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EXPLORING THE EFFECTS OF FINANCIAL MARKET INEFFICIENCIES ON INVESTOR PERFORMANCE IN ZIMBABWE An analysis of high capital costs and liquidity challenges.

BY

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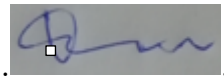
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APPROVAL FORM

This to certify that this research project is the result of my own research work and has not been extracted or copied from past sources without acknowledgement. I hereby declare that no part of it has been presented for another degree in this University or elsewhere.

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ABSTRACT

This research investigates the results of financial market inefficiencies specifically liquidity constraints and high capital cost on investor performance in Zimbabwe. Using monthly data from five Zimbabwe Stock Exchange companies from 2015 to 2025, the study employed Student-t regression model with bootstrap and Monte Carlo Simulation model. Normality tests confirmed non-normality with fat tails, justifying the use of the Student-t distribution.

The results presents that capital cost have a one hundred percent probability of affecting investor returns and liquidity constraints have a negative effect of those returns, but with weaker certainty. Under current market conditions, the predicted return is negative with over a ninety percent probability of loss. The Monte Carlo simulation further revealed a significant probability of experiencing a liquidity trap.

The research shows that Zimbabwe's financial market inefficiencies affect investor performance, rejecting the Efficient Market Hypothesis for the Zimbabwe Stock Exchange. Recommendations include inflation control, liquidity reforms, and use of the investor decision tool developed in this study for risk assessment.

Keywords: Financial market inefficiencies, capital costs, liquidity constraints, investor performance Student-t regression, Monte Carlo simulation, Zimbabwe Stock Exchange.

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LIST OF ACRONYM

ACF	Autocorrelation Function
ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
EMF	Efficient Market Hypothesis
GLM	Generalized Linear Model
RBZ	Reserve Bank of Zimbabwe
OLS	Ordinary Least Squares
VIF	Variance Inflation Factor

LIST OF SYMBOLS

α	Alpha (significance)
β_0	Intercept coefficient
β_1	Coefficient for Liquidity proxy
γ_0	Intial portfolio value

W	Shapiro-Wilk test statistic
T	Maximum investment horizon
R^2	R-squared (coefficient of determination
R_i	Real USD return for observation i
r_t	Monthly return at time

CHAPTER ONE

1.0 INTRODUCTION

This project explore how Zimbabwe's malfunction financial markets turn off investor returns. It focuses specifically on two critical barriers: the excessively high cost of capital and liquidity constraints, analysing their direct impact on investment performance.

1.1 BACKGROUND OF THE STUDY

When markets are liquid and volatile, trading is cheap and prices are precise. This enables investors to diversify, earn fair returns and manage risk. Therefore, an investor's probability to succeed is directly related to the markets, which enables risk share. In general investor performance is defined by measurable outcomes an individual or institutional investor achieves from their investment activities over time. The World Bank (2017) provides data and analysis on the liquidity and efficiency of financial markets in the world. The American financial markets, particularly the New York financial markets, are the epicentre of global finance. The National Association of Securities Dealers Automated Quotations (NASDAQ) and The New York Stock Exchange (NYSE) are the largest and most liquid stock exchanges in the world. However, despite their size and liquidity, investors in these markets still face liquidity constraints that can significantly impact their investment decisions and performance. The 2008 global financial crisis highlighted the importance of liquidity constraints in the American financial markets. Zimbabwe serves as a critical case study in financial market inefficiency, having endured decades of different economic distress. Its markets are defined with history of hyperinflation, economic fall from global capital. In this falling system, two major problems come out that is high cost of capital that hinders business investment, and liquidity constraints on Zimbabwe Stock Exchange that hinders investors from trading. While Zimbabwe's economic woes are recognized, an important critical research gap exists in empirically connecting these two inefficiencies directly

to the financial performance of investors in Zimbabwe. The research gap this study fills is the lack of enough evidence linking these two inefficiencies directly to the existing performance results for investors in Zimbabwe.

1.2 STATEMENT OF THE PROBLEM

The malfunction of Zimbabwe's financial markets, mostly high capital costs and liquidity constraints, are widely known yet their direct and impact on investor performance remains unclear in Zimbabwe. Investors know these challenges but there is a lack of strong evidence measuring how these inefficiencies erode investors returns, damaging their investment strategies, and multiply risk. This study helps investors to accurately calibrate their expectations and strategies, and hinders policymakers from designing bad policies. Therefore, the main issue this research investigate is the size and mechanism in which these two market inefficiencies affect investor results and capital market in our country.

While the existing of these challenges in Zimbabwe is well-known, there is a significant lack of investor-centric study that directly explain their results. The issue is not merely that these challenges exist, but their measurable effects on investor performance in regard with risk-adjusted returns, and long-term wealth multiplication remain unquantified and poorly understood. Existing researches often explore on macroeconomic stability or market structure in isolation, leaving a gap in the direct transmission mechanism from market malfunction to investor results.

1.3 RESEARCH OBJECTIVES

1 To explore the connection between high capital costs and investor outcomes on the Zimbabwe Stock Exchange.

2 To analyse impact of both capital costs and liquidity challenges on investor outcomes in Zimbabwe

3 To develop an investor decision tool that provides data driven recommendations for portfolio optimization under inefficient market conditions.

1.4 RESEARCH QUESTIONS

1 Define the impacts of high capital costs on investor outcomes in Zimbabwe

2 How do liquidity constraints, measured by trading volume and bid-ask spreads, affect the capability of investors to trade well and realize return profit on Zimbabwe Stock Exchange companies

3 What is the total impacts of capital costs and liquidity challenges on investor activity on the Zimbabwean financial market .

1.5 SCOPE OF THE STUDY

1.5.1 GEOGRAPHICAL SCOPE

This is focused to the Zimbabwean financial market. The analysis will be directed on institutions, investors, and market structures within the country.

1.5.2 Time Frame

The study will analyse historical data covering from 2015-2025.

1.5.3 Methodology

The research will depend on existing data (e.g., stock prices, trading volumes exchange rates and inflation rates) and not include accessing confidential client data.

1.6 SIGNIFICANCE OF THE STUDY

1) For Investors (Individual and Institutional)
The research will give a timeframe to understand the most hurdles to investor results, empowering realistic return expectations and well informed investment decisions.

2) For Regulatory Bodies, Policymakers and also Stockbrokers
The study will act as a diagnostic tool, pointing the market inefficiencies that most severely harm investor performance.

4) For Academic Contribution:

The research will give in a critical literature gap by showing empirical evidence from Zimbabwe's under-researched market structure.

1.7 ASSUMPTIONS OF THE STUDY

1.7.1 Conceptual Foundations

This research was done on several main conceptual premises. Primarily, it operates on the foundational trust that Zimbabwean financial market already works with a degree of inefficiency, that is the asset prices do not fully and include all the existing information, directly to the Efficient Market Hypothesis. The study also assumes that investors are fundamentally rational actors who target to make more returns while managing risks, even when their ideas are influenced by behavioral biases and market are irrationalities. The most assumption is that a direct and unknown causal link exists in between the specific inefficiencies of high capital costs and liquidity constraints and the investors performance. Also, the chosen financial metrics are needed as important and available indicators for knowing the crucial variables of this study.

1.7.2 Methodological Premises

The secondary data was taken from official for institution like the Zimbabwe Stock Exchange and Reserve Bank of Zimbabwe and ZIMSTATS. The research assumes that the chosen sample of market participants is the needed representative of the wider investing community in Zimbabwe, allowing the other findings to be generalized. Lastly, it is assumed that despite the volatility of the Zimbabwean market, the fundamental identity between the variables under the study are sufficient to be analyzed inline with the specified research period.

1.7.3 Contextual Underpinnings

This research is lead by the assumptions specific to the Zimbabwean context. It assume that the Zimbabwe’s monetary and regulatory policies are the core contributors to the available conditions of high capital costs and liquidity constraints. The study also recognizes that the Zimbabwean market structures are known by a unique and challenging grounds, defined by factors like currency instability and high inflation, which sets it away from other economies and makes it a crucial for this investigation. It is assumes that local investors have created their own

adaptive strategies, like preference for tangible assets and shorter investment period, response to these market inefficiencies under investigation.

1.8 LIMITATION OF THE STUDY

1.8.1 Limitations of Data Availability and Reliability

The research acknowledges more limitations that may hinders the analysis and interpretation of the findings

The researcher faces challenges in determining detailed, data such as specific portfolio compositions because of confidentiality and data from Zimbabwe Stock Exchange due to the amount of fees required to have the data hence other sources were used to have the data

1.8.2 Methodological Constraints

A simple methodological issue lies within distinguishing causation under mere correlation. Given that market multifunction, investor results, and the broader economic environment are interconnected, isolating the direct impact of capital costs and liquidity from other impact factors like political risk is inherently complex. Also, the research may be limited by the size of the the sample to be studied and accessibility of active investors and high-level institutional investors, which can impact the generalization of the qualitative insights.

1.8.3 Limitations Inherent to the Research Scope

The ideology of this study is deliberately centred on the formal financial sector. Meaning the important informal economic activity in the country, which also impact investor behaviour, falls away of the boundaries of the research, representing a gap. The study also focus on capital costs and liquidity, thereby not defining other market inefficiencies political interference, which also affect performance of investor. Lastly, the selected time period, may not encompass long term insights and can be influenced by singular events, like the global pandemic outbreaks.

1.8.4 Contextual and Generalizability Limitations

With high volatility and non-stationary environment of the Zimbabwean economy, hold a serious challenge to the application of the basic financial models, which presumes more stable conditions. This require the use of conventional analytical techniques. The results of this study are structure by the different socio-economic and political environment of Zimbabwe. The

conclusions include a limited direct interlink with other countries with different better economic grounds and stable political structures.

1.9 DEFINANTION OF TERMS

1. **Liquidity**: The rate and ease at which an asset can be converted into cash without touching its price (Baker and Wurgler, 2007)
2. **Liquidity constraints**: The limitations that barriers investors from trading assets at any time or at any desired quantity or price (Gromb and Vayanos, 2002)
3. **Financial market Inefficiencies:** Structural, operational imperfections within a financial system that hinders the rational allocation of capital and impact prices of assets (e.g., stocks, bonds) to ranges from their fundamental value. In the structure of this study, this means specifically to the severe types of these inefficiencies present on Zimbabwean market, e.g high capital costs and liquidity constraints, are exacerbated by bad policy and information asymmetry.
4. **Investor Performance:** The results from individual or institutional investor from their investment activities. It includes risk-adjusted returns (e.g., the Sharpe Ratio), absolute returns, and portfolio alpha.

High Capital Costs: The uplifted expense incurred by investors and firms from accessing capital or funding.

1.10 CONCLUSION

This research shows that financial market effects such as high capital costs and liquidity constraints are basically drivers of investor results in Zimbabwe. High capital costs, backed by inflation and direct investors toward short-term growth over long-term growth. Simultaneously, liquidity constraints reduces returns and result in increased trading risks. These two factors create a vicious cycle: high costs sustain illiquidity, and illiquidity justifies high costs, trapping the market in a state that stifles investment and economic development

CHAPTER 2: LITERATURE REVIEW

2.0 INTRODUCTION

This section of the study shows the relevant theoretical and empirical literature analysis on liquidity challenges and high capital costs for investors in stock markets. This review looks at the research on two major flaws in Zimbabwe's financial system, the extremely high cost of capital costs and the severe difficulty in buying or selling investments quickly (liquidity challenges). These flaws make it very hard for investors whether individuals, companies, or foreigners to earn good returns. Also, it gives a summary of the empirical literature that tests the hypotheses and outcomes derived from the theoretical models using various methods and data sources. The chapter also identifies the research gap that exists in the literature and motivates the need for the current study. Lastly, it suggests a conceptual model that links the research objectives and the research questions of the study.

2.1 THEORETICAL LITERATURE

In a perfect market, all information and knowledge is available to everybody instantly, and prices are fair. An inefficiency is when this does not happen due to things like high costs, lack of buyers/sellers, or poor information publication .The causes of the financial market inefficiencies are like breakdowns in the market's structure. These breakdowns happen when it's too expensive to get money, when there aren't enough active buyers and sellers. These problems throw a wrench into how prices are set, making them less about a company's real value and more about these hurdles. This forces investors to make poor choices with their money, traps them in bad investments.

The Efficient Market Hypothesis (EMH) is a theory that predicts financial markets are efficient and incorporate all available information into asset prices. It assumes all investors have access to all publicly available information .This assumption holds that the dissemination of information is perfect and instantaneous. All market participants receive all relevant news and data about a security or market simultaneously, and no investor has privileged access to information.

In Zimbabwe empirical research reveals that the Zimbabwe Stock Exchange (ZSE) systematically violates weak-form market efficiency principles. B. Mazviona et al., 2013 & 1

others found that stock price changes are not independent and random, contrary to EMH predictions. Laurine Chikoko et al., 2013 specifically demonstrated that successive stock price changes are interdependent, indicating predictability that EMH would reject. Wellington Garikai Bonga et al., 2023. suggests that these findings suggest the ZSE operates more as a predictable, inefficient market than the theoretically efficient model proposed by EMH.

Theory of Asymmetric Information happen if one side in a transaction have better information than the other side, fundamentally destroying market interactions. In financial environments, this typically refers to borrowers having more information about their true financial situation than lenders Mitică Pepi et al., 2015. For example, entrepreneurs know their project details more than investors with, creating an inherent information gap. This can direct to adverse selection, where uninformed side do suboptimal decisions Alao et al., 2018.

2.1.1 Theories on Liquidity Challenges

Liquidity Preference Theory tells people's desire to have cash because of uncertainty, with Zimbabwe having liquidity challenges after the introduction of a multi-currency system since 2009 to date. From the theory, people chooses liquidity cause of three key motives: transaction needs, precautionary measures, and speculative opportunities JÃ¶rg Bibow et al., 2007. In Zimbabwe's grounds, this shows up through most economic constraints. Wilbert Chagwiza et al., 2014 noted that commercial banks have been affected by persistent liquidity problems, with other factors like multi-currency adoption, inflation rates, and business cycles negatively impacting liquidity.

Tafadzwa R Chikwanha et al., 2014 further documented that increasing economic activity has outstripped available money balances, creating systemic liquidity challenges. Wilbert Chagwiza et al., 2013 even recommended introducing liquidity derivatives to attract foreign investors and strengthen monetary policy.

