UNIVERSITY OF GHANA

OPTIMAL ASSET ALLOCATION OF DEFINED CONTRIBUTION PENSION FUNDS IN GHANA

MAXWELL BAIDOO JNR

(10598935)

THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MPHIL RISK MANAGEMENT AND INSURANCE DEGREE

JULY, 2018

DECLARATION

Candidate's Declaration

I do hereby declare that this work is the result of my own research and has not been presented by anyone for any academic award in this or any other university. All references used in the work have been duly acknowledged.

I bear sole responsibility for any shortcomings.

…….. ……

MAXWELL BAIDOO JNR DATE

(10598935)

CERTIFICATION

We hereby certify that this thesis was supervised in accordance with procedures laid down by the University

……..… ……..…

DR. CHARLES ANDOH DATE

(SUPERVISOR)

……..… ……..…

PROF. GODFRED ALUFAR BOKPIN DATE

(SUPERVISOR)

ABSTRACT

The study investigated asset allocation of defined contribution (DC) plan in Ghana using the Tier 2 Master Trust Occupational Pension Scheme (MTOPS) as a case study. The focus of the study was to compare optimal asset allocation solutions under quantitative restrictions and prudent person's principle and further assess the risk exposure of portfolio returns using CVaR. The financial market invested by MTOPS predominantly consisted of six financial assets: government securities and bonds, corporate bonds, the money market (T-Bills and Cash deposits), listed equities, other collective investments and open and close end funds. The investment returns from MTOPS followed a geometric Brownian motion and simulated for 10,000 scenarios over 50-year time horizon. Most MTOPSs violated some quantitative restriction guidelines such as Petra whose average allocation to the money market was 54.64% which exceeds 35% of the NPRA investment guidelines. However, the average investment returns of the six financial assets were within the limits. Beyond the investment restrictions, MTOPS allocated higher Master Trust Funds (MTF) in low-risk assets: government securities and bonds, T-bills and cash deposits. On the average, low-risk assets seem to be more rewarding and stable compared to high-risk assets in the short-term. High-risk assets however outperform low-risk assets in the long-term. Only MTOPS with large market share allocated considerably in high-risk assets: corporate bonds and listed equities. Financial assets were weak and negatively correlated which is indicative of a more diversified portfolios of MTOPS. The average MTOPS allocated 43.01% of MTF in government bonds and securities, 35.61% of MTF in the money market specifically in T-Bills and cash deposits, 18.30% in corporate bonds, 5.79% in listed equities, 3.02% in other collective investments, and 4.67%

in open/close end funds. At optimal levels, MTOPSs are expected to invest 55.11% of MTF in government securities, 0.08% in corporate bonds, 34.99% in the money market, 0.81% in listed equities, 4.75% in other collective investments, and 4.98% in open/close end funds under quantitative restrictions. Applying the prudent person's principle, optimal solution was obtained by investing 70% in government securities and bonds, 10% in corporate bonds, 10% in the money market, 7% in listed equities, 1.8% in open/close end funds and 1.2% in other collective investments. This indicated an investment return of 20.93% with 12.43% average portfolio risk as compared to 20.56% investment return with 6.79% portfolio risk in the restricted optimization. Given the investment returns over time, CVaR for the total portfolio was 12.81% at 95% confidence level in the worst-case scenario. The fund value based on current average allocations outperforms the optimal allocations in the long-term due to higher allocations of high-risk assets that accumulate higher returns in the accumulation phase.

Keywords and Phrases: *Defined Contribution; Master Trust Occupational Pension Scheme; Optimal Asset Allocation; Prudent Person's; Principle Quantitative Restrictions*

DEDICATION

I dedicate this work to Almighty God, my wife, Naomi Baidoo and mother, Sarah Acquah.

ACKNOWLEDGEMENT

First, I want to acknowledge the enormous contributions and guidance of my supervisors, Dr. Charles Andoh and Prof. Godfred Alufar Bokpin. I am eternally grateful.

I also wish to express my gratitude to all my colleagues who contributed in diverse ways to a successful completion of this thesis. Special thanks to Richard Cosmos Abekah for proofreading my thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ALM	Asset–Liability Management
AUM	Assets under Management
BSDE	Backward Stochastic Differential Equations
BNSSS	Basic National Social Security Scheme
BoG	Bank of Ghana
CAPM	Capital Asset Pricing Model
CEV	Constant Elasticity of Variance
CTTPS	Contributory Three-Tier Pension Schemes
CVaR	Conditional Value-at-Risk
DB	Defined Benefit
DC	Defined Contribution
ERR	Expected Rate of Return
ESS	Employer Sponsored Scheme
ESG	Environment, Social and Governance
EU	European Union
FVPA	Fair Value of Pension Assets
GDP	Gross Domestic Product
GBM	Geometric Brownian motion
GMM	Generalized Method of Moments
GPA	Global Pension Assets
IOPS	International Occupational Pension Supervisors
MTOPS	Master Trust Occupational Pension Scheme
MTS	Master Trust Scheme
MTF	Master Trust Fund
NHIS	National Health Insurance Scheme
NPRA	National Pension Regulatory Authority
OPS	Occupational Pension Schemes
OECD	Organisation for Economic Co-Operation and Development
PAYG	Pay-As-You-Go

PBO	Pension Benefit Obligations
PFA	Pension Fund Amount
PFPPS	Provident Fund and Personal Pension Schemes
SSRF	Social Security Reserve Fund
SSNIT	Social Security and National Investment Trust
SWF	Sovereign Wealth Fund
TPFA	Temporary Pension Fund Amount
TTPS	Three-Tier Pension System
UK	United Kingdom
US	United State
VaR	Value at Risk
VAR	Vector Autoregression

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Ageing is an inevitable life process in human development. As we age through growth, we may not be able to perform certain functions and activities we used to do. It is therefore imperative to plan during our working lives to mitigate any contingencies in the future that may require the meeting of financial obligations. The future of most pensioners especially in developing countries are characterized by inadequate financial preparation coupled with deteriorating health risks and longevity risk. Pension provides employees regular fixed-income amount or a lump sum after retirement age (Josa-Fombellida & Rincon-Zapatero, 2012). Ordinarily, pensioners are require to live similar or better life as enjoyed during their active working lives during retirement. Josa-Fombellida and Rincon-Zapatero (2012) underscored the point that a good retirement plan helps in the reallocation of individuals' wealth from their working life to retirement.

Globally, pension has not been a source of retirement income for pensioners only but also served as a source of national savings for the capital market due to its deferred-payment nature. Stimulation of private and public national savings, high economic growth through improved corporate performance and influencing of the stock and equity market volatility are some roles of pension fund investments in the economy (Thomas, Spataro & Matthew, 2014; Antón, Munoz & Fernandez-Macias, 2011; Rezk, Irace, & Ricca, 2009; Clark & Hebb, 2004; Impavido, Musalem & Tressel, 2002; Guercio & Hawkins, 1999). The Global Pension Assets Study (GPA) in 2012 by Towers Watson revealed that pension assets or investment grew by 3.9% on the average globally. The study further identified countries such as US, Japan and UK as

having the largest pension assets markets relative to GDP ratios of 58.5%, 12.2% and 8.7% respectively (Judd & Yin, 2012). The global outlook of pension today indicates robust and rapid growth of the world's pension system. Pension systems in developing countries including Ghana, have not only provided adequate retirement income for pensioners but have also introduced social protection systems (Stewart & Yermo, 2009). Some of these social protections are poverty reduction among the elderly, reduction of government cost of funding pensions and redirect funds to other important sectors of the economy and encouraging national private and public savings.

Ghana's new pension scheme called contributory Three-Tier Pension System (TTPS) was implemented in 2010 through an Act of parliament. This replaced the old pension system that was managed by the Social Security and National Investment Trust (SSNIT). Under this TTPS, pension is to be funded directly by the contributions of employers and employees in a predetermined proportion with oversight supervision by the National Pension Regulatory Authority (NPRA) as the regulator (NPRA, 2012). The TTPS consist of a SSNIT managed mandatory basic social security, a privately managed mandatory occupational pension schemes and voluntarily managed pension scheme. Registered corporate trustees under the supervision of NPRA privately manage both the other two. The new pension reform, which replaces the old pension system, was because of public outcry about the provisions under the old scheme.

The pension system in Ghana, especially the mandatory occupational pension scheme otherwise known as Tier-2 is growing exponentially amidst allocation challenges. The fund has grown from 1% of the GDP in 2012 to 4.5% of the GDP in 2016

(NPRA, 2017). The fundamental challenge has been the untimely migration of the Temporary Pension Fund Amount (TPFA) onto the Assets under Management (AUM) fund amount for onward investments. However, the TPFA earn a minimal base rate interest from the bank of Ghana (BoG) as returns on the TPFA before they are finally transferred to the AUM fund managed by the pension fund trustees (NPRA, 2017).

The introduction of TTPS confirms the paradigm shift in choice of the type of pension plans for reforms around the globe. The two main types of pension plans under the TTPS are the defined benefit (DB) and defined contribution (DC) pension plans. The employer supplemented by the employee sponsors the defined benefit pension plans. The risk associated with this plan in terms of investment is that, the sponsor is unaware in advance the contribution rate for the promised benefit, which is fixed based on predetermined calculations (Gerrard, Habberman & Vigna, 2004). Contrary to the above, defined contribution is sponsored by the employee and supplemented by the employer. The risk is however borne by the employee or active member. This is because contributions are fixed but the future benefit is unknown and depends on the investment performance experience and the price of the annuity at retirement (Gerrard, Habberman & Vigna, 2004). The focus of the study is on the new Tier-2, which subscribes to DC pension plan model.

In relation to investment returns, DC pension plans is comparatively superior to DB pension plans. As a result, this has ignited a worldwide drift from the popular DB to DC pension plans. A pensioner is better off in a DC plan due to plausible extra benefit in a likely event that investment decision and economic variables are favourable. The DC pension plan allows contribution rates from employees' working life to retirement,

be allocated in a way that satisfies the preference of active members (Blake, Wright & Zhang, 2014). According to Booth, Chadburn, Haberman, James, Khorasanee, Plumb and Rickayzen (2005), if inflation rate is positive, the real value of the contributions will diminish over time. This reduces the real time value of the benefit received by the pensioner. The risk of losing the real time value of investments by market risks such as inflationary rates and interest rates has ignited debates on the use of stochastic models for investment strategy decisions.

The ability for any pension plans/fund to offer superior benefit depends largely on the choice of optimal asset allocation through prudent investment decision strategy. It is important to note that the ultimate aim of a manager of a particular pension plan is to determine best allocation of assets in financial markets (Guan & Liang, 2016). According to Guan and Liang (2016) in order to minimize risk in the financial market, pension plan managers mostly, invest in the cash, bond and stock. Booth et al. (2005) pointed out that pension fund managers prefer optimal strategies that compensated for market risks with high investment returns through short term and long-term investment instruments.

Regulatory bodies in most countries mostly regulate the investment decisions for asset allocations by fund managers and trustees. The regulations are to guide fund managers and trustees investment decisions. There have been arguments from several studies to suggest that quantitative restriction on asset allocations is an obsolete risk management approach. These restrictions curtail higher investment returns decision by fund managers due to restricted allocations to less risky and less diversified portfolios (Horvathova, Feldthusen & Ulfbeck, 2017). Global solutions and alternate approach is the adaptation of “the prudent person’s rule”. The prudent fund manager

or trustee make prudent risk based investment decisions in more diversified and carefully selected portfolios. Most studies reveal that investment returns on prudent decisions are more improved, efficient and higher than the quantitative restriction approach. The main research objective of this study is to investigate the optimal asset allocations of defined contribution pension funds in Ghana using the various asset class options mostly invested in by pension funds in Ghana namely government securities and bonds, listed equities, corporate bonds, collective investment instruments and open/close end funds. The ultimate aim of the study is to do a comparative analysis on investment returns and losses of restricted and unrestricted optimal asset allocations.

1.2 Research Problem

The public outcry of public servant retirees' on their inadequate retirement incomes and the harsh realities of an unstable economy in Ghana have been resolved by government's implementation of the TTPS reform (NPRA, 2012). The old pension scheme, which mandated SSNIT to collect premiums from active private and public servants to investment during their active working period and make adequate retirement income provisions at their retirement age was reformed (NPRA, 2012). The reform apportions SSNIT only 11% out of 18.5% premium contributions for official pension arrangements in Ghana by both employees and the employer as tier-1 contribution. This is supposed to provide retirement income in a form of annuity for pensioners (SSNIT, 2011). Out of the remaining 7.5%, 2.5% is premium contribution to the National Health Insurance Scheme for all active members in both the private and the public services. The NPRA receives the remaining 5% for onward disbursement to the tier-2 occupational pension plan corporate trustees and fund managers.

Ghana's infant mandatory tier-2 defined contribution pension plan that seeks to give active members improved and sufficient retirement income is based on quantitative restrictions approach. Given the volatile economy of Ghana, these restrictions are aimed at deterring pension fund managers from allocating funds into more risky investments closing the window for more diversified portfolio. According to Siaw (2014), investors and portfolio managers will underperform if investment decisions largely depend on quantitative restrictions that lack the requirement for robust portfolio construction.

A more efficient way of taking optimal investment decisions for allocation of assets is the risk-based approach. Fund managers and trustees will make optimal assets allocation decision using the prudent person's rule. The prudent person's rule ensures fund managers allocate workers' pension contributions into investment portfolios that could strategically have higher returns on investment with minimal risk without any restrictions. The first cohorts of the tier-2 occupational pension plan receive their retirement income lump sum in 2021. Will the fund achieve its objective of providing an improved retirement income for current active members with all the restrictions from the regulator on the activities of the fund managers and trustees? Are retirees better off under the risk-based approach of a prudent fund manager or trustee than the current arrangement?

Studies conducted in the pension sector of Ghana have mostly concentrated on stochastic models and risk behaviour of asset classes' allocations of pension funds (Tee & Ofosu-Hene, 2016; Donkor, 2015; Kuditcher, 2015). Many studies on optimal assets allocation have been conducted on the DB plans of SSNIT. None has been conducted on DC pension plan, which is privately managed by registered corporate

trustees and supervised by NPRA. The focus of the study was investigating the optimal asset allocations of defined contribution pension plans in Ghana. The study specifically limits its scope to the mandatory occupational pension scheme of the Tier-2 (Master-Trust Fund) for the formal sector in Ghana.

1.3 Purpose of the Study

The main purpose of the study is to investigate the optimal asset allocation of defined contribution pension funds in Ghana. However, the study specifically, optimizes the some selected privately managed mandatory top occupational pension schemes in Ghana in terms of their assets under management. The study compares optimized asset allocations of selected schemes using quantitative restrictions provided by NPRA and the non-restricted scenario underpinned by the "prudent man rule".

1.4 Research Objectives

The specific objectives of the study are to;

(a) Investigate the optimal assets mix for pension funds in Ghana given the prudent person's rule.

(b) Investigate the optimal assets mix for pension funds given quantitative restrictions from the regulator.

(c) Assess the risk exposure and loss distribution of pension funds.

1.5 Research Question

(a) What is/are the restricted optimal asset allocation decision(s) for pension fund in Ghana?

(b) What is/are the unrestricted optimal asset allocation decision(s) for pension fund in Ghana?

(c) What is/are risk exposure of pension funds in Ghana amount over a given time horizon?

1.6 Significant of the Study

Studies on pensions are globally important due to its numerous benefits to stakeholders such as pensioners, employers, employees, prospective employees and employers, insurance providers, investors, fund managers, corporate trustees, and regulators, which is NPRA in the case of Ghana. The study would be beneficial to these stakeholders in three key areas: policymaking, industrial practices and future research.

Policymaking: The study reviews asset allocations of pension funds in Ghana and assess its performance in terms of investment returns. It also projected future investment returns of pension schemes and risk exposure of investment allocations. This study therefore serves as a guide in shaping the policy direction of regulators, whose core mandate is to guide and supervise the activities of corporate trustees. Trustees are entrust with the contributions of workers to manage in other to attract favourable returns on investments that could secure the future of currently active workers when they attain their retirement age. It provides the necessary reviews for regulators to formulate regulations and provide effective supervision that maximize participants' contributions through efficient investment decisions while reducing the risk exposure of funds.

Industrial practice: The study is beneficial to prospective pensioners, investors and other participants in the pension industry with evidence of scheme's performance and their risk and loss distributions, which would serve as a guide to employers, in their selection decision for high performing pension schemes. This is achievable since the

study ranks selected pension schemes under study based on their investment performance and risk exposure.

Future research: The study finally contributes to existing literature on optimal asset allocations of pension funds for further academia and industrial studies on the subject matter. The unique contribution of the study is the introduction of Monte Carlo simulation to project future investment returns based on the optimal combinations of asset classes with current investments.

1.7 Scope of the Study

Optimization of pension funds is generally beneficial to the new pension industry. It would have been more helpful if the study had optimized the entire pension funds in Ghana. However, due to time constraints and availability of data, the study is limited to only ten selected defined contribution pension schemes managed privately by the top eight pension funds in Ghana. The size of the selected eight pension funds made up of over 80% of the total pension Asset under Management (AUM), which is a fair representation of the AUMs privately managed by corporate trustees. The study specifically optimizes the current investments of pension funds given the available asset classes and restrictions by NPRA, evaluates the performance of each scheme and assesses their risk exposure. The study further considers and undertakes unrestricted optimization process for each pension scheme and makes comparative analysis with the initial restricted optimization of pension schemes. The study also does not attempt to optimize the total value of pension funds in Ghana but the expected returns of investments given the various asset class allocations.

1.8 Definitions of key terms

Asset Allocation: The percentage of individual asset classes in an investment portfolio.

Asset Class: A group of securities that has similar features and behaves similarly in the marketplace.

Asset under Management: The total market value in terms investment portfolio of fund at any given time.

Benefit: Entitlements payable to members in a pension fund given the occurrence of events such as natural retirement, transfer, death or withdrawal of member.

Corporate Trustee: licensed Company by NPRA to manage pension schemes under a Trust.

Defined Benefit Scheme: A scheme in which a member's benefits are unknown based on some predetermined variables and indicators relating to the member at retirement age.

Defined Contribution Scheme: A scheme in which a member's benefits are determined by his/her contributions and investment returns accrued to those contributions subject to market conditions.

Master-Trust Scheme: An investment scheme sponsored and run by a Corporate Trustee for employees of multiple organizations.

Money Market: This is the type of financial market, which deals with trading in short term financial assets. It consists of individuals, organizations who wish to lend out money on a short term, and those who wish to borrow.

Pension Scheme: A the plan allows active members to make regular contributions into a common fund that is invested to provide the members with regular or specified income at retirement.

1.9 Organization of the Study

The study was organized into five chapters. Chapter one dealt with the background to the study, statement of the problem, purpose of the study, research questions, significance of the study, and organization of the study. The chapter two deals with relevant literature to the study, while chapter three focuses on the general methodology of the study. Chapter four presents the analysis of the data collected. The final chapter deals with the summary of the study, conclusions and recommendations.

1.10 Chapter Summary

The chapter discussed the background study to challenges faced by pensioners and highlighted the research focus of the study. The chapter further highlighted the current problem of the occupational pension scheme of the Tier-2 in Ghana privately managed by corporate trustees while focusing on possible opportunities of future investment returns of schemes through optimization of AUMs. Based on the purpose and objectives of the study, three research questions were drawn and addressed by the study. The remaining part of chapter one presented the significance of the study, the scope of the study, outlines some terms operationalized in the study and finally outlines how the rest of the chapters are organized in the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

The chapter focuses on theoretical, conceptual and empirical reviews relevant to the study. The chapter reviews extensively on contemporary, global issues and debates on pension reforms and the adaptation of new plans and retirement incomes for employees in Ghana as well as the types of post reform pension schemes and pre-reform pension schemes, asset allocation and investment choices, theories underpinning the study and empirical results of similar studies. The chapter begins with concepts and theories in pension related to the study followed by theoretical framework underlying the study and empirical reviews of other studies related to the study.

2.2 Global Pension Perspectives and Reforms

The global basis for pension is to serve as social security for employees during retirement. Social security is aimed at protecting the population. Provision of pension incomes in many countries, was traditionally the sole obligation of the employers and the state. According to Borch-Supan and Miegel (2001), pension system operations differ from one country to the other. Even within more closely connecting countries such as the European Union (EU), a number of varied old age pension systems coexist. They added that the differences are borne from the modalities of pension calculations, collection of contribution, generosity of pension payment and basic conceptions of the role of state and individuals in planning the financial need of their retirement. Reference could be made for instance to the pay-as-you-go systems in France, Germany and Italy and funded systems in Great Britain, the Netherlands, and

Switzerland. Again, whilst Germany has an insurance-oriented approach, Netherlands and Switzerland's provide largely flat pensions (Borsch-Supan & Miegel, 2001).

The framework of public and private pensions could be described in three-pillar scheme: system parameters, interaction with social security net and public acceptance. This constantly gives rise to misunderstandings as different countries interpret differently (Borsch-Supan & Miegel, 2001; World Bank, 1994). According to the World Bank (1994), the first pillar refers to the state's compulsory financial obligations to pensioners as a form of social security. Hence, it is considered as the basic flat state insurance scheme. The second pillar, which consists of public, individual and/or employer-based pension plans, is a mandatory, earnings-related defined benefit plans that supplements the first pillar, comprises of public, individual and/or employer-based pension plans. The voluntary aspect is the third pillar (World Bank, 1994). These pillars form the basis of old-age pension systems adopted in various countries in recent dispensations.

