, and government-led infrastructure projects. Unlike Kenya and Uganda, Tanzania's economy-maintained growth throughout the pandemic, with GDP rising from 30.78 trillion in 2019 to 32.18 trillion in 2020. This resilience can be attributed to its reliance on domestic economic activity and a relatively lower dependence on international trade. The growth trajectory continued post-pandemic, with GDP increasing to 33.73 trillion in 2021 and 35.31 trillion in 2022, showcasing the strength and diversification of Tanzania's economic base.

When comparing the three countries, Tanzania and Uganda exhibited larger GDP values in local currency terms compared to Kenya. However, Kenya's consistent growth and economic stability solidify its role as a financial hub in the region. Tanzania's robust growth rate highlights its potential as an emerging economic leader, while Uganda's economic expansion reflects steady development driven by infrastructure and agriculture. The slight stagnation observed in Kenya and Uganda during the pandemic underscores their vulnerability to global economic shocks, while Tanzania's continuous growth emphasizes its relative insulation from external disruptions. All three countries demonstrated strong post-pandemic recoveries in 2021 and 2022, underscoring the resilience of the East African region and its ability to adapt to economic challenges.

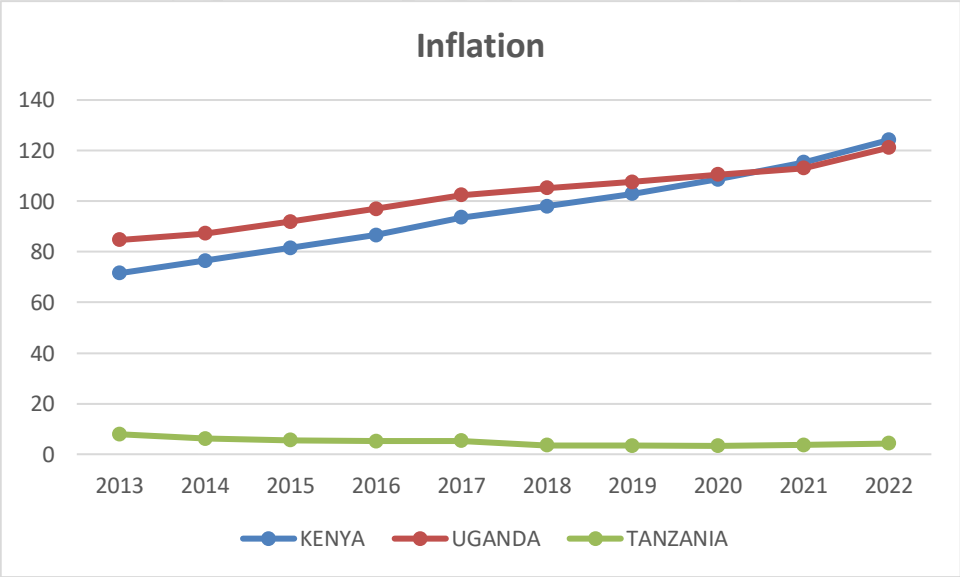

Figure 4. 5: Inflation Rates for Kenya, Uganda, and Tanzania (2013 to 2022)

The inflation rates for Kenya, Uganda, and Tanzania from 2013 to 2022 reveal distinct patterns that highlight the differences in macroeconomic stability and monetary policy effectiveness across the three East African countries. While Kenya and Uganda exhibited relatively high and gradually increasing inflation rates, Tanzania experienced notably lower and more stable inflation throughout the period. These trends reflect the structural and policy-driven differences in how these economies managed price levels and responded to domestic and external pressures.

Kenya's inflation rates showed a steady upward trajectory over the ten years, increasing from 71.54 in 2013 to 124.16 in 2022. This consistent rise in inflation indicates persistent upward pressure on prices, driven by factors such as demand-side pressures, supply chain challenges, and changes in energy or food prices, which are significant components of inflation in the region. The year-on-year increase highlights challenges in stabilizing inflation through monetary policy measures. The gradual increase in inflation is also indicative of economic expansion and structural transformations in Kenya, which can lead to upward price adjustments. However, the steadily rising rates may also reflect underlying inefficiencies or external vulnerabilities, such as import dependency or exposure to global price shocks.

Uganda's inflation rates followed a similar pattern of gradual increase, starting at 84.67 in 2013 and reaching 121.14 in 2022. Although slightly higher than Kenya's rates, the upward trend suggests comparable macroeconomic pressures in Uganda, including rising consumer demand, currency fluctuations, and the effects of global commodity price changes. The rise in inflation over the decade underscores the challenges faced by Uganda in maintaining price stability, despite its efforts to foster economic growth and development. The relatively consistent growth in inflation rates suggests that Uganda, like Kenya, has struggled to balance economic expansion with effective inflation control.