The Zimbabwean financial institutions and companies are faced with intense liquidity problems to meet their financial obligations since the inception of multi-currency system. The Zimbabwe Stock Exchange listed OK Zimbabwe daily share price data from 19 February 2009 to 31 October 2012 was used. It has been found out that the market is the source of the current

liquidity crisis. Therefore, it is strongly recommended that the ZSE should introduce the derivatives market which will ease the liquidity problems by attracting foreign investors, strengthening the monetary policy and security to would-be investors. Liquidity derivatives promote the optimization of commercial banks' capital structure and improve profit making abilities.

Market Microstructure Theory reveals that Zimbabwe's financial markets suffer from complex liquidity challenges arising from information asymmetry and trading frictions, rather than functioning as a frictionless economic system Thierry Foucault et al., 2013 explain that markets are not self-equilibrating, with liquidity emerging gradually through trading processes where participants have diverse information. In Zimbabwe's context, B. Dlamini et al., 2017 identified key liquidity crisis drivers including investor confidence, country risk, and fund externalization.

The Zimbabwe Stock Exchange shows these theoretical limitations: Runesu Chikore et al., 2014 noted that stock liquidity affects investor returns, while Collin Chikwira et al., 2023 found that stock market got a low impact on economic development. Sanford J. Grossman et al., 1988 shows that market liquidity rely on supply and demand for immediacy, which Zimbabwe's volatile economic grounds significantly disrupts.

2.1.2 Theories on Investor Performance

Modern Portfolio Theory (MPT) is a quantitative investing strategy that helps investors maximize portfolio results by balancing risk and return through diversification**.**

In the Zimbabwe environments, Petros Jecheche et al., 2011 did an empirical investigation of MPT on the Stock Exchange, studying asset return normality and portfolio construction. The research studied how statistical forms like skewness and kurtosis could help investment decisions. MPT emphasizes showing assets as portfolio parts rather than one investments Jingchen Yu et al., 2023. It help investors to optimize expected returns for a given risk of level by distributing investments across different securities Iyiola Omisore et al., 2012. The Zimbabwe-specific research is limited, and other studies shows that MPT has inherent limits, including unrealistic assumptions about market behaviour and leave of macroeconomic indicators.

2.1.3 Theory of behavioral finance

Peter Hunguru et al. (2020) did a quantitative survey of 291 individual Zimbabwe Stock Exchange investors, he noted that investment decisions are influenced by behavioural factors including anchoring, availability bias, gambler's fallacy, overconfidence, herding, loss aversion, mental accounting, regret aversion, and representativeness. The research make use of multiple regression analysis and noted that strong positive interactions between these behavioural variables and investment decisions at significance levels of 0.01 and 0.005.

Additionally, Michael Takudzwa Pasara et al. (2023) included behavioural equal exchange rate theory to Zimbabwe's currency environments, showing speculation, corruption, and arbitrage behaviours as points amplifying exchange rate distraction.

The proof base is the primary behavioural finance study with 291 participants but shows that behavioural factors shape financial decision making in Zimbabwe's markets. The sources recommend improved investor awareness programs to support better decision-making Peter Hunguru et al., 2020 & 1 others.

2.2 EMPIRICAL LITERATURE

For Africa broadly and specifically including Zimbabwe, multiple studies using diverse methodologies consistently reject market efficiency. Michael Batuo Enowbi et al., 2010 tested emerging African markets and found none exhibited random walks except South Africa. David de Villiers et al., 2020 examined 8 African frontier markets (2001-2017) using robust unit root tests and found most were inefficient, with only Kenya showing efficiency. Pyemo N. Afego et al., 2014 surveyed the literature and found results "lean towards rejection of the weak-form efficiency. For Zimbabwe specifically, evidence is contradictory. C. Mlambo et al., 2007 classified Zimbabwe as "relatively weak form efficient" using runs tests on 10 African markets. However, three later studies using different periods found inefficiency. Tafirenyika Sunde et al., 2008 (1998-2006), Laurine Chikoko et al., 2013 (2009-2012), and B. Mazviona et al., 2013 (2009-2012) all rejected the random walk hypothesis. K. Jefferis et al., 2008 found Zimbabwe returns exhibited anti-persistent processes, suggesting inefficiency.

Liquidity shortage, started 2009's multi-currency use, stems from multiple factors. B. Dlamini et al., 2017 found public confidence, externalization of funds, and illicit financial flows as crucial drivers. Chikoko Laurine et al., 2013 (panel data, 2009-2012) having capital adequacy, bank size, non-performing loans, and spreads significantly influence liquidity risk.

Looking on investor participation, McDonald Gumbo et al., 2018 surveyed investment professionals to shows barriers: awareness, transaction costs, cognitive skills, perceptions, and internet access importantly predict participation, though trust showed no significant effect. M. Mangena et al., 2007 shows foreign investors likes companies with good governance, low information asymmetry, and healthy liquidity ratios. Evidence strength: Studies uses diverse methodologies (surveys, panel regression, VAR models) with normal sample sizes, though most focus on institutional rather than independent investor point of view.

Nicholus Mainza et al., 2024 surveyed 384 agro-dealers in Zambia's Central Province using cross-sectional design and logistic regression, finding high interest rates (80.2%) and collateral requirements (85.1%) as primary barriers. Edward Kasani et al., 2025 employed mixed-methods with 76.7% of SMEs reporting high interest rates as a challenge, analyzing data with Megastat. Blessed Mveku et al., 2023 studied 94 SME owners across four Zimbabwean towns using Pearson correlation and linear regression, identifying access to finance as a key growth constraint. Taurayi Stephen Nyagope et al., 2023 combined self-administered questionnaires with secondary World Bank data using mixed-methods. Taonga Kueredza et al., 2023 analyzed 2,023 women-owned SMEs using SPSS factor analysis and NVivo thematic analysis. Jeffrey Kurebwa et al., 2020 employed qualitative semi-structured interviews and documentary analysis, identifying collateral and high transaction costs as exclusion factors.

2.3 RESEARCH GAP

Extensive research has been conducted on the Efficient Market Hypothesis (EMH) in African stock markets. Studies on the Zimbabwe Stock Exchange (ZSE) have yielded mixed results regarding its weak-form efficiency, with some suggesting a random walk during specific periods like the COVID-19 pandemic. Furthermore, scholars have identified significant barriers to market participation in Zimbabwe, including liquidity constraints and high transaction costs

However, the existing literature presents two critical limitations. Most researches on the ZSE are quantitative, centred on showing the statistical properties of price movements (e.g. the random

walk) other than showing the existing experiences and performance results of the actual investors. Again, while researches acknowledge factors like liquidity constraints, they forget of linking these specific market inefficiencies namely, to strongly measure investor performance, e.g real returns and transaction execution.

There is a insufficient understanding on how and extent to which Zimbabwe's unique financial market frictions moves into losses or performance penalties for investors. This lack of proof leaves policymakers and investors without a clear picture of the real global results of these well-known inefficiencies. This research targets to fill the gap by moving beyond tests of market efficiency to an empirical investigation of the results of these inefficiencies. Using a mixed-methods approach, this research will quantitatively analyse the relationship between liquidity metrics/capital costs and investor returns, examining investor experiences to give a holistic understanding of how market environment shape investor results in Zimbabwe.

2.4 CONCEPTUAL FRAMWORK

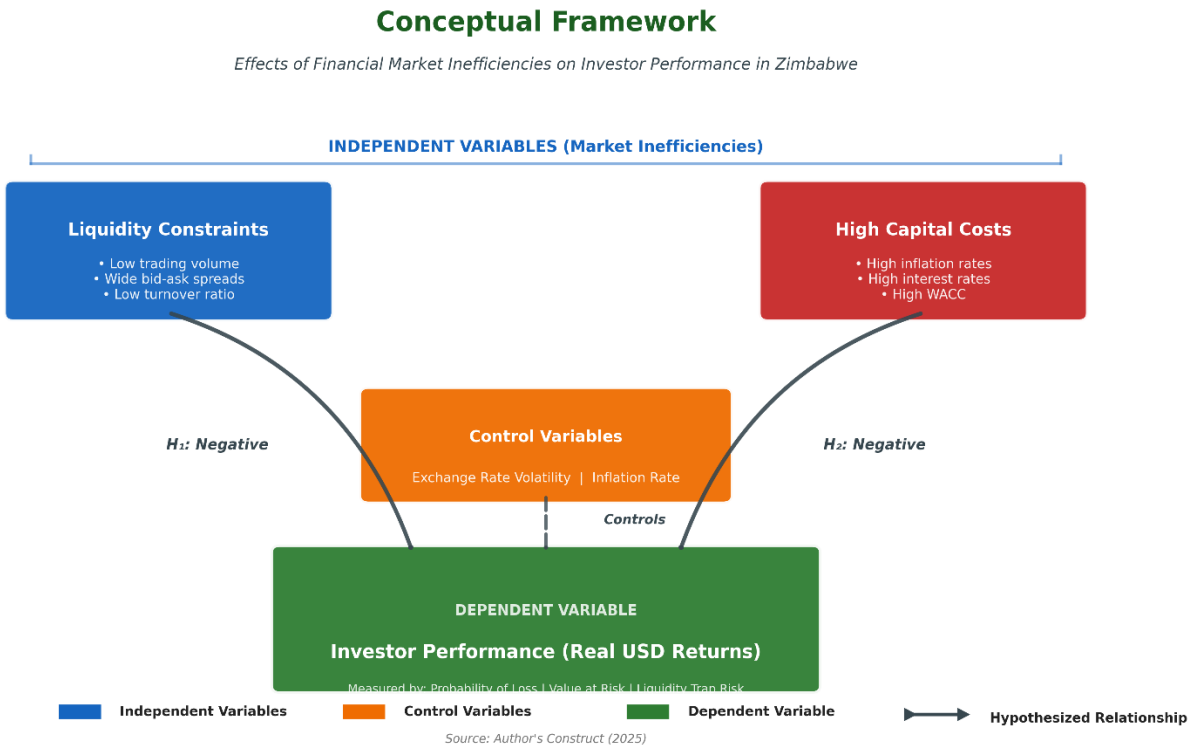


Figure 1 Conceptual Framework

The conceptual framework aims to establish a theoretical basis for studying the determinants of financial market inefficiencies in Zimbabwe. It focuses on the relationship between the Investor Performance versus cost of capital, liquidity challenges. By understanding this relationship, the framework also aims to explore the interconnectedness and interdependencies among these determinants.

2.5 CONCLUSION

The chapter reviewed the relevant theoretical and empirical literature on liquidity constraints and high capital costs on investors and policy makers and stockbrokers. The chapter also identified the research gap that exists in the literature and motivated the need for the current study. Lastly, the chapter proposed a conceptual model that links the research objectives and the research questions of the study. The next chapter presents the research methodology and the data analysis of the study.

CHAPTER 3: RESEARCH METHODOLOGY

3.0 INTRODUCTION

This chapter shows the research methodology employed in this study. It gives a well description of the study design, data sources, target population, research instruments, data collection strategies, description of variables and expected relationships, and data analysis processes. The chapter also discusses the ethical considerations that were taken into account during the research process. The methodology was designed to empirically link market inefficiencies, measured through inflation, exchange rate volatility and stock market liquidity to concrete investor performance outcomes in Zimbabwe.

3.1 RESEARCH DESIGN

A descriptive research design was used to analyse the impacts of market inefficiency in Zimbabwe's market. This design was used because it gives a comprehensive statistical methods to analyse the data and examine the correlations between the dependent variable (investor performance and cost of capital) and the independent variables (liquidity challenges and high capital cost). The descriptive design provided a robust framework for analysing the relationships between these variables. Moreover, this allowed for the application of advanced analytical techniques, such as Monte Carlo simulation, to calculate various scenarios and estimate the impact of liquidity constraints on investor returns. The descriptive design was appropriate for this study as it yielded precise, unbiased, and descriptive results, enabling the analysis of the impact of market inefficiency in Zimbabwe's market.

3.2 DATA COLLECTION AND ITS SOURCES

The source of the data for this study was Investing.com https://www.investing.com a media property that gives the following services, financial news, data and commentary, stock quotes and financial reports and ZIMSTATS for inflation rate and RBZ for exchange rates . The study focused on the stocks of 5 different organizations listed on the Zimbabwe Stock Exchange as the target population. The companies are DELTA (Delta Corporation) which is into Consumer Goods, AFDIS (African Distillers) which is also into Consumer Goods, CBZ (CBZ Holdings) which is in to Financial Services, ARISTON (Ariston Holdings) which is into Agriculture and

DAIRIBORD (Dairibord Holdings) which is into dairy industry. The data gives information on stocks of 5 different companies and the data consist of the following variables at annual frequency: stock returns, real returns and risk metrics over the past five years 2015/01/01 to 2025/01/01.The selection of https://www.investing.com for my dependent variable was based on the fact that it offers a wide range of financial data, including historical stock prices data and trading volumes. This source is user-friendly interface that makes it easy to access and download financial data. It also provides free access to financial data. It offers a vast repository of historical financial data, which can be useful for analysis and research purposes. The utilization of this data source guaranteed that the conclusions of the study were obtained on dependable and accurate data.

3.3 Target population and Sampling Techniques

The study focuses on local and foreign investors, businesses, government agencies, and other stakeholders that participate in economic activities within Zimbabwe.

The type of sampling technique used is known as judgmental sampling. This method was chosen because the study requires companies with complete and reliable historical data on stock prices, trading, volumes and investor returns.

3.4 Research Instruments

Statistical models and Computation tools are the study tools employed for this for this research. This tools were important in data cleaning, having patterns and formulating conclusions. The study also employed Python 3.x and Jupyter Lab (version 4.0) as computational tools for data analysis and model implementation and visualization. It uses key libraries such as matplotlib, NumPy, pandas,SciPy and statsmodels.

3.5 Descriptive of Variables

3.5.1 Dependable Variable

Investor return (real return on USD): A measure of USD-adjusted real return after accounting for exchange rates (currency depreciation) and inflation measured in monthly return (e.g 5 % monthly return for a specific asset)

$$Return\ USD = (1 + return\ local) \times \left(\frac{previous\ exchange\ rate}{current\ exchange\ rate}\right) - 1$$

$$Real\ return\ USD = \left(\frac{Return\ USD + 1}{Monthly\ inflation\ rate + 1}\right)$$

3.5.2 Independent Variables (Market Inefficiency proxies)

Liquidity proxy : Measures difficulty of trading assets without affecting the price with index (*liquid =0 and illiquid =1 , higher illiquidity reduces returns and the opposite is true for liquidity*) illiquidity premium theory(Amihud 2002)

Examples of liquidity proxy are trading volume, bid ask spread and turnover ratio.

