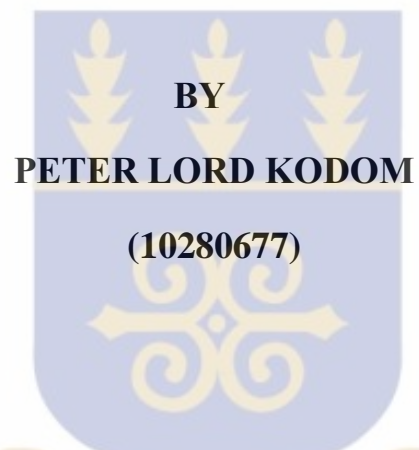


UNIVERSITY OF GHANA

RISK MANAGEMENT OF A DEFINED BENEFIT PENSION SCHEME: A STOCHASTIC PROGRAMMING APPROACH



**A THESIS SUBMITTED TO THE DEPARTMENT OF FINANCE,
UNIVERSITY OF GHANA BUSINESS SCHOOL, UNIVERSITY OF
GHANA, LEGON IN PARTIAL FULFILLMENT OF THE
REQUIREMENT FOR THE AWARD OF AN MPhil FINANCE DEGREE**

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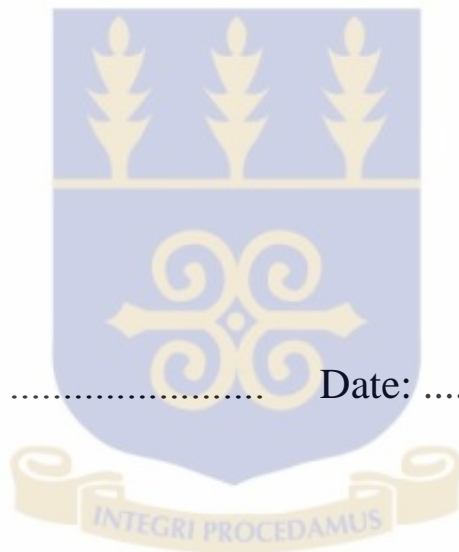
DECLARATION

I do hereby declare that this thesis is the result of my own original 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 fully acknowledged. Nonetheless, I bear sole responsibility for all errors and omissions within the work.

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CERTIFICATION

I hereby certify that this thesis was supervised in accordance with the procedures laid down by the University of Ghana.

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2nd Supervisor's Signature:

(ANTHONY AFFUL- DADZIE, PhD)

Date:

DEDICATION

I dedicate this work to my parents who gave me support in every step on the way to attaining this height.



ACKNOWLEDGEMENT

I wish to thank the Almighty God for without Him I could not have had the strength to carry on in this journey. My immense gratitude goes to my supervisors Dr. Eric Dei Ofosu-hene and Dr. Anthony Afful Dadzie for their guidance and tutelage, which helped in improving the work. I also appreciate Dr. Simon Harvey for his valuable comments on the work. To my family and friends who gave me tremendous support during my study period, I say Thank You.

Finally, to all those who have made an impact in my life, I say I cannot thank you that much; only God can bless you that much.



ABSTRACT

This study investigates how the investment returns of Social Security and Insurance Trust (SSNIT) of Ghana has performed over the years compared with the financial market and designs a method for the optimal asset mix strategy for the scheme under different risk preferences using stochastic linear programming approach.

A time series of annual data on returns on equity and treasury bills from the year 2001 to 2013 were used to investigate the performance of the SSNIT investment compared with Ghana's financial market using a trend analysis. A twenty-four annual market data of returns on equity and treasury and average wage growth rate spanning from 1990 to 2014 was used to simulate stochastic future wage growth and return on equity and Treasury bill using Vector Autoregressive model.

The study found that the SSNIT investment returns on equity and treasury bills outperformed that of the financial market. The study also found that the optimal asset allocation for the risk adverse model has a higher allocation to treasury bills than equity. Again, it was found that the final wealth (i.e. the ratio of assets to liabilities) is greater than one with all the risk preference models. Also the asset composition of risk neutral models has a higher allocation to equity than treasury bills. It was also found that the optimal asset allocation and the final expected wealth are sensitive to changes in the transaction cost.

The study then recommends that the SSNIT pension scheme should adapt stochastic programming model for the optimal asset allocation. Also the SSNIT pension scheme should trade with least transaction cost since higher transaction decreases the final expected wealth value.

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LIST OF ABBREVIATIONS

NPRA	National Pension Regulatory Authority
SSNIT	State Social National Insurance Trust
VAR	Vector Auto Regression Model
DC	Defined Benefit
DB	Defined Contribution
MAD	Mean Absolute Deviation
ALM	Asset/Liability Management

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Every nation considers pensions provision for its citizens as a primary social obligation. This goal of providing for the aging population is universal and strategic objective for all nations, regardless of their level of economic security and development (Lachman, 2013). All countries irrespective of their economic state have this common objective of creating a pension scheme, which will bring financial security to its citizens and retirees (Barr and Diamond, 2010; Dorfman and Palacios, 2012). The social security and national insurance trust fund (SSNIT) is the largest pension scheme in Ghana (Kpessa, 2011). It has close to one million active members with over 119,323 pensioners who still receive monthly pension income (SSNIT, 2013).

The objective of the scheme is to replace income lost as a result of old age, disability and death to members or beneficiaries (Kpessa, 2011). Currently SSNIT operates a three-tier contributory pension scheme, which comprises of two compulsory schemes and a voluntary scheme. The first and second tiers are compulsory for all public and private workers with contributions linked to employment earnings while the third tier is voluntary (Kpessa, 2011). SSNIT manages 11% of members' contribution at tier one and the benefits received by members under this tier are regular monthly payments of income at retirement (Nelson- Cofie, 2009). However benefits earned are based on a predefined formula for computation with the goal of the Scheme being to provide to its members benefits between 37.5 and 60 percent of the average of best three years' salary (SSNIT, 2013). However, the actual benefits payment depends on the number of years of contribution to the fund (pension right) and the average of the best three years' salary.

Tier one is a Defined Benefit pension scheme, which is a pension scheme where the pension benefit payout is related to the member's salary or some other value fixed in advance (Maer and Thurley, 2009) which is typically financed under the Pay-As-You-Go (PAYG) arrangement (Lachman, 2013). With this scheme benefit payment is dependent on the employees' wage and years of service; however, the amount of pension benefits earned is independent of the total amount of contribution by members and return on investment of the contributions. This impliedly means that benefits earned by members do not depend on the total contribution made during their working life, as a result of this the scheme operator bears all the risk associated with investing the contributions, therefore the onus is on the pension provider to make efficient investment strategies in order to honour the contractual obligations. According to Mulvey, Gould and Morgan (2000) the goal of a Defined Benefit pension scheme is to design an investment plan capable of meeting its liabilities, optimizing surplus and minimizing the company's contribution over time. The liability is the benefits to be paid to members when they go on retirement and the size of the liability is the present value of future expected benefit payments (Kouwenberg, 2001). Lachman (2013) purports that the Defined Benefit scheme is prone to financial and longevity risks. These risks are factors that can cause the pension scheme to be unable to meet its contractual obligations of future retirement benefits. There are factors from both the asset and liability side that can make the pension fund unable to honour its contractual obligations which includes exposure of the fund to wage inflation, mortality and interest rate risk, all on the liability side (Babel, Bornsdorf & Kahlenberg, 2008) and then on the asset side the fund is exposed to risk from different markets of which they are invested in, such as fixed income, equity and credit (Clark, Munnell & Orzag, 2006). These risk exposures emanating from both the asset and liability sides have varying correlations among themselves (Maer and Thurley, 2009) and the pension

fund will be in a worse situation if there is a decrease in asset prices and bond yields and an increase in wages (Maer and Thurley, 2009), which implicitly means that the future cash inflows from returns on asset would be less than the future cash outflow causing an underfunding scenario.

An enterprise risk management strategy such as Asset/Liability Management (ALM) is required to manage the risk exposure of the pension fund and according to the Society of Actuaries (1998) Asset/Liability Management is the practice of managing a business so that decisions on assets and liabilities are coordinated. Generally ALM simulates investment policy with liability decision so as to maximize a company's surplus while maintaining a safe level of operation (Mulvey et al., 2000), it is therefore an important step to ensuring that the contributions and investment returns are adequate to pay the benefits and expenses of the pension scheme. ALM does this by planning financial resources in the face of uncertainty about the economy, capital market, actuarial, and demographic conditions (Kouwenberg, 2001) and hence aids in the determination of the funding level of the pension fund.

The funding level of a pension plan is the ratio of market valuation of plan assets to the market valuation of plan liabilities (Kouwenberg, 2001) and when the funding level is below 1, the plan is considered as underfunded, which is undesirable because pension schemes are expected to meet the minimum funding ratio requirement set by regulators which is usually 1.5, reflecting the solvency requirements by regulators who require that returns on the plan assets are supposed to meet liabilities in the short-term (Kouwenberg, 2001).