In contrast, Tanzania exhibited significantly lower and more stable inflation rates during the same period, starting at 7.90 in 2013 and decreasing to a low of 3.29 in 2020 before slightly increasing to 4.33 in 2022. This level of stability reflects Tanzania's effective monetary policies and its success in maintaining price stability

through measures such as controlled money supply, fiscal discipline, and relatively low exposure to external inflationary shocks. Tanzania's declining inflation rates from 2013 to 2020 demonstrate strong policy interventions and economic conditions conducive to price stability. The slight increase in inflation in 2021 and 2022 suggests moderate price pressures, potentially linked to post-pandemic recovery efforts and global inflationary trends. Nevertheless, Tanzania's inflation rates remained well below those of Kenya and Uganda, showcasing its comparative advantage in macroeconomic stability.

When comparing the three countries, Kenya and Uganda experienced higher inflation rates, with similar upward trends, reflecting shared structural challenges in managing price stability amid economic growth. In contrast, Tanzania maintained a markedly different trajectory, with significantly lower and declining inflation over most of the period. These differences may be attributed to variations in economic policies, reliance on imports, and the degree of exposure to global economic pressures. Kenya and Uganda's rising inflation rates suggest the need for enhanced monetary policy interventions and structural adjustments to address underlying inefficiencies and mitigate inflationary pressures. On the other hand, Tanzania's success in achieving low inflation highlights the benefits of disciplined monetary and fiscal management, which contributed to a stable macroeconomic environment.

4.3 Anomaly Detection

This section focused on detecting anomalies in financial market indices across East African stock markets using two approaches: Z-scores and neural network analysis. These methods identify deviations from expected patterns to uncover potential irregularities in inflation, GDP, and stock indices.

	Minimum	Maximum	Mean	Std. Deviation
Z-score: Inflation	-1.37754	1.21173	.0000000	1.00000000
Z-score: GDP	-1.38441	1.21047	.0000000	1.00000000
Z-score: NSE	-1.98951	1.42185	.0000000	1.00000000

Z-score: USE	-1.56919	1.66207	.0000000	1.00000000
Z-score: DSE	-1.59490	1.68084	.0000000	1.00000000

4.3.1 Z-Score

The Z-score method identifies anomalies by measuring how far a given value deviates from the mean in terms of standard deviations. This approach highlights potential outliers in inflation rates, GDP, and stock indices to determine whether extreme deviations exist across the dataset.

Table 4. 2: Z-Score Anomalies Table

Table 4.2 of Z-scores presented for inflation, GDP, and stock indices (NSE, USE, and DSE) highlights that the values fall within a normal range of variability, with the minimum and maximum Z-scores ranging from approximately -1.38 to 1.52. These values are well below the standard anomaly threshold of ±3, indicating that no extreme outliers exist in the dataset.

For the inflation data, the Z-scores ranged from -1.37754 to 1.21173, with a mean of 0 and a standard deviation of 1. This suggests that while there were fluctuations in inflation rates across the countries, these variations were generally within expected limits. The slight variability in inflation Z-scores implies that while inflation rates fluctuated over time, they did not experience extreme deviations from the mean, suggesting that the inflation data across Kenya, Uganda, and Tanzania were stable and did not exhibit significant anomalies during the study period.

The GDP data also exhibited Z-scores within the range of -1.38441 to 1.21047, with a mean of 0 and a standard deviation of 1. This indicates that GDP growth across the three countries generally followed expected patterns without significant outliers. The variability captured by these Z-scores suggests that while GDP figures varied, there were no extreme deviations that would point to significant anomalies in economic performance. The results highlight a stable but varying economic environment across the countries.

When examining the Z-scores for the stock indices (NSE, USE, and DSE), the range of values for the Nairobi Securities Exchange (NSE) was from -1.98951 to 1.42185.

The mean was 0, and the standard deviation was 1, suggesting that the NSE had some variability in its performance over the study period. While the negative Z-score (-1.98951) indicates instances where the index performed below its historical mean, the maximum value of 1.42185 shows that there were occasional years with above-average performance. This variability, however, remained within the normal range, suggesting no extreme fluctuations in the NSE.

For the Uganda Securities Exchange (USE), the Z-scores ranged from -1.56919 to 1.66207, again with a mean of 0 and a standard deviation of 1. The positive skew in the Z-scores indicates that the USE generally performed above average during the period, especially during certain years when the index exceeded its historical mean. The highest Z-score of 1.66207 reflects periods of stronger market performance, but like the other indices, there were no extreme outliers beyond the ±3 threshold, signifying that fluctuations in the USE were not abnormal.

Similarly, for the Dar es Salaam Stock Exchange (DSE), the Z-scores ranged from -1.59490 to 1.68084, with a mean of 0 and a standard deviation of 1. This range shows that the DSE experienced periods of stronger performance, particularly reflected in the maximum Z-score of 1.68084. Despite this variability, the absence of extreme outliers indicates that the performance of the DSE was within the expected bounds and did not experience any significant deviations that would suggest anomalies.

Overall, these descriptive statistics confirm the earlier findings that no extreme anomalies are present in the data, and the observed patterns align with expected economic and financial market behaviour across the East African countries in the study period.