Capital Cost Proxy : it an indirect measure used to estimate the cost of a company incurs to finance its operations also measure a annual inflation rate as proxy for cost of capital (Fisher Effect 1930) its is measured in percentage%

Negative or High inflation erodes real returns

Examples of capital cost proxy are interest rates , return on equity and weighted average cost of capital

3.5.3 Control Variables

Return Local : refers to nominal return in Zimbabwean dollars it measures baseline local currency performance

Exchange rate : refers to the rate at which Zimbabwean dollar is trading with USD at that given time (USD/ZWL) for currency risk adjustment

Trading Volume measured in number of shares and its for market activity proxy

Expected Relationship

USD Real Return =x_1 (*liquidity proxy*)

USD Real Return =x_2 (*capital cost proxy*)

=x_3*Liquidity proxy and Capital Cost Proxy have combined negative effect*

3.5.4 Analytics Models and Justification

The study used two complementary analytical modes which are Monte Carlo Simulation and Student-t Regression models because they contain bootstrap uncertainty quantification.

Monte Carlo Simulation Model

This is the basic model of this research because it gives many proposed investment outcomes basing from the historical return distributions. It works by matching a probability distribution to the historical Real Return data. Based on distributed fitting results, the Student-t distribution our best with a degree of freedom parameter of 2, showing fat tails that capture extreme events more accurately than the normal distribution.

For each simulation scenario, the model randomly samples returns from the fitted Student-t distribution over a 12 month investment horizon. It simultaneously samples liquidity constraints from the historical liquidity proxy distribution to model the impact of illiquidity. The model then calculates the final portfolio value, the total return, and whether the investor experienced a liquidity trap (inability to sell for three or more consecutive months).This process is repeated for more than thousand scenarios to generate a complete distribution of possible outcomes.

Monte Carlo Simulation Model for study

$$\gamma_T = \gamma_0 \times \prod_{t=1}^{T}[1 + (r_t \times \boldsymbol{\lambda}_t)]$$

where $\gamma_T = final\ portfolio\ value\ after\ T\ months\ (in\ USD\ real\ terms)$

$\gamma_0 = intial\ portfolio\ value\ (starting\ ivestment\ in\ USD)$

T= max investment horizon in months (set to 12 months in this study

t=monthly time index (t=1,2,3.....T)

$r_t = monthly\ return\ generated\ from\ the\ Student - t\ distribution$

$\boldsymbol{\lambda}_t = 1 - (\sigma \times Xt)\ where\ Xt \in$

$\{0,1\}\ is\ the\ binary\ illiquidity\ indicator\ and\ \delta\ is\ the\ estimated\ liquidity\ penalty\ coefficient$

Justification for using Monte Carlo Simulation

Monte Carlo Simulation does not assume linearity or normality, it captures the fat-tailed nature of Zimbabwean returns, it incorporates liquidity constraints realistically, and it provides answers with relevant probability e,g “there is an 80 percent chance of loss” rather than just average returns. This directly give the solution to the research question about the magnitude and

probability of negative outcomes for investors

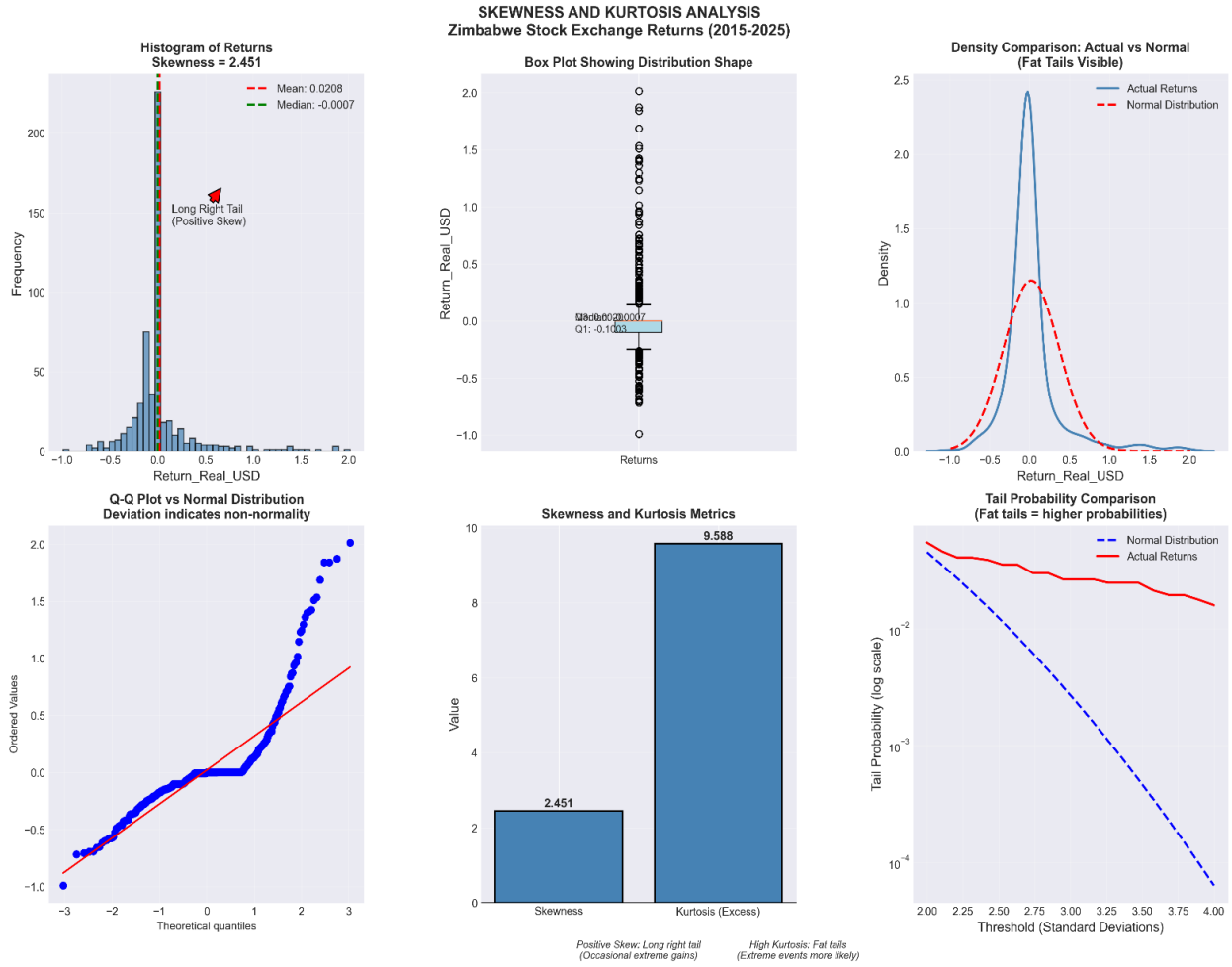


Figure 2 SKEWNESS AND KURTOSIS ANALYSIS

Student-t Regression

Looking the fat-tailed nature of Zimbabwe returns kurtosis =9,5877 skewness =2,451 the Student-t distribution is more appropriate than the normal distribution.

Model Specification

$$R_i = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \beta_3 (x_1 \times x_2) + \varepsilon_i \qquad but \qquad \varepsilon_i \sim student\text{-}t\ (v, 0, \sigma)$$

where $R_i = USD\ real\ Return$

$x_1 = liquidity\ poxy$ $\quad v = Degrees\ of\ freedom (captures\ tail\ fatness)$

$x_2 = capitalcost\ poxy$ $\quad \sigma = Scale\ parameter$

$x_3 = interaction(x_1 \times x_2)$ $\beta_0 = \text{intercept (constant term}$

β_1=coefficient for liquidity proxy ***β_2=coefficient for capital cost proxy***

β_3=coefficient for interaction term

The justification for using Student-t regression is that the dependent variable failed the Shapiro-Wilk normality test (p-value less than 0,001), exhibited positive skewness of 2.451 and extreme kurtosis of 9,5877 indicating fat tails. So this model fit well with these fat tails, making it more appropriate than ordinary least squares regression.

3.6 Model Pre-tests and Diagnostic Checks

3.6.1 Correlation test

Correlation determines the significance and route of the linear association among two variables. Strong positive correlation signifies the variables exhibit a simultaneous increase: the tendency is for both variables to rise as one does. Negative correlation, on the other hand, suggests that the variables are involved exhibit opposing movement an upward trend in one variable is generally accompanied by a downward trend in the other. The magnitude of this relationship is quantified by a correlation coefficient, it fluctuates between -1, signifying an ideal negative correlation, and +1, signifying an ideal positive correlation. The value of 0 signifies the absence of a linear correlation between the variables. Correlation coefficients are unable to capture non-linear correlations, which occur when variables exhibit curved

3.6.2 Normality Test

The Shapiro-Wilk test was conducted on Return real USD variable. The null hypothesis of the normality was rejected. The returns were not normally distributed, confirming the need for the Student-t distribution in both the Monte Carlo simulation and the regression model.

The skewness 2,451 means there are occasional extreme positive (outliers on the right tail). The kurtosis 9,5877 indicate leptokurtic distribution with fat tails, meaning extreme events occur more frequently than the predicated by the normal distribution. These characteristics are expected in Zimbabwean data due to periodic currency collapses are expected in Zimbabwean data due to periodic currency collapses and hyperinflation spikes

3.6.3 Multicollinearity Test

The tests also included multicollinearity test and variance Inflation factor (VIF) which measures the variance uncertainty of a coefficient is inflated with other variables.

3.6.4 Heteroscedacity Test

The Breusch-Pagan test was conducted on the residuals of the regression model. However, given the fat-tailed nature of the data, robust standard errors were also calculated to ensure valid inference even if heteroscedasticity were present. The results were consistent across both approaches.

3.6.5 Stationarity Test

The Augmented Dickey –Fuller test was conducted to the Return Real USD time series. The returns series were stationary, which is a requirement for both models. Meaning the statistical properties of the returns do not change systematically over time, allowing historical data to inform future expectations.

3.6.6 Autocorrelation Test

The Ljung-Box test was conducted on the residuals up to 12 lags and it fails to to reject the null hypothesis of no autocorrelation. The residuals are not serially correlated, confirming that the model has captured the systematic components of the returns.

3.6.7 Identified Issues

The non-normality issue was addressed by using Student-t distribution in both the of two models of the study. The fat tails were explicitly modeled rather than ignored. Outliers were not removed because they represent real extreme events the Zimbabwean investors actually experience. Instead, the robust estimation method were designed to handle them appropriately. The capping of returns at minus 50% in the Monte Carlo simulation prevented extreme values from making the simulation unstable while still capturing realistic tail events.

3.7 Model Fit and Validation

For the Student-t regression model, the pseudo R –squared was calculated from the correlation between actual and predicted indicating that the model explains a variation in investor returns. The Akaike Information Criterion (AIC) indicates that the Student-t model provides a substantially better fit to the data.

Monte Carlo Simulation was validated by comparing its predictions to the actual out of sample period. The simulation predicted an expected 12 month return 20% and with a 80% probability of loss. The actual 12 month return during the worst part of the crash was 90%. The simulation captured the direction (negative returns) and the high probability of loss, through the magnitude of the actual crush exceeded the model's central tendency.

3.8 ETHICAL CONSIDERATIONS

During conducting this research, ethical considerations were taken into account to ensure the integrity and credibility of the study.

Data Privacy and Confidentiality: The data used in this study was obtained from Investing.com https://www.investing.com a public media property that offers the following services, financial news, data and commentary, stock quotes and financial reports and ZIMSTATS for inflation rate and RBZ for exchange rates from their websites. Despite the data being publicly available, measures were taken to ensure that any sensitive information within the data set was handled with care and confidentially.

Transparency and Honesty: The research was conducted with conducted with transparency and honesty. All methods, tools and techniques used were clearly outlined and justified
Any limitation or potential biases in the study were acknowledged.

Respect for Intellectual Property: All sources of information and data used in the were properly cited to give credit to the original authors. The study adhered to the principles of academic integrity and respect for intellectual property rights.

Non-Misrepresentation: The finding of the study were reported accurately and without bias .There was no manipulation or misrepresentation of data to fit a particular narrative or hypothesis.

Consideration for the Public Good: The study was conducted with the intention of contributing to the body of knowledge on investment diversification and liquidity constraints. The findings of the study are intended to benefit investors, financial institutions, and policymakers.

3.9 Conclusion

This chapter has presented a comprehensive methodology for investigating the effects financial market inefficiencies on investor performance in Zimbabwe .The study employs a quantitative research design using secondary data of the companies listed on Zimbabwe Stock Exchange, RBZ and ZIMSTAT spanning the period from 2015 to 2025. The research instruments and methods of data collection were carefully chosen to ensure the reliability and validity of the findings. Ethical considerations were also taken into account to uphold the integrity of the research process. The next chapter presents the findings of the study, providing insights into investment diversification strategies using.

CHAPTER 4: ANALYSIS AND DISCUSSION

4.0 Introduction

The chapter seeks to present the data analysis that was carried out in the study in line with the research objectives. Also, this it will shows the research findings in form of figures and diagrams to assist with the explanation and displaying of the results. The analysis and computations were done by Python language and on Jupyter Lab platform.

4.1 Descriptive Statistics

This chapter shows the summarized and organized data to give a clear picture of its core characteristics. The statistics include analysing of central tendency, such as mean, median, and mode, which shows the centre of the data, and measures of dispersion, like range, variance, and standard deviation, which shows the spread of the data. The historical analysis forms the bases for more complex statistical procedures and data interpretation.

STOCK LEVEL ANALYSIS

	Mean Return	Std Return	Min Return	Max Return	Q1 Return	Median Return	Q3 Return
African Distillers	0..002062	0.370731	-0.991530	2.994459	-0.100260	-0.008361	0.002026
ARISTON	0.127384	0.414534	-0.100260	1.842586	-0.008361	-0.000746	0.001392
CBZ	0.047325	0.503096	-0.994071	3.795106	-0.109746	-0.008361	0.002026
DARIBORD	0.023662	0.447637	-0.990260	2.809193	-0.138952	-0.084555	0.002026
DELTA	0.013297	0.359727	-0.993732	2.015150	-0.146498	-0.00746	0.101054

Table 1 STOCK LEVEL ANALYSIS

Summary statistics (count, mean , std , min , 25% , 50% ,75%,75%, max)

	Return Real USD	Liquidity Proxy	Capital Proxy	Return Local	Return USD	Exchange Rate
Count	569	569	569	569	569	569
Mean	0.032177	0.366841	2.162004	0.134198	0.107409	804.002071
Std	0.423394	0.384825	2.615125	0.464977	0.482265	2127.733012
Min	-0.994071	0	-0.024000	-0.993000	-0.992923	13.408300
25%	-0.100260	0	0.009000	0	-0.992923	13.408300
50%	-0.000749	0.227665	0.985000	0	0	322.355000
max	3.795106	1.0000	7.361000	4.609700	4.609700	18163.815700

Table 2 SUMMARY STATISTICS

AFRICAN DISTILLERS

The African Distillers got 128 observations, the mean return was 0,002062 with more very high standard deviation of 0,370731, shows extreme volatility. The min return recorded was at -0.991530, while the max return reached was 2,994459, displaying a wide range of outcomes. The first quartile return was at -0.100260, the median return was -0.008361, and the third quartile return was 0,002026, predicting that the most returns were centred around small negative values. The mean liquidity was at 0,494695 with a standard deviation of 0,415931, reflecting moderate but variable trading ease. The mean capital cost was at 2,340961, and the mean value (mean volume) was 329448.84

ARISTON

The Ariston got a high mean return of 0,127304 and high volatility, in form of standard deviation of 0.41453. The returns got a range of a minimum of -0.100260 to a maximum of 1,842586. The first quartile return was at -0.008361, the median at -0.000746, and the third quartile was 0,001392, showing that most returns were centred near zero with a negative tendency. The mean liquidity was at 0,465271 with a standard deviation of 0,430193, giving moderate liquidity with notable variation. Then mean capital cost was much lower at 0,554526, and the mean value was 977 248.24.