Due to the uncertain nature of the returns on investment and liabilities, a stochastic programming approach with dynamic strategy is suitable under this setting of uncertainty (Kouwenberg, 2001). Stochastic programming is a mathematical modeling technique that deals

with optimization problems under uncertainty and its validity for ALM problems, in particular, is enhanced by the fact that it readily incorporates in a common framework, multiple correlated sources of risk for both the asset and liability sides and has long time horizons, accommodating risk aversion, and allowing for dynamic portfolio rebalancing while satisfying operational or regulatory restrictions and policy requirements (Kouwenberg, 2001).

1.2 Statement of the Problem

In January 2003, the pension fund consultant, Watson Wyatt Worldwide, estimated that global pension funds had balance sheets of –US\$2.5 trillion. This is as a result of liability growth because pensioners are living longer, and assets returns declined due to the fall in equity returns from 2000 to 2002 (Ziemba, 2003). The Global pension fund balance sheet also worsened in 2011 losing 4.3% in the asset/liability indicator despite the growth in assets (Waston, 2012).

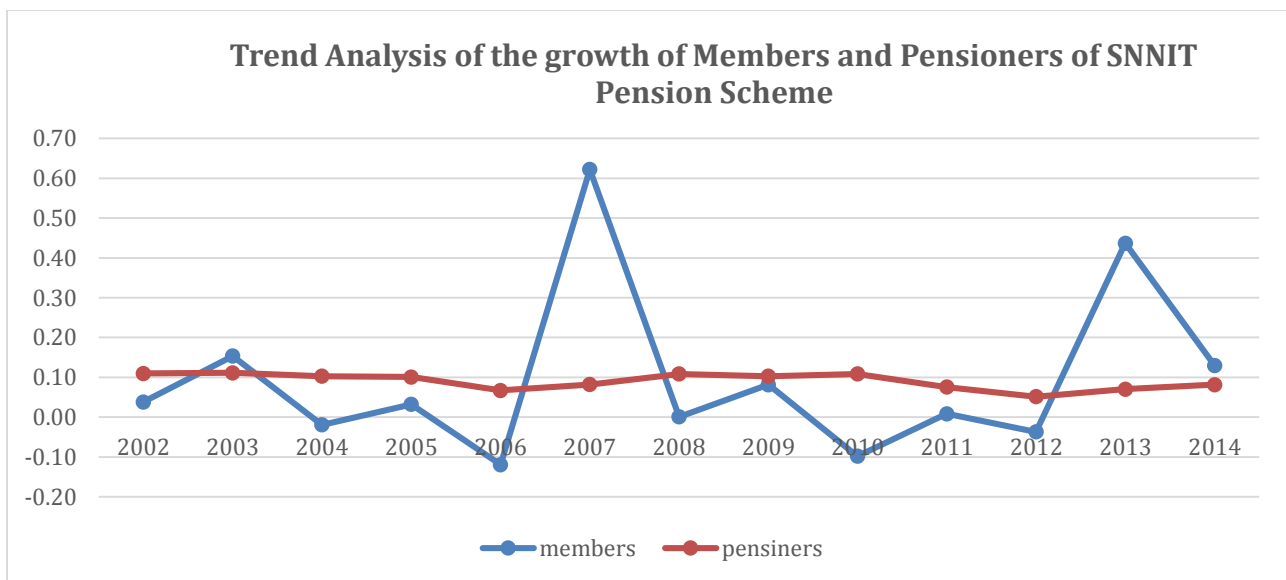
The demographic and labour market environment in which a pension system is established and operates determine many of its salient characteristics. Trends in these factors will determine the future age distribution of populations, which is key to the long-term dynamics and financial viability of the pensions system. Information on rates of fertility, life expectancy at birth, and life expectancy at older attained ages (age 60 and 65 which are typically the normal age of eligibility for benefit receipt), are the most relevant indicators for the analysis of pension systems (Lachman, 2013). Demographics have a direct impact on pension systems via the potential number of contributors and pensioners. Fertility has a direct impact on the number of workers, which determines both the potential contributors to the systems at any point in time as well as the number of people eligible in the future to receive benefits. An increase in life expectancy at old age implies that pensions are paid for longer periods. This is central to determining the ratio of contributors to beneficiaries, which is a primary determinant of the financial balances within a

system (Lachman, 2013). According to Lachman (2013) the rapid fall in fertility and increase in the life expectancy of the world's population, is a problem which pension fund administrators should consider.

According to the UN projections, the share of the elderly (65+) in the developed countries is projected to increase from 15.3 percent (2005) to 26.1 percent (2050), representing an increase of more than two-thirds. In the less developed countries, the proportional increase is even greater with nearly a three-fold increase in the share of the elderly population, from 5.5 percent (2005) to 14.7 percent (2050). According to the World Bank projection, the number of people aged 65 and older in Ghana is expected to roughly increase by 176.9 percent, whereas the number of people within the age of 15 and 64 will roughly increase by 85.2 percent from 2010 to 2050. This indicates that there will be an increase in the dependency ratio.

The figure below shows the trend of the growth of the contributors and pensioners of the SSNIT pension Scheme for the period 2002 to 2014.

Figure 1. 1Trend analysis of the growth of members and pensioners.



Source: computation from Research Data, 2015

The figure above shows that the growth of the number of pensioners lies above that of the contributors of the scheme except 2003, 2007, 2013 and 2014. The rate of growth of members fell to negative during the years 2004, 2006, 2010 and 2012. If this persists, there will be an increase in total liability payment and a decrease in the contributions, which will have adverse effect on the sustainability of the pension scheme.

SSNIT however cannot control these demographic factors but a way to deal with this risk of increasing dependency ratio and its adverse impact on the sustainability of a pension scheme is either to reduce benefits and/or increase contributions Lachman (2013) or to have a good risk-adjusted investment returns (Ziemba, 2003). This study adopted the former approach since higher real returns would have resulted in better funded pension plans, higher pension payments, or lower contribution rates for members of the scheme (Ziemba, 2003).

The investment returns on the pension funds of United States, United Kingdom and Ireland are higher than Netherlands, Belgium, Germany, Spain and Denmark (Ziemba, 2003). This is linked to the asset mix strategy; United States, United Kingdom and Ireland have more equities, whereas Netherlands, Belgium, Germany, Spain and Denmark have the bulk of their capital invested in bonds European commission (1997). Studies by Dimson, Marsh, and Staunton (2002), Keim and Ziemba (2000), and Jorion and Goetzmann, (1999), used the Sharpe ratio and the capital asset pricing model and found that equity returns outperformed bond returns in risk-adjusted terms over a long run period. However, it was estimated in 2008 that private pension funds lost about 23% (\$ 5.4 trillion) of their pre-crisis valuations. This was mainly due to the sharp drop in value of equity investments (Whitehouse, 2009).). In October 2008, the stock indexes dropped by nearly 50% of their pre-crisis levels across the industrialized world (Yermo & Salou, 2008). The largest drop in the value of pension funds was recorded in Ireland, at 35%.

The lowest drops were in Mexico, Czech Republic and Germany at 5.2%, 7.2%, and 8.5% respectively (Lachman, 2013). Also, countries like Australia, US, Iceland, Canada Japan, United Kingdom, the Netherlands and Switzerland were reported to have had significant negative returns on their pension funds in 2008 (Lachman, 2013). These outcomes were inevitable, since these pension funds had been heavily invested in the stock markets (Lachman, 2013). From the observations above, it can be stated that the financial market is linked with the pension fund performance, thus the proportion of pension fund capital allocated to various financial assets should be strategic. However SSNIT portfolio real returns fell from 10.93% in 2007 to 2.4% and -7.60 in 2009. This loss in 2009 is linked to the loss in listed equity by 30.35%. Also in 2005 the portfolio real returns of SSNIT loss by -8.36% with a corresponding loss in returns on listed equity by 21.20%. This means that the performance of the Ghanaian stock market affects the portfolio returns of SNNIT. However the extent with which a sub asset class affects the portfolio returns depends on the weight of that financial asset. For instance, in 2005 and 2009, out the total fund value 22.16% and 20.93% respectively were invested in listed equity. During these time periods the allocation to listed equity were the second largest.

The investment strategy of pension fund aims at achieving its goal of been able to pay pension benefits. The traditional investment approach of pension investment excluded liabilities and its associated risks. The returns of the asset may perform better but an increase in the liabilities due to the risk of economic factors will cause the asset liability ratio to fall (Meder and Staub 2006). Selecting investment portfolios without factoring liability impliedly means that the liability has no risk at all not even market related.