The crass of these pillars are hinged on the method of financing and form of contract. The former comprises of the pay-as-you-go (PAYG) and fully funded whilst the latter comprises of DB and DC (Borsch-Supan & Miegel, 2001). The first and second pillars in most countries are dominated by PAYG and DB whiles the second and third for some other countries is characterized by full funding and DC. For example Germany, Netherlands and Ghana's public retirement insurance benefits are largely anchored on net wages and employers' contributions whilst fully DC plans depends solely on pension saving plans and fixed monthly installments (Borsch-Supan & Miegel, 2001). The benefit of the fully funded DC is dependent on contributions and rate of returns on pension investments.

Historically, Chancellor Birsmack of Germany was the first person to institute a formal pension system in the world. This was because of numerous workers' unrest after retirement in Germany about a century ago (Borsch-Supan & Miegel, 2001). The underlying philosophy for the retirement insurance was that pension is a shared responsibility among the state, workers and employers. This pension system, which was designed purposely for formal workers, was in sharp contrast to the fixed base pension scheme for everyone under the Beveridgian social security pension practiced in other parts of the world such as UK, U.S.A and Netherlands (Borsch-Supan & Miegel, 2001). The world's pension system has undergone several changes from fully PAYG to partially funded systems. Pension reforms around the world in the early 20th century emanated from forecasts on population ageing and imbalanced demographic dependency ratios (World Bank, 1994; OECD, 1988).

According to OECD (1988), the effect of population ageing on PAYG pension system was long studied in the 80's. Other factors for reforms, most especially for emerging countries with less problem of population ageing inflation risk, longevity risk, higher returns for pensioners and check for corruption practices (Josa-Fombellida & Rincon-Zapatero, 2012; World Bank, 1994). Stiglitz (2001) have however, questioned the World Bank's assumption that a corrupt government under the old system can somehow be converted into a benevolent government under the new, privatized alternative.

Modigliani and Muralidhar (2005) outlined reform objectives of some countries as contribution to national savings, sustainability, insulated from political risk that is indiscriminate use of fund by government, universal availability, certainty of outcomes, and higher returns. Even though a high rate of national savings is critical to sustain growth in a country, the PAYG scheme contributes less to national savings.

On the other hand, contributions in a fully funded system are invested in earning assets and increase national savings and wealth as long as they exceed outlays for the payment of benefits (Modigliani & Muralidhar, 2005; Hemming, 1998). PAYG scheme fails in the mix of demographic changes, sustainability of scheme to ensure adequate resources for residual insurers and the ability to smoothen intertemporal volatility (Modigliani & Muralidhar, 2005). Some reforms in both developed and developing countries were initiated to diffuse the misuse of fund accumulated by profligate governments and increase the confidence of the citizenry.

The history of pension is illustrated with examples of governments, utilizing monies set aside for old age to finance deficits or so-called development projects (Modigliani & Muralidhar, 2005). According to Modigliani and Muralidhar (2005), it is advantageous for society to create a mandated scheme that is available to all citizens. Chile, Italy, Mexico, and the United States have mandated universally available systems. The U.S. 401(K) plan, however, is voluntary and not universally available (Aaron & Reischauer 1998). Outcomes of PAYG schemes are influenced by salary growth over working life, the contribution and accrual rates (or return on investments), and whether payouts are promised in real or nominal terms. Social security in most countries have certain outcomes than DC schemes (Diamond, 1997).

According to Borsch-Supan and Miegel (2001), Germany's reform policy debate had been centred on downsizing the system by decreasing benefits through subtle and indirect mechanisms. Some of the measures employed were tightening the eligibility for disability pensions, increasing the retirement age and hoping for an increase in female labor force participation. The solution proposed for this reform centred on three options: reducing pension benefits that are fully funded mandatory retirement

system that links benefits strictly to contributions, and a Beveridgian system of a base pension financed by general taxes. Just as the reform in Germany, radical reforms in most European countries means the greater involvement of the private sector and a drift from PAYG pension system to fully funded schemes (Arza & Kohli, 2008). Structural change in old pension systems implies the modification of institutional designs.

In the past decades, both the academic and policy making arena have widely debated about how pension designs and outcomes are connected (Arza & Kohli, 2008; Feldstein & Liebman, 2000; Feldstein, 1997). The debate on reform is well beyond funded versus pay as you go (Arza & Kohli, 2008; Holzmann & Palmer 2006; Disney, 1999) and the incorporation of reform experiences within the context of World Bank approach (Arza & Kohli, 2008). Rather the emphasis of recent debates centre on issues such as aggregate savings and private provision, financial sustainability, poverty prevention and benefit adequacy (Arza & Kohli, 2008).

According to Modigliani and Muralidhar (2005), the challenge of the original pension scheme in US and the need for reform was that the social security system made little contribution to national savings, and the redistributive elements could lead to evasion where possible. The system is unsustainable because of low growth of population and productivity, and smoothing is not feasible. Social security is not entirely PAYG in US after a reserve is set aside in a reform. The reserve, however, would be consumed entirely in a finite period of time and lack of choice, particularly with regard to spending patterns, makes these social security schemes seriously defective (Modigliani & Muralidhar, 2005). The Chilean model is self-financing and sustainable as compared to the US social security. However, it fails to facilitate

smoothing, but minor adjustments can be made to permit borrowing against accumulated resources (Modigliani & Muralidhar, 2005). The risks associated with the model are the uncertainty of outcome, which, in volatile asset markets, can lead to substantial poverty among many cohorts, and the extremely high management fees given the absence of incentives for regulators to control (Modigliani & Muralidhar, 2005). Countries such as Argentina, Colombia, and Peru have adopted a partial variant of the Chilean model by offering participants a choice: either an individual account, privately managed DC system or a public PAYG DB system (Mitchell & Barreto, 1997).

Within the larger region of transition economies, Lithuania was the pioneer in pension reform in 1995 by being the first country to make a post-transition pension law (OECD, 2004). Estonia based on the advice of the World Bank and key policy advisers adopted the three-pillar reform, which was homegrown product (Lindeman, 2004). In Africa, Nigeria's new pension reform replaced their old DB pension scheme system with Contributory Pension Scheme, which has been very beneficial to the development of the capital market of Nigeria. Nigeria's pension assets which became effective in 2006 saw a tremendous increase from N649.92 billion to N3.1 trillion in 2012 (Madukwe, 2015). Kenya's pension reform of 2000 consolidated the existing Retirement Benefits Act (1997) with investment guidelines of pension funds for DC plan for retirees. The purpose was to deal with the problems that the industry was facing at the time.

Many countries and reformers have made the case for privatized schemes based on an inappropriate comparison in seeing the potential shortcoming of the PAYG and DB pension system (World Bank, 1994). Nevertheless, some analysts have suggested that

some of the adverse features of DC plans, namely, high administrative costs, difficulties in securing diversified portfolios, imperfections and high costs of annuities, and high transition costs, are reasons for caution (Asher, 1998).

In designing and adopting DC plans for reformers, countries ought to consider distinguishing between governance and development of investment policy, private investment management, and passive versus active management in the presence of clearly defined market benchmarks (Modigliani & Muralidhar, 2005; Asher, 1998). According to Walker and Lefort (2000), Chile has one of the oldest pension reforms. Their pension fund reform, which is characterized by improved professionalism in decision-making regarding investment, transparency and integrity, good corporate governance balance and dynamic legal framework, has facilitated the accumulation of institutional capital in Chile (Walker & Lefort, 2000).

2.2 Pension Reform in Ghana

Modigliani and Muralidhar (2005) have demonstrated that the entire pension reform debate is focused on whether countries that move to funding pension systems should adopt DB or DC pension plans, whether arrangements should be based on individual accounts or pooled arrangements, whether assets should be publicly or privately managed, and whether asset management fees are appropriate or too high. The move for reform in Ghana was mostly anchored on the low amount paid out to pensioners as retirement incomes rather than population ageing phenomena around the globe. Specifically in advanced countries such as Japan, Canada, and US among others, OPS are shifting from DB to DC schemes at very fast pace (Bonoli & Shinkawa, 2005). In assessing the relationship between population ageing and investment returns, they

assert that several pension reforms will now focus on the transfer of burden of risk from the employer to the employee.

According to the NPRA (2012), the major reason for the 2010 reform in Ghana, interestingly, began with agitations of pensioners on low standard of living after retirement. This was due to woefully inadequate retirement income juxtapose to high cost of living due to inflationary hikes rather than population ageing even though it may be an afterthought as it was considered in the policy document. The committee set up to delve into the concerns of pensioners in 2006 made proposals and recommendations which were similar to international standard of multi-pillar pension systems. As a result, international drift from DB to DC was highly recommended and adopted by committee. Before the implementation of the reform in 2010, Ghana's pension system consisted of parallel social security for all government and private employees managed by SSNIT, "CAP 30" for some selected civil servants and forces and Superannuation Schemes for selected services and universities.

Superannuation Schemes were introduced for certified teachers, university lecturers, and all government workers. The term "CAP 30" is derived from Chapter 30 of the Pension Ordinance of 1946, which is a small-unfunded DB scheme that covers police, military and a few civil servants (Ashaley, 2012; Kumado & Gockel, 2003). CAP 30 expenditure as of 2012 accounted for 1.3% of GDP to the government of Ghana and has been increasing exponentially since 2000. Although the current compulsory early and late retirement age in Ghana is 55 and 60 respectively, the early retirement age for CAP is 45. Early studies on CAP 30 revealed three main challenges as lack of actuarial basis, inequality among members contributing and those who did not contribute and huge arrears for pensioners who were yet to receive their pension

(Ashaley, 2012). Due to lack of access to the CAP 30 by majority employees in Ghana, the government in 1965 passed a new Act called Social Security Act (No. 279). This new Act was extended to cover all worker in both the private and public sectors that were not covered by the CAP 30 pension system (Kumado & Gockel, 2003).

The Act initially served as Provident Fund providing lump sum for pensioners until it was repealed and given way to SSNIT in 1972 under the NRCD 127 to manage the National Social Security Scheme (Kumado & Gockel, 2003). Under the trust, the Provident Fund was managed for pensioners for over twenty-five years on the re-establishment of SSNIT. In 1991, the 1972 Provident Fund was converted into a pension scheme which was partially funded PAYG under the Social Security Law (Ashaley, 2012). SSNIT's mandate was to engage in rigorous investments, which would be enough to provide pensioners with adequate retirement incomes specifically the lump sum amount.

The policy also extended to provide old-age pensions, invalidity, and benefits associated with death of members. The new source of funding was a contribution rate of 17.5 percent of the employee's salary (NPRA, 2012; Ashaley, 2012; Kumado & Gockel, 2003). The minimal contributory period for a member to warrant his/her benefits is 240 months. The scheme introduced a new retirement age of 60 years for employees with normal job conditions and 55 years for hazardous working conditions. Early retirement is available at age 55 with reduced benefit. According to the Pension Reform Committee in 2006, SSNIT has active members of 900,000 and 65,000 pensioners. Even though SSNIT was reestablished through the enactment of Social Security Act, 1991 to convert Provident Fund to DB scheme which is accompanied by

broad investments in diverse portfolios, the rising inflation rate in Ghana makes the pension lump sum insignificant (Ashaley, 2012).

The Pension Reform Committee chronicled the major challenges of SSNIT in meeting their obligations. These challenges enumerated by the committee included low efficiency, high administrative costs, substantial slippage in real value of the pensions, inadequate investment returns and low coverage with marginalization of informal sector (NPRA, 2012; Ashaley, 2012).

To this end, there was the need for a more sustainable scheme that yields high returns in more diversified portfolio for pensioners irrespective of inflation rate dynamics as well as to ensure a very decent life for retirees. The challenges that bedeviled SSNIT ignited the desire for new reform in Ghana's pension system. The current reform in Ghana began with the setting up of a Presidential Commission on Pensions that was under the chair of Mr. T.A Bediako (NPRA, 2012). The Bediako Commission was tasked with the responsibility of examining the then pension system and make recommendation for a sustainable pension schemes that would ensure retirement income security for Ghanaian workers with special reference to public sector (NPRA, 2012).

The Bediako Commission was tasked to examine the pension system and to make recommendations for a more sustainable pension scheme that would provide retirement income security for all workers especially those in the public sector. The white paper issued by the Bediako Commission to the government lead to the establishment of the Pensions Reform Implementation Committee (PRIC). The outcome of PRIC was the enactment of the National Pensions Act, 2008 (Act 766) in 2008 (Ashaley, 2012).

The detailed recommendation entailed a Contributory Three-Tier Pension Scheme (CTTPS) and a National Pension Regulatory Authority (NPRA) with the mandate to regulate and oversee the efficient administration of pensions in Ghana.

According to section 1 of Act 766, the CTTPS consist of

(a) A mandatory basic national social security scheme;

(b) A mandatory fully funded and privately managed occupational pension scheme, and

(c) A voluntary fully funded and privately managed provident fund and personal pension scheme

The First-Tier that is referred to as Basic National Social Security Scheme (BNSSS) is a fully tax-exempt contribution managed by SSNIT and mandatory for all employees in both the private and public sectors. It consists of a monthly contribution of 13.5% on the basic salary of all employees (11% towards monthly pensions and 2.5% contribution to NHIS). The BNSSS is a DB scheme, which mandates SSNIT to pay regular monthly pensions to the contributors upon reaching the retirement age (NPRA, 2012; Ashaley, 2012; National Pension Act 766, 2008).

The Second Tier is referred to as Occupational (Or Work-Based) Pension Scheme (OPS) that is made up of 5% mandatory contribution for all employees but privately managed. It is designed to ensure contributors earn higher lump sum benefits than under the Cap 30 or SSNIT pension schemes. Like any other DC, it comprised of all contributions made under the scheme in addition to all returns yielded on their contributions. The Tier 2 scheme has two types namely Master Trust Scheme (MTS) and Employer Sponsored Scheme (ESS). The MTS is a scheme whose membership is open to employees of different companies whereas the ESS is a scheme whose

membership is limited to the employees of a specific company (NPRA, 2012; Ashaley, 2012; National Pension Act 766, 2008).

Finally, the third Tier is a voluntary Provident Fund and Personal Pension Schemes (PFPPS), which is made up of 16.5% contribution rate supported by tax benefit incentives. The main purpose is to make available additional funds to workers who want to enhance their pension benefits to make voluntary contributions (NPRA, 2012; Ashaley, 2012; National Pension Act 766, 2008).

Eight years after the full implementation of the Ghanaian Pension Reform System which is consistent with the multi-pillars system at the global level, cooperate trustees are yet to paid out benefit to the first batch of member of the scheme who are likely to retire in 2021. Of particular interest, is the MTS under the OPS of Tier 2 that replaces the lump sum component of the old pension system for all public/civil servant employees and other employees that was managed by SSNIT. The study sought to simulate optimal asset allocations using the current conditions of the reform to ascertain the optimal asset mix that is likely to give members adequate pension. In fact, one of the expectations of Pension Reform Act 766 is to pay out adequate lump sum benefits to exiting members to provide income security during retirement. This arrangement is expected to be better as compared to the arrangement in erstwhile lump sum benefit under SSNIT.

2.3 Pension Plan

A pension plan is a plan that provides an active worker with the opportunity to contribute a proportion of their income while in active service in order to meet financial obligation after attaining the retirement age. Booth et al. (2005) defined pension plan as a financial agreement between a pension provider and the member(s)

for providing income for the member at retirement. According to Bodie and Davis (2000) pension funds collect, pool and invest funds contributed by sponsors and beneficiaries to provide for the future pension entitlements of beneficiaries. The advantage is that it provides a means for individuals to accumulate saving over their working life to finance their consumption needs in retirement. Members provide periodic contributions; refer to as contribution rate to the pension provider in return for benefit at the end of the contract.

There several kinds of pension plan based on their categorization under contribution and benefit, coverage and funding. In terms of coverage, there are three types of pension plans namely single – member plan, group – member plan and state pension plans. The single – member plan involves an individual contributing to personal fund. The group – member plan involves a group of employees contributing to the same fund. The state pension plan usually involves public sector employees. The contribution of this retirement plan is usually paid by the state on behalf of the employees (Booth et al., 2005; Gerrald, Haberman & Vigna, 2005).

The categorization based on funding comprises three types namely funded plan, unfunded plan and partially funded plan. The funded plan is a plan where the cost of providing the pension is financed through accumulation of fund over the same period of member's service before the retirement age. The funding is usually sponsored with the accumulated contributions of members and accrued investments from funds over the same period. Unlike the fully funded pension plan where contributions are accumulated and invested for active members over the active period of service, the cost of unfunded pension plan is borne out of the contributions of members at the same period of time (Booth et al., 2005). In an unfunded pension plan, the

contribution of active members at a certain point in time is used to pay the benefits of retiring members at the same point in time. An example of a fully funded pension plans in Ghana are the occupational pension scheme and personal pension schemes of the Tier 2 and Tier 3 respectively.

The erstwhile public pension scheme managed by SSNIT and CAP 30 was to a large extend an unfunded pension plans. The hybrid funded pension plan which is mostly referred to as partially funded pension plan is a plan whose cost of pension is partially funded by accumulated contributions of member over the active period and partially funded by the contributions of active members at a particular period of time to pay pensions of member who are retiring at the same period of time. All defined contribution pension plans are fund while defined benefit pension plans could be fully funded, partially funded or unfunded depending on the country (Yao, Lai & Jian, 2014; Booth et al., 2005; Rezk, Irace & Ricca, 2004).

The final category of pension plans in terms of the contributions and benefits of active and retiring member respectively is also made up of three types of pension plans namely defined contribution (DC), defined benefit (DB) and the hybrid pension plan. The study would pay more attention on reviewing this category of pension plans based on the purpose of the study.

2.3.1 Defined Benefit Pension Plan

The DB pension plan is a plan that pays members a predetermined amount of retirement benefits beginning the retirement or vesting date. The return to members may be overlaid by a guarantee of the rate of return by the sponsor (Bodie & Davis, 2000). According to Yao, Yang and Chen (2013), a DB pension fund is a pension scheme in which the sponsor fixes the benefits in advance, and contributions are set

and subsequently adjusted to ensure that the fund remains in balance; hence, the risk is borne by the sponsor. The pension benefit amount is usually determined based on factors pertaining to individual participant such as years of service, age, and salary (Li, Rong, Zhao & Yi, 2017; Booth et al., 2005). Unlike the defined contribution, which is affected by the market risk, DB scheme is also influence by interest rate risk, mortality risk, falling asset returns, and change in government regulations (Davis, 2000). The present value of all participants' total benefits represent a sponsor's projected pension benefit obligations (PBO). Sponsors are required by laws and regulations of the country to set aside a certain amount of assets to meet these pension obligations. The market value of the entrusted assets or plans' asset is called the fair value of pension assets (FVPA) (Li, Rong, Zhao & Yi, 2017). DB plans are popularly associated with large pension plans such as managed by SSNIT in Ghana and S & P 500.

The DB pension plan is usually linked with the salary for two reasons: to protect benefit levels against inflation and to enable members maintain a standard of living in their retirement age that commensurate with how they lived during their working period. The link with the salary is usually based on the career life salary plan or final salary plan. The career salary plan of a DB plan links the benefit of members to the average of their entire working salary. The disadvantage of this plan is that early years salaries of members are likely to reduce their average salary at the end of their service (Booth et al., 2005; Bodie & Davis, 2000). The final salary plan is determined by finding the average of member's best final three or five year salaries depending on the country. The advantage of the final salary plan, however, is that members are expected to have their highest salary in their last years of service.

2.3.2 Defined Contribution Pension Plan

The DC pension plan defines the method of calculation and the frequency of payment of the contributions allocated to the account of the active member. Returns to members of the DC pension plans are purely dependent on the market (Bodie & Davis, 2000; Davis, 2000). There is no guarantee regarding assets at retirement, which depend on growth in the assets of the plan. In DC pension scheme, contributions are fixed, and therefore the benefits depend solely on the returns of the fund's portfolio; hence, the financial risk is borne by the contributors (Yao, Yang & Chen, 2013). The member usually determines the contribution rate and the member can vary at will in a single – member plan. In a group – member plan, both the employee and the employer of the plan determine the contribution rate.

Due to the critical feature of DC plan relating to the contribution rate, DC plan contribution rate can be determined in three ways namely: fixed monetary contribution, fixed salary contribution and variable percentage of salary. The fixed monetary contribution enjoins the member or the employee to contribute a fixed amount to the fund. The real value of the contribution rate for a fixed monetary contribution scenario reduces as inflation rate increases with time. The fixed percentage of salary contribution approach in a DC plan allows the employee and employee to pay a fixed percentage of the pensionable salary of the active member. The percentage of salary paid as contribution rate is usually unequal between the employee and employer. In most developed countries, the employer pays a greater percentage than the employee does.

A positive increase in inflationary rate decreases the real value of contributions over time in the fixed percentage of salary. The problem of DC is solved when the

contribution rate is varied upward intermittently with respective to increase in inflation. This highlights the major advantage of the variable percentage of salary in a DC plan where the participant varies the contribution rate with the age or years of service of employee. According to Booth et al. (2005), as contributions paid close to retirement, the accumulated interest is less subject to time. An age – dependent contribution rate could be calculated to produce a uniform expected rate of benefit accrual as a fraction of final salary in a final salary DC plan.

In the DC plan, contributions are supposed to be a predetermined amount of money as premiums and the pension funds are allowed to be invested in a financial market, which consists of a risk-free asset and other risky assets such as equity, stocks, and bonds (Li, Rong, Zhao & Yi, 2017). The financial risk involved in a DC plan is borne by the provider of a defined contribution plan. In most cases, the sponsor and the investment manager employs the choice of portfolio distribution, and hence there is a risk of legal action by beneficiaries against poor investment.

For that matter, the input of member in the decision to invest is usually appreciated. The obligation on the sponsor is to maintain contributions (Booth et al., 2005; Bodie & Davies, 2000; Davies, 2000). The objective of this plan in principle is to maximize return for a given risk, to attain as high as possible a replacement ratio at retirement (Chen, Sun & Li, 2017; Booth et al., 2005; Bodie & Davies, 2000; Davies, 2000). Advertently the plan is shifted from higher risk to lower risk assets associated investment for member who may be approaching their retirement age to reduce the exposure to market volatility, which may sharply reduce pensions (Chen, Sun & Li, 2017).