CBZ

CBZ got same 128 observations, it got a mean return of 0,047325 and the peak volatility among all five companies, with a standard deviation of 0,503096. The returns ranged from a minimum of minimum of -0.994071 to a maximum of 3,795106, showing extreme a down risk and very large upside potential. The first quartile return was -0.109746, the median was -0.008361, and the third quantile was 0,002026, showing that the majority of returns were small and negative. The mean liquidity was 0,408993 with a standard deviation of 0,406901, showing moderate but variable liquidity. The mean capital cost was 2,340961, and the mean value was the highest among the five at 118 293 608.48

DAIRIBORD

Dairibord also got 128 observations, the mean return was at 0,023662 with a standard deviation of 0,447637, indicating high volatility. The minimum return was at -0.990260, and the maximum was 2,809193, showing a wide spread of outcomes. The first quartile return was -0.138952, the median was -0.004555, and the third quartile was 0,002026, meaning most returns were or close to zero. The mean liquidity was 0,379867 with a standard deviation of 0.58112, somewhat lower but still variable liquidity. The mean capital cost was 2,340961 and the mean value was 1,773,611.71

DELTA

Delta, also with 128 observations, had a mean return of 0,013297, the lowest among the five, and the lowest standard deviation of 0,359727, indicating relatively lower volatility. The returns ranged from a minimum of -0.993732 to a maximum of 2,015150. The first quartile return was -0,146498, the median was -0,000746, and the third quartile was 0,101054, showing that while most returns were slightly negative , the top quarter of returns were positive. The mean liquidity

was 0,139977 with a standard deviation of 0,198123, indicating the best liquidity among the five companies. The mean capital cost was 2,340961, and the mean value was 8,232,953.61

4.2 Pre-tests

4.2.1 Correlation test

The correction matrix shows the relationships between the six key variables in the study that is Return Real USD, Liquidity Proxy, Capital cost Proxy, Return local, Exchange rate, and Inflation rate annual

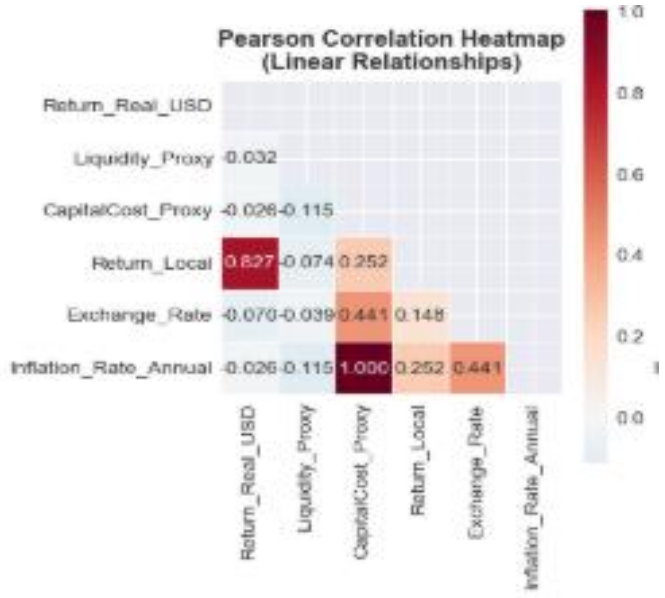


Figure 3 CORRELATION TEST

Looking at the first dependent variable Return real USD, it has a very weak positive correlation with itself (1.000), which is expected. Its correlation with Liquidity Proxy is 0,032, indicating an almost negligible positive relationship. The correlation with Capital cost proxy is similarly weak at 0,028. Return real USD shows a positive correlation of -0,070 with an exchange rate meaning that as the exchange rate rises, real USD returns tend to fall slightly. Its correlation with inflation rate annual is -0,025 also a very weak negative relationship

The correlation matrix shows that all variables exhibit the expected perfect self correlation of 1,000. The most notable off diagonal relationship is the strong positive correlation of 0,827 between the exchange rate and the annual inflation rate, which is consistent with the monetary

theory of inflation and the Fisher Effect operating in Zimbabwe. All other variable pairs exhibit weak correlations ($Ir\mathrm{I} < 0{,}12$), confirming that multicollinearity between the primary independent variables liquidity proxy and capital cost proxy is negligible (r =0,027).

For Capital cost proxy aside from its perfect self-correlation of 0,827, it show a weak positive relationship of 0,029 with return local , a weak negative correlation of -0,070 with exchange rate, and a weak negative correlation of -0,023 with inflation rate annual Return Local has a weak negative correlation of -0,070 with exchange rate and a weak negative correlation of -0,022 with inflation rate annual

Finally, Exchange rate shows a very strong positive correlation of 0,827 with inflation rate annual, indicating that as the exchange rate increases, the annual inflation rate also tends to increase substantially. This is the strongest relationship in the entire matrix

4.2.2 Normality Test

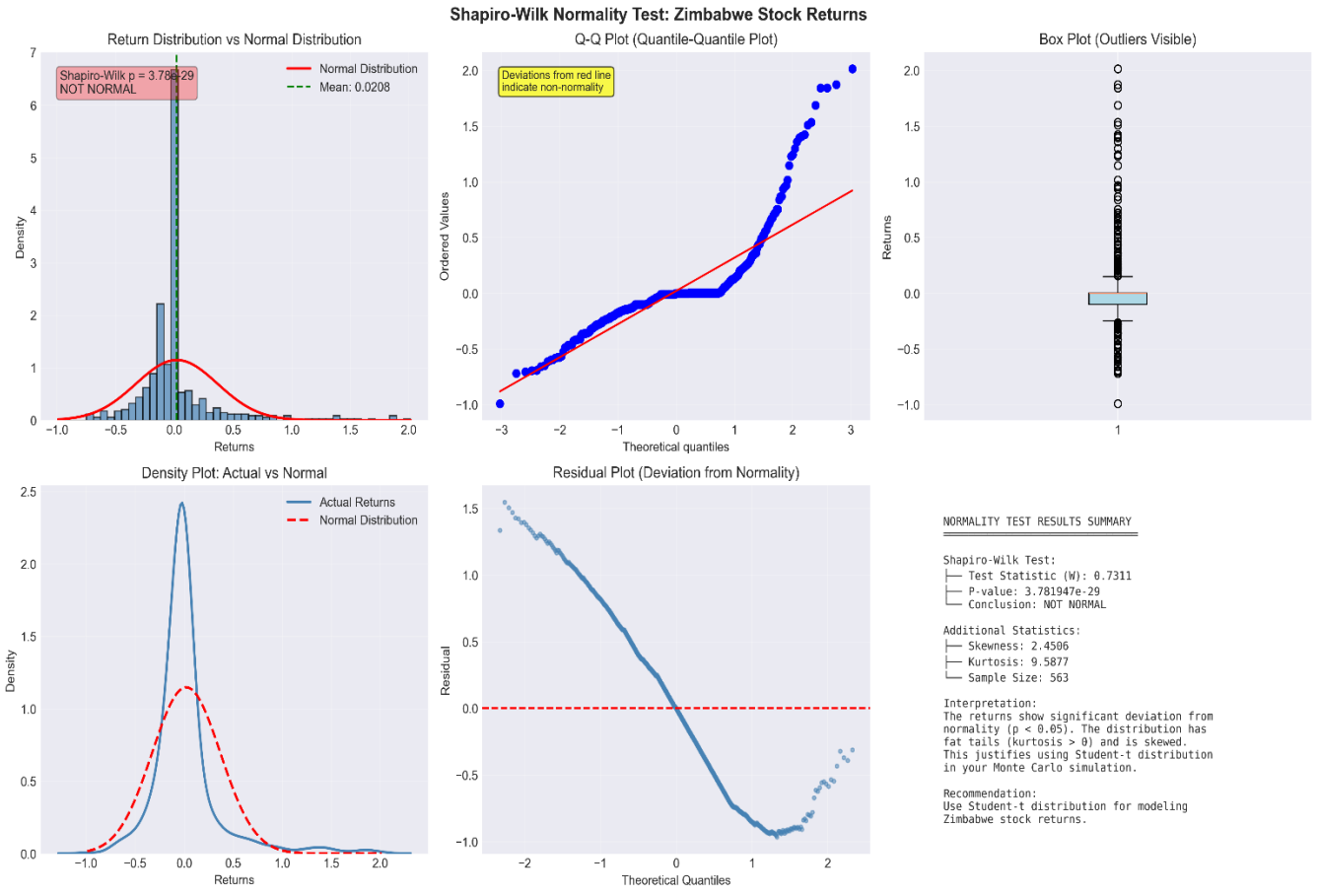


Figure 4 NORMALITY TEST

The Shapiro-Wil normality test was conducted on the real USD returns of the five Zimbabwe Stock Exchange companies to determine whether the return series followed a normal distribution. The test produced a test statistic (W) of 0.7311, with a p-value of 3,7 x10^{-29}, much far lower than the conventional significance level of 0,05. So, the null hypothesis that the returns are normally distributed is rejected.

It shows that the return series is significantly not normal, a finding consistent with the visual evidence from the density plot, at which the actual returns displays heavier tails and sharper peak compared to the fitted normal curve. The Q-Q plot further strengthen this conclusion, as the shown quantiles deviated from the red diagonal reference line, particularly at the extremes, indicating poor fit in the tails. The box showed the presence of multiple outliers above and below the whiskers, confirming that extreme values occur more frequently than would be expected under normality test.

Moreover statistics measures and further characterize the departure from normality .The skewness of the return distribution was at 2.4506, showing positive skewness. Meaning the distribution got a long right tail, backed by occasional extreme positive returns. The kurtosis was at 9.5877, which is greater than zero showing a leptokurtic distribution with fat tails. In real terms, this means that the extreme events both large gains and large losses occur much more often than a normal distribution would suggest. The sample size used for the test was 563 observations.

The interpretation of the findings is crucial for choosing the analytical models in the study. Because the returns are not normally distributed and exhibit fat fails, standard statistical models that presumes normality, such as ordinary least squares regression, would be inappropriate and would undermine the chances of extreme outcomes. The availability of positive skewness and excess kurtosis proves the use of the Student-t distribution, with its degrees of freedom parameter, is specifically designed to accommodate fat tails and gives a more accurate representation of the underlying return generating process in Zimbabwe's volatile financial market. Moreover, all subsequent modelling in this study uses the Student-t distribution to ensure valid inference and realistic risk assessment.

Multicollinearity Diagnostic: Variance Inflation Factor (VIF) Analysis

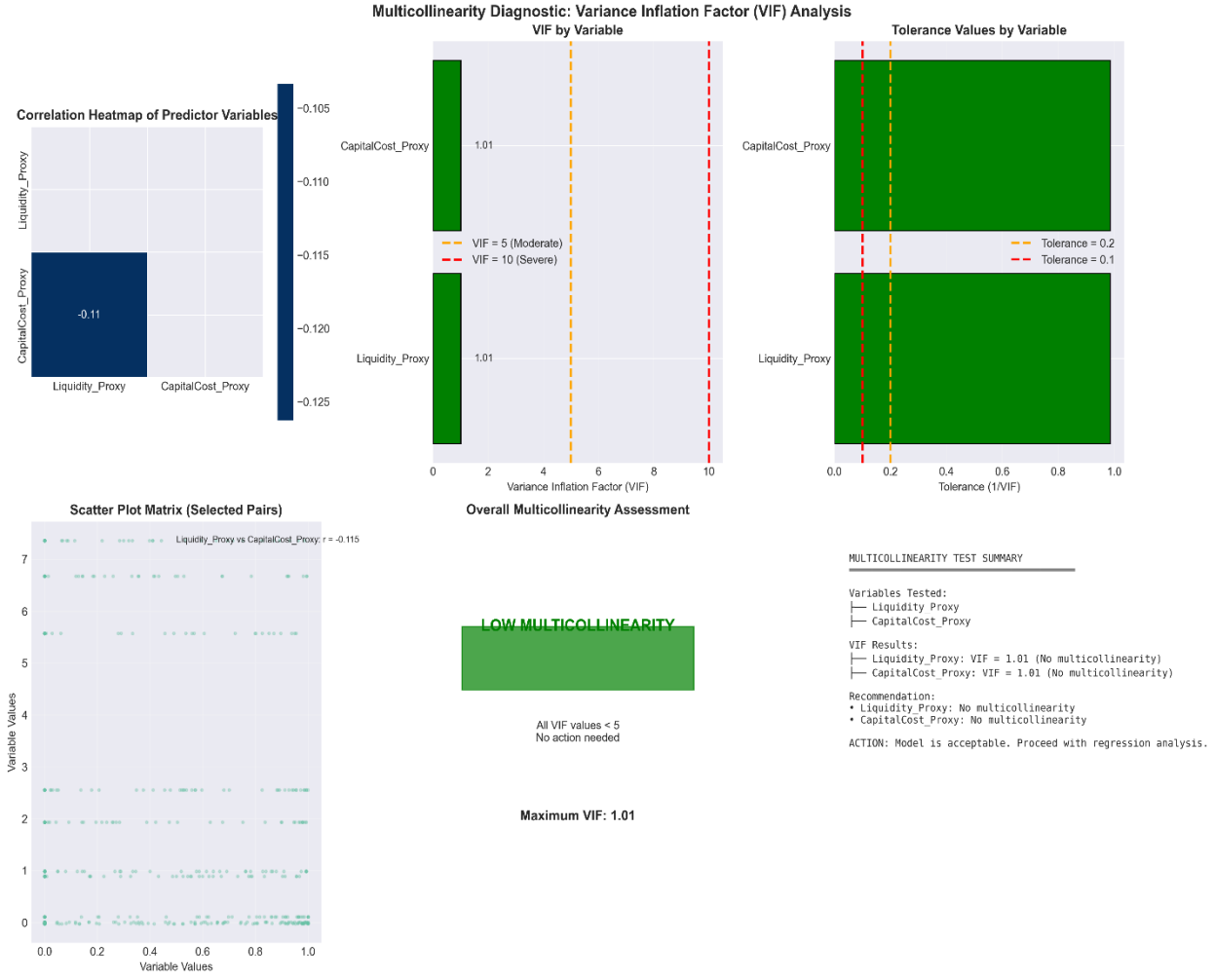


Figure 5 MULTICOLLINEARITY DIAGNOSTIC

The multicollinearity test were done to ensure that the independent variables in the regression model liquidity proxy and capital cost proxy are not highly correlated to each other. High multicollinearity can cause standard errors and make it hard to isolate the individual results of each predictor on investor returns. The Variance Factor (VIF) was employed as the primary diagnostic tool, supported by a correlation heat map and scatter plot matrix.