Also, investment approach in recent times is more holistic and attempts to manage liability exposure as well as seeking to add value within a given risk budget. Asset /liability management

aims at achieving excess returns above a liability benchmark at some specified level of risk (Babel *et al.*, 2008). Manuela, Devolder & Domínguez-Fabián, 2002, Bogentoft, Romeijn, & Uryasev, 2001, Meder and Staub, 2006 have made empirical studies on asset liability management of a defined benefit pension scheme. These studies used a deterministic programming model and recommended that more than half of the pension fund assets should be invested in bonds. Studies made by Kouwenberg, 2001, Mulvey et al., 2000, Fombellida, 2004, Dempster, 2009, Boeder, 1997 adopted stochastic programming approach in asset/liability of defined benefit pension scheme. Kouwenberg (2001) recommended that 0.37, 0.30 and 0.33 of pension fund assets should be invested in bonds, real estate and stocks respectively. Mulvey et al., (2000) recommended that the optimal asset mix portfolio of a pension should comprise of 0.50, 0.1, 0.15, 0, and 0.2 of large cap US equity, small cap US equity, international equities corporate bonds and 20-year treasuries respectively. Boeder (1997) also recommended that the optimal asset mix portfolio should comprise of 0.35 in bonds, 0.30 in equities and 0.35 in real estate. These studies are not extensive since they were conducted on only developed countries. Even though the structure of the defined benefit pension scheme of these countries is similar to the SSNIT pension Scheme but the results are likely to be different in Ghana if the study is made using the same approach. This is because of the difference in economic conditions and financial market. Few empirical studies have been made in the sub-Saharan Africa on the risk management of pension schemes. The studies conducted in Ghana on pension mostly focus on the pension scheme reforms, governance and policy issues. Few empirical studies focus the risk management of the SSNIT pension scheme. This study aims at managing the risk of SSNIT pension scheme by developing an effective method for determining the optimal asset allocation that would ensure the sustainability of the pension scheme by adopting a stochastic programming approach.

1.3 Objective of the Study

Generally the study seeks to investigate the performance of the SSNIT investments compared with the financial market and design a strategic asset mix policy for SSNIT, which is capable of meeting liabilities.

Specifically, the study seeks to:

- I. Investigate the investment performance of SSNIT compared to the financial market.
- II. Develop an effective method for the optimal asset mix strategy that will ensure the sustainability of the pension fund using a stochastic programming approach.
- III. To investigate the differences in asset allocation under various risk preferences.

1.4 Research Question

To facilitate the achievements of the aforementioned objectives the following research questions have been developed:

- I. What is the performance of the SSNIT investment portfolio compared to the financial market?
- II. What is the effective method for the optimal asset mix strategy that will ensure the sustainability of the pension fund?
- III. What are the differences in asset allocation under various risk preferences?

1.5 Significance of the Study

According to Keith Brainard, Research Director of National Association of State Retirement Administrators (NASRA, 2005), pension funds provides a long-term source of capital and also contribute significantly to the financial stability and liquidity of both the money and capital markets. Pension funds provide vital capital for new business projects, expansion, and public debt financing, and they also enhance the liquidity and stability of financial markets. The role of pension funds is seen as engines of economic growth and development (Lachman, 2013). Pension funds are major players in the financial market and as a results, its management has a considerable economic interest (Josa-Fombellida aRincón-Zapaterond, 2004).

The findings of the study recommended a method for the optimal asset allocation, investment policy for the SSNIT pension scheme, which will ensure the sustainability of the scheme despite the increase in the dependency ratio. This study will not only help members of the pension scheme understand the risks and opportunities related to capital market investments and other major decisions, but also assist SSNIT in their financial planning process so as to improve its investment and liability payment decisions and its overall risk management likewise contributing to the existing literature, enhancing the current research experience and lay a foundation for further research in the area.

1.6 Chapter Disposition

The rest of the study is organized as follows; Chapter two reviews extant literature on risk management of the defined benefit pension scheme theories and empirical studies. Chapter three discusses the methodological approach adopted for the study. The fourth chapter presents the

findings and discussion of the results while chapter five summarizes, concludes and provides recommendations for investment management of the SSNIT pension and as well as suggestions for future studies.

CHAPTER TWO

LITERATURE REVIEW

2.0. Introduction

This chapter of the study deals with the conceptual and empirical literature relevant to the research and reviews works done in similar studies.

2.1. Pension

People around the world used to work until they drop as a result of disability or death or illness. However, in recent times people stop work not only as a result of disability or illness or death but also old age and other factors. To be able to support themselves financially during the non-working periods, funds are set-aside during the working years (Ando and Modigliani, 1963). According to Agbobli (2010), pension is a means of saving for retirement purposes. Lee (1986) also defined occupational pension schemes as the “arrangements by means of which employers or groups of employers provide pensions and related benefits to their employees”. Pension promises inherently a long-term compensation arrangement whereby, a worker earns (“accrues”) a right to an eventual pension benefit, payable after the employee attains “certain eligibility criteria, with benefits frequently commencing at retirement and continuing until death (Gustman et al., 1994). Almost all Corporations have retirement plans for their workers. These pensions clearly encompass three aspects: insurance, compensation, and severance. Under the social insurance programme, workers earn entitlement to family benefits upon retirement, disability, or death (Schwartz and Ziemba, 2007). (OECD, 2005) defines pension funds as “the pool of assets that forms an independent legal entity that are brought with the contributions to a pension plan

for the exclusive purpose of financing pension plan benefit.”

2.1.1. Types of Pension Schemes

Pension systems can be broadly categorized by the benefits they promise and the way they finance that promise (Modigliani 2001). Basically, there are two types of pension plans, namely: defined benefit (DB) and defined contribution (DC).

2.1.1.1. Defined Benefit Pension Scheme

Maer and Thurley, (2009) defines a Defined Benefit pension scheme as “one where the pension is related to the member’s salary or some other value fixed in advance which is typically financed under the Pay-As-You-Go (PAYG)”. Modigliani (2001) also defined the DB pension one with a “pre-specified annuity either in absolute currency or as a fraction of a measure of salary (for example, a defined percentage of the final salary or an average of some past years of salary)”. However the guaranteed pension benefit could be in either real or nominal terms.

In a Defined Benefit pension plans, regular contributions made by participants, sponsors or both could change over time (Haneveld, Streutker and van der Vlerk, 2009). The participant may not be able to identify any linkage between contributions and benefits but, the administrators of the scheme and pension finance experts know there is a unique “budget constraint” that links contributions, returns, and benefits to a given replacement rate (Asad-Syed, Muralidhar, and van der Wouden 1998). Traditionally, corporate Defined Benefit pension formulas define annuities based on the number of years of service multiplied by some accrual factor. Implicitly, the

product of these two factors is the pension right (Modigliani and Muralidhar, 2004). Godoy and Valdes-Prieto (1997) have provided a general condemnation of all Defined Benefit plans by suggesting “the defined benefit approach exposes workers to the risk of a low final wage on which benefits are based and must pay an implicit fee to the agents that provide the guarantee on investment returns.” Modigliani and Muralidhar, (2004) on the other hand, argues that this condemnation is unwarranted because a Defined Benefit plan is only a promise to provide a guaranteed replacement rate, and there is no need to use the preceding formula to do so.

Defined Benefit plans spread investment risk across a large number of individuals of different ages and over different time horizons (Maer and Thurley, 2009). These plans pool risk within a cohort and across cohorts. The plan sponsor, who generally bears the investment risk of the plan, has a much longer time frame and a much higher risk-bearing capacity than individuals in the plan (Modigliani and muralidhar, 2004).

2.1.1.2. Defined Contribution Pension Scheme

OECD (2005) defines defined contributions as “an occupational pension under which the plan sponsor or firm pays fixed contributions and has no legal or constructive obligation to pay further contributions to an ongoing plan in the event of unfavourable plan experience”. This means that in defined contributions pension schemes, participants, sponsors, or both, make pre-specified contributions either in absolute currency or as a fraction of a measure of salary (Modigliani and Muralidhar, 2004). These contributions may also be partially or totally voluntary. However the final pension is uncertain (prior to retirement) because it depends entirely on asset performance of the accumulated contributions (Modigliani and Muralidhar, 2004). This implies that there can be the possibility that two individuals with identical

contributions, but different investment portfolios can receive widely divergent pensions. Further, two individuals with identical contribution histories can receive widely divergent pensions over different time periods. With traditional defined contributions, members bear the investment risk. An important point is, even in defined contributions plans, it is possible for contributions to change over time. This could happen because of changes in tax laws (either for mandated or voluntary schemes) or if existing contributions provide an insufficient or excessive replacement rate (Modigliani and muralidhar, 2004).

In conclusion, in a defined contributions plan the time horizon is the life of one individual, whereas in Defined Benefit plans the time horizon is much longer (if not infinite). For these reasons, Defined Benefit plans on average can take on more risk, but generate higher returns, and their asset allocation policy tends to take longer to change than individual plans (Orszag and Stiglitz, 2001). However, by pooling assets, Defined Benefit plans incur lower costs for managing assets, whereas Defined Contributions plans enable individuals to tailor their portfolio to the risk they wish to bear and allow for a better match to their preferences. With Defined Contribution, individuals participate in all the gains and losses of their plan, but incur higher costs in managing their assets, but Defined Benefit plans provide insurance for longevity risk (Blake 2000). The possibility that the money will run out before the individual dies is largely nonexistent unless the sponsor defaults and there is no insurance coverage in Defined Benefit plan. Defined contributions plans do not make provision for insurance, and annuities can be expensive to purchase. Often, it is difficult to access inflation-indexed life annuities in Defined Contribution plans (Modigliani and muralidhar, 2004).

2.1.2. Funding Methods

There are several ways to fund Defined Benefit or Defined Contribution plans. The funding methods of Pension plans are generally described as “pay-as-you-go” (PAYGO) and funded.

Presently, social security systems are overwhelmingly PAYGO. A typical PAYGO has no accumulation of funds because all contributions are disbursed to service pensions.