2.3.3 Hybrid Pension Plan

The hybrid pension plan combines the advantages of both DB and DC in one plan. Hence, this is a pension plan, which is partly DB and partly DC. The investment risk is borne wholly by the employer in the DB plan and wholly by the employee in the DC plan (Booth et al, 2005). Members are guaranteed specific benefits at the end of the plan against the uncertain returns with the DC plan.

2.4 Theoretical Framework

There are several theories underlying investment. However, theories that are more profoundly considered with regulations to investments are prudent person's rule and regulatory quantitative restrictions. The theories underlying this study are the prudent person's rule and regulatory quantitative restrictions based on the objective of the study to elucidate the nature and consequences of regulations on the asset portfolios. The main objective of a pension fund manager and trustees is to take optimal investment decision strategies on the allocation of pension fund assets under their management. The regulatory bodies in most countries for that matter the National Pension Regulatory Authority for Ghana's objective is, to regulate the activities of fund managers and trustee to take prudent investment decisions that would provide sufficient retirement incomes for active members who retire from the scheme.

Again, the regulations ensure that a framework for legal provisions in respect of contracts, bankruptcy fraud and corporate governance are put in place to formalize the plan (Booth et al., 2005; Bodie & Davis, 2000). They argued that the government's intervention with regulation is only necessary when the operations of the market activities fail due to information asymmetry, eternality and monopoly to attain a

Pareto optimal outcome. They further argued that when competitive markets achieve efficient outcomes, there is no case for regulation.

These regulatory guidelines formulated by government for pension fund are referred to as quantitative portfolio restrictions which are simply quantitative limit on holdings of a given asset class. This means the government determines the holdings that are invested in each asset classes subject to the levels of risk irrespective of the returns for fear of beneficiaries losing their investments in the future. Quantitative portfolio regulations and restrictions have been the subject of criticism because they lead to lower returns, are inflexible when necessary to adjust and adapt investment strategies and tend to discourage competition among investors (Horváthová, Feldthusen & Ulfbeck, 2017).

For that matter, most countries are moving away from the expensive but secure sponsoring of DB pension plans to a more sustainable DC plans which give higher rewards but risky. It is, however, important to underscore the role of regulators whose main objective is to seek the interest of active members by giving guidelines and restrictions to fund managers on how investment decisions should be made. These restrictions have been assessed by some studies as bottlenecks to optimal assets allocation by portfolio managers. The restrictions limit holdings of certain types of asset within the portfolio. Davies (2000) underscored the point that investment restrictions typically apply most strongly to asset allocation between instruments but may also affect security selection. The nature of Pension fund allows strategic asset allocation that is usually in a long-term but for tactical asset allocation to meet the short-term needs of paying liabilities and cost of administrative expenses, these restrictions are necessary to regulate the activities of the fund.

The alternative suggested by most studies is the "prudent person's rule". The prudent person's rule allows the fund manager and trustee to take optimal investment decisions without restrictions. The prudent person rule was historically developed in common law jurisdictions, namely England and the US, via case law (Horváthová, Feldthusen, & Ulfbeck, 2017). The legal restrictions on trustees' investment then were very conservative and preserved wealth instead of reproducing wealth. The evolvement of the markets and novel investment possibilities necessitated the need for open market investment to increase the wealth of investors. The "prudent person" was clarified in the famous case of Harvard College verse Amory which was decided by the Massachusetts Supreme Judicial Court in 1830. The judge stated that:

> *"All that is required of a trustee to invest, is, that he shall conduct himself faithfully and exercise sound discretion. He is to observe how men of prudence, discretion, and intelligence manage their own affairs, not in regard to speculation, but in regard to the permanent disposition of their funds, considering the probable income, as well as the probable safety of the capital to be invested."*
>
> (Horváthová, Feldthusen & Ulfbeck, 2017).

Bodie and Davis (2000) argued that the prudent person's rule ensures adequate diversification, thus protecting the beneficiaries against insolvency of the sponsor and investment risks. It is advantageous for two basic reasons: firstly, fund managers are allowed to use risk-based measures to allocate resources in a more diversified portfolio in return for higher rewards and secondly, good investment decisions by fund managers provides adequate and sufficient incomes for pensioners in their retirement age. Prudent person rules enjoin portfolio diversification and broad asset - liability matching (Davis, 2000). Goldman (2000) indicated that the logic of the quantitative restriction or "prudent investment" approach is that prudence is equal to safety, where security of assets is measured instrument by instrument according to a

fixed standard. Quantitative regulation of portfolio distributions limit on holdings of assets with relatively volatile nominal returns, low liquidity or high credit risk, such as equities, venture capital/unquoted shares and property, as well as foreign assets, even if their mean return is relatively high. This is to protect beneficiaries against insolvency of operators and investment risks, by ensuring adequate diversification of assets.

Prudent person's principle focuses on the behaviour of the person concerned such as the asset manager, the institutional investor and the process of decision-making (Davis, 2000). This involves the need to assess whether, for example, there has been a thorough consideration of the issues, there is not blind reliance on experts and it is essential to have undertaken a form of "due diligence" investigation in forming the strategic asset allocation and prior to any change or variation to it. The institution would also be expected to have a coherent and explicit statement of investment principles. The prudent person rule, in effect, allows the free market to operate throughout the investment process while ensuing, along with solvency regulations, that there is both adequacy of assets and appropriate levels of risk (Davis, 2000).

In the current dispensation of pension fund amidst reforms all over the globe, adopting any of the two polar extremes are rare. In most developed countries especially European countries, prudent person rules are typically accompanied by a quantitative restriction on self-investment, while some countries with asset restrictions also introduce concepts of maximizing safety and profitability to their investment laws. According to the European Commission (1999) using only quantitative restrictions for optimization of asset allocation and security selection result in suboptimal return and risk taking. Additionally, the use of quantitative restrictions do

not provide the needed incentives for the investor to nominate investment managers with skills to achieve higher return and lower risk by equity and international investment, discourages competition among asset managers, encourages inefficient allocation of capital, increases employers' costs, hinder the dynamic small firm sector and drawbacks the development of the industry as a whole. Conversely, whereas investment regulations on domestic assets may seem appropriate in a small domestic market where there is high volatility and undiversifiable risk in equities, to ensure adequate diversification and portfolio liquidity (Davis, 2000). Quantitative restrictions are therefore encouraged when investors and industry are highly inexperienced and the regulator is uncertain about internal control measures.

Prudent person's rule on the other hand seek to have a wider and more flexible choice of financial assets than regulations may allow, including taking advantage of the risk diversification, offered by international investment. Davis (2000) argues that the danger of unrestricted investments is providing pension contracts that seek to boost yield to attract clients, at a cost of excessive risk, which could ultimately be borne by the government. Studies show that portfolios with prudent person rules have fewer bonds, more equities and foreign assets than those with quantitative restrictions. This is, however, dealt with adequately by the prudent person's rules.

The flexibility of the prudent person's rule has encouraged many countries to switch from quantitative restrictions to the former. The prudent person's principle currently dominates developed countries' pension systems such as US, UK, Netherlands, Canada, Finland, Italy and Japan who are currently leading the world in terms of pension fund amount relative to their GDP (Horváthová, Feldthusen & Ulfbeck, 2017; Davis, 2000). The progress of these countries' pension systems has necessitated

reforms around the globe. The challenge however, for developing countries is adopting the prudent person rule fully as part of the reform due to the turbulent nature of their economic indicators which is likely to affect investment in spite of the numerous advantages attributable to the prudent person's rule. Nevertheless, with a well-structured legal framework, the prudent persons' rule could be a superior option for sponsors to increase the pensions of employees to ensure a better and guaranteed standard of living for pensioners in Ghana.

2.5 Empirical Review

Many studies have been done on the optimization of pension fund. Most of these studies were conducted on defined benefit pension plans because of its simplicity compared to defined contributions pension plans. Most optimization process, which are made with restrictions, gives lower investment returns than unrestricted optimizations. A study by Haberman and Vigna (2002) formulated the optimal investment allocation in a DC pension scheme in the UK. In a two-asset case, the study revealed the presence of a high-risk and a low-risk asset; the returns are correlated in the market. Concerning the investment allocation, members who have attained retirement age's optimal investment strategy show disutility function. The study observed that not only did risk adverse retirees depend on the value of alpha, but also aversion was found to have an inversely proportional to alpha values. This implied that lower alpha has more risk and vice versa.

Another study carried out in U.S by Campbell, Chan and Viceira (2003) developed optimal solution for portfolio decision of a likely long-lived investor faced with set of investment returns and their consumption with Epstein–Zin utility. Analysis suggests that the stock predictability increases the demand for stocks profoundly at optimal

levels. The study revealed that long-term bond portfolios depended largely on the impact of real interest rate risk with respect to other sources of risk. Again, the utility of traditional investors increased tremendously in long-term inflation-indexed bonds.

In a simulating exercise, Gerrard, Haberman and Vigna (2005) provides consumption and investment choices for retirees of DC pension scheme in UK at optimal levels based on an income drawdown approach after retirement. The paper considered the insurance option after retirement until annuitized income or dead. The trade-off between the different desires of the pensioner regarding consumption and final annuity target was dealt with by choosing appropriate weights for these factors in the initial setting of the optimization problem.

Again, Hoevenaars, Molenaar, Schotman and Steenkamp (2008) investigated the strategic asset allocation for an investor with risky liabilities which are subject to real interest rate risk and inflation investing in government bonds, stocks, corporate bonds, listed equities, T-bills and real estate, commodities and hedge funds. The vector autoregression model was used for liabilities, returns and macro-economic state variables. The result showed that horizon has a direct effect on real interest rate, inflation, hedge, risk diversification and time diversification. Differences in global minimum variance and liability hedge portfolio accounted for strategic portfolios for asset-only and asset–liability investors. Investors benefited significantly in the long than occurring of liabilities.

Thomas, Spataro and Mathew (2014) investigated the relationship between the stock market volatility and share assets invested in stocks by pension funds in OECD markets. The paper reported significantly negative relationship between the share of assets invested in stocks and stock market volatility by pension

funds. The paper validated the argument that institutional investors such as pension funds can dampen the volatility of stock market using Binary Probit and Logit models. Fernandez (2014) investigated pension funds under individual capitalization-based system and volatility of stock. Pension Fund Amount (PFA) holdings of 42 active firms on the Santiago Stock Exchange between December, 2002 and July, 2008 data was gathered for the analysis. The findings revealed that PFAs' stock holdings had mild effect on stock return volatility. Increase in stock return volatility led to a moderate decrease in PFAs' stock holdings. This implied PFAs' preference for safer stocks. PFAs' stock trading were found to have no destabilizing impact on the domestic stock market.

Yao, Lai and Jian (2014) investigated an asset allocation problem for DC pension fund with stochastic income and mortality risk under a multi-period mean–variance framework. Adopting the Lagrange dual theory, the stochastic optimal control method and the state variable transformation technique, the study obtained efficient investment strategy and the efficient frontier. Broeders, van Oord and Rijsbergen (2016) investigated the performance of a pension fund using 225 Dutch occupational pension funds with a total of 928 billion euro of AUM. The finding show large pension fund with 10 times more AUM on average reported less cost on investment that was 7.67% lower than smaller pension funds. They found significant economies of scale in commodity portfolios, fixed income and equity. However, the study found no significant economies of scale in private equity, real estate investments and hedge funds. Large pension funds paid significantly higher performance fees for private equity, hedge fund investments and equity.

Blake, Sarno and Zinna (2017) examined defined-benefit pension fund asset allocations in terms of their hedging behaviour using dataset that covers UK over the past 25 years. The study showed evidence that pension funds end to herd in subgroups defined by fund size and sponsor type and displayed strong herding behaviour. Additionally, pension funds tend to switch to bonds from equities as their liabilities mature by rebalancing their portfolios in the short term mechanically. Finally, instruments prices impact were unstable and not persistent. There were marginal cross-sectional differences in returns across pension funds with consistent widespread herding behaviour.

Siemiatychi (2015) examined the barriers and opportunities to pension funds in terms of taking on a more significant role in delivery and operation of transportation infrastructure and financing. The study assessed seven large Canadian pension funds largely renowned for investing in infrastructure. The study analyzed interviews with fund managers as well as an examination of annual reports, media coverage and industry studies. Canadian pension funds were found to invest in operational projects in established marketplaces.

Guan and Liang (2016) investigated the risk management of the financial market that consisted of cash, bond and stock for DC pension plan. The study modeled interest rate as an Ornstein–Uhlenbeck process while the contribution rate followed a geometric Brownian motion. Optimal solution was obtained under loss aversion and Value-at-Risk (VaR) constraints. The loss aversion pension manager was found to be sensitive to losses while the VaR pension manager ensured the quality of wealth at retirement. Fewer stocks were allocated at optimal levels under loss aversion. The sensitivity analysis, however, showed risk averse investors invest more in the stock.

Yao, Chen and Li (2016) investigated the ideal situation of a Markovian regime-switching market problem in a multi-period defined contribution US pension fund investment using mean – variance criterion. Both mortality risk and stochastic wage income are incorporated in the model. The study observed changes in expected returns or bank interest rate and covariance matrix of stocks based on the state of the market. The dynamic programming approach, matrix representation method and Lagrange duality technique were used to derive expressions for efficient investment strategy and hence obtained the efficient frontier in closed-form.

Zhang and Chen (2016) investigated mean–variance ALM problem under the constant elasticity of variance (CEV) process based on the assumption of $n+1$ assets: one risk-free bond and n risky stocks. The geometric Brownian motion is used to model the uncontrollable liability payment. Several numerical examples are simulated using Monte Carlo to demonstrate how the efficient frontier is affected by the key parameters.

Li, Rong, Zhao and Yi (2017) investigated the optimal solutions for investment problem of DC pension plan with default risk in a mean–variance framework. The study assumed that surviving members share the difference between return and accumulation equally. Taking into account the volatility of the accumulation and the pension fund size, the original optimization problem was decomposed into two sub-problems: a post-default case and a pre-default case. The result showed that fund size is reduced by the return of premium mechanism. At equilibrium, investment strategy depends on the start age of the accumulation period and the maximal age of the life table.

Doyle (2017) investigated how long-run expected rate of returns (ERR) persist for corporate pension plans. Data on ERR showed persistency for over 50% of corporate firms and remain unchanged year on year for a longtime. The rate was modelled to capture the persistence using a first-order auto regression with information of asset allocation. Endogeneity bias was addressed with the use of a GMM estimator. No evidence of earnings management in terms acquisition activity and relative size of the pension plan to net income was found.

Nepp, Larionova, Okhrin, and Sesekin (2018) study aimed at demonstrating the dependence of the target functions of pension systems in Russia. The paper draws the attention on the influence of demographic parameters on funded and unfunded pension systems and shows the importance of institutional risks in both types of systems. The values of the state-regulated parameters for 2030 were specified to maximize the key target functions: the replacement rate and pension benefits. Delgado de Oliveira, Filomena and Righi (2018) investigated the differences in two stochastic scenario tree-generation approaches in Brazil. They considered Moment matching methods and classical Monte Carlo sampling. The resampled average approximation and moment matching are more stable than the other two strategies.

Alda, Ferruz and Gallagher (2012) examined the performance of pension funds in Spain adopting multiple nonlinear and linear performance models. The trends in higher-order moments revealed distortions in performance using traditional models. The result suggests Spanish pension funds exhibit selectivity ability and positive market timing. Higher performing pension funds had a higher exposure to size and book-to-market risk and vice versa. Small sized pension funds exhibited low volatility with stronger alpha performance.

Kiplagat (2014) investigated the financial performance of pension funds resulting from asset allocation of pension fund portfolios in Kenya. The study adopted a descriptive survey and utilized a sample of 40 schemes drawn from a population of 1232 schemes in Kenya. The findings of the study showed that asset allocation explained 58% of the variability of fund performance and that 42% was due to other factors of timing of investments, securities selection and manager's selection within as asset class and the management style adopted by the fund managers of the fund. The study further established that of all the asset classes invested in, Government securities, property, cash deposits and quoted shares were relatively more important in determining the overall performance of the pension funds.

Chen, Sun and Li (2017) reviewed strategic asset allocation for some selected large Social Security Reserve Funds (SSRFs) in advance economies in the world. The study adopted the mean-variance approach with conditional value-at-risk (CVaR) constraints for allocation. They suggested that significant proportion of pension assets should be invested in direct equity investments and stocks. Time horizon was found to significantly affect asset allocation of pension fund. If time horizon is longer, more time horizon significantly influences asset allocation of pension fund. The effect was more profound in longer time horizons. Equity investments and stocks of pension funds perform better in the longtime.

Adami, Gough, Mukherjee and Sivaprasad (2014) examined the performance of pension funds' investments in UK. Three standards of performance namely Fama-French model, and the Carhart model and the capital asset pricing model (CAPM) were used for measurement. The CAPS-Mellon survey data for the period between 1990 and 2008 was used. There was little evidence to explain that abnormal returns

were due to book-to-market values, size of pension funds, momentum, the term spread and market returns. Abnormal returns were obtained for bond than equities while smaller funds outperformed larger pension funds. Finally, linear factor models showed superior performance of pension funds.

Papaioannou and Rentsendorj (2015) used the Markowitz portfolio theory to allocate assets of sovereign wealth funds (SWFs) in Norway. SWFs allocation was widely consistent with one-period Markowitz model generated allocations. The performance of investment to a large extent depended on risk tolerance , strategies mandated in attaining the set portfolio objectives and assets classes that are permissible. Finally, rebalancing of asset weights allowed for higher returns to be achieved in future to meet long-term investment objectives. Angelidis and Tessaromatis (2010) examined investment cost of pension fund portfolios due to constraints. The study quantified portfolios losses suffer due to sub-optimal asset allocation and under-diversification. The result indicated that investing in higher proportion into equity portfolios amounted to significant utility loss and return. The situation escalates when the lack international diversification is also considered. When weights of equities is restricted to 23% of the total portfolio weight, sub-optimality of asset allocation which comes at a cost of 2%-3% per annum compared to global benchmarks was obtained.

Finally, on optimization of portfolio assets, de Resende Baima and da Costa (2006) investigated the relationship between pension fund size and investment expenses in terms of investment performance and its influence on future performance in Brazil. The result showed inverse relationship between expenses and performance. Current performance of pension funds had weak correlation with future performance of funds. This implies that good strategies implemented by an effective administration was not

sustainable and needed to be dynamic to meet future objectives. Finally, pension fund performance had inverse relationship with portfolio size.

Based on the objective of the study, the study reviewed empirical studies on the theoretical foundation of this study. Horvathova, Feldthusen and Ulfbeck (2017) examined the prudent person principle as applied in the situation where European Union encourages individuals to save in private and occupational pension funds to complement their state saving-plans. The study emphasized that in prudent person principle, the fund is managed with skillsets of expert, prudence and due diligence. Responsible Investment coexisted with inclusion of the ESG-principles (Environment, Social and Governance) introduced by the EU and the Prudent Person Principle and whether all funds are obliged to make only responsible, environmentally and socially beneficial investments is examined. The results revealed that even though, under the prudent person principle the approach towards investments has been liberalized, it was of best interest to beneficiaries of pension funds as compared to the ESG friendly investments that they predicted would be eventually be preferred.

Again, Jomer (2013) examined the ability of pension fund managers to determine whether their performance was due to seer luck or skills. The study engaged 102 actively managed UK equity pension funds to determine whether they had sufficient skill to generate risk adjusted return to cover the cost imposed on the investors. The result indicated that the active pension funds in aggregate, before expenses, held a portfolio that imitated the market returns during 2000 to 2012. A bootstrap simulation suggested that only eight funds out of the sample of 102 have skilled managers and six of these managers are skilled enough to produce risk

adjusted excess return large enough to cover the expenses imposed on the investor through prudent person principle.

Strumskis and Balkevicius (2016) examined how fund manage company's shareholders and coordinate interests of second pillar pension fund participants in Lithuania. Participants of 507 were sampled to obtain information on their expectation and attitudes. Most of participants who were dissatisfied with the performance of pension funds, disagreed with allocation of additional resources for hiring of competent managers and experts. The paper suggested that stabilization of the pension accumulation ensures participatory interest of shareholders. The importance of promoting mutual confidence among interested parties, elucidated issues for participants and reflect real performance of pension funds.

Davies (2000) examined compared portfolio regulations to prudent man rule for life insurance and pension in UK. Institutional investors are assumed to make long-term investments. Among others, the author concluded that regulation of life insurance and pensions must not necessarily be identical. The study found quantitative restrictions to be less superior to prudent person rule for pension funds except for certain specific circumstances. Although general restrictions was desirable for life insurance in most cases than pension funds, using the prudent person rules were more appropriate for pension funds.

2.6 Summary of Chapter

The chapter began with pension reforms around the world, to better appreciate the objectives of the Ghana's pension reform. The chapter highlighted the global paradigm shift from DB to DC pension plans due to the flexibility and unique diversification of the DC pension plan that results in higher rate of returns amidst the

high market and investment risks that are likely to influence the DC scheme negatively. Additionally, the study elucidated the types of pension plans and their kinds, indicating their strengths and weaknesses. More attention was drawn on the type of pension plan, which was largely based on the benefits, and contributions since it formed the core of the study. The study identified three pension plans under this categorization as DB, DC and hybrid pension plans. Based on the objectives of the study, the theoretical framework reviewed literature on quantitative restrictions on investment portfolios and the prudent person's principle.