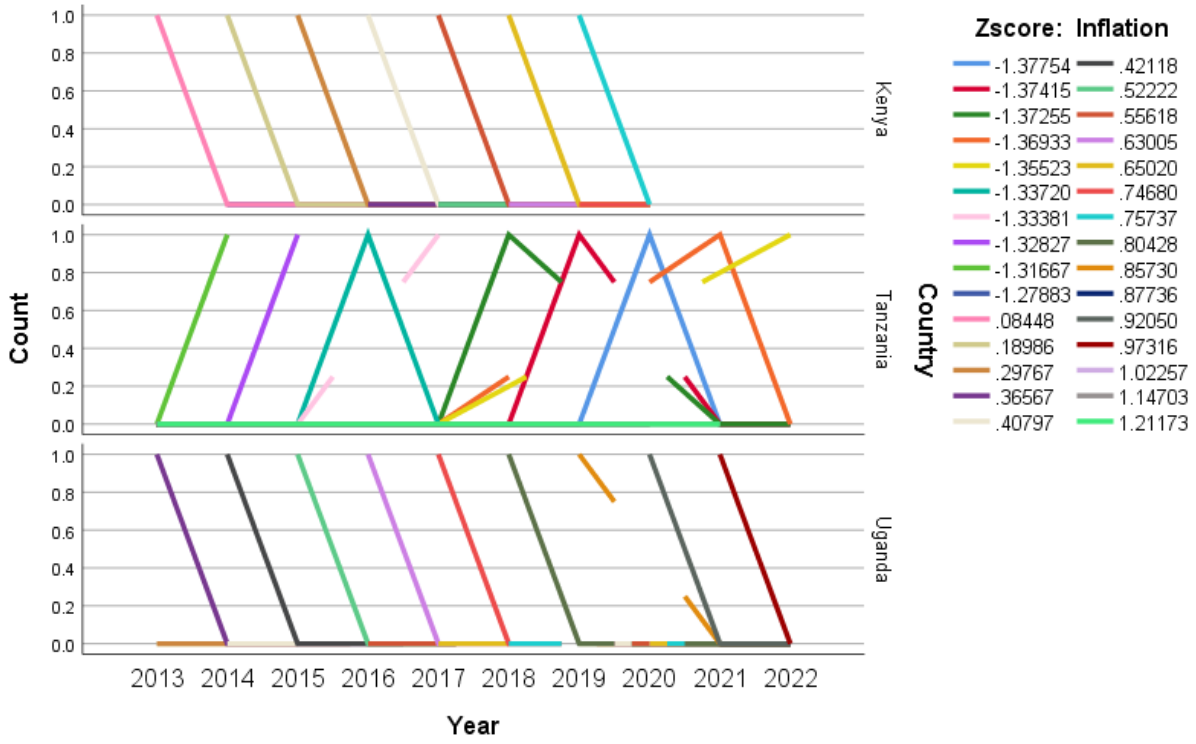

Figure 4. 6: Z-scores for Inflation per Year (Per Country)

Figure 4.6 provided insights into how inflation in these countries deviates from their historical averages. In Kenya, the Z-scores display a gradual upward trend over the decade, starting near zero in 2013 and reaching a peak of approximately 1.21173 in 2022. This consistent increase suggests rising inflationary pressures in Kenya over time, which may reflect a combination of factors such as demand-side pressures, currency fluctuations, and global price trends, particularly in later years like 2022. While the Z-scores remain within the range of ±2, indicating no extreme anomalies, the steady rise highlights persistent inflationary challenges relative to Kenya's historical baseline.

In contrast, Tanzania demonstrates remarkable inflation control, with consistently negative Z-scores throughout the decade. Starting at -1.37754 in 2013, the Z-scores remain stable, with only slight increases toward -1.35523 in 2022. This trend indicates that Tanzania's inflation rates were consistently below its historical average and significantly lower than those of Kenya and Uganda. The stability in Tanzania's Z-

scores reflects effective monetary and fiscal policies, as well as the country's relatively lower exposure to external inflationary shocks. Tanzania's ability to maintain such stability underscores its success in managing price levels compared to its regional counterparts.

Uganda's Z-scores for inflation follow a trajectory similar to Kenya's, with a gradual increase from 0.36567 in 2013 to 1.14703 in 2022. This upward trend indicates moderate inflationary pressures over time, comparable to Kenya's experience. While Uganda's inflation rates remain within the expected range and show no anomalies, the rising Z-scores suggest that inflationary challenges have steadily grown over the years. These increases may be attributed to structural economic factors, including rising consumer demand and shifts in commodity prices.

When comparing the three countries, it is evident that Kenya and Uganda share similar inflationary trends, with Z-scores steadily increasing over the decade. This reflects shared regional inflationary pressures, possibly influenced by factors such as global oil price volatility, economic expansion, and domestic policy limitations. On the other hand, Tanzania stands out with consistently low and stable inflation, as evidenced by its negative Z-scores. This difference highlights Tanzania's stronger inflation control mechanisms, which have enabled it to maintain price stability throughout the decade.