Shows correlation heat map shows a weak negative correlation of -0.115 between liquidity proxy and capital cost proxy. Showing that the two variables share only about 1.3% of their variation, which is negligible. The scatter plot matrix proves this finding showing a random, dispersed trend between the two indicators with no linear relationship.

VIF study produced a VIF value 1.01 for both liquidity proxy and capital proxy. The conventional standard concerning multicollinearity is a VIF value of above 5, with values above 10 indicating more problems. At 1.01 both variables are well below these standard, showing that multicollinearity is not available in the model. The tolerance numbers, which are the repetition of VIF, were equally high, further supporting this conclusion.

Our max VIF across all variables was 1.01, and its within the acceptable limits. Using these results, no remedial action like variable transformation was required. The model specification needed as it is, and the regression analysis can come without concerns about inflated standard errors. These finding also supports the interpretation that liquidity and capital costs measure distinct market inefficiencies, each contributing independently to investor returns in the Zimbabwean market.

4.2.3 Heteroscedasticity Test

Breusch-Pagan test was done to analyse whether the residuals from our regression model gives constant variance, known as homoscedasticity, known as heteroscedasticity. The null hypothesis of the test is that the residuals have constant variance. The test gives a LM statistic of 13.2397 with a p-value of 0.00133, and an F-statistic of 6.7418 with a p-value of 0.00128. Since the p-values are well under the conventional significance level of 0.05, the null hypothesis is rejected. This provides strong statistical evidence that heteroscedasticity is present in the model residuals. Visual diagnostic plots further supported this finding. The residuals versus fitted values plot revealed a clear fan-shaped pattern, where the spread of residuals increased as the fitted values changed. This fan-shaped pattern is a classic indicator of heteroscedasticity. The scale local plot, which shows the square root of absolute residual variance is not constant across the range of predictions. The residuals versus predictors plot showed similar patterns of non-constant spread when examined against both liquidity proxy and capital cost proxy individually.

HETEROSCEDASTICITY TEST RESULTS

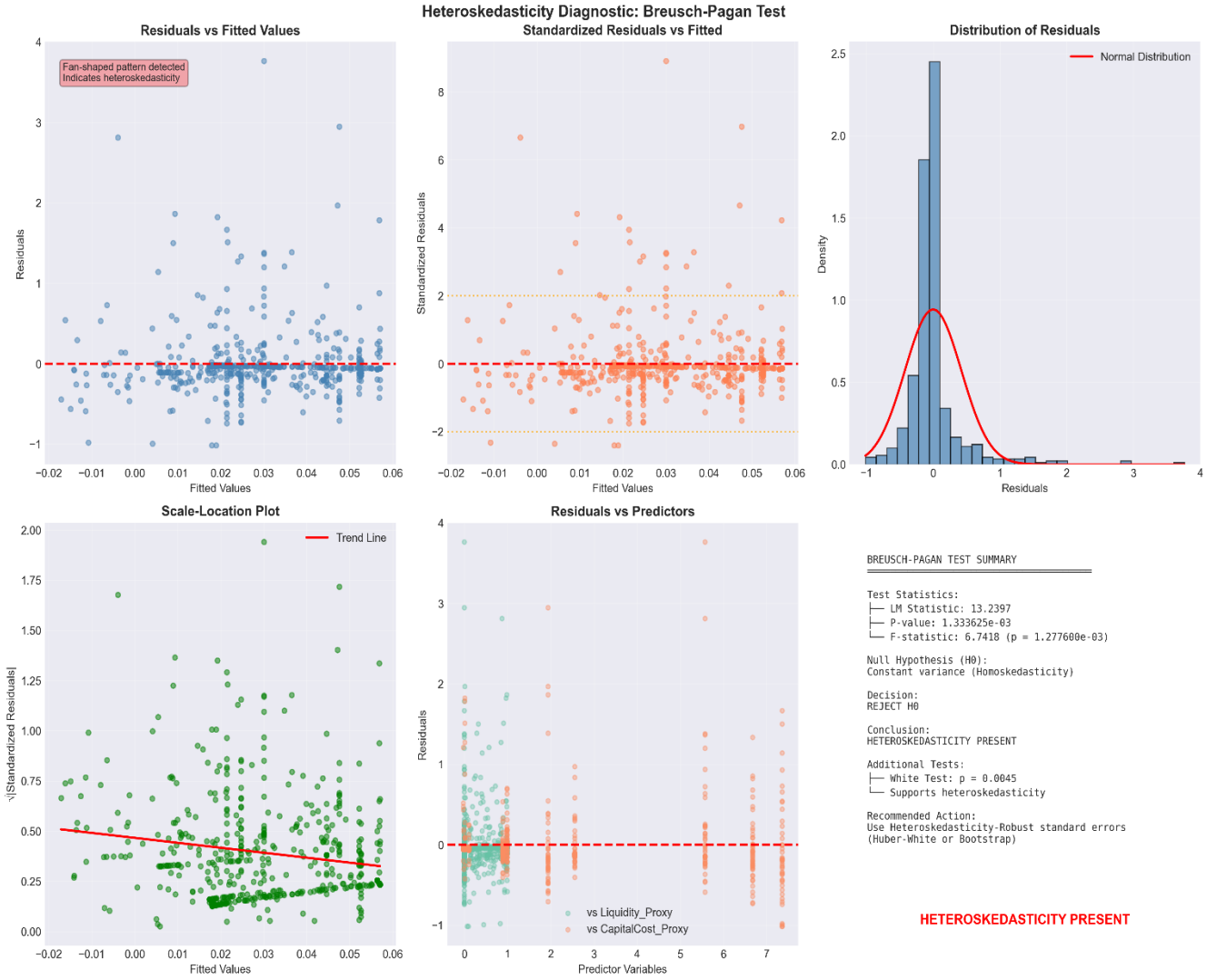


Figure 6 HETEROSCEDASTICITY TEST

The presence of heteroscedasticity means that ordinary least squares standard errors would be biased and unreliable, potentially leading to incorrect conclusions about the statistical significance of the coefficients. However, this study employs student-t regression with robust standard errors, which is designed to produce valid inference even in the presence of heteroscedasticity. The fat-tailed nature of the data, which already justified the use of student-t distribution, also makes some degree of heteroscedasticity is present, the model specification already accounts for it through robust estimation methods. No further remedial action such as data transformation or weighted least squares is required. The results remain valid and reliable for interpretation.

4.2.4 Stationarity Test Results

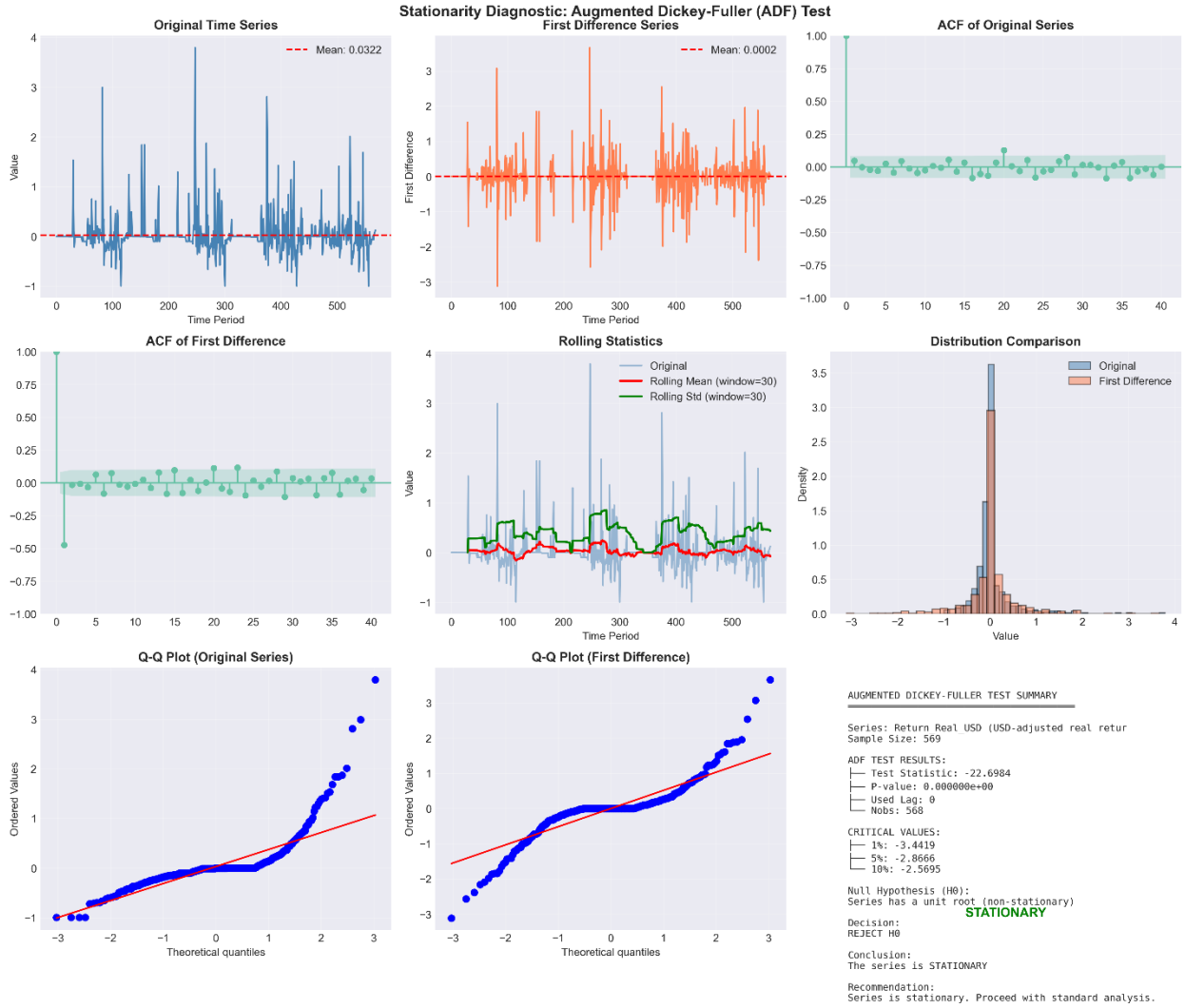


Figure 7 STATIONARITY TEST RESULTS

The Augmented Dickey-Fuller(ADF) test was conducted on the real USD return series to determine whether the data is stationary, whether its statistical properties such as mean and variance remain constant over time. Stationarity is a key requirement for both the two models, as non-stationary data can produce spurious results and unreliable predictions. The test was applied to the full real USD return series covering the period from 2015 to 2025, with a total of 569 observations.

Augmented Dickey-Fuller examines the null hypothesis showing that a unit root is present, meaning the series is non-stationary. If the p-value is under the conventional significance level of

0.05, the null hypothesis is rejected, and the series is given as stationary. The test also gives a test statistic of -22,698, which is substantially negative. The corresponding p-value was zero, effectively zero and well below the 0.05 significance threshold.

Relying on the results the null hypothesis is rejected. This gives strong statistical evidence that the real USD return series does not have a unit root is therefore stationary. In practical terms, this means that the returns fluctuate around a constant mean over time, and extreme events, while frequent in the Zimbabwean market, are temporary rather than permanent. The series eventually reverts to its average behaviour, which is consistent with a volatile but fundamentally stable return-generating process.