The quantitative restrictions, which would be connoted to restricted optimization subsequently, restrict sponsors in the selection of investment instruments and asset allocations of pension schemes. The effects of these restrictions on the portfolio are lower rate of returns and less diversification of assets in portfolio. The discussions on the prudent person's principle, which is subsequently connoted to unrestricted optimization, allowed sponsors to make prudent investment decisions in allocating assets of pension portfolios that would yield higher investment returns for members and secure their retirement in future. The chapter finally reviewed empirical studies around the globe based on the objectives of the study. The review captured results of empirical studies on studies in pension reforms, optimal asset allocations of DC pension funds and studies on prudent person's rule and quantitative restrictions of investment decisions.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The chapter provides description of the various methods and procedures that was used in addressing the main objectives of the study: investigating the optimal allocation of pension funds based on the prudent person's rule, investigating the optimal allocation of pension funds based on regulatory quantitative restriction rules and examine the worst case scenario given a loss distribution of the pension funds under the prudent person's and regulatory quantitative restriction rules. This involved information on the data collected, the asset model, variables used and tools used for the study. The study takes a positivistic approach by assessing research findings that are observable and quantifiable. The positivistic approach allowed the researcher to analyze the findings in an objective and independent manner because of facts and information available. Moreover, the use of a positivistic research approach better addresses the purpose of the study in a manner that fits the objectives of the study (Esterby-Smith, Thorpe & Jackson, 2015).

3.2 Master Trust Occupational Pension Schemes in Ghana

The 2008 pension reform in Ghana saw the categorization of the pension sector into 3 –Tiers. The Tier – 1 is made of a Defined Benefit Pension Scheme manage by SSNIT while the Tier – 2 and Tier –3 are Defined Contribution Pension Schemes managed by private pension Corporate Trustees. The National Pension Regulatory Authority currently regulates the pension sector. Based on the scope of the study which captures only the Master Trust Occupational Pension Scheme (MTOPS) is in the Tier–2 category, the rest of this section focuses on the composition of Tier–2 and the Master Trust Occupational Pension Scheme. This is a formal sector mandatory Defined

Contribution Pension Plan which Corporate Trustees (Sponsors) establish and opened to multiple employers in the formal sector and provides lump sum payment to members on retirement.

The scheme was selected for the study because it is opened to all formal sectors both private and public sector employees. Information available at the time of conducting that study indicated that the registered Corporate Trustees in good standing with NPRA managing the MTOPS were 29 schemes (NPRA, 2015). These Corporate Trustees (Schemes) are ranked and grouped by NPRA based on their Assets under Management (AUM), which determines their market share. Out of the 29 schemes, eight schemes were selected for the study. The criteria for selection were based on two factors. First, the AUM and market share of schemes according to the NPRA ranking was considered. Again, the availability of up-to-date and audited financial reports submitted to the NPRA was considered as criteria for selection. The selection of the top eight schemes for the study is justifiable due to their market share, which exceeds 82.01% of the total market share. The table below displays the list of eight selected schemes showing their ranks and AUM (Market share).

Rank	**MTOPS**	**AUM (GHS)**	**Market Share (%)**
1	Enterprise	363,120,546.46	32.16
2	Petra	243,416,032.70	21.56
3	United Pension	125,206,490.75	11.09
4	Axis Pension	104,459,022.00	9.25
7	Negotiated Benefit	46,045,424.06	3.89
9	Glico Pension	26,698,431.25	2.36
12	Stallion Trust	16,308,816.10	1.44
16	NTHC	2,137,232.66	0.19
Total		**927391996.1**	**82.01**

Source: NPRA (2015)

3.3 Data Source

The study is conducted using secondary data, which consisted of financial reports of Defined Contribution Master Trust Occupational Pension Schemes in Ghana from NPRA. The study extracted information such as annual investment returns on government securities, corporate bonds, fixed deposits, money market, collective investments, listed equities and open/close – end funds, expenses, contributions of members, total asset under management and benefits paid out to members from 2012 to 2016, when most pension schemes in Ghana were active and NPRA regulations were proactively enforced. The data for the study also include statistics of pension scheme in Ghana as obtained from NPRA database that was last updated in 2017.

3.4 Asset Allocation and Asset Classes

An asset is any possession that has value in an exchange (Pachamananova & Fabozzi, 2010). This could be tangible or intangible. The tangibility of an asset depends on the physical properties possessed by the asset in question. Examples of tangible assets are buildings and lands while intangible assets include legal claims to some future benefits and knowledge that can be used to produce goods and services (Pachamananova & Fabozzi, 2010; Bodie, Kane & Marcus, 2008). Financial assets, financial instruments or securities are intangible assets such as stocks and bonds. Financial assets simply define the allocation of income or wealth among investors (Bodie, Kane & Marcus, 2008). They stressed that asset allocation is the decision made to select among broad investment classes, rather than among the specific securities within each asset class.

Pachamananova and Fabozzi (2010) identified four asset classes for financial assets as common stock, bonds, cash equivalents and real estate. An asset class is a group of assets that are influenced by similar characteristics such as economic, risk and return and legal or regulatory structure. Apportioning assets of a fund in various percentages of the total assets in different asset classes is referred to as aset allocation. Meucci (2009) emphasized that portfolio allocation could also be viewed as a method of maximizing the degree of satisfaction of the investor.

The study considered all asset classes used by pension funds in Ghana. An IOPS study conducted by Morales, Fuentes, Searles and Stewart (2017) reported that pension funds in Ghana predominantly invested equities, bills, bonds, cash and deposits. Per the provision in the investment guidelines of the NPRA, pension schemes are allowed to invest in diverse financial instruments subject to their adherence to regulatory restrictions of the NPRA investment guidelines. The study, however, is limited to the financial assets reported by Master Trust Occupational Pension Schemes of the eight selected pension schemes for the study. These include government securities, corporate bonds, listed equities, money market, open/closed funds, collective investments and fixed deposits.

Generally, asset allocation is dependent on several factors subject to the legal or regulatory frameworks of a country. The asset allocation of Pension Insurance Funds in Germany has a very conservative profile from a risk-return perspective (Hertrich, 2013). On average, 86.6% of assets under management are invested in highly rated corporate or risk-free government bonds, whereas 5.2% are allocated towards real estate assets and only 4.6% into equities (Hertrich, 2013). UK, Australia and US allocates higher weight of assets to equities than other countries, even though the

general outlook around the globe shows an increase in bond allocations and a fall in allocations to listed equities (Judd & Yin, 2012). They also indicated that global asset allocation of the seven largest markets in 2011 was 37.7% equities, 40.1% bonds, 3.7% cash and 18.5% of other assets including properties and other alternatives. Just like Ghana, the study also indicated Japan, Swizerland and Netherland pension funds use a more conservative strategies like investing more in bonds and less in equities.

Table 3.1: Summary of asset allocation of investments by the NPRA Ghana

No.	Asset Class	Maximum Investment as % of Pension Fund Assets
1	Government Securities	Government of Ghana – 75% Local Govt. – 30%
2	Corporate Bonds/Debt (including REITs, Mortgage and Asset Backed securities and debentures)	30%
3	Money Market	35%
4	Ordinary Shares	10%
5	Open and Closeend Funds	5%

Source: NPRA (2011)

3.5 Portfolio Returns Modeling

According to Chalabi and Wurtz (2015) the most common transformation yields arithmetric returns is defined at time $\boldsymbol{t}$ by

$$\boldsymbol{r_t = \frac{P_t - P_{t-1}}{P_{t-1}} = \frac{P_t}{P_{t-1}} - 1} \quad \textbf{(3.1)}$$

where $\boldsymbol{P_t}$ and $\boldsymbol{P_{t-1}}$ are the prices of the financial asset at time $\boldsymbol{t}$ and $\boldsymbol{t-1}$ respectively. The aggregation of annual returns over period $\boldsymbol{T}$ is

$$\boldsymbol{r_T = \frac{P_T}{P_0} - 1 = \frac{P_T}{P_{T-1}} . \frac{P_{T-1}}{P_{T-2}} \dots \frac{P_1}{P_0} - 1 = \prod_{t=1}^{T} \frac{P_t}{P_{t-1}}} \quad \textbf{(3.2)}$$

Let $\boldsymbol{W_t}$ be the portfolio wealth at time, $\boldsymbol{t}$. $\boldsymbol{W_t}$ is given as

$$\boldsymbol{W_t = \sum_i P_{i,t}} \quad \textbf{(3.3)}$$

The portfolio return at time , $\boldsymbol{R_t}$, transforms as

$$\boldsymbol{R_t} = \frac{1}{W_{t-1}} (\boldsymbol{W_t} - \boldsymbol{W_{t-1}}) \quad \textbf{(3.4)}$$

$$\boldsymbol{R_t} = \frac{1}{W_{t-1}} (\sum_i \boldsymbol{P_{i,t}} - \sum_i \boldsymbol{P_{i,t-1}})$$

$$\boldsymbol{R_t} = \frac{1}{W_{t-1}} (\boldsymbol{P_{1,t}} + \boldsymbol{P_{2,t}} + \boldsymbol{P_{3,t}} + \cdots + \boldsymbol{P_{N,t}} - \boldsymbol{P_{1,t-1}} + \boldsymbol{P_{2,t-1}} + \boldsymbol{P_{3.t-1}} + \cdots + \boldsymbol{P_{N,t-1}}) \quad \textbf{(3.5)}$$

$$\boldsymbol{R_t} = \frac{1}{W_{t-1}} (\boldsymbol{P_{1,t}} - \boldsymbol{P_{1,t-1}} + \boldsymbol{P_{2,t}} - \boldsymbol{P_{2,t-1}} + \boldsymbol{P_{3,t}} - \boldsymbol{P_{3,t-1}} + \cdots + \boldsymbol{P_{N.t}} - \boldsymbol{P_{N,t-1}})$$

$$\boldsymbol{R_t} = \frac{1}{W_{t-1}} (\boldsymbol{P_{1,t-1}} \boldsymbol{r_1} + \boldsymbol{P_{2,t-1}} \boldsymbol{r_2} + \boldsymbol{P_{3,t-1}} \boldsymbol{r_3} + \cdots + \boldsymbol{P_{N,t-1}} \boldsymbol{r_N})$$

$$\boldsymbol{R_t} = \sum_i^N \frac{\boldsymbol{P_{t-1}}}{\boldsymbol{W_{t-1}}} \boldsymbol{r_i} = \sum_i^N \boldsymbol{w_i}\ \boldsymbol{r_i} \quad \textbf{(3.6)}$$

where $\boldsymbol{w_i}$ is the allocated weights.

The price of financial asset especially on stock follows a Brownian motion and by extension returns on investment due to their leptokurtic nature. Brooks (2008) opined that returns follow a random drift. The return is modeled stochastically using the Geometric Brownian motion (GBM). A process takes on geometric (also known as exponential) Brownian motion if its logarithm follows a Brownian motion (Shi, 2017). In other words, only fractional changes take place as random variation. The return on investment could be derived as

$$\boldsymbol{r_t} = \textbf{In}\ \left(\frac{\boldsymbol{P_t}}{\boldsymbol{P_o}}\right) \quad \textbf{(3.7)}$$

$$\boldsymbol{P_t} = \boldsymbol{P_0} \boldsymbol{e^{rt}} \quad \textbf{(3.8)}$$

Introducing a random variable $\boldsymbol{\beta B_t} \sim \boldsymbol{N}\ (\boldsymbol{0}, \boldsymbol{1})$, which is normally distributed with mean zero and unit variance to capture the randomness of return. It follow from **(3.8)** that,

$$\boldsymbol{P_t} = \boldsymbol{P_0} \boldsymbol{e^{rt+\beta B_t}} \quad \textbf{(3.9)}$$

Taking the natural logarithm on both sides of **(3.9),**

$$In\ \frac{P_t}{P_o} = In(e^{rt+\beta B_t}) \quad \textbf{(3.10)}$$

$$r_t = rt + \beta B_t \sim N\ (rt, \beta^2 t) \quad \textbf{(3.11)}$$

where rt is the average returns and βB_t is assumed to be normally independently distributed with zero mean and constant variance. r_t is the return at t which normally distributed with mean rt and variance $\beta^2 t$. Hence, we obtain a geometric Brownian Motion Process for return r_t.

3.6 Pension Fund Modeling

The study considered the allocation of six assets namely listed equities, corporate bonds, government securities and bonds, money market, collective investments and open/close end funds in one pension fund portfolio. Given that A_t is the value of all assets owned by the fund at time **t**, $X_{n,t}$ (decision variable) is money invested in assets n at time t and $r_{n,t}$ (random variable) which is return on investment on asset n at time t. The total asset allocated in the chosen portfolio is

$$\sum_{n=1}^{6} X_{n,t} = A_t + C_t - (B_t + E_t) \quad \textbf{(3.12)}$$

Where **t** = 1,2… The total portfolio is modeled as A_t , value of the fund at time t and contributions made at time wages of active members at time t, excluding paid out benefits, B_t and expenses incurred in running the fund, E_t. A_t, could also be described as the available asset for paying benefits. The forecast for future value of asset available is modeled as;

$$Projected\ Value\ of\ Fund = A_t \prod_{t=0}^{T}(1 + r_t) \quad \textbf{(3.13)}$$

3.7 Risk Exposure Measure

Pension funds are exposure to several risk factors. Notable among these risks are market risk, liquidity risk, operational risk and longevity risk. Risk is the probability that something goes wrong during the accumulation period of funds (An, Huang & Zhang , 2013; Booth et al., 2005). The measure for risk is important risk management process because it gives the fund manager the opportunity to assess and control by taking adequate risk mitigating process to reduce or avoid risk when they are known (Promislow, 2011 ; Bogentoft, Romeijn, & Uryasev, 2001). Risk measure is important for pension plans because of the possibility that future liabilities may exceed available assets. The study adopted the Conditional Value at Risk (CVaR) which is also known as the expected shortfall for estimating the risk exposure of financial assets of pension schemes.

According to Brooks (2008), Value at Risk (VaR) is an estimation of the probability of likely losses, which could arise from the changes in market prices due to direct effect of investment returns. In other words, it is the money loss of a portfolio that is expected to happen in a predetermined horizon with a specific confidence interval. However, the VaR does not take into account how bad the losses can be when they exceed the chosen quantile (Promislow, 2011). Due to the numerous shortcomings of VaR, the CVaR, which is modified and inculcate the worst-case scenario, is preferred. The advantages of CVaR over VaR are that, CVaR is sub-additive that is diversification reduces CVaR. It is also a coherent measure of risk. The quantile $\boldsymbol{q}_{\propto}$ is defined as**:**

$$\boldsymbol{q}_{\propto} = \boldsymbol{min}\,\{\boldsymbol{x}: \boldsymbol{F}_{\boldsymbol{X}}\,(\boldsymbol{x}) \geq \propto\} \qquad \textbf{3.14}$$

$F_X(x)$ is the $\propto$-quantile of X and X is a random number between 0 and 1 .

CVaR of X quantity given the probability of error α is mathematically written as

$$CVaR_{\propto}(X) = q_{\propto} + \frac{1}{1-\propto} E(X - q_{\propto})_{+} \quad (3.15)$$

where X is the loss in the discrete form. In the continuous distribution, the CVaR is

$$CVaR = q_{\propto} + \frac{1}{1-\propto}\int_{q_{\propto}}^{\infty}(x - q_{\propto})f(x)dx \quad (3.16)$$

where x is the loss in continuous form, $q_{\propto}$ is the probability of loss and $f(x)$ is the probability of loss distribution function of x.

3.8 Simulation

The study adopted Monte Carlo simulation for simulating 10,000 random variables for the variables of interest over 50 - year horizons. Simulation was required to do what if test analysis based on the objective of the study. This enabled the study to draw several random numbers based on the available historical parameters of the quantity of interest. This was done after the modeling of the quantity of interest and establishing the parameters to project the returns on the financial assets considered for the study. Monte Carlo simulation is a valuable tool for evaluating functional relationships between variables, visualizing the effect of the multiple correlated variables and testing strategies. Simulation model uses probability distribution assumptions on the uncertainties as inputs and generate scenarios or trials that may occur with the probabilities of the assumed probability distributions (Pachamananova & Fabozzi, 2010). Despite the complicities in simulation, it provides an approximate evaluation of a function of a random variable. The difficulty in simulation exercise is assuming and selecting the appropriate distribution for simulation.

Monte Carlo simulation involves creating scenarios for output variables of interest by generating scenarios for input variables for which we have the information. As indicated by Brooks (2008), Monte Carlo simulation is very powerful and flexible method for generating VaR estimates since any stochastic process for the underlying assets can be specified. The accuracy of estimation through simulation is related to the number of generated scenarios. In order to attain accuracy for variables with non-linear relationships, generated scenarios should be quadrupled (Pachamananova & Fabozzi, 2010; Brooks, 2008). The sampling variation of Monte Carlo is estimated by the standard error estimate denoted $\boldsymbol{S_x}$

$$\boldsymbol{S_x} = \sqrt{\frac{\boldsymbol{Var}\ (\boldsymbol{x})}{\boldsymbol{N}}} \qquad \textbf{(3.16)}$$

$\boldsymbol{Var}\ (\boldsymbol{x})$ is the variance of estimate of the quantity of interest over the $\boldsymbol{N}$ replications. To reduce the standard error by a factor, the number of replications must be increased.

3.9 Portfolio Optimization of Assets

Portfolio is the process of selecting an optimal strategy given an objective and a set of constraints (Pachamananova & Fabozzi, 2010). The objective of an investor is to maximize returns while shedding off or reducing the exposure to risk. This forms the fundamental principle of optimization. There are several methods of classifying optimization problems such as convex, linear, quadratic second-order cone and integer and mixed integer programming. The choice of any of these optimization strategies is subject to the formulation of objective function and constraints (Pachamananova & Fabozzi, 2010; Haberman & Vigna, 2002).

The study objective function and constraints are linear and therefore the linear programming optimization strategy is considered. Linear programming belongs to the

class of convex problems where local optimal solution is guaranteed to be the global optimal solution. There is no guaranteed solution for a strategy. The solutions obtained are subject to the constraints of the portfolio. This usually arises in a number of financial applications such as asset allocation and identification of arbitrage opportunities (Pachamananova & Fabozzi, 2010). In line with the study objectives, optimization problem is solved both with constraints and without constraints.

Objective 1: Let $\boldsymbol{x} = (\boldsymbol{x_1}, \boldsymbol{x_2}, \boldsymbol{x_3}, \boldsymbol{x_4}, \boldsymbol{x_5}, \boldsymbol{x_6}, \boldsymbol{x_6})$ be return vector of government securities and bonds, corporate bonds, money market, listed equities, collective investments, open and close end funds respectively.

Let $\boldsymbol{w} = (\boldsymbol{w_1}, \boldsymbol{w_2}, \boldsymbol{w_3}, \boldsymbol{w_4}, \boldsymbol{w_5}, \boldsymbol{w_6})$ be the vector of weights for government securities and bonds, corporate bonds, money market, listed equities, collective investments, open and close end funds respectively, the objective function for the first objective of the study is formulated as

$$\textbf{max } \boldsymbol{f(x) = w' x} \qquad \textbf{(3.17)}$$

$$\textbf{subject to} \begin{cases} \sum_{i=1}^{6} \boldsymbol{w_i} = \mathbf{1} \\ \sum_{t=1}^{6} \boldsymbol{\sigma_t x_t} = \boldsymbol{\sigma_A A_t} \\ \boldsymbol{x_i} \geq \mathbf{0} \\ \boldsymbol{w_1} \leq \mathbf{0.75} \\ \boldsymbol{w_2} \leq \mathbf{0.30} \\ \boldsymbol{w_3} \leq \mathbf{0.35} \\ \boldsymbol{w_4} \leq \mathbf{0.10} \\ \boldsymbol{w_5} \leq \mathbf{0.05} \\ \boldsymbol{w_6} \leq \mathbf{0.05} \end{cases} \quad \textbf{i =1…6} \qquad \textbf{(3.18)}$$

$\boldsymbol{A_t}$ is the amount available for investment at time $\boldsymbol{t}$ and $\boldsymbol{\sigma_t}$ is the average risk of the portfolio at **t**. Weights assigned is based on NPRA investment limits (see Table 3.1)

Objective 2: Objective function is formulated based on prudent man rule assumption (unrestricted by investment weights)

$$\max \; f(x) = w' x \tag{3.19}$$

$$\text{subject to} \begin{cases} \sum_{i=1}^{6} w_i = 1 \\ \sum_{t=1}^{6} \sigma_t x_t = \sigma_A A_t \\ x_i \geq 0 \end{cases} \qquad \text{i =1…6} \tag{3.20}$$

A_t is the amount available for investment at time t and σ_t is the average risk of the portfolio at t.

3.9.1 Assumptions

(a) All capital must be invested in the portfolio

(b) Only buy shares and therefore have only position-related weights. This satisfies the constraints of non-negativity.