However, corporate or occupational DB or DC schemes tend to be funded (partially and/or fully). Funding requires an accumulation of funds before retirement to service future liabilities (Modigliani and Muralidhar, 2004). Logue and Rader (1997) have suggested that DC plans are always fully funded whereas DB is often PAYGO. This is true, according to Modigliani and muralidhar (2004) in the sense that the pension is entirely paid out of whatever capital that has been accumulated, but it can be misinterpreted to suggest that the sponsor is indifferent to the size of the pension. Muralidhar and Van der Wouden (1998b) have suggested that DC plans are underfunded if the assets in the plan are insufficient to deliver a target replacement rate.

2.2 Insight into Ghanaian Pension System.

The social security in Ghana provides income replacement as a result of old age, death (Survivor benefits), and Disability.

2.2.1 Historical Context

The historical context is in four fold, pre – colonial era, colonial, post-colonial era and the current three tier pension scheme.

2.2.1.1. Pre-Colonial Era

According to Kpessa (2010), most Ghanaians relied on traditional forms of social protection such as the extended family and a number of mutual aid organizations for their security, welfare and social protection before the advent of the rule. The extended family was the institution in Ghanaian communities that provided social and economic support to various family members at the appropriate times of need. Traditionally, the family was the critical focus in the provision of support when members become old and are threatened by economic deprivation, disability, and social isolation. However the aged without family were cared for by the community as a whole.

2.2.1.2. Colonial Era

With the advent of colonial rule in Ghana, a number of western institutions and programs were established by the British colonizers. Western-style social security was introduced to Ghana, together with other bureaucracies and institutions during the colonial era. Like other social institutions introduced during this era, the Ghanaian social security system was designed to cater for the needs of urban workers.

Kpessa (2010) finds that, “the first programme was designed as a means of encouraging loyalty and efficiency within the colonial civil service”. This retirement benefit was not one that was carved from deferred incomes by the retiree, but rather it was seen and considered as a reward for people who served the Queen and the colony diligently till their old age. Thus, public servants had no entitlement to such programmes unless they were judged by colonial administrators as meeting eligibility requirement of loyalty (Government of Ghana, 2006).

The income protection policy was introduced to only urban dwellers that were Europeans and some few Africans in the colonial Bureaucracy (Asamoah and Nortey, 1987). The Old age, income protection policy that was working during the colonial era was accompanied with the introduction of the Colonial Development and Welfare Act in the 1940s (Darkwa, 1997).

Later, a Pension Ordinance was enacted by the British government to replace and unify the Pensions (European Officer) Ordinance (CAP-29, 1936) and the pensions (Non-European Officer) Ordinance (CAP-30, 1936) into a single non-discriminatory pension scheme that offered equal benefits to both expatriates and local workers during this era (Government of Ghana, 2006). In its unified form, the scheme was referred to as CAP-30. This name was derived from chapter 30 of the 1950 Pension Ordinance (Kumado and Gockel, 2003).

2.2.1.3. Postcolonial Era

The Social Security Act of 1965 (Act 279) was enacted as a National Provident Fund Scheme to provide the initial framework for the Ghanaian scheme. The act was superseded by the Social Security Decree of 1972 (N.R.C.D. 127), which set up the Social Security and National Insurance Trust (Kumado and Gockel, 2003). Legislative Instrument 818 established rules and regulations for employers and mandated all employers with a minimum of five employees to participate in the scheme (Asamoah & Nortey, 1987; Kludze, 1988; US Department of Health and Human Services, 1990). Some organizations (such as the armed forces, police, and prison and university staff) had their own superannuation schemes and retirement benefits were exempted from the scheme (Kludze, 1988). Such organizations are still excluded under the revised scheme (the Social Security and National Insurance Trust) implemented in 1992. The

scheme did not cover workers in the informal sector (such as agriculture, fishing, and petty traders). The eligible participants receive benefits when they retire from active employment at age 60. The scheme created Old-Age pensions, Survivor Benefits, and Disability Pensions. Kpessa (2010) finds that members of the scheme can receive a maximum benefit of 80% of the average of an employee's three best years' salary provided they made a contribution for 40 years and beyond. Contributors earn a pension right of 2.5% every year for the first 20 years and 1.5% every year for the subsequent years of contributions until retirement. A member of the pension does not qualify for a full pension if he or she contributes less than 240 months (Osei, 2005). For example, those who retire at age 55 receive 60 percent of the full pension; with the pension rate increasing to 90 percent at age 59 (Estrin, 1992). The scheme makes provision for the payment of survivor's benefits. Survivors of insured persons who die before retirement or after retirement, but before the age of 72 are paid a lump sum equivalent to what would have been paid provided the deceased had contributed a minimum of 240 months (Estrin, 1992). This means that survivor's benefits will not be paid if the insured person dies after age 72. Disability compensation is paid to workers who are either temporary or permanently disabled and have retired from employment on that basis. A lump sum equal to the total employer and employee contributions plus 3 percent compounded interest is paid to workers (Estrin, 1992).

The scheme also makes provision for the payment of life insurance. It sets aside one percent of the employer's contributions for life insurance benefits to be paid to nominate relatives or other family members (Kludze, 1988). About 1% of the employer and employee contribution is deducted for unemployment insurance and paid to employees who've made at least 36 monthly contributions, and two monthly contributions in the last four months before becoming unemployed (Kludze, 1988).

In its initial stages, the State Insurance Corporation (SIC) administered the scheme. The retirement benefit was in the form of a provident fund. The term provident fund refers to a pension plan under which retiring workers received lump sum benefits in the form of financial assets to build up over a period of time through membership contributions and investment returns (Dixon, 1989, 1993, 2000). Under this arrangement “an individual’s pension is annuity whose size, at any given life expectancy and rate of interest, is determined only by the size of his or her lifetime pension accumulation (Barr, 2002).

However, this responsibility was later transferred to the Social Security and National Insurance Trust (SSNIT). SSNIT invests a sizable percentage of the money collected in a trust, and in loans and other securities of the Ghanaian government, mainly in overseas countries.

The scheme is financed by 5% deductions made by employers from workers’ salaries at source, and pay 12.5 percent of employees’ monthly salary into the security fund (Estrin, 1992). Thus, employees contribute 5 percent and employers contribute 12.5 percent into the fund, which sum up to monthly total contribution of 17.5 percent.

As a result of low interest rates and the rising inflation at the time, the lump sum benefits due to retiring beneficiaries were meaningless. Following the negative impact of the economic crisis on the provident funds, the labour unions demanded the conversion of the provident funds to pay-as-you-so (PAYG) social insurance that pay regular monthly benefits to retirees (Kpessa, 2010).

Workers who were under the Provident Fund were automatically enrolled in the new social insurance scheme and “Individuals who attend the retirement age at the exact date of the transition were given the option to choose between monthly benefits and lump sum payment, and pension entitlements were extended to employees who aged 55 (the retirement age under the

provident funds) with less than 240 of months participation but more than 180 months contribution to smoothen the transition process” (Dei, 1997).

2.2.1.4 The Three-Tier SSNIT Pension Scheme

Kumado and Gockel (2003) reported emphatically that; “Clearly, retirement benefits under CAP 30 are undoubtedly better than those under the SSNIT scheme, which is why those who can keep themselves in the plan do so, and others outside it are fighting to get on it. The problem is not only that there is great dissatisfaction among those workers who do not enjoy the superior coverage of CAP 30; it is also that the largely unfunded nature of the plan is a drain on general revenue.” The three-tier pension scheme was established due to agitation about the gap between CAP 30 and the SSNIT with regards to benefit payment. In July 2004, The President of Ghana appointed a nine member presidential commission on pensions, chaired by one T.A. Bediako, to examine existing pension scheme(s) that will ensure retirement income security for Ghanaian workers. The Bediako Commission submitted its final report to government in March 2006 and the main recommendation of the commission was the creation of a new contributory three-tier pension system for Ghana comprising two mandatory and a voluntary scheme and the phasing out of CAP 30. This pension reform introduced had its firm grounds from National Pensions Act, 2008 (Act 766).

The first tier is a basic national social security scheme, which is the regular monthly benefit payments managed by SSNIT and mandatory for all employees in both the private and public sectors in the formal sector. The improvements under the first tier basic national social security scheme are the reduction in the number years of contribution to qualify for full pension (from 20

years to 15 years) and the increase in guarantee age from 72 to 75.

The second tier occupational (or work-based) pension scheme is mandatory for all employees in the formal sector, but privately managed, and designed primarily to give contributors higher lump sum benefits than the “25% lump sum” available under the SSNIT or Cap 30 pension schemes. The second-tier is privately managed by approved Trustees, licensed by the Pensions Regulatory Authority. The second tier mandatory and privately managed defined contribution scheme is equitable to all members as the amount of accrued benefit is directly related to the contributions made.

The third tier is a voluntary provident fund and personal pension schemes, supported by tax benefit incentives to provide additional funds for workers who want to make voluntary contributions to enhance their pension benefits as well as workers in the informal sector. The third-tier is also privately managed by approved Trustees, licensed by the Pensions Regulatory Authority. Contributors have control over their pension benefits under the second and third tier schemes.

2.2.2 Institutional Structure

Currently the National Pensions Regulatory Authority (NPRA) regulates the entire administration of pensions in Ghana. SSNIT is also administered by a board of directors at the national level. In addition, there are regional, district, and agency offices across the country who administer the scheme (Kumado and Gockel, 2003).