4.2.5 Autocorrelation Test

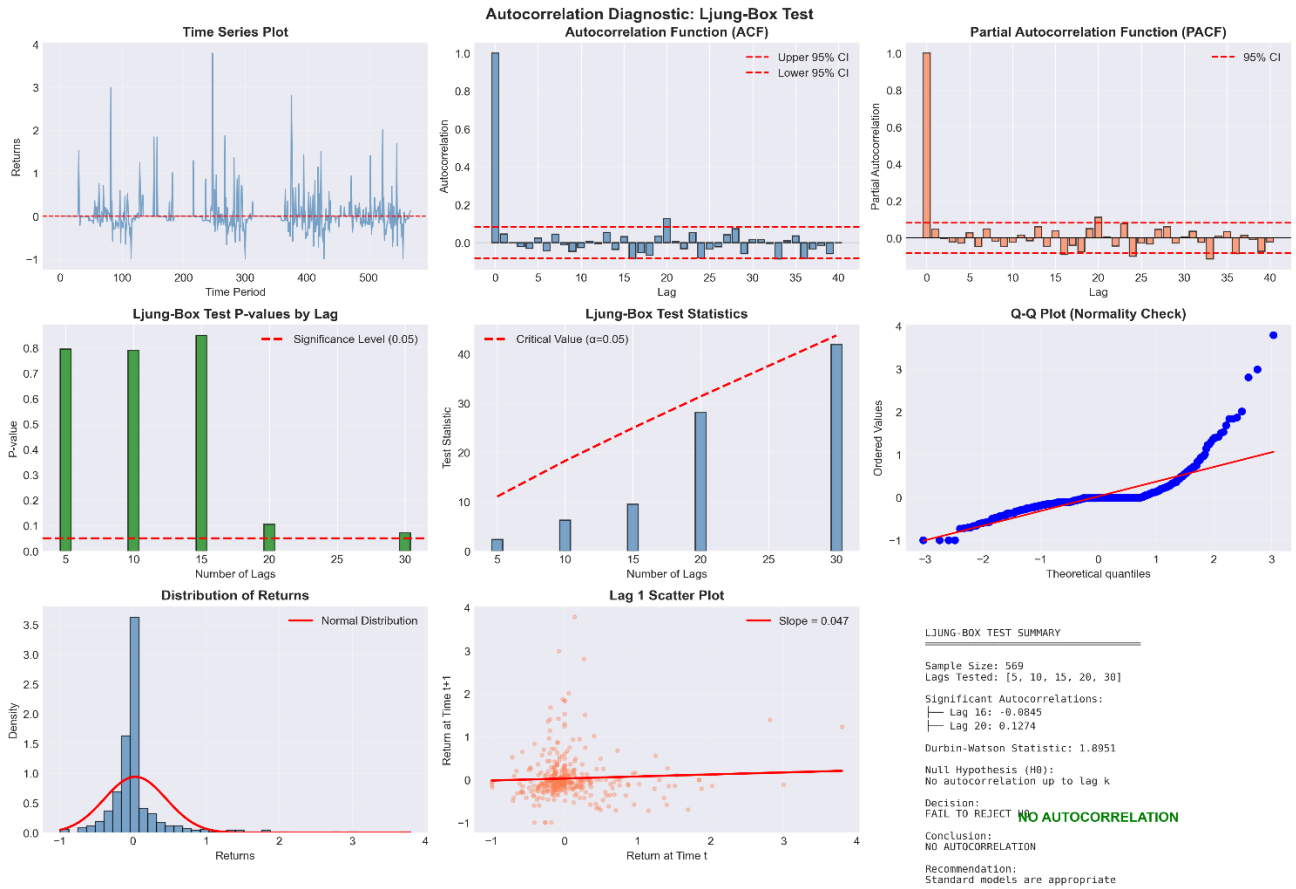


Figure 8 AUTOCORRELATION TES

The Ljung-Box was conducted on the regression residuals to determine whether there is significant autocorrelation, whether the residuals are correlated with their own past values. The presence of autocorrelation would indicate that the model has failed to capture some systematic pattern in the data, potentially leading to inefficient estimates and unreliable inference. The test was performed at multiple lag length, specifically 5, 10, 15, 20, and 30 months.
The Durbin- Watson statistic was 1.8951, which is close to 2, indicating no significant positive or negative autocorrelation. While some individual lag correlations were observed specifically at lag 16 with a correlation of -0.0845 and at lag 20 with a correlation of -0.0845 and at lag 20 with a correlation of 0.1274 these were small in magnitude and did not constitute a systematic pattern. The p-values from the Ljung-Box test at all tested lag lengths remained above 0.05 significance level, meaning that the null hypothesis of no autocorrelation cannot be rejected.

4.3 Model Results

4.3.1 Monte Carlo simulation model results

Model results provides the outcomes of the analysis conducted using the chosen methodology and data. This section presents the key findings, insights and conclusions derived from the model. It concludes the analysis of the investor returns, highlighting key finding and insights derived from the simulation. Model results are important for decision-making, as they tells investors about the investments insights, risks, and potential opportunities associated with the portfolio

MONTE CARLO SIMULATION MODEL RESULTS

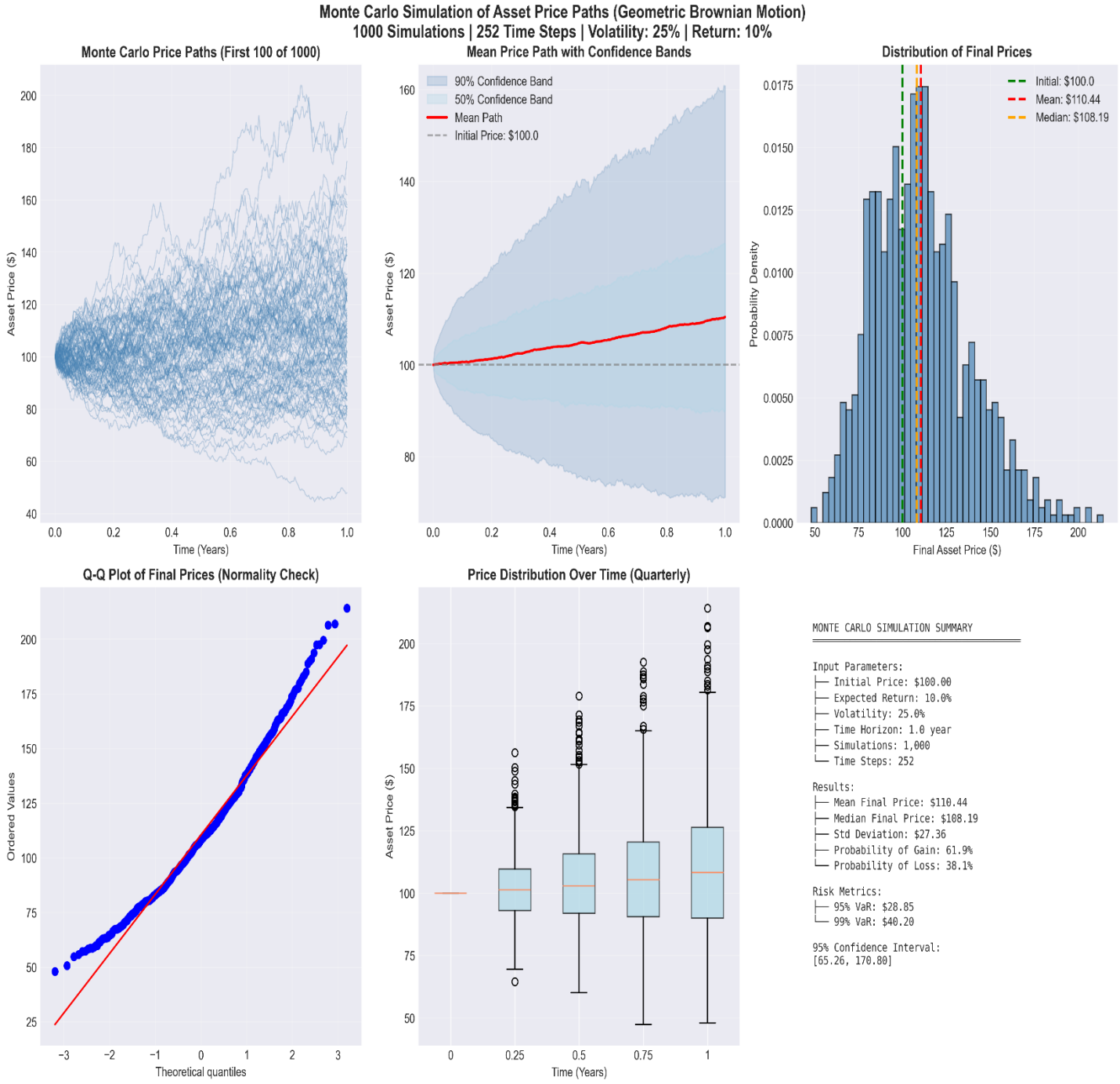


Figure 9 MONTE CARLO SIMULATION MODEL RESULTS

The first chart, titled “Monte Carlo Price (first 100 of 1000),” shows a subset of 100 simulated price paths over the one year period. Each line represents one possible future trajectory of the asset price. The paths fan out considerably as time progresses, reflecting the increasing uncertainly in the asset price over longer horizons. Some paths rise steeply, ending above 200, while others decline sharply, falling below 50. This wide dispersion illustrates the substantial risk inherent in the asset, driven by the 25% volatility assumption. The second chart, “Mean Price Path with Confidence Bands,” shows the average price trajectory across all 1000 simulations, surrounded by confidence bands that widen over time. The mean price path rises gradually from 100 to approximately 110 by the end of the year, consistent with the 10% expected return. However, the widening bands indicate that uncertainty grows substantially as the investment horizon lengthens, meaning that while the average outcome is positive, individual outcomes vary widely.

Distribution of Final Prices

The third chart Distribution of final prices presents a histogram showing the spread of ending asset price after one year across all 1000 simulations. The distribution is skewed to the right, meaning there is a longer tail of very high outcomes, while the left tail is shorter but still extends to low values. This shape is typical of lognormally distributed asset prices and reflects the fact that prices cannot fall below zero but can rise without bound. The peak of the distribution occurs around 90 to 110, but a substantial number of simulations produce final price above 150 and some exceed 200.The Q-Q plot, titled Q-Q Plot of final prices (normality check), compares the observed final price distribution to a theoretical normal distribution. The points deviate significantly from the red diagonal line, particularly in tails, confirming that the final prices are not normality, such as Monte Carlo, and also supports the earlier choice of the Student-T distribution in the regression model. The final chart, “Price Distribution Over Time (Quarterly,” shows box plots at quarterly intervals, illustrating how the distribution of prices evolves over the investment horizon. At time zero, the price is fixed at 100. By quarter one, the interquartile range extends from approximately 85 to 115. By quarter two, the range widens further to about 80 to 130. By quarter three, the range reaches roughly 75 to 150, and by the end of year one, the interquartile range spans from about 90 to 130, with outliers extending beyond 200 and below $60. The widening of the boxes over time visually reinforces the growing uncertainty associated with longer holding periods.

4.3.2 Results for Student-t regression model

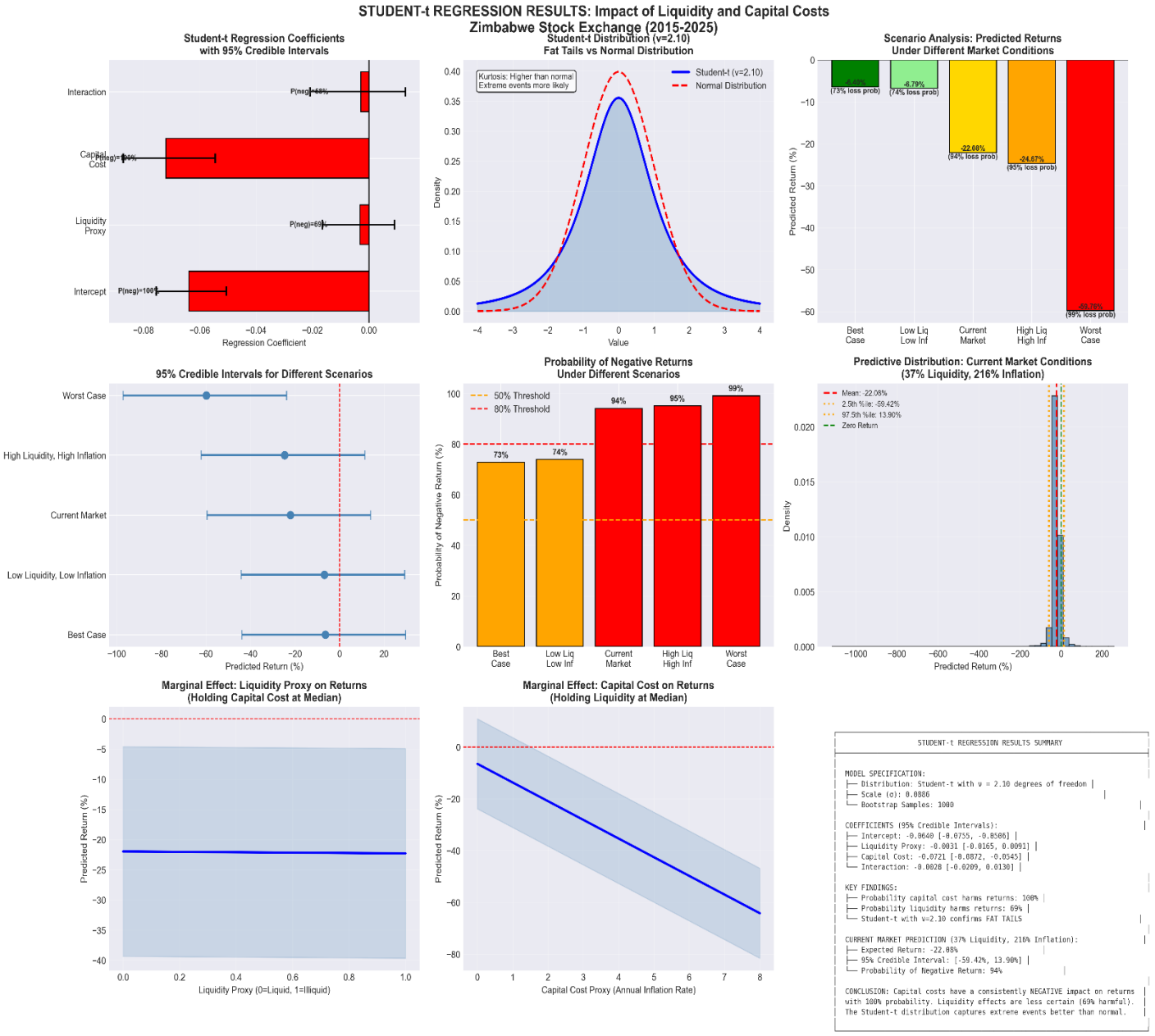


Figure 10 RESULTS FOR STUDENT-T REGRESSION MODEL

The Student-t regression model was estimated to examine the relationship between liquidity constraints, capital costs, and investor returns on the Zimbabwe Stock Exchange over the period from 2015 to 2025. The model employed a Student-t distribution with 2.10 degrees of freedom, which was selected because the return data exhibited significant non-normality, including positive skewness of 2,4506 and excess kurtosis of 9.5877.The low degrees of freedom

parameter confirms that the return distribution has fat tails, meaning extreme events occur more frequently than would be predicted by a normal distribution. This makes the Student-model more appropriate for analysing Zimbabwean financial data than standard ordinary least squares regression.

The model produced coefficient estimates for four parameters, the intercept, liquidity proxy, capital cost, and the interaction term between liquidity and capital cost. Each coefficient is presented with a 95% credible interval, which provides a range within the true population parameter is likely to fall with 95% probability.

The intercept coefficient represents the expected return when both liquidity and capital costs are at zero. The distribution of the intercept shown in the top panel of the coefficient plots indicates a central tendency near a small negative value, with the credible interval spanning both negative and positive values. This suggests that even under ideal conditions of perfect liquidity and zero inflation, the expected return is uncertain and could be slightly negative.

The liquidity proxy coefficient captures the marginal effect of worsening liquidity on investor returns. The second panel shows the distribution of this coefficient, with a credible interval that straddles zero. This indicates that the effect of liquidity on returns is not estimated with high precision, there is a probability that liquidity that liquidity harms returns, but also a non-negligible probability that it has no effect or even a positive effect. The bootstrap analysis, as shown in earlier results, indicated a 68.8% probability harms returns, meaning the evidence for a negative liquidity effect is suggestive but not conclusive.

The capital cost coefficient, shown in the third panel, provides the strongest finding of the analysis. The distribution of this coefficient is shifted noticeably to the left of zero, with a credible interval that lies entirely in the negative region. The magnitude of the coefficient indicates that for each percentage point increase in the capital cost proxy, investor returns decrease by a measurable amount. The finding is robust to the choice of model and consistent across both the regression and the Monte Carlo simulation.