3.10 Chapter Summary

The chapter presented the research methodology for achieving the purpose of the study. The chapter began with a description of the study population. The study population consisted of 29 MTOPS. Out of these, eight MTOPSs were selected for the study based on their market share and availability of data. The eight selected MTOPS represented approximately 82.01% of MTOPS in terms of market share. Source of data analyzed was the financial reports from 2012 to 2016 of MTOPSs obtained from NPRA. The chapter further reviewed asset allocation in Ghana citing the permissible investment limits. The chapter also indicated the models for portfolio returns, pension fund, risk exposure, simulation and optimization of assets. Portfolio returns were modeled as a geometric Brownian Motion Process and simulated over 50-year horizon in Monte Carlo simulating exercise. Finally, the chapter outlined on the assumptions underlying the optimization of financial assets process.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSIONS

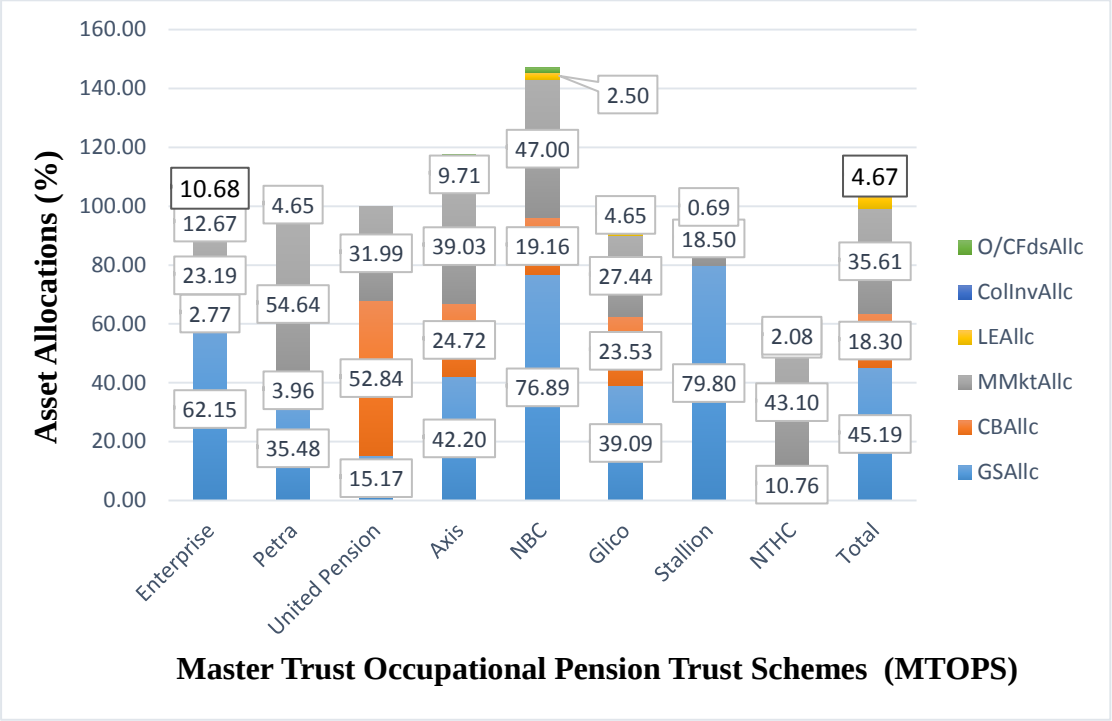
4.1 Introduction

The chapter presents the results of analysis of data obtained based on the objectives of the study. The data obtained was on financial data of eight selected MTOPS. The period for the data, which was unbalanced due to the ununiformed dates of schemes' establishment, spanned from 2012 to 2016. Data analyzed included investment returns on financial assets, contributions of member, benefits paid out to pensioners or members withdrawing from fund, administrative expenses and total asset. The first part of the chapter highlighted some descriptive statistics of the analyzed data. The values of data presented were mostly estimated in averages due to inconsistencies in the data from schemes. The second part of the study present the asset allocation distribution in MTOPS in Ghana. The third and final part of the chapter presents the results of optimizations. This presented optimal solutions estimated by the optimization solvers.

4.2 Descriptive Statistics of Selected MTOPS in Ghana

The section presents key descriptive statistics of the eight selected schemes in terms of their average asset allocation, average returns on investments, average benefits paid out to contributors over the period under study, average contribution of members, average expenses on administrative activities and total average asset available for benefit payment. For the purpose of easy identification of colours in the charts, the colour green represented open and close-end funds, blue represented collective investments, yellow represented listed equities, grey represented the money market, orange represented corporate bonds and light blue represented government securities.

Figure 4.1: Average Asset Allocation Distributions by MTOPS



Source: Author's Estimation (2018)

Figure 4.1 displays the graphical view of how the selected MTOPSs on the average, allocate financial assets in pension fund portfolio. On the average, Enterprise allocated 62.15% and 23.9% of its pension scheme's asset into government securities and money market respectively. Enterprise also allocated 12.7% and 10.68% in listed equities and open/close end funds respectively on the average between 2015 and 2016. Enterprise invested 2.7% of assets in listed equities within the same period. On the average, Petra invested as high as 54.64% of pension scheme assets in the money market while investing 35.48% into government bonds and securities.

Petra invested 3.96%, 4.14%, and 4.65% in corporate bonds, listed equities, and collective instruments respectively on the average, between 2013 and 2015. The result further revealed that United Pension invested as high as 52.84% of total MTF in corporate bonds, 31.99% in the money market, and 15.17% in government securities and bonds. Axis invested 42.20% of MTF in government bonds and securities and

39.03% in the money market. It also allocated 24.72% and 9.71% in corporate bonds and listed equities respectively.

Negotiated Benefit Company (NBC) allocated as high as 76.89% in government bonds and securities and 47.00% in the money market (T-bills and cash deposits). The results also revealed that NBC invested 2.5% and 1.46% of MTF in listed equities and open/close end funds respectively between 2014 and 2015. Glico, on the average allocated 39.09% of MTF in government bonds and securities and 27.44% of MTF in the money market. Glico also allocated 23.53% of MTF in corporate bonds and 4.65% in listed equities.

In addition, 4.65% of Glico's MTF allocated to collective investments between 2014 and 2016. On the average, Stallion Trust allocated as high as 79.80% of MTF in government bonds and securities as well as 18.03% of MTF in the money market. The results also revealed that, the average allocation of MTF into listed equities and other collective investments was 1.1% and 0.69% respectively between 2013 and 2015. Finally, NTHC, which is the smallest fund in terms of MTF size, allocated 43.10% of MTF in the money market and invest 10.76% of MTF in government bonds and securities on the average. It further revealed that, an average allocation of 2.08% of MTF was invested into other collective investments between 2015 and 2016 by NTHC.

On the average MTOPSs allocated higher proportion of pension fund assets in government securities followed by money market and corporate bonds. Proportion of assets into collective investments, listed equities, and open/close end fund portfolios were smaller. Empirically, the MTOPS allocated 43.01% of MTF in government bonds and securities and 35.61% of MTF in the money market specifically in T-Bills

and cash deposits on the average. The schemes under the period of review also allocated 18.30%, 5.79%, 3.02% and 4.67% of MTF in corporate bonds, listed equities, collective investments, and open/close end funds respectively on the average. The results of the analysis also indicated that schemes invested in four asset classes at a time while some majority of the schemes were involved in acts of violation against the regulations of NPRA in terms of maximum limits to investments.

According to the NPRA investment restrictions (2012), Corporate Trustees can only invest up to 75% of assets into government bonds and securities, 30% in corporate bonds, 35% in the money market, 10% in listed equities, 5% in other collective investments and open/close end funds respectively. For instance, Petra, Axis and NBC's allocation strategies into low-risk financial instruments such as T-bills, government bonds and securities and cash deposits exceeded the investment restrictions/limits of 35% of MTF in the money market and 75% of MTF in government bonds and securities. Enterprise Trust investments in listed equities exceeded the maximum investment limit of 10% while United Pension's allocation of MTF into corporate bonds exceeded the maximum investment limit of 30%. Large MTOPS in terms of market share of asset under management invested in more risky financial assets than smaller schemes.

Table 4.1: Correlation Matrix of Asset Allocations of Financial Instruments

	Government Securities	Corporate Bonds	Money Market	Listed Equity	Collective Investments	Open/Close end Funds
Government Securities	1					
Corporate Bonds	-0.305	1				
Money Market	0.204	0.410	1			
Listed Equity	0.010	-0.044	0.555	1		
Collective Investments	0.133	-0.185	-0.447	-0.408	1	
Open/Close end Funds	-0.119	-0.287	0.241	0.739*	-0.569	1

* Correlation is significant at the 0.05 level (2-tailed)

Source: Author's Estimation (2018) using SPSS version 20.0

Table 4.1 above displays the correlation matrix between allocations of financial assets of MTOPS. The result shows a negative but weak correlation of -0.305 between government bonds and securities and corporate bonds. This was statistically insignificant. The relationship is indicative of the trade-off between allocations of assets in a more secured government bonds and securities and relatively riskier asset such as corporate bonds. The implication of the relationship is that as fund managers shift from investing funds in government bonds and securities, they tend to invest into high yielding instruments with higher risk such as corporate bonds.

The results also reveal a negative but weak correlation of -0.119 between open/close end funds and government bonds and securities. This implies a bad investment allocation in open/close end funds and corporate bonds do not directly affect government bonds and vice versa. However, government bonds and securities correlated positively with allocations into listed equities, collective investments, and

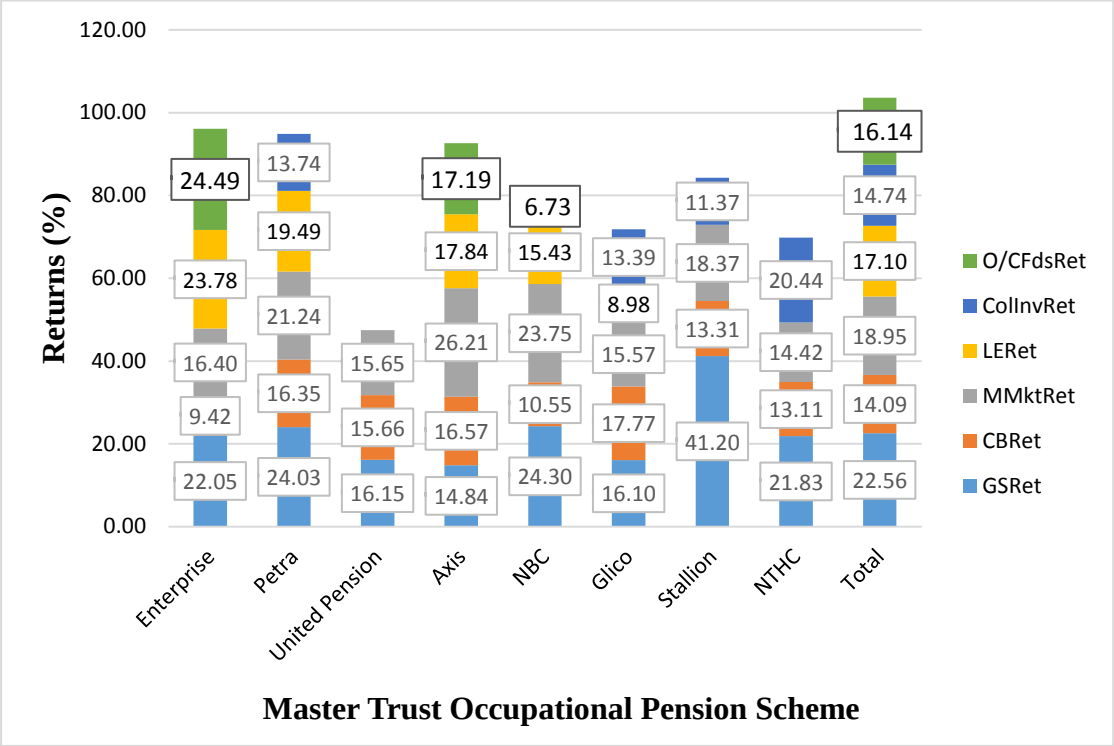
the money market. The implication is that increase in investment allocations of MTF in government bonds and securities increases allocations into listed equities, collective investments, and the money market portfolio.

Corporate bonds allocations of MTF correlated negatively with listed equities, collective investments, and open/close end funds while the money market correlated positively by corporate bonds (0.410). The implication is that a fund manager reduces allocation in listed equities, collective investments, and open/close end funds when investments in corporate bonds are increased. This was however, statistically insignificant. In addition, increased allocation of MTF funds in corporate bonds resulted in an increase in allocation of MTF into the money market. The positive correlation between corporate bonds and the money market was however, found to be statistically insignificant. Finally, open/close end funds correlated positively but weak with the money market while there is a statistically significant and positive correlation of open/close end funds with listed equities.

Judd and Yin's (2012) study in Global Pension Assets indicated that the Ghanaian pension sector invest predominnatly in T-bills, cash deposits and government securities. This collaborates with the findings of this study as the result indicates that significant amount of pension funds are invested in low-risk assets. Researches conducted in most developing economies indicate that most of the asset classes invested in are Government securities, property, cash deposits and quoted shares were relatively more important in determining the overall performance of the pension funds (Kiplagat, 2014). Kiplagat (2014) demonstrated that 58% of the variability in fund performance is explained by the allocation of assets and 42% was due to other factors

of timing of investments, securities selection and manager's selection within as asset class and the management style adopted by the fund managers of the fund.

Figure 4.2: Average Return Distributions of MTOPS



Source: Author's Construct (2018) using Excel 2013

Figure 4.2 displays a chart of annual average returns of financial assets of MTOPS in Ghana. The investment returns pattern of Enterprise revealed an average annual returns of 22.05%, 9.42%, 16.40%, 23.78% and 24.49% on portfolio investments in government securities, corporate bonds, money markets, listed equities, and open/close end funds respectively. Petra Trust earned an average of 24.03% on government securities and bonds investments, 16.35% on corporate bonds, 21.24% on the money market, 19.49% on listed equities, and 13.74% on collective investments over the period under review. United Pension earned 16.15% on government securities and bonds, 15.66% investment return on corporate bonds and 15.65% return on investment from the money market. The average annual return pattern of Axis

showed investment return of 14.84% on government securities and bonds, 16.57% on corporate bonds, 26.21% on money market, 17.84% on listed equities and 17.19% on open/close end funds.

The average investment return pattern of NBC indicated that 24.30% was earned on government securities and bonds, 10.55% on corporate bonds, 23.75% on the money market and 15.43% on open/close end funds on the average in the period of review. On the average, Glico Trust made net gain of 8.98% of returns on investment in listed equity investments, 16.10% investment return on government securities and bonds, 17.77% investment return on corporate bonds, 15.57% investment returns on the money market and 13.39% on other collective investments.

Stallion Trust recorded an average investment return of 41.20% on government securities and bonds, 13.31% on corporate bonds, 18.37% on the money market and 11.37% from other collective investments. Estimates of investment returns of NTHC revealed an average return of 21.83% on government securities and bonds, 13.11% on corporate bonds, 14.42% on the market and 20.44% on open/close end funds. The general average returns for MTOPS was 22.56% on government securities and bonds, 14.09% on corporate bonds, 18.95% on the money market, 17.10% on listed equities, 14.74% on other collective investments and 16.13% on open/close end funds. On the average, investments in government securities and bonds were more attractive followed by investment on the money market contrary to the assertion that risk free instrument earn lower investment returns.

Table 4.2: Correlation Matrix of Investment Returns of Financial Assets

	Government Securities	Corporate Bonds	Money Market	Listed Equity	Collective Investments	Open/Close end Funds
Government Securities	1					
Corporate Bonds	-0.372	1				
Money Market	-0.325	-0.020	1			
Listed Equity	0.277	-0.178	-0.182	1		
Collective Investments	-0.313	-0.222	0.292	-0.128	1	
Open/Close end Funds	0.319	-0.235	-0.328	0.801**	-0.301	1

**. Correlation is significant at the 0.01 level (2-tailed)

Source: Authors' Estimation (2018) from SPSS version 20.0

Table 4.2 shows the correlation matrix of investment returns among some selected financial instruments in the MTOPS in Ghana. As indicated in the table, government securities and bonds had weak and negative correlation with investment returns from the money market, other collective investments, and corporate bonds. The implication is that corporate bonds, the money market and other collective investments earned considerably higher, given a fall in investment returns on government bonds.

The relationship is also indicative of the independency between these financial assets. In the event of bad investment returns from corporate bonds, the money market, and collective investments do not affect government bonds returns adversely. Investment returns on corporate bonds correlated negatively with government securities, listed equities, the money market, collective investments, and open/close end funds. This illustrated the diversity among financial asset returns. As investment returns on corporate bonds increase, returns on other assets are likely to fall and vice versa. In terms of risk trade-offs, high investment returns from corporate bonds is accompanied with high risks and vice versa.

This is appropriate for portfolio managers whose objective is to assemble negatively correlated financial instruments in order to mitigate risk of loss in the total portfolio. Investment returns from the money market correlated negatively with listed equities and open/close end while that from collective investments correlated positively with the money market. Investment returns on the money market directly affect returns on collective investments. Listed equities correlated positively with open/close end funds. This was statistically significant.

Listed equities also correlated negatively with investment returns from collective instruments while returns on collective investments and open/close end fund correlated negatively. This implies a reduction in investment returns of collective instrument is likely to increase returns on open/close end funds. The result of the correlation is indicative of the diversification options of MTOPS. This implies that allocation of funds into combination of any two or more of the instruments is likely to reduce the total portfolio risk while earning high investment returns.

Judd and Yin (2012) corroborated the result of the study by indicating that the Ghanain pension fund invest predominnatly in T-bills, cash deposits and government securities. This collaborates with the findings of this study as the results indicates that significant amount of pension funds are invested in low-risk assets. Alda, Ferruz and Gallagher (2012) indicated that the stronger performing pension funds have a higher exposure to size and book-to-market risk. Small-sized funds with less volatility exhibit stronger alpha performance.

Table 4.3: Distribution of Financial Instruments (in millions of Ghana Cedis)

Assets	Average Returns (%)		Std Dev. (%)		Jarque-Bera
	Original	Simulated	Original	Simulated	
Government Securities	22.56	22.45	13.89	7.98	91.77 (0.0000)
Corporate Bonds	14.09	13.47	8.14	46.77	16.29(0.0003)
Money Market	18.95	18.88	8.46	4.86	52.72(0.0000)
Listed Equities	17.10	16.85	39.70	19.93	28.17(0.0000)
Collective Investments	14.74	14.67	9.38	5.34	26.92(0.0000)
Open/Close-end Funds	16.13	16.05	10.78	6.19	70.67(0.0000)

Source: Author's Estimation (2018) Frequency/Simulation (N=23/10,000)

Table 4.3 shows the distribution of financial assets and the comparative analysis between the original values of returns on data and simulated values of the raw data. Due to inconsistence in data and few data points from individual MTOPS, data was simulated for further in-depth analysis. The preliminary analysis showed significant for all return averages for the various asset classes in a Jarque-Bera test. This implied that average returns for the entire asset classes were not normally distributed which is typical of financial data.

The leptokurtic nature of returns necessitated the modeling of returns in a Geometric Brownian Motion (GBM) before simulating 10,000 random numbers. The results showed slight variances in values between the original and simulated data. The differences are due to variance in time (See Appendix for graphs). Zhang and Chen (2016) investigated a mean–variance asset–liability management (ALM) problem using geometric Brownian motion and applying the Monte Carlo simulation for several numerical examples to demonstrate influence of parameters.

4.3 Optimal Solutions to Optimization Strategies (Restrictions) of MTOPS

This section addresses the first research question. The objective was to find the optimal portfolio strategy for MTOPS in Ghana given the investment restrictions/limits by NPRA. The following solutions given some underlying assumptions were obtained and displayed in Table 4.4.

Table 4.4: Optimal Asset Strategy for MTOPS with Restrictions

Financial Asset	Weights of Returns (%) Portfolio Return (μ) and Risk (σ)			
	μ = 20.53% σ = 6.74%	**μ=20.49% σ = 6.73%**	**μ = 20.56% σ = 6.79%**	**μ = 19.31% σ =14.27%**
Government Securities	55	55.09	55.11	43.01
Corporate Bonds	0	0	0.08	17.48
Money Market	35	34.99	34.99	32.99
Listed Equities	0	9.83	0.81	3.89
Collective Investments	0.05	0.047	4.75	1.44
Open and Close end Funds	0.05	0.049	4.98	1.48

Source: Authors' Estimation (2018) using R

Table 4.4 presents the optimal solutions for MTOPS given the assumption of full investment and long only strategies. The assumptions ensured that all the assets were invested in portfolio and did not allow opportunity for selling of financial assets. The result indicated that given the minimal risk level of 6.74% for losing investment returns in a portfolio, MTOPS must invest 55% of MTF in government securities and bonds, 35% in the money market and 0.05% in collective investments and open/close end funds respectively to earn an average investment return of 20.53% annually on portfolio. MTOPS could also operate at a reduced risk of 6.73% while they earn an average investment return of 20.49% annually.

The optimal solution for setting an objective to fully maximum investment returns while investing a minimal amount in all the six financial assets indicated that MTOPS managers must invest 55.11% of MTF in government securities and bonds, 0.08% in

corporate bonds, 34.99% in the money market (T-bills and other forms of cash deposit), 0.81% in listed equities, 4.75% in other collective investments and 4.98% in open/close end funds. For the purpose of comparative analysis, the optimal solution for MTOPS in Ghana based on prevailing return averages for each financial asset was determined. The result indicated that MTOPS were operating at a maximum investment returns on assets of 19.31% at a higher risk of 14.27% given the current 43.01% in government securities and bond, 17.48% in corporate bonds, 32.99% in the money market, 3.89% in listed equities, 1.44% in collective investments and 1.48% in open/close end funds.

4.4 Optimal Solutions to Optimization Strategies (Unrestricted)

This section addresses the second research question. The objective was to find the optimal portfolio strategy for MTOPS based on the prudent person's principle which allows fund managers to invest in selected financial assets in a portfolio. This is based on some principal criteria without restrictions. The following solutions given some underlying assumptions were obtained and displayed in table 4.5. Key among the assumptions was the assumption of undiversified portfolios (investing only one asset) and diversified portfolios based on the discretion of the fund managers.