2.2.3 Major Challenges and Outlook

SSNIT is faced with some administrative problems that hinder the progress of the industry. According to the SSNIT 2010 annual report, Government, the largest contributor to the SSNIT scheme most often delay in payment of the contributions thus causing SSNIT to delays in its projects and investment. Some of the board members and are appointed by government and are part of government as such the Government more or less has control, thereby causing a conflict of interest which is likely to lead to inefficiencies. There has been a continuous reduction in the rate of increase in total contributions received by SSNIT from 2006 to 2008 and increased in 2009 and fell in 2010 (SSNIT 2010) which is partly as a result of high unemployment rate.

2.3 Asset/Liability Management

The objective of most institutions with assets to invest is to fund some sort of liability, as is the case with banks, insurance companies, pension funds, and so forth (Ryan, 2013). The International Association of Insurance Supervisors (2006) defines asset/liability management as “the practice of managing a business so that decisions and actions taken with respect to assets and liabilities are coordinated”. Oracle Financial Services (2008) also define asset/liability management for banks as “a mechanism to address the risk faced by a bank because of a mismatch between assets and liabilities resulting from either differences in liquidity or changes in interest rates”.

According to Exley, Mehta, and Smith (1997), asset/liability management as practiced by pension schemes should differ from asset/liability management by banks. McDaniel (2011) also added that pension liabilities should be treated in the same way as bank and insurance liabilities,

giving each a proper asset/liability management focus.

2.3.1 Evolution of Asset Liability Management

The history of formal ALM for pensions (sometimes referred to as liability- driven investing, or LDI) is littered with false starts (Ryan, 2013). The dedication was the earliest form of asset/liability management for pensions. The model assumed a 100% bond portfolio held to maturity or to the liability payment dates (termination dates). The quest was thus to find the least expensive collection of bonds to perform this future-value matching (Fabozzi, 2005a). Black (1980) posits that by investing in bonds the pension fund's debt capacity increases because the volatility of the future will be reduced.

Dedication had several distinct advantages such as certain or predictable cash flows risk reduction, specificity, simple asset allocation and passive asset management (Leibowitz, Martin, 1986a) According to Ryan (2013), dedication had several disadvantages, which, in time, may have led to its failure as the core strategy for pension plans, these are; complicated mathematical model thus hard for clients to understand, requirement for accurate projected liability payment. The model is designed to match future values, not present values. This issue creates potential volatility for funding ratios (which are based on present values or market values) if asset market values do not behave in sync with liability market values. Also the transaction cost of dedication was highly interest rate sensitive (inversely correlated), so as the secular trend to lower rates continued from 1982 onward, dedication became increasingly more expensive to execute (Ryan 2013).

Due to the above disadvantages, immunization replaced dedication as an ALM Strategy (Ryan 2013). This approach also reduced the volatility of contribution costs, which are based on the funded ratio. Immunization ensures that the investment of assets is done in such a way that the existing business is immune to a general change in the interest rate (Redington, 1952). Immunization focused on matching the interest rate sensitivity of liabilities in present value dollars (Choie, 1992). As a result, it focused on duration (or modified duration) in harmony with horizon analysis (Fabozzi 2001). Duration measures the average life of a security (asset or liability) in present value dollars and a fair proxy for price return movement given an interest rate movement (Fabozzi, 2001). As interest rates rose in a long secular trend from 1974 to 1982, the financial industry began to pay more and more attention to duration. Realizing that higher interest rates would allow them to lock in unprecedented rates of return, defined benefit pension fund managers embraced the concepts of dedication and then immunization (Fabozzi, 2005b). Ryan (2013) accounts that in early 1982, interest rate began to fall, and call risk began to surface as a serious impediment to immunization and dedication models, especially for those who ventured into mortgage-backed securities. This prepayment and call risk altered cash flows and maturity structures, which damaged the integrity of immunization and dedication models dependent on these certain cash flows and maturity dates

When the interest rates went below the ROA assumption rate (around 8%) in the late 1980s, dedication and immunization strategies fell out of vogue because they locked in a return that would not be sufficient to neutralize or overcome pension expense, resulting in a drain on, or a charge against, earnings per share (Ryan, 2013). As a consequence, dedication and immunization were largely replaced by surplus optimization strategies that aimed for the growth of pension assets to outpace liability growth, thereby creating a pension surplus that would reduce or even

eliminate contribution costs. The pension fund portfolio composition included equities.

However the equity crisis during 2000 to 2002 became a pension tsunami causing the pension assets to underperform the ROA (actuarial loss), and in some cases, insolvency of the sponsor, with several companies filing for bankruptcy because pensions tend to be the largest liability of many firms (Ryan, 2013). After the 2000 to 2002 equity redress, the stage was set for the rebirth of the basic concept of asset/liability management because of deteriorating funded ratios, large actuarial losses, and spiking contribution costs (Ryan, 2013). The assets allocation however moved away from bonds, but this time with less equity concentration and many new asset classes and strategies (hedge funds, alternative investments and so on) (Collie, 2012).

2.4 Empirical Review on the Asset Liability Management of a Defined Benefit Pension Scheme

Boulier et. Al (1995) used stochastic control to obtain an optimal asset allocation between a risky asset and a riskless asset and the contribution policy of a defined benefit pension scheme. Also, the study used the France, US and Japan pension scheme as the case study and found that the proportion of the risky asset and the level of contribution are both proportional to the difference between the maximum wealth necessary to fund all pensions, and the actual wealth of the pension fund.

Consigli and Dempster (1998) adopted a dynamic stochastic programming for asset/liability management for a defined benefit pension scheme. The study considered a pension fund problem in which portfolio rebalancing is allowed over a long-term horizon at discrete time points and where liabilities refer to five different classes of pension contracts. In conclusion, the study

indicated that solving large financial planning problem with stochastic programming, nested Benders decomposition technique is superior to other techniques.

Kouwenberg (2001) developed and tested scenario generation methods for asset liability management models. The study used random sampling, an adjusted random sampling approach and a tree fitting method to construct event trees for the stochastic programming model. It was found that Rolling horizon simulations indicate that the random sampling approach might lead to excessive asset mix switching and spurious profits. Also the adjusted random sampling procedure considerably reduced the asset mix switching and drastically improved the performance of the ALM model but the tree fitting procedure slightly outperformed the adjusted random sampling technique. The study however proposed a stochastic programming model for a Dutch pension fund.

Bogentoft et. al, (2001) studied the formal optimal decision approaches for a multi-period Asset/Liability Management model for a pension fund. The study used Conditional Value-at-Risk (CVaR) as a risk measure and linear programming technique to solve the optimization problem. Also, Bogentoft et. al, (2001) formulated a model for finding optimal contribution rates and portfolio allocations, taking into account the funding situation of the fund. The study then found that using dynamic decision making through the use of paths leads to much lower costs to the fund than the alternative without grouping.

Gondzio and Kouwenberg (2001) used a stochastic programming model to solve the financial planning problem for the Dutch defined benefit pension scheme. The study showed that very large instances of stochastic programming models for asset/liability management could be solved if an efficient model-generation tool and a decomposition technique for optimization are

integrated in a high-performance computing environment. Gondzio and Kouwenberg (2001) found that the initial asset weights of stocks, bonds, and real estate varied significantly between the smaller models with up to eight nodes. The study concluded that there is a potential benefit of solving large stochastic programming models for practical purposes.

A study by Consiglio and Zenios (2001) adopted a stochastic programming model to solve an optimum asset mix problem for a defined benefit pension scheme. The study incorporated the risk tolerance of the portfolio manager either a utility function or a (modified) mean absolute deviation function. Consiglio and Zenios (2001) proposed stochastic programming for solving financial planning problem for a defined benefit pension scheme.

Josa-Fombellida et. al (2004) considered a continuous time dynamic pension funding model in a defined benefit plan of an employment system. The study aimed at minimizing the solvency risk and the contribution rate risk of a defined benefit pension fund. Three different scenarios were considered with regards to the investment decision taken. The scenarios are; the fund is invested in a constant risk free rate of interest, the promoter invests in a portfolio with n risky assets and a risk-free security and finally, the rate of return is stochastic. The study found that the expected value of the fund converges faster in the long run to the expected value of the actuarial liability when the agent diversifies her or his investment. Josa-Fombellida et. al (2004) proposed that the scheme should invest more in risky assets when the level of the fund is low, but it demands selling the risky assets short when the fund is operating with a large surplus.

Huang & Cairns (2006) investigated how to make use of market information to reduce contribution rate volatility of a defined benefit pension scheme. The objective of the study is to provide a model for determining an appropriate contribution rate for defined benefit pension

plans under a model where interest rates are stochastic and rates of return are random. The study first introduces a model for short-term interest rates, which can be used to help control contribution-rate volatility. Also three assets rather than the usual one (cash, bonds and equities) was modeled to allow comparison of different asset strategies. The study found that a number of illustrative examples have been given which demonstrate that the new adjustment to the contribution rate, taking account of current interest rates, does improve stability significantly, particularly where there is a strong degree of persistence in interest rates. The approach therefore indicates that the standard approach to liability valuation using an artificial valuation interest rate can be improved upon by making an adjustment for market conditions. We have proposed a simple method for adjusting the contribution rate to account for the current level of interest rates as well as the usual adjustment for the current funding level. However the study failed to look at direct methods for valuing liabilities using the current term-structure of interest rates.