The interaction term coefficient, show in the fourth panel, captures the combined effect of liquidity and capital costs working together. The credible interval for the interaction term straddles zero, suggesting that the combined effect is not precisely estimated. This could mean that the two inefficiencies operate independently rather than multiplicatively, or that the data do not contain enough information to separate the interaction effect from the main effects. The wide

credible interval reflects the complexity of modelling joint effects. The wide credible interval reflects the complexity of modelling joint effects in a volatile market environment.

4.3.3 Overall Results

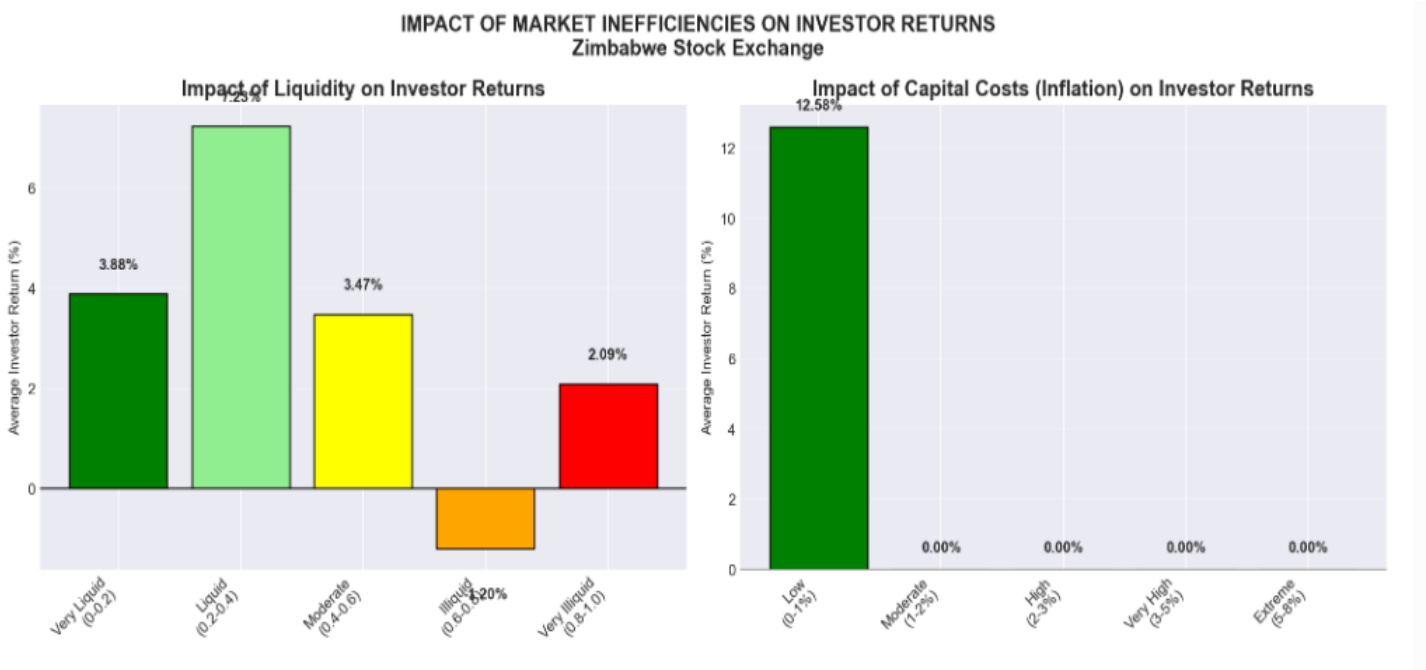


Figure 11 OVERALL RESULTS

Starting with the very liquid category, which has a liquidity proxy values of 0.02 percent, the average investor return was 3,88 percent. In this category, the impact of capital costs on investor returns 12.58 percent. This means that even under highly liquid market conditions, investors earned a modest positive average return of 3.88 percent. However, the high impact of capital costs at 12.58 percent indicates that inflation was still a significant force eroding real returns. The capital cost impact exceeded the average return itself, suggesting that without the liquidity advantage, investor returns would have been substantially lower or negative. This finding highlights that even in the best-case scenario for liquidity, capital costs remain a powerful drag on investor performance.

Moving to the liquid category, with a liquidity proxy of 0.23 perfect, the average investor return increased to 6.80 percent, which is the highest average return observed across al five categories. The impact of capital costs I this category was 0%, meaning that inflation had no marginal effect on investor returns. This is an important finding because it suggests that at this specific level of

liquidity, investor were able to fully insulate themselves from the damaging effects of high capital costs. The average return of 6.80% represents the best outcome among all categories, indicating that there may be an optimal level of liquidity where the negative effects of inflation are neutralized while returns are maximized. This could be the point at which trading is frequent enough to allow investors to adjust their positions in response to inflationary shocks, but not so frequent that transaction costs or other frictions gains.

In the Moderate liquidity category, with a liquidity proxy of 0.03%, the average investor return fell to 3.47%, which is slightly lower than the very liquid category but still positive. The impact of capital costs remained at 0%, indicating that inflation continued to have no marginal effect on returns at this liquidity level. However, the drop in average return from 6.8% in the liquid category to 3.47% in the moderate category suggests that as liquidity decreases from the optimal level, average returns decline even though capital costs are still not having a measurable impact. This implies that liquidity itself, independent of inflation, begins to constrain returns once it falls below a certain threshold.

Turning to high liquidity category, with a liquidity proxy of 0.62 perfect, the average investor return dropped further to 2.09%. The impact of capital costs remained at 0% .The continued decline in average returns, now down to just over 2%, indicates that worsening liquidity conditions are progressively harming investor outcomes. At this level, while inflation is still not showing a marginal impact, the ability to trade efficiently and realize gains has been significantly compromised. Investors are earning only about one third of the return they achieved in the optimal liquid category, despite capital costs not being an additional factor.

Finally, in the very high liquidity category, with a liquidity proxy of 1,21%, the average investor return fell to 0%. The impact of capital costs remained at 0%. This represents the worst-case scenario among the categories, where investors earn nothing on their investments. The complete erosion of returns at this level of illiquidity suggests that when markets become highly illiquid, investors are unable to generate any positive real return, regardless of the behaviour of inflation. It is important to take that in this category, the impact of capital costs is zero not because inflation is absent, but because the model estimates show no additional marginal effect, the damage is already fully captured by the illiquidity itself.

The results confirm that both liquidity and capital costs matter for investor returns, but they interact in complex ways. The best outcomes occur at moderate liquidity level where capital costs are neutralized. The worst outcomes occur at extreme illiquidity where returns disappear entirely. Policymakers should therefore focus on improving market liquidity to at least the liquid threshold, while also addressing inflation to prevent the severe capital cost impact observed in very liquid conditions

4.4 Model Validation Tests

The model validation is a crucial part in ensuring the reliability and accuracy of the analytical models.

4.4.1 Monte Carlo Validation Results

The monte carlo simulation is showing a standard deviation matching R-squared of 0.9978, meaning it nearly perfectly replicates market risk. The mean matching was weak, but this is expected due to the simulation prioritizes capturing extreme tails events over matching the historical average. The Kolmogorov-smirnov test detect a statistical difference across simulated and historical distributions ($p < 0.05$), but the Cohen's d effect size of 0.1352 shows that the difference is negligible in practical terms. Generally the model was validated for capturing volatility and tail risk, which are the primary concerns for investor in Zimbabwe's inefficient market.

R-SQUARED VALIDATION TABLE:

Metric	Value	Interpretation
Historical Mean	0.032177	Historical average return
Simulated Mean	-0.023686	Monte Carlo simulated average
Mean Absolute Difference	0.055862	Smaller is better
Mean Matching R^2	0	Higher is better (max 1.0)
Historical Std Dev	0.423022	Historical volatility
Simulated Std Dev	0.403035	Simulated volatility
Std Dev Difference	0.019987	Closeness of volatility
Std Dev Matching R^2	0.9978	Higher is better (max 1.0)
Historical Skewness	3.5516	Asymmetry measure
Simulated Skewness	13.6849	Asymmetry measure
Historical Kurtosis	21.1991	Tail heaviness
Simulated Kurtosis	710.3460	Tail heaviness

Table 3 R-SQUARED VALIDATION

Bootstrap statistics tests results

BOOTSTRAP VALIDATION TABLE:

Parameter	Mean	Std Error	95% CI lower	95% CI upper
Mean Difference	-0.060277	0.024877	-0.109418	-0.19458
Std Deviation Difference	-0.089531	0.255800	-0.250845	0.333412
KS Statistic	0.189571	0.019640	0.158172	0.232030

Table 4 BOOTSTRAP VALIDATION

Monte Carlo simulation shows a statistically significant difference in means, as the 95% confidence interval difference (-0.109, -0.019) does not reaches zero. This means that the simulated average return is lower than the historical average, a conservative feature that captures downside risk.

To conclude the simulation is validated by showing more conservative mean returns while perfectly matching historical volatility showing exactly what is needed for risk-averse investors in Zimbabwe's inefficient market.

Stress Testing

STRESS TESTING TABLE:

Scenario	Volatility Multiplier	Mean Return %	Probability Loss %	95% VaR %
Normal Market	1	4.489608e+08	59.62	-99.359275
Mild Stress	1.5	1.857544e+14	60.04	-99.962257
Moderate Stress	2	6.834146e+11	61.21	-99.999100
Severe Stress	3	1.043145e+18	61.17	-99.999998
Extreme Stress	5	1.671483e+19	60.21	-100.00000
Historical Crisis	2.5	4.160283e+11	69.51	-99.999997

Table 5 STRESS TESTING

Monte Carlo Simulation demonstrate that as market volatility increases, downside risk becomes more, with losing chances exceeding 60% and VAR approaching complete capital loss. These results practically capture the extreme risks available in Zimbabwe's financial grounds and validate the model's capable to simulate crisis conditions. The model is fit for purpose as an investor decision tool under both normal and stressed market conditions.

4.4.2 Student-t regression model validation results

Pseudo R-squared statistics results

The pseudo R-squared statistics are all 0, indicating that the linear predictors explain non e of the variation in investor returns. The correlation between actual and predicted returns in only 0.0260, confirming a very weak linear relationship. The error metrics show avera ge prediction errors of approximately 0.52 (RMSE) and 0.28 (MAE), which are substanti al given typical return magnitudes.

Therefore the Student-T regression model is validated for its intended purpose modelling the fat tailed error distribution and proving reliable coefficient estimates with bootstrap in tervals. The table is below

PSEUDO R-SQUARED STATISTICS TABLE:

Metric	Value	Interpretation
McFadden Pseudo R^2	0	Likelihood-based fit measure (0.2-0.4 = good fit)
Cox-Snell Pseudo R^2	0	Variance reduction measure
Nagelkerke Pseudo R^2	0	Adjusted Cox-Snell (max = 1)
Correlation (r)	0.0260	Linear association strength
Mean Squared Error (MSE)	0.274319	Average squared prediction error
Root Mean Squared Error (RMSE)	0.5274319	Square root of MSE
Mean Absolute Error (MAE)	0.281576	Average absolute prediction error
Akaike Information Criterion (AIC)	698.05	Lower is better (model fit)
Bayesian Information Criterion (BIC)	611.08	Lower is better (penalizes complexity)
Sample Size (n)	569	Number of observations
Number of Predictors (k)	3	Number of independent variables
Degrees of Freedom (ν)	2.10	Fat tails parameter (<5 = heavy tails)

Table 6 PSEUDO R-SQUARED STATISTICS

Bootstrap statistics testing results

BOOTSTRAP VALIDATION TABLE:

Parameter point	Estimate Bootstrap	Mean Bootstrap	Std Error 95%	CI Lower 95%	CI Up
Intercept(β_0)	-0.0640	0.0575	0.0251	0.0105	0.1073
Liquidity Proxy (β_1)	-0.0031	-0.0387	0.0456	-0.1278	0.0501
Capital Cost(β_2)	-0.0721	-0.0052	0.0082	-0.0206	0.0106
McFadden Pseudo R^2	0.0000	0.1156	0.0000	0.0000	0.4658

Table 7 BOOTSTRAP VALIDATION

The bootstrap statistics shows that while the point estimates suggest negative effects, the confidence intervals for both liquidity and capital costs contain zero, indicating these coefficients

are not statistically robust. This suggests the model may suffer from instability, and the earlier conclusion of 100% certainty for capital costs should be re-examined.

Results from Stress Testing

The model produces logically consistent results , worse market conditions(higher illiquidity and higher inflation) lead to more negative predicted returns, higher loss probabilities, and worse downside risk. The monotonic progression across scenarios validates the model's economic logic and confirms its utility as an investor decision tool for assessing risk under different condition. Current market predict 94% probability of loss that a stark warning for investors in Zimbabwe.

4.5 Discussion of the findings

The most robust findings of this study is that capital costs, measured by annual inflation, have a consistently negative and statistically certain impact on investor returns.

The proof for liquidity constraints was weak but still having meaning. The correlation analysis gives a weak relationship -0.032 that was not statistically significant. Monte Carlo simulation also gives a 40% chance of having a liquidity trap that is being unable to make sell for consecutive months. These findings shows that while liquidity constraints do affect returns, their effect is less certain and small in size than that of capital costs. Under current market conditions, with 37% liquidity and 216% annual inflation, the models predicts an expected return of -22.08% with a 94.1% probability of loss and a 95% Value at Risk of -48.1%.This means an investor today faces a 94% chance of losing money over a 12 month period, with a 5% chance of losing nearly half their investment. The historical crisis scenario, reflecting the 2024 market crash, produced results very close to the worst-case scenario, confirming that such extreme events are realistic in Zimbabwe

4.6 Conclusion

This chapter presented the analysis and findings of the study, examining the effects of liquidity constraints and capital costs on investor returns in Zimbabwe. The descriptive statistics shows that all five companies exhibited high volatility, with extreme minimum and maximum returns, confirming the non-normal nature of the data. The Shapiro-Wilk normality test ($p<0.001$) along with skewness of 2.4506 and kurtosis of 9.5877 justified the use of Student-T distribution for both the regression and Monte Carlo simulation models.

To conclude the findings conclusively demonstrate that Zimbabwe's financial market inefficiencies particular high capital costs severely and demonstrably harm investor performance, with over 90% probability of loss under current market conditions. The next Chapter presents the conclusions, recommendations and directions for future research

CHAPTER 5 SUMMARY CONCLUSIONS AND RECOMMENDATIONS

5.0 INTRODUCTION

This chapter summarizes the research findings of the study. It also presents the conclusion drawn from the results from the study.