Overall, the graph reveals that while inflation rates in Kenya and Uganda have steadily risen, they remain within the bounds of normal variability. Tanzania, in contrast, demonstrates exceptional stability in managing inflation. The absence of extreme anomalies (Z-scores beyond ±2) across all three countries suggests that inflation has not reached critical levels relative to historical patterns. However, the upward trends in Kenya and Uganda warrant attention, as they point to sustained inflationary pressures that could pose challenges to economic stability in the future. This analysis underscores the importance of regional collaboration and robust monetary policies to address inflationary trends in East Africa.

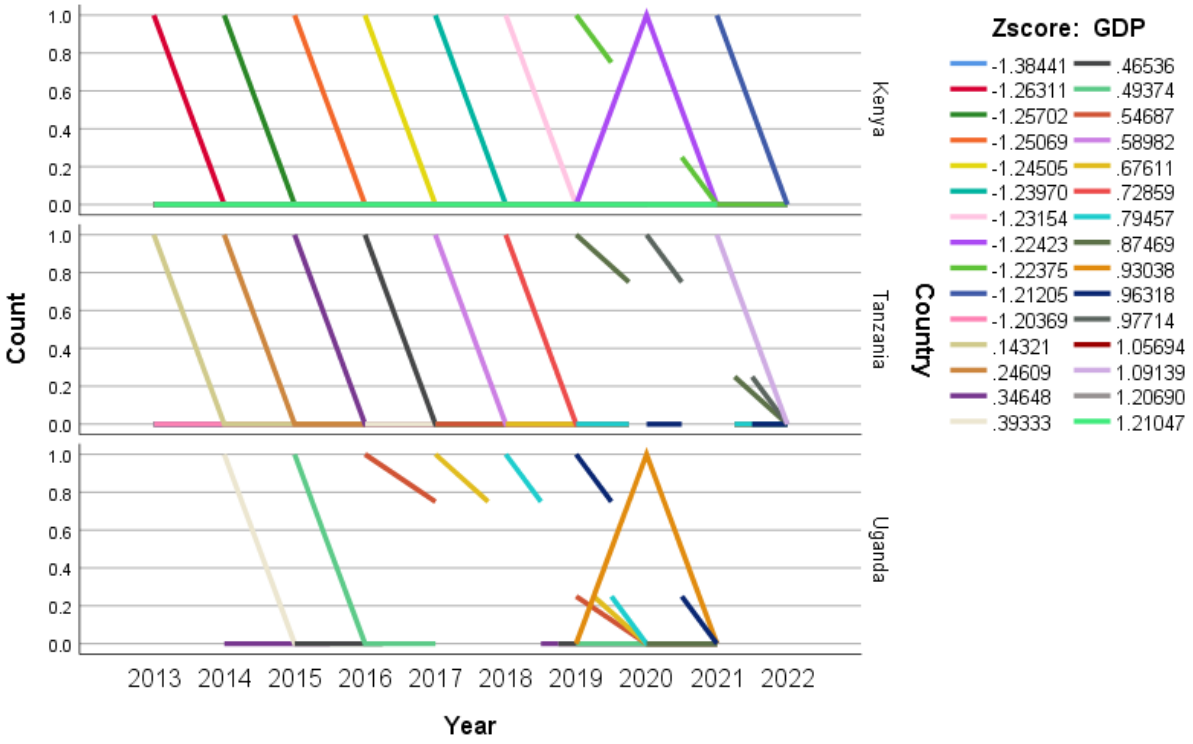

Figure 4. 7: Z-scores for GDP per Year (Per Country)

For Kenya, the Z-scores for GDP remain consistently negative across the entire period, starting at -1.38441 in 2013 and gradually increasing to -1.20369 by 2022. This indicates that Kenya's GDP values consistently fell below the average GDP values in the dataset, reflecting its comparatively smaller economy within the East African region. While the Z-scores show a slight upward trend, suggesting gradual economic growth, Kenya's economy remains relatively less dominant in terms of scale compared to Uganda and Tanzania. The absence of any extreme deviations (Z-scores beyond ±2) suggests that Kenya's GDP growth, while slower, has been stable and within expected variability.

In Tanzania (middle panel), the Z-scores for GDP are predominantly positive and exhibit a steady upward trend. Starting at -1.22375 in 2013, the Z-scores rise consistently over the decade, reaching a peak of 1.20690 in 2022. This pattern reflects strong and sustained economic growth in Tanzania, which outperformed its historical average GDP values and those of its regional counterparts. Tanzania's positive Z-

scores highlight its robust economic trajectory, driven by factors such as infrastructure investments, diversified exports, and relatively stable macroeconomic policies. Similar to Kenya, no extreme deviations are observed, indicating steady growth within expected bounds.

For Uganda (bottom panel), the Z-scores exhibit more variability compared to Kenya and Tanzania. Uganda's Z-scores transition from negative in earlier years, such as -1.38441 in 2013, to positive values by 2022, with the highest Z-score of 1.21047 recorded in 2022. This sharp increase highlights rapid economic growth in Uganda, particularly in recent years. However, Uganda also shows temporary drops in Z-scores during 2020, reflecting the economic impact of the COVID-19 pandemic. This dip aligns with global economic disruptions during the pandemic and underscores Uganda's sensitivity to external shocks. Despite this temporary setback, Uganda's Z-scores recover quickly, suggesting resilience and a strong post-pandemic recovery trajectory.