Dempster et al (2009) adopted a dynamic stochastic optimization model for an asset/liability management that would be useful for underfunded defined benefit pension scheme on best practice that will return the scheme to solvency and long long-term sustainability. This study considered two cases, the case where the pension scheme is under- funded and a case the scheme is well funded. With these two cases it was found that the optimal initial asset allocations are largely made up of long maturity inflation linked bonds than equity. However, the study recommended that stochastic programming model should be used to solve asset/liability problem.

2.5 Empirical Studies of Pension in Ghana

Darkwa (1997) examined the major features of the Ghanaian social security system. The paper discussed the Ghanaian pension scheme by examining the extent of coverage, criteria for eligibility, and the method of administration and financing. The paper proposed that there should be an extension in coverage, adjusting the benefit formula, increasing expenditure on social services for the elderly, adjusting benefits to reflect the cost of living index, creating employer-based private pension schemes, and exploring alternative ways of investing social security accumulated funds.

Kpessa 2011 in his paper “Provident Funds, Pension programmes in English-Speaking Sub-Saharan Africa: A Look in the Rear Mirror and Lessons for the Future” analysed the previous experience of English-speaking Sub Sahara Africa countries with provident funds. The study found that pension plans that are designed on the principles of defined contribution are evidently vulnerable to several socioeconomic and political factors due to lack of effective and reliable financial markets and basic education of how defined contribution operates. The paper then recommended strong government policies that can ensure the political sustainability of the pension schemes.

Kpessa 2011 in his paper “A comparative analysis of pension reforms and challenges in Ghana and Nigeria” examined the complete and partial shifts to defined contribution pension programmes in Nigeria and Ghana respectively, and points to a number of contextual and contingency factors that challenge the use of defined contribution schemes as a means to address problems of benefit adequacy, institutional fragmentation and political interference that prompted the respective national reforms in the sub-Saharan African context. In doing this, the

article provided an overview of the institutional development of pension programmes in both countries of the colonial era to the present. It was found that the scope of coverage under pension programmes in both countries remains very limited, covering less than 20 per cent of the working population in each country.

The study then recommended that the fragility of national financial markets and the private sector, the overly bureaucratic institutional design of the new pension systems, a lack of adequate knowledge about markets and financial instruments, as well as general administrative weaknesses are important factors that must be addressed if the current pension system arrangements in Ghana and Nigeria are to meet the objective of providing adequate benefits.

Kpessa and Béland (2012) studied the regional context of the pension reform debate in Sub-Saharan Africa, and showed that, at least since the 1980s, there has been significant attention to pension reforms in Africa by global policy actors, including the World Bank. It was found that the regional environment of pension reform in Sub-Saharan Africa is characterized by a fierce competition between the World Bank and the International Labour Organization (ILO), with each institution promoting different policy preferences unlike Latin America and Central and Eastern Europe, where the World Bank proved dominant. The World Bank on one hand recommended to the policy makers of the French speaking Sub Sahara countries to privatize the Pay As You Go social insurance schemes inherited from the colonial system and on the other hand recommended that the Sub Sahara English-speaking countries should keep their defined contribution (provident fund) arrangements.

Mensah (2013) an MPhil thesis unpublished examined the trends in pension contributions and national savings in Ghana and established the relationship between pension contributions and

national savings, likewise identifying the prospects and challenges in the pension industry. The study used an Overlapping generation model in the study and employed the Ordinary Least Squares to establish the linear relationship and the Vector Error Correction Model as the estimation technique.

It was found that one of the predominant challenges facing the scheme was an insufficient monthly benefit. Also from the secondary data result showed a positive correlation between pension contribution and savings. The study then recommended that SSNIT should increase the monthly benefits of pensioners, so that consumption will be smoothed during the days of retirement and increase the contribution rate.

2.6 Conclusion

From the above, it can be concluded that the studies conducted in Ghana on pension mostly focus on the pension scheme reforms, governance and policy issues. Mensah (2013) suggested an increase in the contribution rate but did not state to what extent the contribution rate increase to should. There has not been any a study that has investigated the actuarial valuation on how the demography of Ghana (fertility rate and life expectancy) can affect the sustainability of the scheme.

Moreover, existing studies on the financial planning of pension schemes focus on developed countries. Very few studies have been made on the financial planning of the Ghanaian pension Scheme.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

The research methodology presents the various methods and techniques used to collect and analyse the data collected for the study. It provides information such as the research design, sample size, sample techniques, method of data collection, data analysis and presentation.

3.1 Research Design

A research design provides a framework for the collection and analysis of data. A choice of research design reflects decisions about the priority being given to the following; expressing causal connections between variables, generalizing to larger groups of individuals than those actually forming part of the investigation, understanding behaviour and meaning of that behaviour in its specific social context and having a temporal (i.e. Overtime) appreciation of social phenomena and their interconnections (Bryman & Bell, 2007). The study employed the quantitative method approach since it is primarily concerned with numbers, high concern for representativeness and highly structured methods for data collection (Hair et al, 2003).

3.2 Data

The study used a twenty four (24) year time series data spanning from 2001 to 2013 in the estimation. Annual data on returns on Listed Equity were obtained from the Ghana stock exchange market, 91 Treasury bills were obtained from the Bank of Ghana, nominal portfolio returns, inflation rate, Average Wage for all ages, Indexation rate, average pension paid at age

60+ were obtained from SSNIT.

3.3 Model Specification

According to Ziemba (2003), stochastic programming leads to models that take into account investor preferences in a simple and understandable way. Stochastic programming ensures that risk and return are balanced to achieve period-by-period goals and targets and long-run objectives (Ziemba, 2003). Thus the models force diversification and the consideration of extreme scenarios to protect investors from the effects of extreme outcomes and also do well in normal times. By its design, stochastic programming models do not let individuals or institutions get into extreme situations, because the models force consideration of all relevant scenarios; the common practice of assuming that low-probability scenarios will not occur is avoided. Most of the natural, practical aspects of asset/liability applications can be modelled well in the multi-period stochastic programming approach (Ziemba, 2003). The use of scenario-based, stochastic programming optimization models in discrete time provide an approach to asset/liability modelling over time. The models provide a way to think about, organize, and do calculations based on how one should choose asset mixes over time to achieve goals and cover liabilities (Ziemba 2003)

According to (Kouwenbeg and Zenois, 2001) Continuous-time models and discrete time models solved with dynamic programming and optimal control can provide good qualitative insights about fundamental issues in investments and ALM, as the optimal decision rules are in feedback form. However, their practical use as a tool for decision-making is limited by the many simplifying assumptions that are needed to derive the solutions in a reasonable amount of time. The advantage of stochastic programming models for multi-period investment and ALM

problems is that important practical issues such as transaction costs, multiple state variables, market incompleteness, taxes and trading limits, regulatory restrictions and corporate policy requirements can be handled simultaneously within the framework (Kouwenbeg and Zenois, 2001).

The relevance of a normative approach can only be judged on the basis of actual performance. Carino, Myers and Ziemba (1998) report good performance of the Frank Russell ALM model applied to Yasuda Insurance, with yearly savings of up to \$79 million compared to a simple constant mix strategy. Mulvey, Gould and Morgan (2000) report an estimate of \$450 to \$1,000 million savings in opportunity costs using the Towers Perrin–Tillinghast model to plan the US West pension plan. Golub et al. (1995), Kouwenberg (1998) and Fleten, Høyland and Wallace (1998) apply simulation in order to test the performance of stochastic programming models, relative to simple one-period models. The results indicate that dynamic stochastic programming models can outperform simple mean-variance models and multi-period models with fixed mix decision rules. Significant savings on transaction costs achieved with stochastic programming models were also demonstrated by Mulvey (1993). The effectiveness of stochastic programming models for tracking broad market indices has been demonstrated by Consiglio and Zenios (2001), Zenios et al. (1998) and Worzel, Vassiadou- Zeniou and Zenios (1994). Golub et al. Also tested the performance of the model against the popular fixed- income portfolio immunization technique (Reddington, 1952, Christensen and Fabozzi, 1987, Zenios, 1993). Their findings were confirmed the conclusions of Mulvey and Zenios (1994), that, modern fixed income securities are best managed by capturing correlations—in a single-period setting in this study instead of using duration matching in an immunization framework. The work of Golub et al. (1995) was extended by Zenios et al. (1998) to multi-stage models. Their empirical investigations were once

more carried out using out-of-sample simulations and rolling horizon dynamic games, but this time comparing single period with two-stage and three-stage models. The three-stage model outperformed the two-stage model for 12 out of the 15 repetitions of the dynamic game, over a three year period. This model was also tested, ex-poste in tracking the Salmon Brothers index of mortgage-backed securities in the US. Back testing was carried out over the three-year period January 1989 to December 1991, in monthly steps. During this period the index realized an annualised return of 14.05%, the single-period period model (mean-absolute deviation) 14.18% and the two- stage stochastic programme 15.10%. (Returns of the model portfolios account for transaction costs). Kouwenberg, 2001 recommended multistage stochastic programming for the asset/liability management for the Dutch pension fund. He compared the average cost and risk of the stochastic programming policy to the results of a simple fixed mixed model.