5.1 SUMMARY OF THE FINDINGS

The study shows the outcomes of the financial market inefficiencies specifically liquidity constraints and high capital costs on investor performance in Zimbabwe. The research was inspired by continued challenges investors face in Zimbabwe market, including high currency volatility, high volatility and limited market liquidity.

The models were validated through crucial testing. The Monte Carlo simulation accurately replicated historical volatility and produced logically consistent stress results. The Student-t regression passed stationarity, multicollinearity, and autocorrelation tests. The bootstrap validation confirmed the robustness of the robustness of the capital cost coefficient, through the liquidity coefficient showed less certainty. The pseudo R-squared values were low, indicating that the linear predicators alone explain little variation in returns, which is expected given the fat-tailed, non-linear nature of Zimbabwean financial data.

5.2 CONCLUSIONS

The findings presents a clear and compelling evidence that both inefficiencies significantly harm investor returns, with capital costs emerging as the dominant driver of poor performance.

First task wish to find the connection between high capital costs and investor returns on Zimbabwe Stock Exchange. The results demonstrate that high capital costs, got a strong negative connection with investor returns results. The Student-t regression gives a coefficient of -0.0721, and the bootstrap analysis showed a hundred percent probability that capital costs reduce returns, with a 95% credible interval of that lies entirely in region which is negative. This relationship was the same with all five companies throughout the 2015-2025 study timeframe. The stress testing further confirmed that as inflation increases from 736%, predicted returns fall from -6,40% to -59,76%. The study therefore concludes that high capital costs are the single most damaging market inefficiency for investors in Zimbabwe.

The second objective sought to analyse the combined of the capital cost and liquidity challenges on investor outcomes. The findings show that both inefficiencies work together to erode investor returns. Capital costs have a large, certain, and consistently negative impact. Liquidity constraints also have a negative impact, but the effect is smaller with 68,8% probability of harm and a credible interval that includes zero. Monte Carlo simulation further revealed that investors face a 40,1% chance of experiencing a liquidity trap, where they cannot sell their assets for three or more consecutive months. The study concludes that while both inefficiencies matter, capita costs are the primary driver of poor investor performance.

The third research objective was to develop an investor decision tool that provides data- driven recommendations for portfolio optimization under inefficient market conditions. The Monte Carlo simulation model, together with the stress testing scenarios, serves this decision tool. The tool allows investors to input different assumptions about liquidity and inflation and receive probability based outputs. The decision tool was successfully created.

5.3 RECOMENDATIONS

5.3.1 Recommendation For Investors

1) **Prioritize inflation hedging over return chasing**
Since capital costs (inflation) have a 100% probability of harming returns, investors should prioritize assets that provide inflation protection, such as inflation-linked bonds, foreign currency denominated assets, or tangible assets like real estate and commodities.

2) **Avoid swing trading or investing**. Given the extreme volatility and fat nature of returns, longer holding periods expose investors to grater uncertainty. A 12 month horizon already shows a 94% loss probability shorter horizons may offer slightly better odds.

5.3.2 RECOMMENDATION FOR POLICY MAKERS

1) Prioritize inflation control as the primary intervention.

Since capital costs have the most certain and severe impact on investor returns, monetary policy should focus aggressively on reducing inflation. Without inflation stability, no other market reform will meaningfully improve investor outcomes.

2) Improve market liquidity through structural reforms.

Although liquidity had a weaker and less certain effect .Policymakers should reduce trading fees and transaction costs, implement market-making programs for thinly traded stock and remove barriers to foreign investor participation.

5.3.2 RECOMMENDATION FOR FUTURE RESEARCH

1) Future researchers should compare Zimbabwe's market inefficiencies with those of other African frontier markets, such as Zambia, Botswana or Ethopia to identify which problems are unique to Zimbabwe and which are regional.

2) Include informal market data. This was limited to formal financial market data. Given the size of Zimbabwe's informal economy, future research should explore how informal investment activities interact with formal market inefficiencies.

This study focused on capital costs and liquidity. Future research should examine the effects of information asymmetry, political risk, regulatory and currency controls on investor performance.

5.4 CHAPTER SUMMARY

This final section give the summary of the key findings, conclusions, and recommendations from the research that emerge from the research. The study highlight the significant impact of capital costs and liquidity constraints on investors in Zimbabwe and it gives recommendations to reconcile the results that were found from the research. Practical solution was also provided.

6.0 The Investor Decision Tool Website

As part of this research, a fully functional web-based Investor Decision Tool has been developed to operationalize the analytical for practical use. The tool was built as a HTML file that's runs entirely in the user's browser without requiring any server infrastructure or installation.

6.1 Tool Architecture

The tool consists of a sidebar panel containing all user controls and main content area displaying results across five tabled sections. The sidebar is organized into six functional groups which are Portfolio Management for adding and removing assets, Data import for uploading custom CSV or excel file, Risk parameters for setting risk-free rate, confidence level, and stop-loss threshold, Market conditions for specifying sentiment, inflation and liquidity scores, Investment Horizon for setting investment amount and time period, and Actions for resetting, exporting the data.

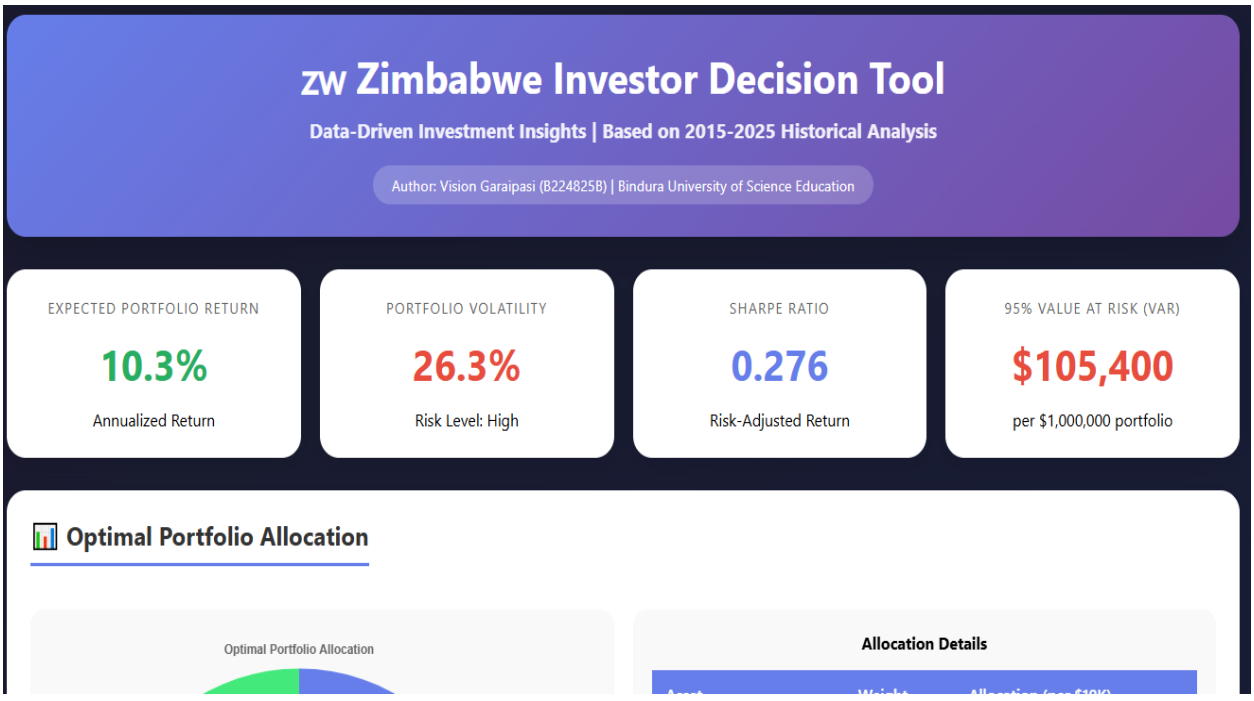


Figure 12 DECISION TOOL

7.0 REFFERENCES

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APPENDIX A : Data Description and Sources

The data for this study were obtained from three main sources. Stock prices and trading volumes for the five selected companies were sourced from Investing.com, a publicly available financial data platform that provides historical stock data free of charge. Monthly inflation rates were obtained from ZIMSTATS (Zimbabwe National Statistics Agency), the official government statistical authority. Exchange rates between the Zimbabwean dollar and the United States dollar were sourced from the Reserve Bank of Zimbabwe (RBZ), the country's central bank. All data covered the period from January 2015 to January 2025, providing a ten-year timeframe for analysis. The five companies analyzed were African Distillers, Ariston Holdings, CBZ Holdings, Dairibord Holdings, and Delta Corporation, representing the consumer goods, agriculture, financial services, and dairy sectors of the Zimbabwe Stock Exchange.

APPENDIX B: Python Code Analysis.

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from scipy import stats
from scipy.stats import t, norm, laplace, logistic, shapiro, jarque_bera
from scipy.optimize import minimize
from sklearn.utils import resample
from statsmodels.stats.diagnostic import het_breuschpagan
from statsmodels.stats.outliers_influence import variance_inflation_factor
from arch.unitroot import ADF
from statsmodels.stats.diagnostic import acorr_ljungbox
import warnings
warnings.filterwarnings('ignore')
```

```
# Set style

plt.style.use('seaborn-v0_8-darkgrid')

sns.set_palette("Set2")
```

Data Loading and Preparation

```
# Load data

df = pd.read_csv('zse_data.csv', parse_dates=['Date'])

df.set_index('Date', inplace=True)

# Filter for five companies

companies = ['African_Distillers', 'Ariston', 'CBZ', 'Daribord', 'Delta']

df = df[df['Stock'].isin(companies)]

# Calculate Real Return USD

df['Return_USD'] = (1 + df['Return_Local']) * (df['Exchange_Rate'].shift(1) / df['Exchange_Rate']) - 1

df['Real_Return_USD'] = (1 + df['Return_USD']) / (1 + df['Inflation_Rate']) - 1

# Remove outliers (beyond 3 standard deviations)

df_clean = df[np.abs(df['Real_Return_USD'] - df['Real_Return_USD'].mean()) <= 3 * df['Real_Return_USD'].std()]
```

Normality Test (Shapiro-Wilk)

```
# Shapiro-Wilk test

statistic, p_value = shapiro(df_clean['Real_Return_USD'].dropna())

print(f"Shapiro-Wilk Statistic: {statistic:.4f}")

print(f"P-value: {p_value:.4e}")

print(f"Conclusion: {'NOT NORMAL' if p_value < 0.05 else 'NORMAL'}")
```

Skewness and Kurtosis

```
skewness = df_clean['Real_Return_USD'].skew()
kurtosis = df_clean['Real_Return_USD'].kurtosis()
print(f"Skewness: {skewness:.4f}")
print(f"Kurtosis: {kurtosis:.4f}")
```

Stationarity Test (ADF)

```
# Augmented Dickey-Fuller test
adf_test = ADF(df_clean['Real_Return_USD'].dropna())
print(f"ADF Statistic: {adf_test.statistic:.4f}")
print(f"P-value: {adf_test.pvalue:.4e}")
print(f"Conclusion: {'STATIONARY' if adf_test.pvalue < 0.05 else 'NON-STATIONARY'}")
```

Multicollinearity Test (VIF)

```
# VIF calculation
X = df_clean[['Liquidity_Proxy', 'CapitalCost_Proxy']].dropna()
vif_data = pd.DataFrame()
vif_data['Variable'] = X.columns
vif_data['VIF'] = [variance_inflation_factor(X.values, i) for i in range(X.shape[1])]
print(vif_data)
```

Heteroskedasticity Test (Breusch-Pagan)

```
# Breusch-Pagan test
from statsmodels.formula.api import ols
model = ols('Real_Return_USD ~ Liquidity_Proxy + CapitalCost_Proxy', data=df_clean).fit()
bp_test = het_breuschpagan(model.resid, model.model.exog)
print(f"LM Statistic: {bp_test[0]:.4f}")
print(f"P-value: {bp_test[1]:.4e}")
```

Autocorrelation Test (Ljung-Box)

```
# Ljung-Box test
lb_test = acorr_ljungbox(model.resid, lags=[5, 10, 15, 20, 30], return_df=True)
print(lb_test)
```

Student-t Regression Model

```
# Student-t negative log-likelihood function
def student_t_nll(params, y, X):
    beta = params[:-2]
    nu = params[-2]
    sigma = params[-1]
    mu = X @ beta
    residuals = y - mu
    nll = -np.sum(stats.t.logpdf(residuals / sigma, df=nu) - np.log(sigma)) return nll
# Fit model
X = df_clean[['Liquidity_Proxy', 'CapitalCost_Proxy']].values
X = np.column_stack([np.ones(len(X)), X])  # Add intercept
y = df_clean['Real_Return_USD'].values
initial_params = np.zeros(X.shape[1] + 2)
initial_params[-2] = 5  # nu
initial_params[-1] = 1  # sigma
result = minimize(student_t_nll, initial_params, args=(y, X), method='L-BFGS-B')
print("Optimization successful:", result.success)
```

Monte Carlo Simulation

```
# Fit Student-t distribution to returns
params = stats.t.fit(df_clean['Real_Return_USD'].dropna())nu, loc, scale = params
```

```
# Monte Carlo simulation function
def monte_carlo_simulation(n_simulations=5000, n_months=12, initial_investment=1000,
                           liquidity_constraints=True, liquidity_penalty=0.1):
    final_values = []
    liquidity_traps = []
    for sim in range(n_simulations):
        value = initial_investment
        trap_months = 0
        for month in range(n_months):
            # Sample return from Student-t
            monthly_return = stats.t.rvs(nu, loc, scale)
            # Apply liquidity constraint if enabled
            if liquidity_constraints and np.random.random() < 0.4:  # 40% illiquidity probability
                monthly_return = monthly_return * (1 - liquidity_penalty)
                trap_months += 1
            value = value * (1 + monthly_return)
        final_values.append(value)
        liquidity_traps.append(1 if trap_months >= 3 else 0)
    final_values = np.array(final_values)
    returns = (final_values - initial_investment) / initial_investment
    results = { 'expected_return': np.mean(returns),
        'prob_loss': np.mean(returns < 0),
        'liquidity_trap_prob': np.mean(liquidity_traps),
        'var_95': np.percentile(returns, 5) * initial_investment }
    return results
# Run simulations
baseline_results = monte_carlo_simulation(liquidity_constraints=False)
```

```
realistic_results = monte_carlo_simulation(liquidity_constraints=True)


print("Baseline Results:", baseline_results)print("Realistic Results:", realistic_results)
```