Comparing the three countries, Tanzania consistently demonstrates positive Z-scores, reflecting its relatively larger GDP and consistent growth. Uganda exhibits more variability, with a significant rise in GDP Z-scores in the later years, indicating rapid economic expansion. Kenya's consistently negative Z-scores reflect its smaller GDP relative to the other two countries, though it still exhibits steady and stable growth over time. None of the countries exhibit Z-scores beyond the ±2 threshold, indicating that GDP variations across the region remain within expected bounds, with no extreme outliers or anomalies.

The Z-scores for GDP across the three countries reveal strong growth trajectories for Tanzania and Uganda, with Tanzania maintaining consistent performance and Uganda showing rapid expansion, especially post-2020. Kenya, while growing more slowly, demonstrates stable and predictable economic trends. The absence of extreme anomalies suggests that GDP growth in East Africa during the study period was largely stable, driven by internal development initiatives and recovery from global economic disruptions. This analysis highlights the relative economic strengths of the three countries and provided a basis for understanding their contributions to regional

economic performance.

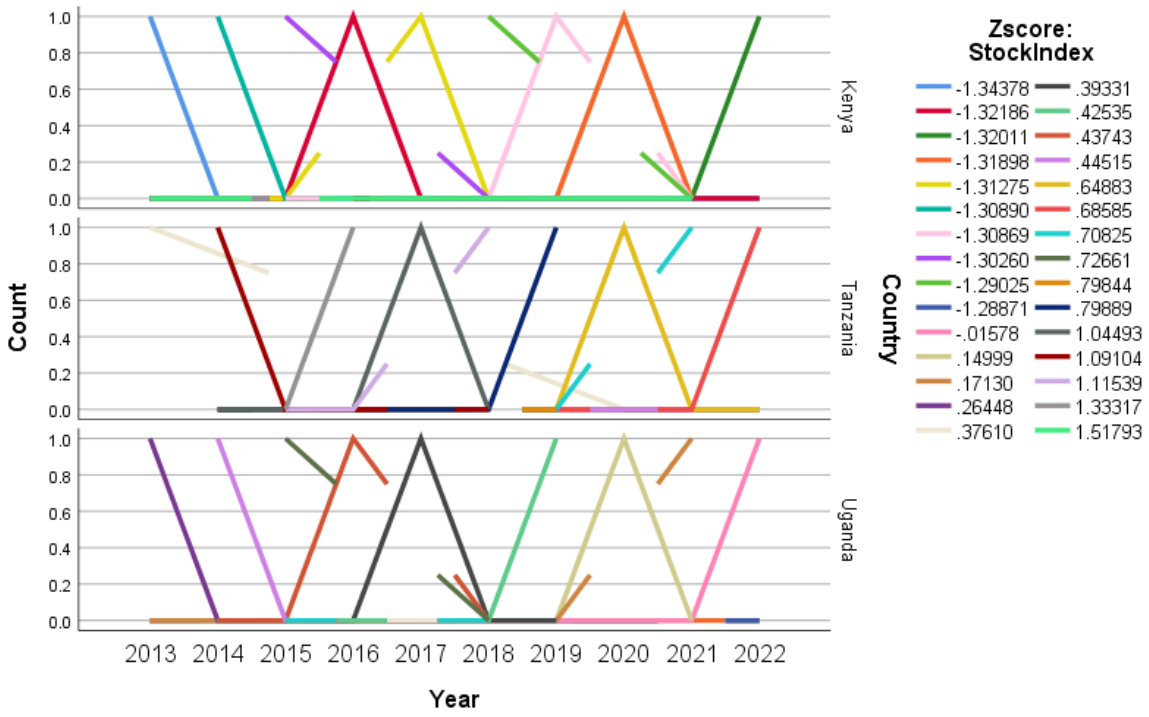

Figure 4. 8: Z-scores for Stock Market Indices per Year (Per Country)

Figure 4.8 highlights deviations in performance relative to their historical averages. In Kenya, the Z-scores remain consistently negative throughout the study period, ranging from -1.34378 in 2013 to -1.32011 in 2022. This consistent trend of negative Z-scores indicates that Kenya's stock market performance was generally below the dataset's average. While there are slight improvements in certain years, such as 2018, when the Z-scores approach closer to the mean, the overall trend reflects weaker market performance compared to its regional counterparts. The lack of significant variability or extreme anomalies suggests a stable yet underperforming stock market, potentially driven by economic challenges, lower investor confidence, or limited market activity.

In Tanzania, the Z-scores show more variability and a stronger overall performance compared to Kenya. The Z-scores range from -1.29025 in 2013 to 1.51793 in 2015, with the 2015 value representing a clear peak. This positive Z-score indicates a period of exceptional stock market performance, likely driven by favorable macroeconomic conditions, increased investor activity, or specific policy initiatives during that year.