Table 4.5: Optimal Asset Strategy for MTOPS without Restrictions (Undiversified)

Financial Asset	Weights of Returns (%) Portfolio Return (μ) and Risk (σ)					
	μ = 22.53% σ = 8.12%	μ = 13.53% σ = 47.52%	μ = 18.99% σ = 4.94%	μ = 17.18% σ = 20.29%	μ = 14.79% σ = 5.28%	μ = 16.17% σ = 6.13%
Govt. Securities	1	0	0	0	0	0
Corporate Bonds	0	1	0	0	0	0
Money Market	0	0	1	0	0	0
Listed Equities	0	0	0	1	0	0
Col. Investment	0	0	0	0	1	0
Open/Close end Funds	0	0	0	0	0	1

Source: Authors' Estimation (2018) using R

Table 4.5 shows the results of optimization process of undiversified portfolios. The objective was to ascertain which financial assets were risky and yields higher investment returns. The most risky asset among the six assets was corporate bonds at 47.52% followed by listed equities at 20.29%. The money market was less risky at 4.94% followed by other collective investments at 5.28% and open/close end funds at 6.13%.

The portfolio with a highest investment return of 22.53% was government securities and bonds followed by the investment return of 18.99% on the money market. The investment return on listed equities was 17.18% but very risky. Open/close end funds also had high investment return of 16.17% at a reasonable risk level. The study further revealed that risky corporate bonds yielded the least investment return of 13.53% which violates the return – risk trade off principle.

Table 4.6*:* Optimal Asset Strategy for MTOPS without Restrictions (Diversified)

Financial Asset	Weights of Returns (%) Portfolio Return (μ) and Risk (σ) μ =18.57 % σ = 6.67% Portfolio 1	μ = 19.85 % σ = 13.27% Portfolio 2	μ = 20.93% σ = 12.43% Portfolio 3	μ = 18.44% σ = 20.46% Portfolio 4
Govt. Securities	41.70	55	70	40
Corporate Bonds	0.000026	12	10	30
Money Market	11.28	18	10	15
Listed Equities	1.41	10	7	10
Col. Investment	44.23	2.5	1.2	2.5
Open/Close end Funds	1.39	2.5	1.8	2.5

Source: Authors' Estimation (2018) using R

Table 4.6 displays the optimal solutions for unrestricted allocation of assets in four different portfolios by selecting from six asset types. Portfolio 1 indicated that fund managers must invest 41.70% in government bonds and securities, 0.000026% in corporate bonds, 11.28% in the money market, 1.41% in listed equities, 44.23% in other collective investments and 1.39% in open/close funds. The underlying assumptions for Portfolio 1 were to invest in less risky financial assets with less than 2% in risky assets.

An average investment return of 18.57% was obtained at a minimal risk of 6.67%. The objective of Portfolio 2 was to invest more than 90% of MTF in top two risky and other two less risky assets. Hence, higher weights were assigned to corporate bonds and listed equities in relative terms. The other two assets with higher weights was the money market and government securities and bonds. The result indicated 19.85% investment return on Portfolio 2 with a significantly reduced risk of 13.27% relative to higher risk associated with the two risky assets.

Portfolio 3 was created apportioning higher weight to financial assets with the highest rate of investment returns. The portfolio was created using 70% in government

securities and bonds, 10% in corporate bonds, 10% in the money market, 7% in listed equities, 1.8% in open/close end funds and 1.2% in other collective investments. The result indicated an investment return of 20.93% with 12.43% average portfolio risk.

Even though the investment return earned was higher than optimal solution obtained the restricted portfolios, the risk of losing part of the return was higher. Finally, Portfolio 4 invested fully in risky assets based on the industrial investment limits. This was created by investing 40% of MTF in government securities and bonds, 30% in corporate bonds, 15% in the money market, 10% in listed equities, 2.5% in collective investments and 2.5% in open/close end funds. The investment return on Portfolio 4 was 18.44% with a risk of 20.46%.

The result of the optimization indicated that fund manager could operate at optimal levels while obeying the regulations of the NPRA. However, such portfolios were risky. Again, even though fund manager could operate using the prudent man's rule, it must be stated that such portfolios are riskier than portfolios created using quantitative restrictions. Davis (2000) indicated that prudent person rule was superior to quantitative restrictions for pension funds except in certain specific circumstances. This is because fund managers are allowed to invest given a certain level of risk in high return assets.

The situation may be slightly different when restrictions binding in asset allocation. Papaioannou and Rentsendorj (2015) argued that investment performance critically depended on its permissible asset classes, risk tolerance and strategies mandated in attaining the set portfolio objectives, such as stability of returns over an assumed time horizon. They added that to achieve a long-term investment objective portfolio appropriate asset weights rebalancing may allow for higher returns.

Horváthová, Feldthusen and Ulfbeck (2017) added that under the prudent person principle, the approach towards investments is liberalized, and it is of best interest to beneficiaries of pension funds. It is, however, associated with higher risk, which is unfavourable for developing economies. Comparing the optimal solutions under quantitative restrictions and unrestricted optimization showed that the unrestricted optimization was superior to the restrictive optimization. This confirms evidence from the European Commission (1999) that using only quantitative restrictions for optimization of asset allocation and security selection result in suboptimal return and risk taking.

4.6 Risk Exposure of Financial Asset Returns of MTOPS

This section addresses the third research question. This sought to estimate the risk exposure of average returns based on the MTOPS current indicators. Due to small data points and inconsistent data obtained, simulated values were used. Brooks (2008) indicated that the value –at – risk of portfolios estimations are data that are more appropriate when large are simulated and use. Table 4.7 displays the results on CVaR for returns on all the financial assets and the total portfolio as well.

The section further present some projected values of MTF over a time horizon and the returns they are likely to lose in the worst-case scenarios over the same period. The first batch of pensioners who are expected to benefit from MTOPS will be in 2021. The projection is made using average weights from the restricted optimization. In addition to that, the current investment return average was also used for comparative purposes. The study there attempted to predict the fund values of MTF.

This is also presented in table 4.8 below.

Table 4.7: Conditional Value at Risk for Financial Asset Returns and the total Portfolio of MTOPS

Risk Exposure of Returns	Govt. Sec.	Corp. Bonds	Money Market	Listed Equities	Collective Investment	Open/Close end Funds	Total Portfolio Risk
CVaR (95%)	0.0932	-0.6355	0.1088	-0.1598	0.0587	0.0589	0.1281
CVaR (99%)	0.0878	-0.6670	0.1056	-0.1733	0.0551	0.0546	0.0953
CVaR (99.9%)	0.0868	-0.6728	0.1050	-0.1757	0.0545	0.0537	0.0874

Source: Authors' Estimation (2018) Using R

As indicated by the table, given 95% confidence level, 9.32% returns on government bonds and securities investment is lost in the worst-case scenario. The worst-case scenario return on government securities and bonds given 99% and 99.9% confidence levels are 8.78% and 8.68% respectively. The CVaR of corporate bonds returns given a confidence interval of 95% was – 63.55%. Given a confidence interval of 99%, the investment returns on corporate bond lost in the worst-case scenario is given as – 66.70%. The worst-case scenario at a confidence interval of 99.9% is – 67.28%.

The negated percentages are because of the negative part of the distribution. This confirms corporate bonds as a risky asset. The money market is expected to lose 10.88% of investment return in the worst-case scenario at 95% certainty. Given a confidence levels of 99% and 99.9%, the investment is likely to lose 10.56% and 10.50% respectively in the worst-case scenarios. Listed equities are expected to lose -15.98% of investment return in the worst-case scenario at 95% certainty. Given a confidence levels of 99% and 99.9%, the investment is likely to lose -17.33 % and -17.57% respectively in the worst-case scenarios.

Other collective investment is expected to lose 5.87% of investment return in the worst-case scenario at 95% certainty. Given a confidence levels of 99% and 99.9%, the investment is likely to lose 5.51% and 5.45% respectively in the worst-case

scenarios. The open/close end fund is expected to lose 5.89% of investment return in the worst-case scenario at 95% certainty. Given a confidence levels of 99% and 99.9%, the investment is likely to lose 5.46% and 5.37% respectively in the worst-case scenarios. The total portfolio risk exposure is 12.81% at 95% confidence level in the worst-case scenario. Given a confidence levels of 99% and 99.9%, the total portfolio investment is likely to lose 9.53% and 8.74% respectively in the worst-case scenarios.

This collaborate the finding of Chen, Sun and Li (2017) that corporate bonds and equities are high-risk assets. They suggested that significant proportion of pension assets should be invested in direct equity investments, bonds and stocks. This is because the yield higher returns in the long term than low risk assets.

Table 4.8: Projected MTOP Fund Values (in GHS)

Year	Time Horizon	Scenario 1 (Best Case)	Scenario 2 (Worst Case)	Scenario 3 (Sector Average)	CVaR (95%)
2018	-	961,147,112.6	879,673,578.6	943,902,426.9	-
2021	**3 years**	**1,116,829,559**	**925,078,391.3**	**1,079,667,011**	**0.0601**
2026	8 years	1,479,052,024	1,011,634,659	1,401,193,093	0.0636
2031	13 years	2,032,222,975	1,114,087,083	1,902,676,386	0.0661
2036	18 years	2,885,799,721	1,235,561,571	2,695,913,521	0.0662
2041	23 years	4,212,797,904	1,379,934,987	3,970,876,908	0.0687
2046	28 years	6,287,013,399	1,551,682,507	6,059,331,523	0.0794
2051	**33 years**	**9,540,507,329**	**1,756,234,114**	**9,555,455,872**	**0.0897**
2056	**38 years**	**14,656,615,701**	**2,000,186,708**	**15,557,495,728**	**0.1058**
2061	**43 years**	**22,717,311,113**	**2,291,362,629**	**26,157,768,833**	**0.1084**

Source: Authors' Estimation (2018) Using Excel

As displayed in Table 4.8, the fund value is expected to be GHS 961,147,112.6 at the end of 2018 all things being constant. In the worst-case scenario, the fund value is expected to be GHS 879,673,578.6. Based on the current average of portfolio investment returns of MTOPS, the expected amount is GHS 943,902,426.9. The fund

value is expected to grow from GHS 961,147,112.6 to GHS 1,116,829,559 in 2021 for the best-case scenario and from GHS 879,673,578.6 to GHS 925,078,391.3 in the worst-case scenario with the risk of losing 6.01% of the investment returns in the worst-case scenario at 95% confidence level. Based on the current MTOPS weights, the expected fund value will grow from GHS 943,902,426.9 to GHS 1,079,667,011 in 2021. Interestingly, the current average exponentially outgrows the expected growth in the best-case scenario from 33 years and beyond. The fund will grow from GHS 6,287,013,399 in 2046 to GHS 9,540,507,329 in 2051 in the best-case scenario with risk exposure of 7.94% while the sectorial average is expected to grow from GHS 6,059,331,523 in 2046 to GHS 9,555,455,872 in 2051 with risk exposure of 8.79% with 95% certainty in the worst-case scenario.

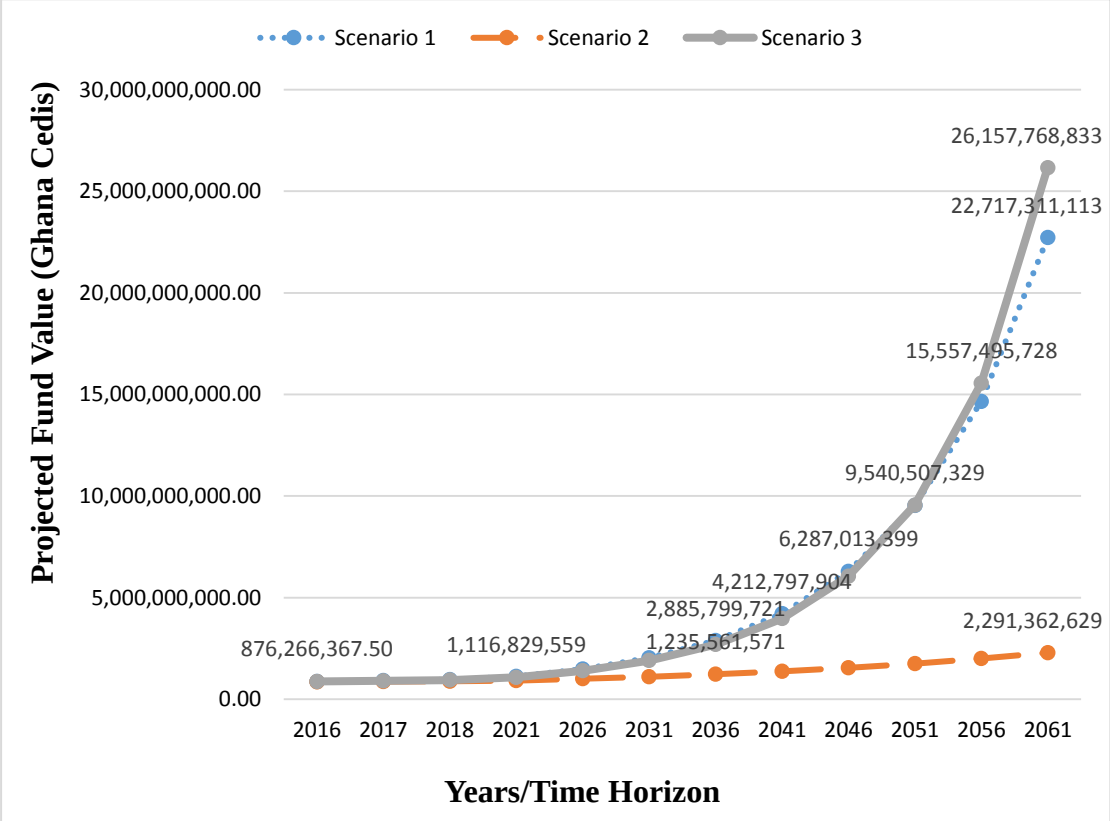
Intuitively the fund amount in the Scenario 3 outgrows the fund amount in Scenario 1 from 2046 to 2051 due to the accumulation factor cumulating from allocating higher weights in risky assets that are expected to yield higher returns in the long term. Due to the high risk associated with financial assets such as corporate bonds and listed equities, MTOPS who are likely to invest in such risky assets will experience marginal investment return losses.

However, risky assets losses are stabilized over time, earn higher returns to overcome portfolios that are likely to invest only into risk free assets during the accumulation period. This explains why large MTOPSs in term of market share such as Petra and Enterprise Trust invest considerably in risky assets. However, small funds allocate smaller weights to risky assets due to investment risk to build up capital that could be used to invest in risky assets in future. The CVaR values also indicate that as the fund

grows the risk exposure increases. The figure below displays the trend in the growth of fund values.

Chen, Sun and Li (2017) confirms that time horizon have significantly effect on asset allocation of pension fund. If time horizon is longer, more time horizon significantly influences asset allocation of pension fund. The effect was more profound in longer time horizons. Equity investments and stocks of pension funds perform better in the longtime.

Figure 4.3: Projection of MTOPS Fund Values (2016 - 2061)



Source: Author's construct (2018) Using Excel

As displayed by the chart fund values for Scenario 1 exceeds the fund value of Scenario 2 and fund value of Scenario 3 marginally. The difference in fund values between Scenario 1 and Scenario 2 begins to widen significantly after 2021. This is

due to the cumulative performance of funds with respect to accumulation factor that is expected to grow exponentially. The losses made in the worst-case scenario in Scenario 2 reduce the growth rate of the fund value. The difference between the growth in Scenario 1 and Scenario 3 is fundamentally derived from the allocations assigned to each of the financial instrument. Empirical studies show risky assets results in capital losses in early investment period. However, the high returns yielded on risky assets in the long term builds up appreciable accumulation factor that exponentially outgrows portfolios created with less risky assets.

As confirmed by Papaioannou and Rentsendorj (2015) investment performance critically depended on its permissible asset classes, risk tolerance and strategies mandated in attaining the set portfolio objectives, such as stability of returns over an assumed time horizon. Time horizon significantly influences asset allocation of pension fund. If time horizon is longer, more time horizon significantly influences asset allocation of pension fund. If the time is longer, more allocation to stock and equity investments helped pension fund to achieve better performance (Chen, Sun & Li, 2017).

From the similar theoretical perspective, Davies (2000) examined compared portfolio regulations to prudent man rule for life insurance and pension in UK. He asserted that institutional investors are assumed to make long-term investments using the prudent person's rule. He found quantitative restrictions to be less superior to prudent person rule for pension funds except for certain specific circumstances.

Although general restrictions was desirable for life insurance in most cases than pension funds, using the prudent person rules were more appropriate for pension funds. Similarly, Jomer (2013) asserted that the performance of firms improve when

managers adopt skills and expertise rather than relying on mere luck. Adopting the appropriate skills by MTOPS fund managers to allocate assets strategically would enable pension fund value to increase astronomically to meet the objective of the reform. This could be done through strategic allocation of more assets in high-risk asset based on financial market indicators. Skilled managers produce risk adjusted excess return large enough to cover the expenses imposed on the investor through prudent person principle (Jomer, 2013).

4.7 Summary of Chapter

The chapter began with the descriptive statistics of MTOPSs data on asset allocations (weights) and returns. The findings indicated the violations of investment limits by some of the MTOPS. The average asset allocation of MTOPS in the financial market, however, indicated a general compliance of regulations even though the average asset allocation to the money market exceeded the investment regulation guidelines. Generally, correlation between the returns of financial asset was negative indicating a more diverse financial market. Due to inconsistent data, the chapter simulated data for the optimization and risk exposure. The mean and standard deviation of simulated data did not vary widely from the original data. Optimal solutions were obtained from the optimization process were presented and discussed. The finding showed some persistence in the current average weights of MTOPS in the long-term and outperforms the optimal solution from 33 years.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The section presents the summary of the major findings of the study that answers the research questions raised based on the objectives of the study. It also gives a brief description of the methodology use for analyzing the study and some of the limitations encountered during the study. It further draws conclusions from the findings and appropriate recommendations made. Finally, some further studies are recommended based on the result of the study.

5.2 Summary

The objective of the study was to investigate the optimal asset allocation of defined contribution pension funds in Ghana. However, the study specifically, optimizes the some selected privately managed Master Trust Occupational Pension Schemes (MTOPS) in Ghana in terms of their assets under management. The study compared optimized asset allocations of selected schemes using quantitative restrictions provided by NPRA and the non-restricted scenario underpinned by the "prudent man rule". The study also projected fund values for MTOPS over a 50-year time horizon. The study modeled investment returns as Geometric Brownian Motions and simulated 10,000 scenarios.

First, the results of the study showed that on the average MTOPS allocated 43.01% of MTF in government bonds and securities and 35.61% of MTF in the money market specifically in T-Bills and cash deposits, 18.30% in corporate bonds, 5.79% in listed equities, 3.02% in other collective investments, and 4.67% in open/close end funds. In addition, government securities and bonds correlated negatively with corporate bonds

and open/close end funds but correlated positively with the money market, listed equities, and other collective investments.

Corporate bonds returns correlated negatively with listed equities, collective investments and the money market. The money market correlated positively with listed equities and open/close end funds but negatively with collection investment returns. Listed equities on the other hand correlated negatively with collective investments and significantly positive with open/close end funds. The result also show that collective investments correlated negatively with open/close end funds.

Secondly, the optimal solution for setting an objective to maximize investment returns while investing a minimal amount in all the six financial assets indicated that MTOPS managers must invest 55.11% of MTF in government securities and bonds subject to the investment restrictions by NPRA. At optimal levels, fund managers are also required to invest 0.08% in corporate bonds, 34.99% in the money market (T-bills and other forms of cash deposit), 0.81% in listed equities, 4.75% in other collective investments and 4.98% in open/close end funds.

On the other hand, the optimal solution under the unrestricted assumption was investing 70% in government securities and bonds, 10% in corporate bonds, 10% in the money market, 7% in listed equities, 1.8% in open/close end funds and 1.2% in other collective investments. The result indicated an investment return of 20.93% with 12.43% average portfolio risk as compared to 20.56% investment return with 6.79% portfolio risk in the restricted optimization.

Finally, the conditional value-at-risk for the total portfolio was 12.81% at 95% confidence level in the worst-case scenario. Given a confidence levels of 99% and 99.9%, the total portfolio investment is likely to lose 9.53% and 8.74% respectively in

the worst-case scenario. The expected fund value grows from GHS 961,147,112.6 to GHS 1,116,829,559 by the end of 2021 for the best-case scenario and from GHS 879,673,578.6 to GHS 925,078,391.3 in the worst-case scenario with the risk of losing 6.01% of the investment returns in the worst-case scenario at 95% confidence level. The prevailing growth of the fund based on the current weighted averages grows from GHS 943,902,426.9 to GHS 1,079,667,011 by the end of 2021.

5.3 Conclusions

Majority of MTOPS in Ghana such as Petra, United Pension, and NBC on the average, violate one or more investment restriction guidelines by exceeding investment limits of portfolios.

The approved and permissible financial assets investment correlated negatively. This diversifies the portfolio risk exposure when financial assets selected carefully.

MTOPS generally allocate higher proportion of pension fund assets in government securities followed by money market and corporate bonds. Proportion of assets into collective investments, listed equities, and open/close end fund portfolios were smaller.

At optimal levels, portfolios with investment restriction maximize returns with less risk exposure while returns on unrestricted portfolios are slightly higher but associated with high-risk exposure. The implication is that high-return investment is associated with higher risk exposure.

The growth of Master Trust Fund is dependent on strategic asset allocation and tolerable level of portfolio risk. Risky assets increase their investment returns

exponentially and builds up appreciable accumulation factor during the accumulation period that can significantly increase fund values over time.

5.4 Recommendations

NPRA should properly supervise the allocation strategies of Corporate Trustees and fund managers through risk-based assessments and ensure that the practices of MTOPS are in conformity to the rules and regulations of the Pension Act 766.

NPRA as part of their investment guidelines should set minimum investment restrictions that would ensure that MTOPS diversifies their investment portfolios to include reasonable level of risky assets that may earns higher returns than risk free assets. This would discourage MTOPS that invest large proportions of their MTF into government securities and bonds and the money market to invest in listed equities and corporate bonds that increase fund values significantly in the long term.