Of course this flexibility comes at a price and stochastic programming also has a drawback. The computational effort explodes as the number of decision stages in a multi-stage stochastic programming model increases (Kouwenbeg and Zenois, 2001). Bogentoft et al, (2001) also argue that implementing a stochastic programming model for ALM often forced to make a tradeoff between the number of decision stages in the model and the number of nodes in the event tree that are used to approximate the underlying returns distributions. When setting up stochastic programming models it is important to keep in mind that a normative model does not necessarily have to include every possible decision moment up to the planning horizon (Kouwenbeg and Zenois, 2001). Capturing the first few opportunities accurately can be good enough to make an informed decision right now. End effects created by limiting the number of stages can be mitigated using the techniques discussed in Carino and Ziemba (1998) and Carino, Myers and Ziemba (1998). In conclusion, Kouwenbeg and Zenois (2001) accent that stochastic

programming has several advantages over other alternative models however it is not without shortcomings.

3.4 General Approach to Solving the Problem

The study employed stochastic programming model to determine the optimal asset allocation policy for the SSNIT pension fund. The model specified sequence of investment decisions at discrete time points. Decisions are at the beginning of each time period. A two stage model is developed with decision made at time instances t_0, t_1, t_2, t_3, t_4 To do this we followed the following algorithm?

- i) The study considered a closed pension scheme from age 15 to 60 and assume that there would be no withdrawal from the scheme until a member is 60 years. In estimating the liabilities (future benefit payment) of this cohort, average wage at each age was predicted for 60 years for each age group in the cohort using a Vector Auto regression Model. This future benefit payment was computed by using the SSNIT old age full pension formula for individual age in the cohort and mortality based annuity factor. These future benefit payments were discounted to the present value for each age in the cohort and summed to determine the total liability the scheme is faced with. However, the total amount paid as pension benefits by SSNIT as at 2014 was not included in the liability.
- ii) Secondly, scenarios were generated for the asset and liabilities. In all thirty-two scenarios were generated. One of the scenarios was used to predict wages in step one. The scenarios were generated using a vector auto regression model (VAR). To do this, a test for stationarity of the data using the unit root test was done and found that

- the data used are stationary. Also, the coefficients of the VAR model were estimated using Matlab software and then checked whether they are significant or not. Again variance-covariance matrix of the VAR model was generated and decomposed it into the lower Cholesky factors. Furthermore, each set of thirty-two normal random numbers generated was then multiplied by the Cholesky decomposition. This was then added to the VAR model to simulate thirty-two scenarios for equity returns, treasury bills returns and wage growth (refer appendix tables A.1, A.2, and A.3).
- iii) Given the thirty-two scenarios generated for wages, average liabilities under each scenario and time period was estimated. This was then multiplied by the expected number of pensioners for each period to determine the expected cash flows for each period under each scenario for the five year period. The cash flow was then discounted to its present value, summed and subtracted from the total liability computed at step one to get the final liability which is the outstanding liability (refer appendix tables A.4, A.5 and A.6).
- iv) The initial fund value, liabilities and the final liabilities were normalized into thousands in order to avoid computational difficulties. This was done by dividing the fund value of SSNIT as at 2014 by itself and then multiplied by thousand. Also, the liabilities and final liability were divided by the initial fund value and multiplied by a thousand. This implies the initial fund value used is set at 1000 Ghana cedis. The absolute magnitude of this figure is unimportant (Nielsen and Zenois, 1994).
- v) The optimal asset holdings, purchases, sales, cash, wealth and expected final wealth were solved in General Algebraic Modeling System (GAMS). The GAMS codes of Consiglio, Nielsen and Zenois in their book “Practical Financial Optimization”

published in the year 2009, chapter 6 page 128 were also modified and used to solve the optimum asset mix by this study.

- vi) The robustness of the model checked by investigating the effect of varying the transaction cost on the optimal asset allocation and the expected final wealth were checked while the transaction cost was varied from 0 to 5% and run the model under each transaction cost.

3.5 Model Formulation

The objective of the model is to construct a portfolio to fund a given stochastic liability stream under a set of scenarios. Among the possible solutions, the model found the portfolio, which has the best risk – return profile over the scenario set.

The objective of the stochastic model is to construct a portfolio whose cash flows match the liabilities in each time period under all scenarios, while having a risk-return profile consistent with a prescribed level of risk tolerance.

In its basic form the model is a two- stage, stochastic programme with recourse. The first stage decision is the construction of the initial portfolio. After realizations of the returns have been observed, the portfolio is rebalanced. The construction of the rebalanced portfolio constitutes the second-stage decision. Thus the rebalancing decisions are contingent upon the realized scenario and the composition of the initial portfolio.

The SSNIT pension fund invests into Equity and treasury bills. The model below specifies a sequence of investment decisions taken by the portfolio manager at discrete time points. Decisions are made at the beginning of each time period. The portfolio manager starts with a given portfolio and a set of scenarios about future states of the economy, which is incorporated

into an investment decision. The investment made at the previous decision point and the scenario realized in the interim determines the precise composition of the portfolio (Koywemberg and zenois, 2001).

The stochastic programming model is developed for a five-year financial planning period from SSNIT. A two-stage model was developed, with decisions made at time instances t_0 , t_1 , and t_2 , t_3 , t_4 . That is decisions are made at 2015, 2016, 2017, 2018 and 2019. Scenarios unfold between t_0 and t_1 , and then again between t_1 and t_2 and also between t_2 and t_3 and then between t_3 and t_4 . At instance t_0 states of nature are anticipated and by instance t_1 this uncertainty is resolved.

3.5.1 Model Definition

Y_{0i} : The initial portfolio (in cash value) of asset i

Y_{ti}^s : Purchase of asset i at time t under scenario s .

Z_{pi}^s : Sale of asset i at time t under scenario s

X_{ti}^s : Holdings (in cash value) of asset i during time t , under scenario s

W^s : final wealth under scenario s .

C : the initial cash invested, consisting of the contribution

L_t^s : The liability due at time t under scenario s

γ : Transaction cost

The model is described in three parts, dealing with asset holdings, cash position and the model objective.

Security Holdings:

$$x_{1i}^s = y_{0i} \quad 1$$

Equation states that the initial holdings equal initial investments. The initial investment must not depend on the scenario to be realized and hence does not have the scenario superscript. These variables are measured in cash rather than face value

$$x_{(p+1)i}^s = m_{pi}^s x_{pi}^s - z_{pi}^s + y_{pi}^s \quad 2$$

Equation 2 defines the changes in the cash value of holdings due to yields, sales and purchases of assets.

$$z_{yi}^s = m_{yi}^s x_{yi}^s \quad 3$$

The multiplier m represents the yields during period p , of instrument I , under scenarios. It is assumed that the final portfolio must be liquidated, and this is ensured by the following constraints, which states that sales after the last period must equal holdings after that period:

Cash position accounting

The initial amount of cash is available is denoted by C . Cash is used for the purchase of assets and payment of liabilities and generated by sales. The constraint for the first time period states that the initial amount of cash available, C , must equal the amount invested in instruments, y_{oi} or held in cash during the first period:

$$\sum_{i \in U} y_{oi} = C \text{ for all } s \in S \quad 4$$

The corresponding cash – flow balance constraints for the intermediate time period are:

$$\sum_{i \in U} ((1 - \gamma)Z_{pi}^s = y_{pi}^s + L_p^s \quad 5$$

Where γ a transaction is the cost (charged as a fraction of the amount of the transaction) when selling the instrument and L is the liability due at the end of period p under scenarios For simplicity, transaction cost on purchases are not used. Rather, should account for total costs. The cash- flow constraints for the last time period is:

$$\sum_{i \in U} ((1 - \gamma)Z_{yi}^s = L_p^s + W^s \quad 6$$

It differs from 5 in not allowing purchases, and in defining the final wealth under each scenario W is the surplus cash after the last liability, L has been paid.

Objective function: the objective of the model is to maximize the expected value of a measure of final wealth across scenarios.

$$U_{\alpha}(r) = \begin{cases} \frac{1}{1-\alpha}(r^{1-\alpha}-1) & \text{for } \alpha \neq 1 \\ \log(r) & \text{for } \alpha=1 \end{cases} \quad 7$$

Where $\alpha \geq 0$ is a risk – aversion parameter. Higher values of α imply more risk-aversion, that is less tolerance for risk on the investor's part. The value of $\alpha = 0$ results in a linear utility function which corresponds to a risk neutral attitude, and $\alpha = 1$ in a logarithmic utility function which correspond to a moderate level of risk-aversion and which is known as the growth – optimal strategy. All scenarios assume equally probable, the objective function of the model is to

maximize the expected utility of the terminal wealth (W) at the end of the five year financial planning period. The terminal wealth is modeled as the ratio of cash available at the end of the financial planning period to final liability. The objective function is defined by;

$$\text{maximize Expected Utility} = U\alpha = \frac{1}{S} \sum_{s \in S} U\alpha (W^s) \quad 8$$

3.6. Scenario Generation

An important issue for successful applications of stochastic programming models is the construction of event trees with asset and liability returns (Kouwenberg, 2001).