After 2015, Tanzania's Z-scores decline gradually, approaching zero by 2019 and becoming slightly negative by 2022. While this decline indicates that stock market performance normalized and fell below the mean in later years, Tanzania's market still demonstrated resilience and outperformed its regional peers in terms of consistency and relative success during the decade.

Uganda's Z-scores exhibit the greatest variability among the three countries, reflecting fluctuating stock market performance over the years. Initially, the Z-scores are negative, but they transition to a peak of 1.51793 in 2015, mirroring the strong performance observed in Tanzania during the same year. This peak suggests that 2015 was a period of favourable market conditions or external influences across the region. However, Uganda's stock index Z-scores fluctuate significantly in subsequent years, showing sharp declines in 2018 and 2020, which may be attributed to economic challenges or external shocks, such as reduced investment activity or the impact of the COVID-19 pandemic. Despite these downturns, Uganda's Z-scores recover in 2021 and 2022, indicating resilience and an ability to rebound from periods of weaker performance.

Comparatively, Tanzania emerges as the strongest performer, with consistently positive Z-scores and a significant peak in 2015, highlighting its relatively robust stock market activity. Uganda shows periods of strong performance but also exhibits notable volatility, reflecting both growth potential and vulnerability to shocks. Kenya, by contrast, lags behind with persistently negative Z-scores, indicating consistent underperformance relative to its regional counterparts. The lack of significant variability in Kenya's Z-scores suggests a stable but less dynamic market that may require structural reforms or policy interventions to boost activity and investor confidence.

The year 2015 stands out as a significant period for both Tanzania and Uganda, with Z-scores peaking at 1.51793 for their stock indices. This simultaneous strong performance may indicate a regional trend or specific events driving heightened market activity during that year. Further investigation into economic or policy conditions in 2015 could provide valuable insights. Overall, while no extreme

anomalies (beyond ±2) are observed in the dataset, the Z-scores underscore important trends: Tanzania's strength and consistency, Uganda's variability and potential, and Kenya's persistent underperformance. These findings highlight the need for targeted efforts to enhance the competitiveness and stability of stock markets across the East African region.

4.3.2 Neural Network Analysis through Multilayer Perceptron (MLP)

The neural network analysis, performed using the Multilayer Perceptron (MLP) model in SPSS, aimed to uncover complex relationships between Inflation, GDP, and Stock Index. This method enhances anomaly detection by identifying patterns and deviations that cannot be easily captured by linear statistical methods.

Table 4. 3: Case Processing Summary

		N	**Percent**
Sample	Training	23	76.7%
	Testing	7	23.3%
Valid		30	100.0%
Excluded		0	
Total		**30**	

A total of 30 valid cases were included in the analysis, with no missing or excluded data, ensuring reliability. The dataset was split into a training sample of 23 cases (76.7%) and a testing sample of 7 cases (23.3%). The training sample was utilized to develop the model, while the testing sample was used to evaluate its predictive performance and generalizability. The absence of excluded cases ensures that the model is based on the complete dataset, providing robust results.

Table 4. 4: Network Information

Input Layer	Covariates	1	Inflation
		2	GDP

	Number of Units[a]		2
	Rescaling Method for Covariates		Standardized
Hidden Layer(s)	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1[a]		1
	Activation Function		Hyperbolic tangent
Output Layer	Dependent Variables	1	Stock Index
	Number of Units		1
	Rescaling Method for Scale Dependents		Standardized
	Activation Function		Identity
	Error Function		Sum of Squares
a. Excluding the bias unit			

The neural network architecture employed in the analysis was simple yet effective. The input layer consisted of two independent variables, Inflation and GDP, which were rescaled using standardization to ensure comparability and improve model training efficiency. These inputs fed into a single hidden layer with one unit, which utilized the hyperbolic tangent activation function. This activation function allowed the model to process the inputs non-linearly, capturing complex interactions between Inflation, GDP, and Stock Index. The output layer, corresponding to the dependent variable Stock Index, applied the identity activation function. This function outputs predicted values directly, making interpretation straightforward. The error function used for optimization was the sum of squares, measuring the differences between predicted and actual values of the Stock Index. This network structure demonstrates a balance between simplicity and capability, tailored to the study's dataset size and complexity.