NPRA should also allow to some extent, fund manager to use their discretion and risk-based approaches to allocate assets in high yielding investment to ensure significant pension for pensioners in the future.

Lastly, fund managers should be courage to use scientific and risk-based approach to invest in lucrative portfolios rather than the current practice of shifting from one asset to the other that yields higher returns at the beginning of each year.

REFERENCES

Aaron, H.J. & Reischauer, R.D. (1998). *Countdown to Reform: The Great Social Security Debate.* New York: Century Foundation Press.

Adami, R., Gough, O., Mukherjee, S., & Sivaprasad, S. . (2014). An empirical analysis of the performance of pension funds: evidence from UK. *Studies in Economics and Finance, 31(2)*, 141-155.

Alda , M., Ferruz, L., & Gallagher, L.A. (2012). Performance of Spanish pension funds: robust evidence from alternative models. *Applied Financial Economics*, 297-314.

An, H., Huang, Z., & Zhang, T. (2013). What determines corporate pension fund risk-taking strategy? *Journal of Banking & Finance (37)*, 597-613.

Angelidis,T., & Tessaromatis,N. (2010). The efficiency of Greek public pension fund portfolios. *Journal of Banking & Finance 34* , 2158–2167.

Antón, J.-I., Mu˜noz, D.B.R., & Fernández-Macías, E.,. (2011). Supplementary private pen-sions and saving: evidence from Spain. *9th International Workshop on Pension, Insurance and Saving* . Paris.

Arza, C. & Kohli, M. (2008). *Pension Reforms in Europe:Politics, Policies and Outcomes.* London: Routledge.

Ashaley, W. (2012). *Pension Reform in Ghana: A Study of Pension Scheme of Three Tiers.* Campinas: UNICAMP.

Asher, M. (1998). The Future of Retirement Protection in Southeast Asia. *International Social Security Review, 51 (1)*, 3-176.

Blake, D., Sarno, L. & Zinna, G. (2017). The market for lemmings: The herding behavior of pension funds. *Journal of F inancial Markets*, 1-17.

Blake, D., Wright, D. & Zhang, Y. (2014). Age-dependent investing: Optimal funding and investment strategies in definedcontribution pension plans when members are rational life cycle financial planners. *Journal of Economic Dynamics and Control, 38(1)*, 105-124.

Bodie, Z. & Davis, E. P. (2000). *The Foundations of Pension Finance.* London: Edward Elgar.

Bodie, Z., Kane, A. & Marcus, A.J. (2008). *Essentials of Investments (7th Ed).* Boston: McGraw-Hill Irwin.

Bogentoft, E., Romeijn, H.E., & Uryasev, S. (2001). Asset/Liability for Pension Fund using CVaR Conatraints. *The Journal of Risk Finance*, 57-71.

Bonoli, G. & Shinkawa, T. (2005). *Ageing and Pension reforms around the world: Evidence from eleven countries.* Cheltenham, UK: Edward Elgar Publishing Limited.

Booth, P., Chadburn, R., Haberman, S., James, D., Khorasanee, Z., Plumb, R.H., & Rickayzen,B. (2005). *Modern actuarial theory and practice.* New York: Chapman and Hall/CRC.

Borsch-Supan, A. H. & MiegeL, M. (2001). *Pension reforms in six countries: what can we learn from each other?* Berlin, Germany: Springer.

Broeders, D.W.G.A. , van Oord, A. & Rijsbergen, D.R. . (2016). Scale economies in pension fund investments: A dissection of investment costs across asset classes. *Journal of International Money and Finance (67)* , 147–171.

Brooks, C. (2008). *Introductory Econometrics for Finance.* Cambridge: Cambridge University Press.

Campbell, J. Y., Chan, Y.L., & Viceira, L.M. (2003). A multivariate model of strategic asset allocation. *Journal of Financial Economics (67)* , 41–80.

Chalabi, Y. & Wurtz, D. (2015). Portfolio Allocation. In A. Charpentier, *Computational Actuarial Science with R* (pp. 447-470). Montreal: CRC Press.

Chen, Y., Sun, X. & Li, J. (2017). Pension Fund Asset Allocation:A Mean-Variance Model with CVaR Constraints. *Procedia Computer Science*, 1302–1307.

Clark, G.L., & Hebb, T.,. (2004). Pension fund corporate engagement: the fifthstage of capitalism. *Relations Industrielles/Industrial Relations 59 (1)*, 142–171.

Davis, E. P. (2000). Portfolio Regulations of Insurance Companies and Pension Fund . *OECD conference on Investment Regulation and Supervision* (pp. 1-36). Paris: OECD .

de Resende Baima, F. & da Costa, N.C.A. (2006). The Influence of Fund Size and Investment Expenses on the Performance of Pension Funds in Brazil. *Latin American Business Review, 6(3)*, 113-132.

Delgado de Oliveira, A. , Filomena, T.P. & Righi, M.B. (2018). Performance Comparison Of Scenario-Generation Methods Applied To A Stochastic Optimization Asset-Liability Management Model. *Pesquisa Operacional 38(1)*, 53-72.

Diamond, P. (1997). Insulation of pensions from political risk. In S. Valdes-Prieto, *The Economics of Pensions: Principles, Policies and International Experience* (pp. 33- 57). Cambridge: Cambridge University Press.

Disney, R. (1999). *Notional accounts as a pension reform strategy: an evaluation', Social Protection Discussion Paper 9928, .* Washington, DC.: World Bank.

Donkor, F. (2016). *Defined Contributions and Defined Benefits: Inherent Risks and Risk Transfers in Pension Scheme Ghanaian.* Accra: Unpublished thesis at the University of Ghana.

Doyle, J. M. (2017). Persistence in the long-run expected rate of return for corporate pension plans. *The Quarterly Review of Economics and Finance (63)*, 271-277.

Esterby-Smith, M., Thorpe, R., & Jackson, P. R. (2015). *Management and business research (5th Ed).* London: SAGE Publications Ltd.

Feldstein, M. & Liebman, J. (2000). The distributional effects of an investment-based social security system. *NBER Working Paper 7492*.

Feldstein, M. (1997). Transition to a fully funded pension system: five economic issues . *NBER Working Paper 6149.*

Fernandez, V. (2014). Stock volatility and pension funds under an individual capitalization-based system. *Journal of Business Research (67),* 536-541.

Garcia, M. (2010). Efficiency evaluation of the Portuguese pension funds management companies. *Journal of International Financial Markets, Institutions & Money (20),* 259–266.

Gerrard, R. J. G., Haberman, S. & Vigna, E. (2005). *The management of decumulation risks in a defined contribution environment (Report No. Actuarial Research Paper No. 161).* London, UK: Faculty of Actuarial Science & Insurance, City University London.

Gerstner, T., Griebel, M., Holtz, M., Goschnick, R. & Haep, M. . (2008). A general asset–liability management model for the efficient simulation of portfolios of life insurance policies. *Insurance: Mathematics and Economics (42)* , 704–716.

Gill, I.S., Packard, T. & Yermo, J. (2003). *Keeping the promise of old age security in Latin America.* Washigton, DC: World Bank.

Goldman, R. (2000). The development of the 'prudent man' concept in relation to pension schemes. *Pensions International Journal (5),* 219.

Guan, G. & Liang, Z. (2016). Optimal management of DC pension plan under loss aversion and Value-at-Risk constraints. *Insurance: Mathematics and Economics 69* , 224–237.

Guercio, D.D., & Hawkins, J., . (1999). The motivation and impact of pension fund activism. *Journal of Financial Economics 52 (3),* 293–340.

Haberman, S., & Vigna, E.,. (2002). Optimal investment strategies and risk measures in defined contribution pension schemes. *Insurance :Mathematics and Economics 31*, 35-69.

Hemming, R. (1998). Should Public Pensions Be Funded? *IMF Working Paper*, 1-35. Online available at https://onlinelibrary.wiley.com/

Hertrich, C. (2013). *Asset Allocation Considerations for Pension Insurance Funds: Theoretical Analysis and Empirical Evidence.* Stuttgart, Germany: Springer Gabler.

Hoevenaars, R.P.M.M, Molenaar, R.D.J.,Schotman, P.C., & Steenkamp,T.B.M. (2008). Strategic asset allocation with liabilities: Beyond stocks and bonds. *Journal of Economic Dynamics & Control (32),* 2939–2970.

Holzmann, R. & Palmer, E. (2006). *Pension Reform : Issues and Prospects for Non-Financial Defined Contribution (NDC) Schemes.* Washington, DC: World Bank. Online available at https://onlinelibrary.wiley.com/

Horváthová, A., Feldthusen, R.K., & Ulfbeck, V.G. (2017, September 26). *Occupational Pension Funds (IORPs) & Sustainability: What does the Prudent Person Principle say?* Retrieved from http://ec.europa.eu/info/law/institutionsoccupational

Impavido, G., Musalem, A.R., & Tressel, T. . (2002). . Contractual savings, capital markets,and financing choices of firms. In: International Bank for Reconstruction and Development. *World Bank economists' Forum Volume 2* , 179–222.

Jomer, E. (2013). *Performance of UK Pension Funds: Luck or Skills?* Uppsala: Published Master Thesis, Department of Economics, Uppsala University.

Josa-Fombellida, R., & Rincón-Zapatero, J.P. (2012). Stochastic pension funding when the benefit and the risky asset follow jump diffusion processes. *European Journal of Operational Research 220* , 404–413.

Judd, C. & Yin, L. (2012). *Global Pension Assets Study.* London: Towers Watson.

Kiplagat, M. (2014). *The Effect Of Asset Allocation On The Financial Performance Of Pension Funds In Kenya.* Nairobi: An unpublished dissertation from the University of Nairobi.

Kuditcher, F. (2015). *Funding and Asset Allocation Policy a Partially funded Defined Benefit Public Pension Plan.* Accra: Unpublished thesis at the University of Ghana.

Kumado, K. & Gockel, A.F. (2003). *A Study on Social Security in Ghana.* Accra: Unpublished Paper at University of Ghana. Online available at https://ugspace.com

Li, D., Rong, X., Zhao, H., & Yi, B. (2017). Equilibrium investment strategy for DC pension plan with default risk and return of premiums clauses under CEV model. *Insurance: Mathematics and Economics (72)*, 6-20.

Lindaman, D. (2004). Review of recent Pension Reforms in the Baltic Region. In OECD, *Pension Reforms in Baltic Region* (pp. 7-24). Paris: OECD.

Madukwe, O. (2015). Effects of Contributory Pension Scheme on the Capital Market in Nigeria. *International Journal of Commerce and Innovations*, 202-211.

Mitchell, O. & Barreto, F.A. (1997). *After Chile, what? Second-round Pension Reforms in Latin America.* Cambridge: NBER Working Paper 6316 Online available at https://onlinelibrary.wiley.com/.

Modigliani, F. & Muralidhar, A. (2005). *Rethinking Pension Reform.* Cambridge: Cambridge University Press.

Morales,A.E.P., Fuentes,o., Searle,P., & Stewart, F. (2017). Pension Funds and the Impact of Switching Regulations:A World Bank Group Survey. *International Organization of Pension Supervisors Working Papers on Effective Pensions Supervision, No.28*, 1-36.

National Pension Act 766. (2008). Pension and Social Security Insurance Regulations in Ghana.

Nepp, A., Larionova, V., Okhrin, O., & Sesekin, A. (2018). Optimal Pension System: Case Study. *Economics and Sociology, 11(1)*, 267-292.

NPRA. (2012). *Annual Financial Report of the National Pension Regulatory Authority.* Accra: NPRA. Online available at https:// npra.gov.gh/

NPRA. (2015). *Annual Financial Report of the National Pension Regulatory Authority.* Accra: NPRA. Online available at https:// npra.gov.gh/

NPRA. (2017). *Annual Financial Report of National Pension Regulatory Authority.* Accra: NPRA. Online available at https:// npra.gov.gh/

OECD . (1988). *Ageing Populations: The Social Policy Implications.* Paris: OECD.

OECD. (2004). *Pension Reforms in the Baltic Region.* Paris: OECD.

Organization for Economic Co-operation and Development. (2015). *Annual Survey of Investment Regulations of Pension Funds.* Paris: OECD.

Pachamananova, D.A. & Fabozzi, F.J. (2010). *Simulation and Optimization in Finance.* Hoboken, New Jersey: John Wiley & Sons Inc.

Papaioannou, M. G. & Rentsendorj, B. (2015). Sovereign Wealth Fund Asset Allocations—some stylized facts on the Norway Pension Fund Global. *Procedia Economics and Finance (29)*, 195 – 199 .

Promislow, S. (2011). *Fundamentals of Actuarial Mathematics (2nd Ed).* Toronto: John Wiley & Sons Ltd.

Rezk, E., Irace, M., & Ricca, V. . (2009). Pension Funds' Contribution to the Enhancementof Aggregate Private Saving: A Panel Data Analysis for Emerging Economies. *Available at SSRN 1992440.*

Shi, A. (2017, October 27). *Stochastic Processes and their Applications in Financial Pricing.* Retrieved from https://sites.math.washington.edu/~morrow/336_10/papers/andrew.pdf

Siaw, R. O. (2014). *Investment Optimization with GARCH Models.* Accra: Unpublished thesis at the University of Ghana.

Siemiatycki, M. (2015). Canadian pension fund investors in transport infrastructure:A case study. *Case Studies on Transport Policy (3)*, 166-175.

Stewart, F. & Yermo, J. (2009). *Pensions in Africa.* Paris: OECD publishing.

Stiglitz, J. (2000). *Privatizing Pensions: The Transnational Campaign for Social Security.* Online available at https://www.ssc.wisc.edu/~scholz/Teaching_742/Orszag-Stiglitz.pdf.

Strumskis, M. & Balkevicius, A. (2016). Pension fund participants and fund managing company shareholder relations in Lithuania second pillar pension funds. *Intellectual Economics (10)*, 1–12.

Tee, E. & Ofosu-Hene, E.D. (2017). Stochastic asset models for actuarial use in Ghana. *International Journal of Statistics and Acturarial Science, 1(4)*, 101-111.

The World Bank. (1994). *Averting the Old Age Crisis: Policies to Protect the Old and Promote Growth.* Oxford: Oxford University Press.

Thomas, A. , Spataro, L. & Mathew, N. (2014). Pension funds and stock market volatility: An empirical analysis of OECD countries. *Journal of Financial Stability*, 92-103.

Walker, E. & Lefort, F. (2000). *Pension reforms and capital markets: Are there any hard links?* Business School, Universidad Católica de Chile.

Würtz, D., Chalabi, Y., Chen, W., & Ellis, A. (2009). *Portfolio Optimization with R/Rmetrics.* Zurich: Rmetrics Association & Finance Online.

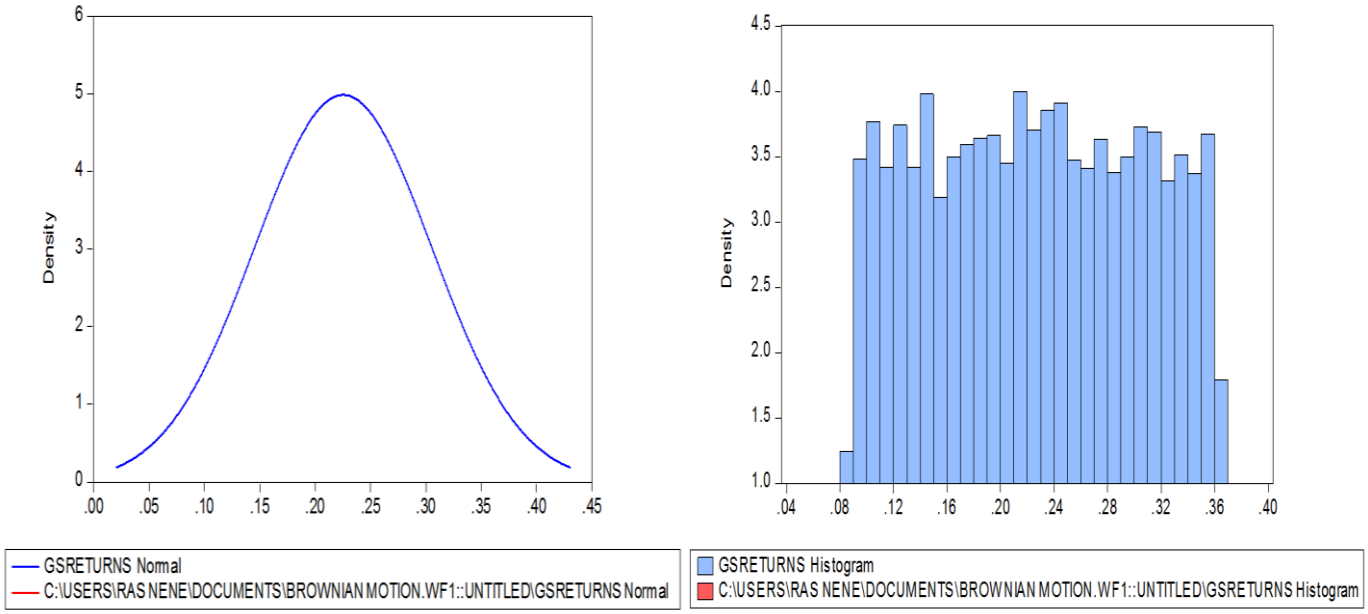
Yao, H., Chen,P. & Li, X. (2016). Multi-period defined contribution pension funds investment management with regime-switching and mortality risk. *Insurance: Mathematics and Economics (72)*, 103-113.

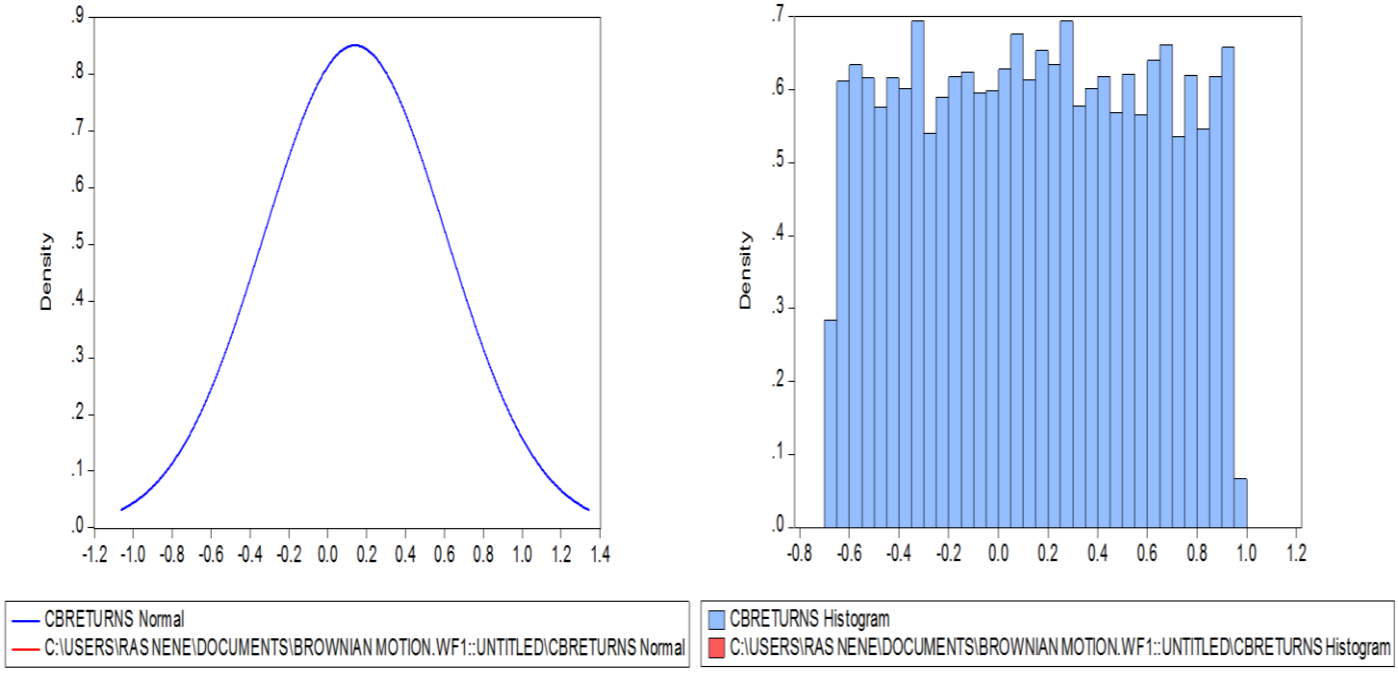
Yao, H., Lai, Y., & Jian, M. (2014). Asset allocation for a DC pension fund with stochastic income and mortality risk: A multi-period mean–variance framework. *Insurance: Mathematics and Economics (54)*, 84-92.

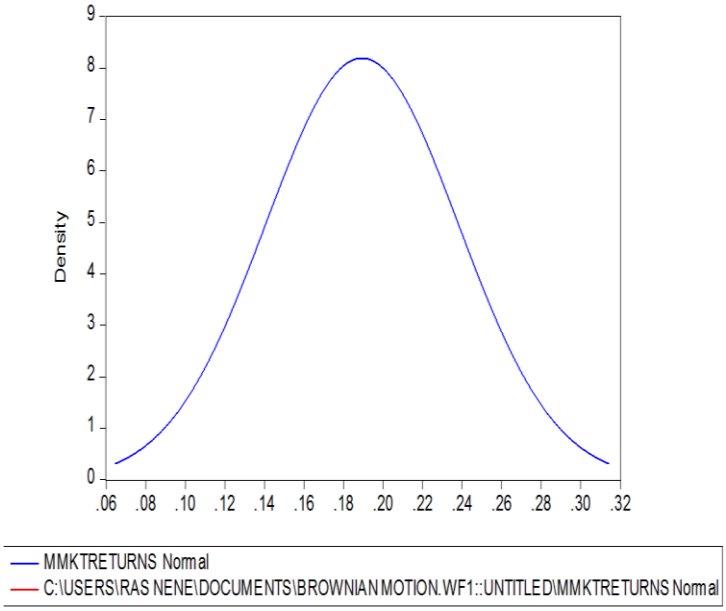
Yao, H., Yang, Z. & Chen, P. (2013). Markowitz's mean–variance defined contribution pension fund management under inflation: A continuous-time model. *Insurance: Mathematics and Economics,53 (3)*, 851-863.