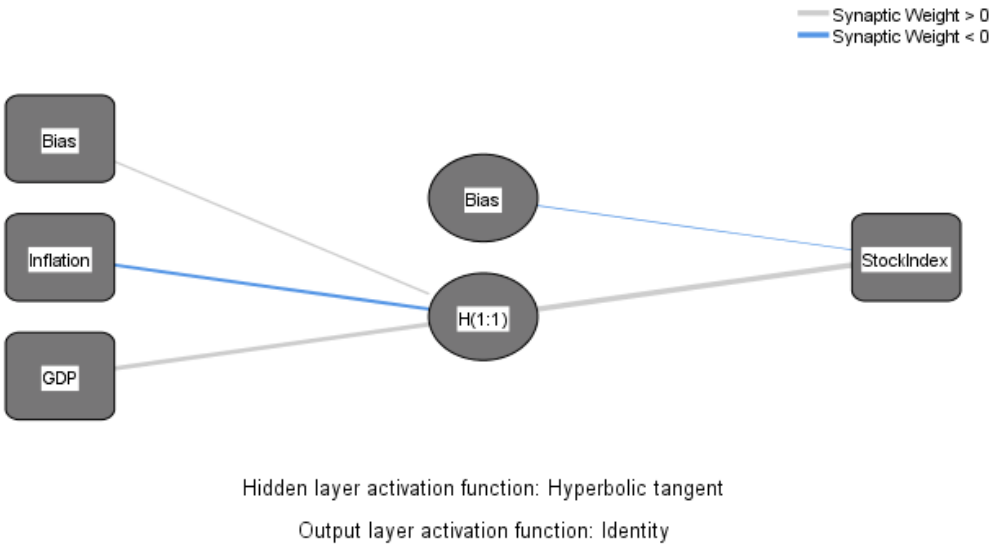

Figure 4. 9: Neural Network Architecture

The neural network diagram illustrates the flow of information through the model. Inflation and GDP are connected to a single hidden layer with one unit, and the hidden layer is further connected to the output layer representing the Stock Index. The synaptic weights between layers are either positive or negative, indicating the direction and strength of the relationships between the variables. Positive weights suggest that an increase in the input variable increases the output variable, while negative weights suggest an inverse relationship. These weights reflect the model's ability to capture the distinct influences of Inflation and GDP on Stock Index values.

Table 4. 5: Model Summary for Training and Testing Results

Training	Sum of Squares Error	2.246
	Relative Error	.204
	Stopping Rule Used	1 consecutive step(s) with no decrease in error[a]
	Training Time	0:00:00.01
Testing	Sum of Squares Error	.181

	Relative Error	.040
Dependent Variable: Stock Index		
a. Error computations are based on the testing sample.		

The model's performance is summarized in the training and testing results. For the training sample, the sum of squares error was 2.246, with a relative error of 0.204. This indicates that the model predictions were, on average, 20.4% off from the actual values during training. The testing results demonstrated a sum of squares error of 0.181 and a relative error of 0.040, showing that the model predictions were only 4% off on average for the testing data. The significant reduction in error for the testing sample suggests that the model generalized well to unseen data, avoiding overfitting. The training process stopped after one consecutive step with no decrease in error, ensuring efficiency while preventing overtraining.

The implications of these findings are significant for this study, which seeks to understand anomaly detection in financial market indices in East African stock markets. The neural network results demonstrate that the Stock Index is influenced by both Inflation and GDP in a meaningful way, as the model achieves high accuracy in predicting stock index values. The strong generalizability of the model (as indicated by the low relative error in the testing sample) suggests that the relationships captured are robust and applicable to unseen data. This highlights the reliability of using macroeconomic variables to detect deviations or anomalies in stock market performance.

Furthermore, the synaptic weights reveal the differential impact of Inflation and GDP on the Stock Index. This provided insight into how economic growth (GDP) positively contributes to stock market performance, while inflationary pressures may have a negative or dampening effect. These relationships are critical for identifying anomalies, as deviations in the Stock Index may be attributable to unexpected changes in these macroeconomic indicators. Overall, the neural network provided a powerful tool for modeling and understanding the dynamics of stock market indices, offering a foundation for anomaly detection and a deeper understanding of the interplay between

macroeconomic factors and market behaviour. This approach complements other statistical methods, such as Z-scores, in highlighting patterns and anomalies in East African financial markets.

4.4 Multiple Regression Analysis

The researcher conducted a multiple linear regression analysis to ascertain the relationship between independent variables (Inflation and GDP) and the dependent variable (Stock Index). The findings are as shown on Table 4.6, 4.7 and 4.8.

Table 4. 6: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.892[a]	.796	.781	407.65235

a. Predictors: (Constant), GDP, Inflation

The Model Summary provided an overview of the strength and fit of the regression model. The correlation coefficient (R) is 0.892, indicating a strong positive relationship between the independent variables (Inflation and GDP) and the dependent variable (Stock Index). This suggests that changes in Inflation and GDP are closely related to changes in Stock Index values. The R-squared value is 0.796, meaning that 79.6% of the variance in the Stock Index is explained by the two predictors, Inflation and GDP. The adjusted R-squared value, slightly lower at 0.781, accounts for the number of predictors in the model and confirms that the model is not overfitted. This indicates how well the model predicts Stock Index values and suggests reasonable accuracy.

Table 4. 7: Analysis of Variance (ANOVA)[a] Results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17521707.894	2	8760853.947	52.719	.000[b]
	Residual	4486871.823	27	166180.438		
	Total	**22008579.718**	**29**			

a. Dependent Variable: Stock Index

b. Predictors: (Constant), GDP, Inflation

Table 4.7 evaluates the overall significance of the regression model. The F-statistic is 52.719, with a highly significant p-value (Sig.) of 0.000. This confirms that the model is statistically significant, meaning the combination of inflation and GDP has a significant effect on the Stock Index. The high F-statistic and significant p-value demonstrate that the model provided a strong fit to the data and that the independent variables collectively explain a substantial portion of the variation in Stock Index.

Table 4. 8: Regression Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	902.621	206.177		4.378	.000
	Inflation	-6.635	1.752	-.356	-3.788	.001
	GDP	4.443E-11	.000	.695	7.404	.000

a. Dependent Variable: Stock Index

Table 4.7 details the contributions of each independent variable to the model. The constant is 902.621, indicating that when both inflation and GDP are zero, the predicted Stock Index value would be 902.621. Inflation has a negative unstandardized coefficient (B) of -6.635, meaning that for every one-unit increase in inflation, the Stock Index is predicted to decrease by 6.635 units, holding GDP constant. This negative relationship suggests that higher inflation adversely affects stock market

performance, likely due to increased costs and reduced investor confidence.

GDP, on the other hand, has a positive unstandardized coefficient (B) of approximately 4.443E-11, indicating that for every one-unit increase in GDP, the Stock Index is predicted to increase by 4.443E-11 units, holding Inflation constant. This positive relationship reflects the role of economic growth in supporting stock market performance.

In conclusion, the regression analysis demonstrates that both inflation and GDP significantly influence stock index values in East African markets. While inflation has a negative impact, GDP exerts a positive and more substantial influence. Further, it was established that GDP had the greatest influence on the stock index values in East African markets, while inflation had the least effect on the stock index values in East African markets. All the variables were significant since their p-values were less than 0.05.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

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APPENDIX

Inflation

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
KENYA	71.54083	76.46	81.4925	86.64167	93.56	97.94917	102.9517	108.5533	115.3317	124.1617
UGANDA	84.66667	87.25833	91.975	97.00833	102.4583	105.1417	107.6167	110.5667	113.025	121.1417
TANZANIA	7.9	6.133333	5.591667	5.175	5.333333	3.525	3.45	3.291667	3.675	4.333333

GDP

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
KENYA	1.65298E+12	1.73596E+12	1.82228E+12	1.89918E+12	1.97207E+12	2.08321E+12	2.18942E+12	2.1829E+12	2.34879E+12	2.46279E+12
UGANDA	0	2.42255E+13	2.55937E+13	2.63178E+13	2.80789E+13	2.96931E+13	3.19908E+13	3.15438E+13	3.32685E+13	3.53606E+13
TANZANIA	2.0817E+13	2.22185E+13	2.35873E+13	2.52071E+13	2.69028E+13	2.87936E+13	3.07848E+13	3.21809E+13	3.37379E+13	3.53118E+13

NSE

2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
121.6004	151.9805	157.4695	140.6927	148.631	168.2294	152.1716	143.206	169.5718	142.2211

DSE

2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1619.888	2242.709	2614.6	2453.646	2202.54	2263.926	1988.201	1857.474	1909.243	1889.725

USE

2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1522.643	1680.039	1925.234	1673.31	1634.876	1987.808	1662.792	1422.905	1441.474	1278.496

Kenya

		Inflation	GDP	NSE
2013	Kenya	71.54083	1.65298E+12	121.6004
2014	Kenya	76.46	1.73596E+12	151.9805
2015	Kenya	81.4925	1.82228E+12	157.4695
2016	Kenya	86.64167	1.89918E+12	140.6927
2017	Kenya	93.56	1.97207E+12	148.631
2018	Kenya	97.94917	2.08321E+12	168.2294
2019	Kenya	102.9517	2.18942E+12	152.1716
2020	Kenya	108.5533	2.18290E+12	143.206
2021	Kenya	115.3317	2.34879E+12	169.5718
2022	Kenya	124.1617	2.46279E+12	142.2211

Uganda

		Inflation	GDP	USE
2013	Uganda	84.66667	0	1522.643
2014	Uganda	87.25833	2.42255E+13	1680.039
2015	Uganda	91.975	2.55937E+13	1925.234
2016	Uganda	97.00833	2.63178E+13	1673.31
2017	Uganda	102.4583	2.80789E+13	1634.876
2018	Uganda	105.1417	2.96931E+13	1987.808
2019	Uganda	107.6167	3.19908E+13	1662.792
2020	Uganda	110.5667	3.15438E+13	1422.905
2021	Uganda	113.025	3.32685E+13	1441.474
2022	Uganda	121.1417	3.53606E+13	1278.496

Tanzania

		Inflation	GDP	DSE
2013	Tanzania	7.9	2.0817E+13	1619.888
2014	Tanzania	6.133333	2.2219E+13	2242.709
2015	Tanzania	5.591667	2.3587E+13	2614.6
2016	Tanzania	5.175	2.5207E+13	2453.646
2017	Tanzania	5.333333	2.6903E+13	2202.54
2018	Tanzania	3.525	2.8794E+13	2263.926
2019	Tanzania	3.45	3.0785E+13	1988.201
2020	Tanzania	3.291667	3.2181E+13	1857.474

2021	Tanzania	3.675	3.3738E+13	1909.243
2022	Tanzania	4.333333	3.5312E+13	1889.725