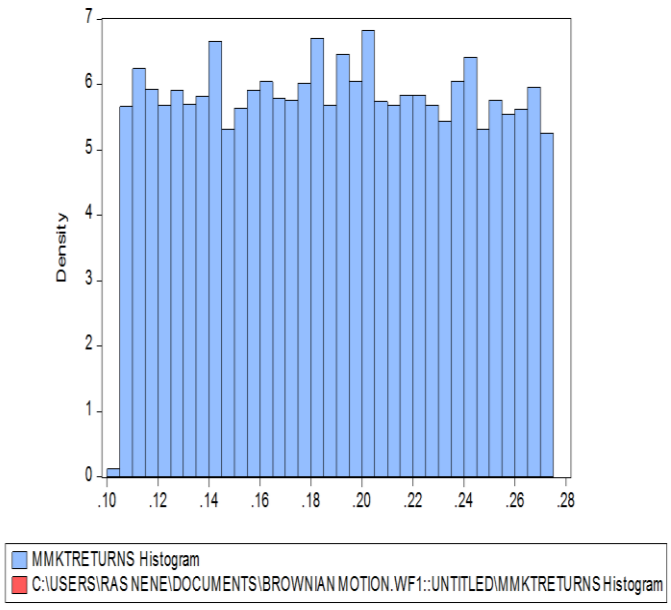
Zhang, M, & Chen, P. (2016). Mean–variance asset–liability management under constant elasticity of variance process. *Insurance: Mathematics and Economics (70)*, 11-18.

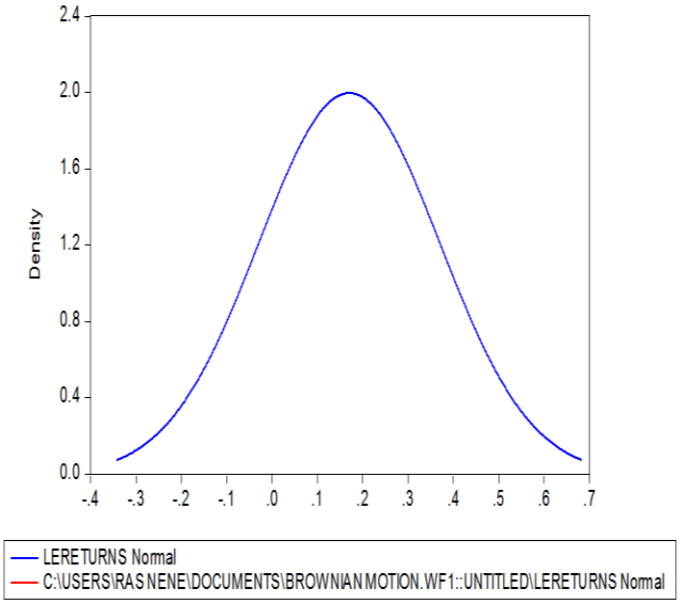
APPENDIX

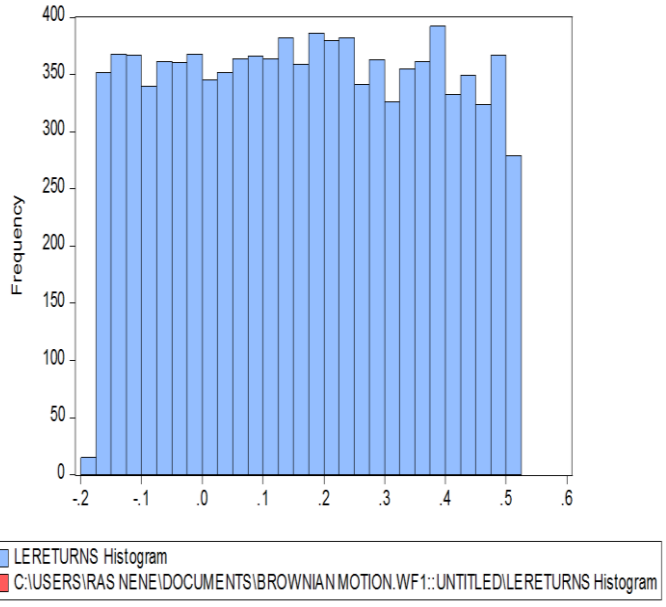


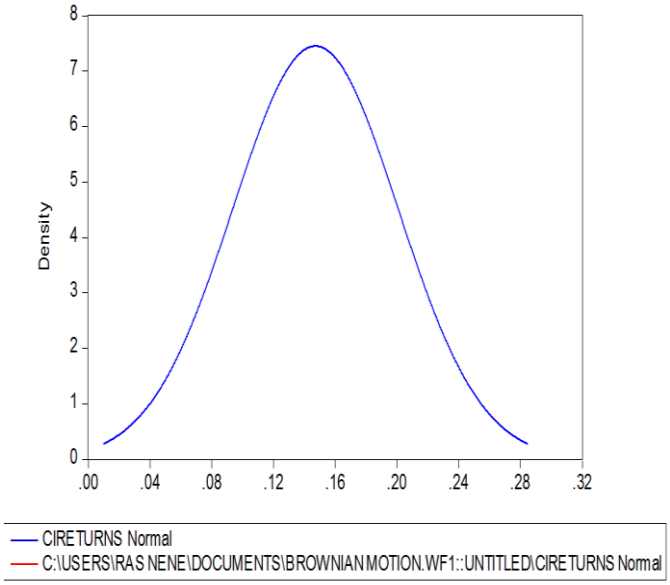


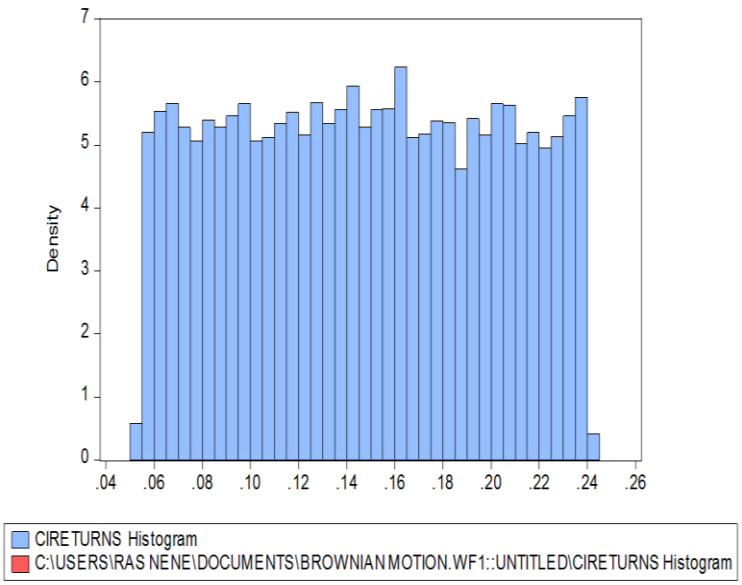


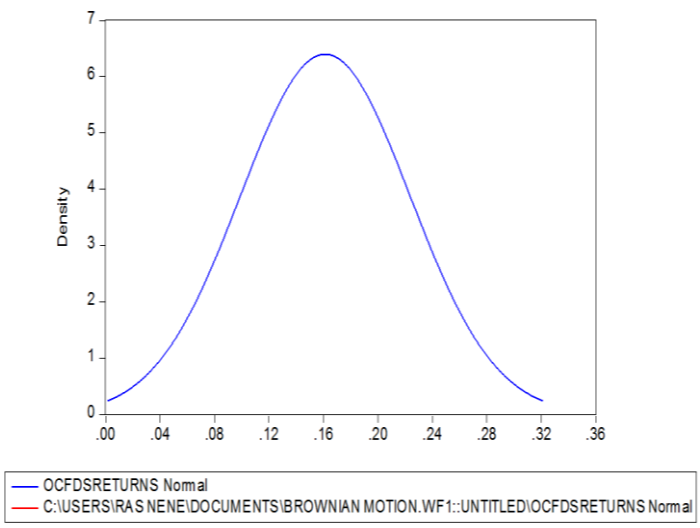


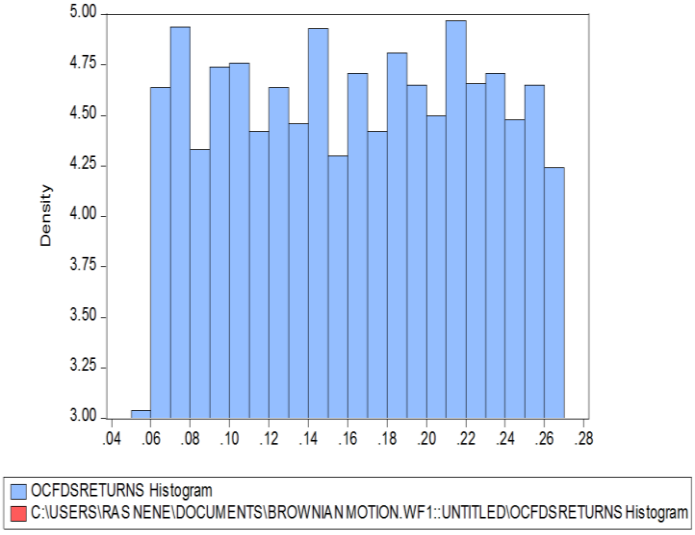




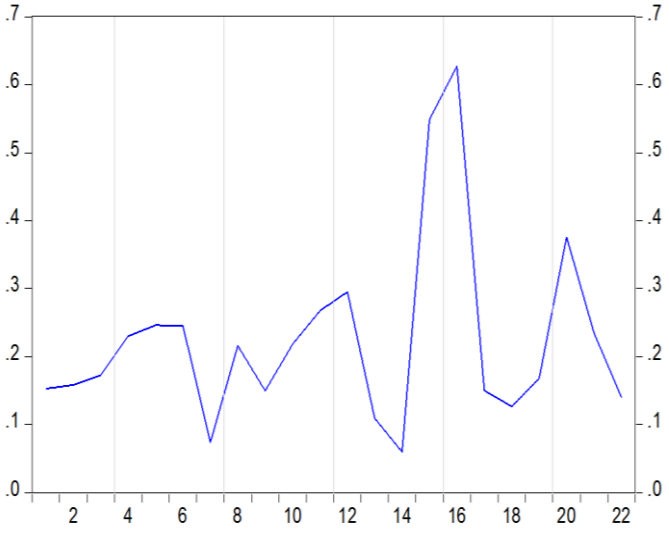




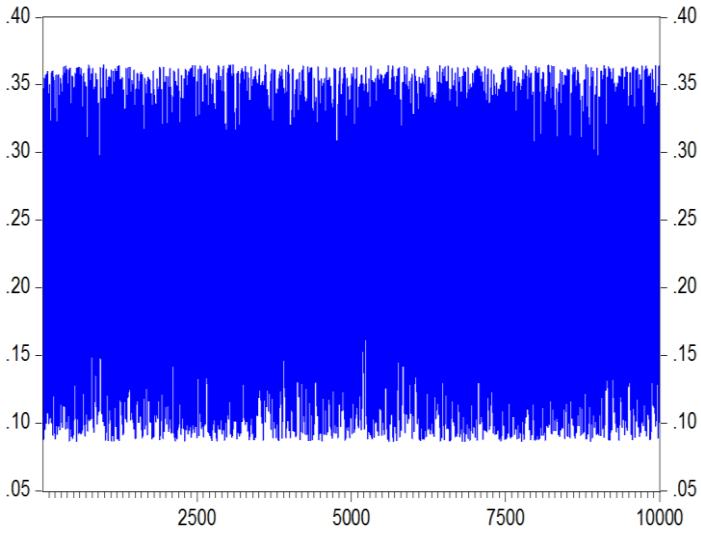




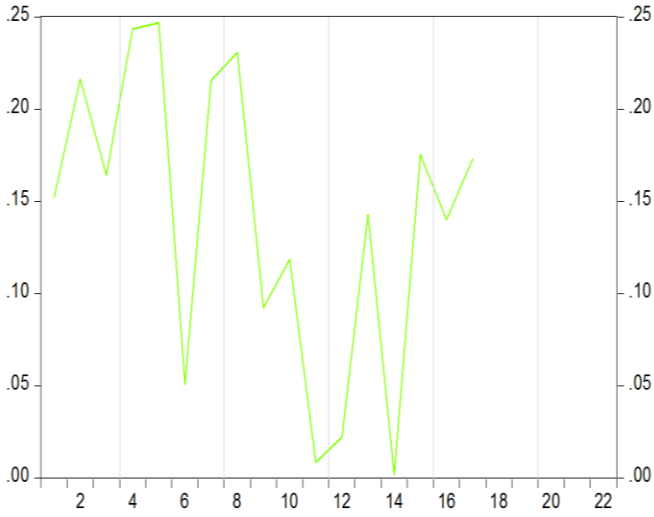
Raw Data of Government Securities



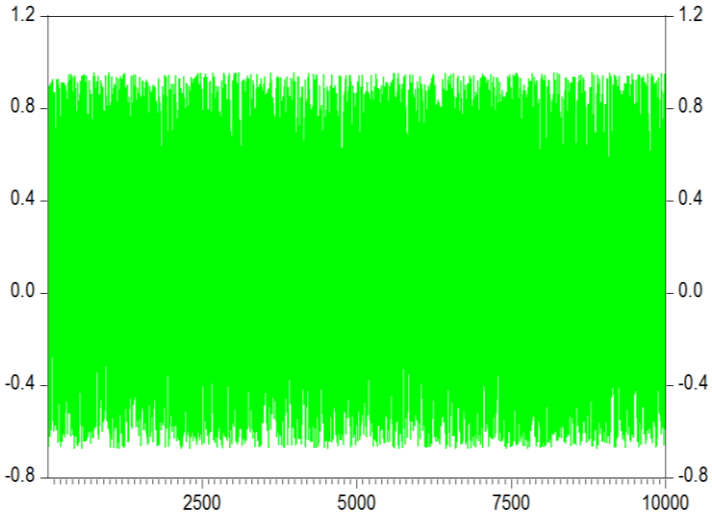
Simulated Data of Government Securities



Raw Data of Corporate Bonds

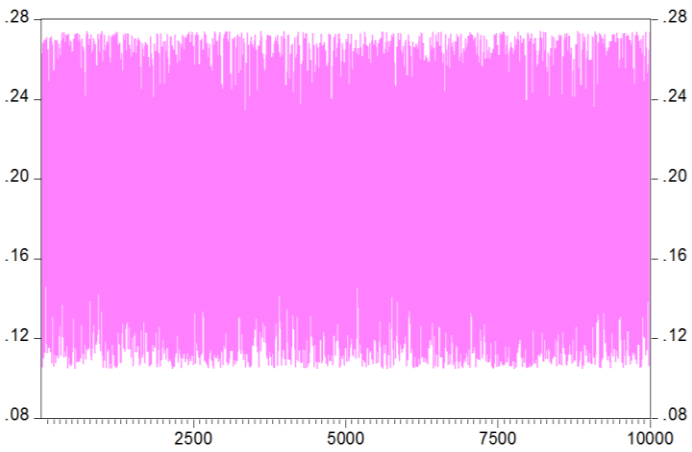


Simulated Data of Corporate Bonds

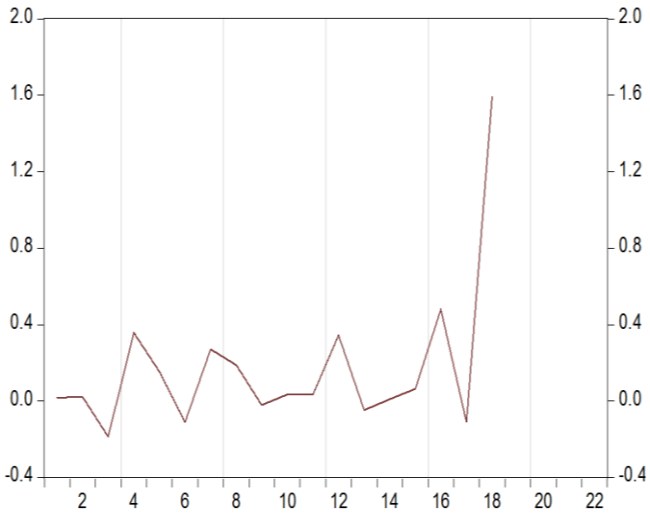


Raw Data of Money Market

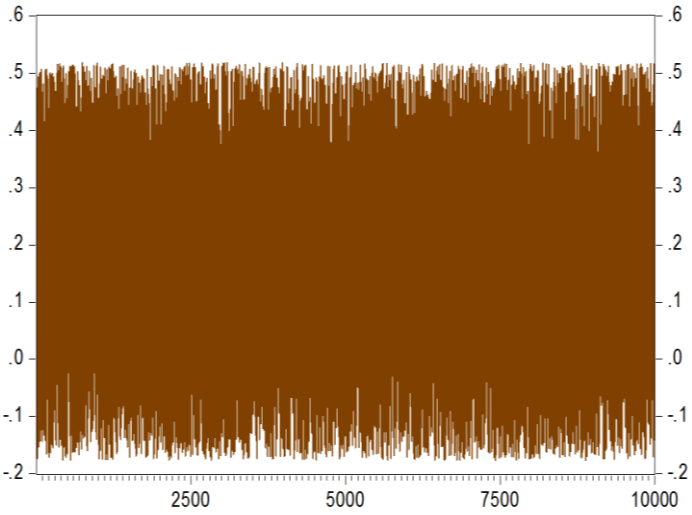
Simulated Data of Money Market



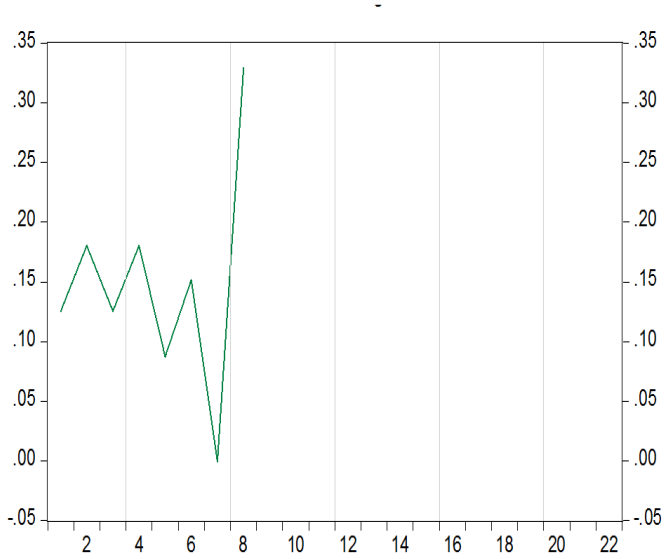
Raw Data of Listed Equities



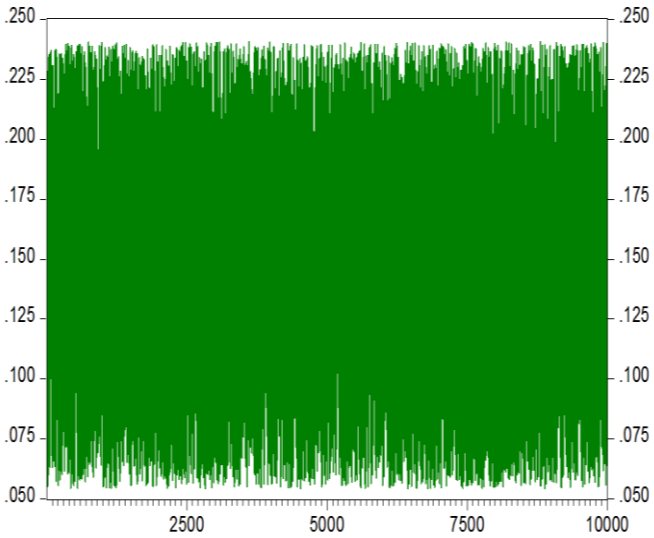
Simulated Data of Listed Equities



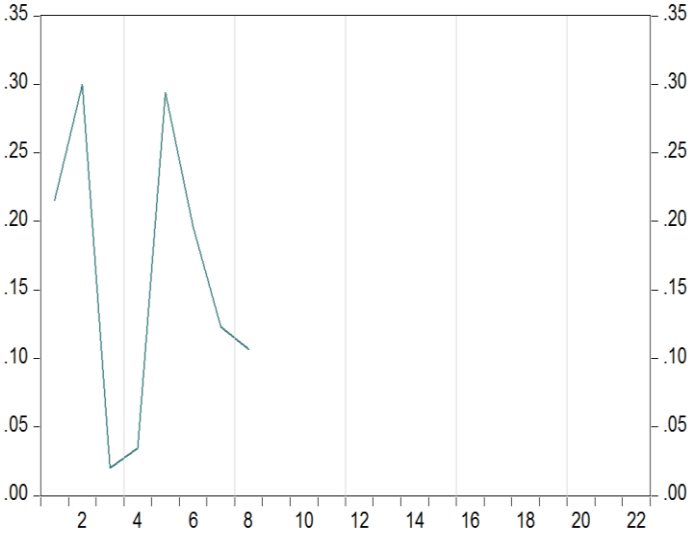
Raw Data of Collective Investments



Simulated Data of Collective Investments



Raw Data of Open/Close end Funds



Simulated data of Open/Close end Funds