3.6.1 Scenarios for the Liabilities

Any asset/liability management model requires a projection of the future value of the liabilities (Kouwenberg, 2001). The liabilities typically represent the discounted expected value of the future obligatory payments by the pension scheme, which is given as.

$$L\kappa(t) = \sum_{j=\max\{1,60-l_{kt}\}}^{\infty} O_k(t) \left(\frac{1}{1+r}\right)^j P^j l_{kt} \quad 9$$

Where $O_k(t)$ are the earned rights of participant k , r discount rate, l_{kt} the age of participant k at time t , $P^j l_{kt}$ is the probability that a person of age l_{kt} will be $L\kappa(t)$ alive in j years' time.

$$O_k(t) = 2\% d_k (S\kappa(t)) \quad 10$$

Where d_k is the number of year's participant K has been building up rights $(S\kappa(t))$ the average of the last three years' salary at time t

3.6.2 Scenarios for Assets

The return distributions underlying the generation process will be discretized with a small number of nodes in the event tree.

3.7 Method for Generating Scenario

In order to illustrate the calibration of a system of equations for economic factor values and asset returns, the ALM simulation system for SSNIT pension funds is considered.

Apart from the returns on these assets, each scenario should contain information about future wage growth in order to calculate the future values of the pension liabilities.

In order to generate asset returns and the wage growth rate a vector autoregressive model is applied by Boender (1997):

$$R_t = c + Vh_{t-1} + \varepsilon_t, \varepsilon_t \sim N(0, Q), t=1, 2, \dots, T, \quad 11$$

$$R_{it} = \ln(1+r_{it}), I=1, 2, \dots, m, t=1, 2, \dots, T, \quad 12$$

Where m denotes the number of asset time series, r_{it} denotes the discrete rate of change of variable i in year t, R_t denotes an m-dimensional vector of continuously compounded rates, c denotes the m-dimensional vector of coefficients, V denotes an $m \times m$ matrix of coefficients, ε_t denotes the m-dimensional vector of error terms, Q denotes the $m \times m$ covariance matrix.

In order to estimate the coefficients of the model the yearly data on the asset returns and the general wage increase in the Ghana from 1990 to 2014 were used.

CHAPTER FOUR

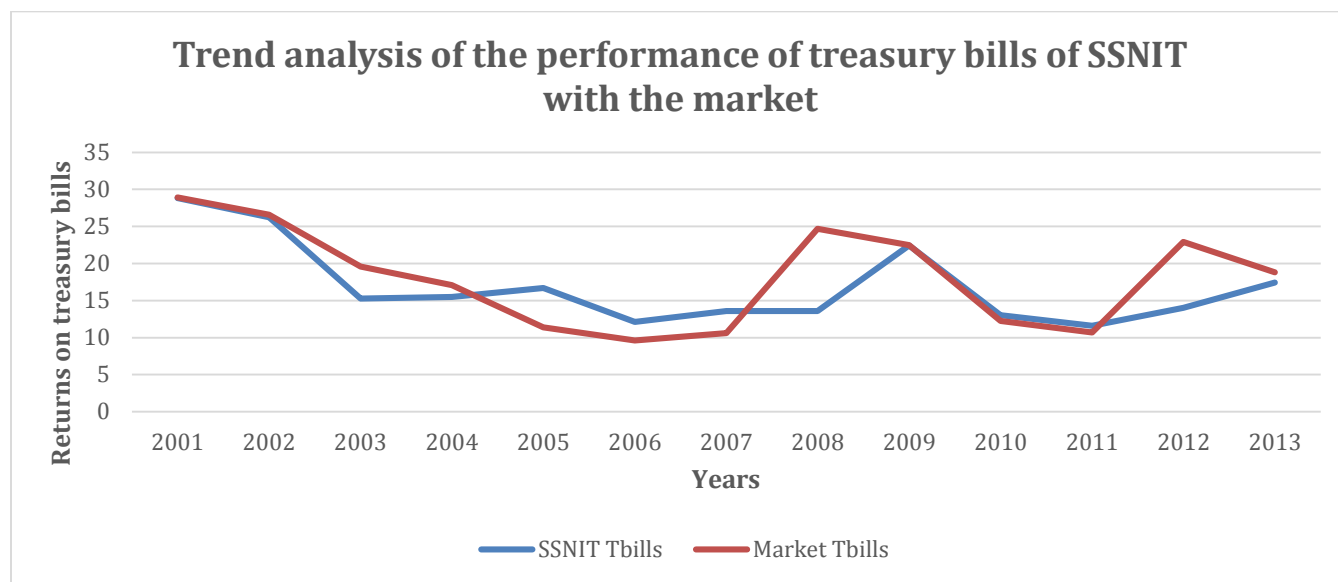
DATA ANALYSIS AND INTERPRETATION

4.0 Introduction

This chapter of the study presents graphs and outputs of statistical analysis from annual data received from the Ghana stock exchange market and SSNIT. Toward the end of this study, this chapter presents an analysis on the investment performance of SSNIT compared with the financial market and also develop a method for an optimal asset mix strategy that will ensure the sustainability of the pension fund.

4.1 Investigating the performance of SSNIT and that of the financial market

Based on the thirteen (13) years' data collected from SSNIT and the financial market, the annual percentage return on treasury bills and percentage return equity are used in this section to investigate the investment performance. The study used trend analysis and various descriptive statistics to help achieve this objective. The figure below indicates how SSNIT performs based on their returns on treasury compared to the financial market over the period of study.

Figure 4. 1: Trend Analysis of the performance of Treasury bills of SSNIT with the Market

Source: computation from Research Data, 2015

From figure 4.1, it can be inferred that the returns on treasury bills for both SSNIT and the market trends over the period of study are more likely closer. Thus, strategies developed by the market and SSNIT yield an almost equal return on treasury bills. The return from treasury bills of SSNIT and the market shows that there have been positive returns throughout the period of study. In order to better determine which of these two returns were better during the periods of the study, descriptive statistics below are also used to help make better judgments on how SSNIT has performed in the financial market.

As indicated from figure 4.1, it is not clear how the performance from the return on Treasury bills is faring. From the table 4.1, it is asserted that the market yielded higher expected returns on treasury bills than that of SSNIT. A mean percentage return of 18.13 compared to that of 16.95 from the financial market and SSNIT operation respectively. However the coefficient of variation (CV) of the market returns is 0.37 and that of SSNIT is 0.32. Even though the market

has higher expected returns than SSNIT, the performance of SSNIT is better than the market in relation to their risk.

Table 4. 1 Descriptive statistics of return on Treasury bill

Statistics	T-bills _Market	T-bills _SSNIT
Mean	18.13	16.95
Standard Deviation	6.72	5.49
CV	0.37	0.32
Kurtosis	-1.47	0.67
Skewness	0.12	1.32
Minimum	9.60	11.59
Maximum	28.94	28.84

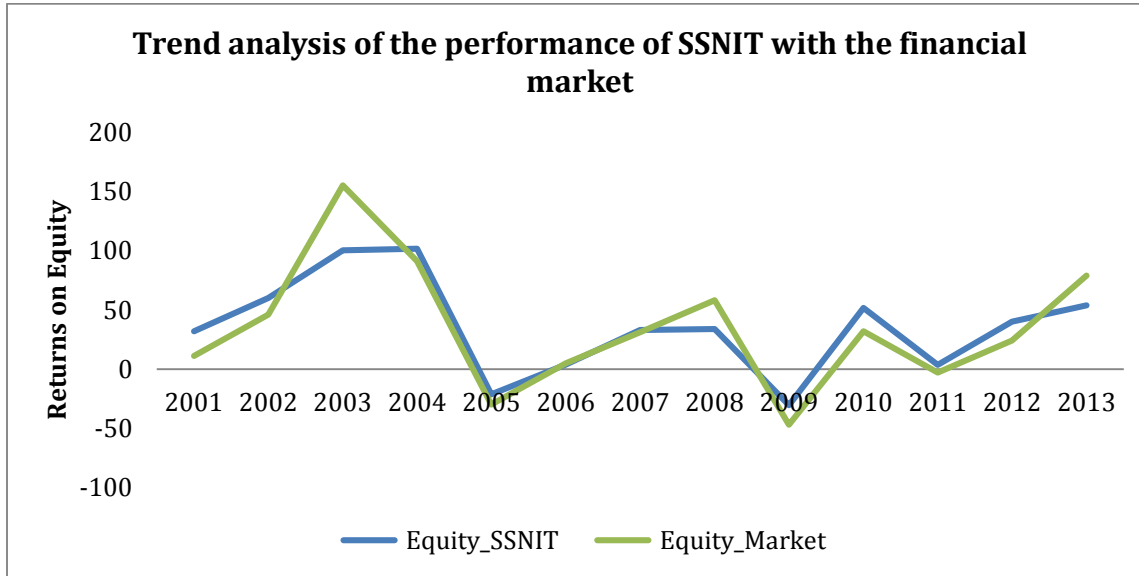
Source: computation from Research Data, 2015

A standard deviation of 6.72 percent compared to that of 5.49 percent of SSNIT also shows that the financial market is susceptible to higher risk of the returns from their treasury operations than that of SSNIT. It is shown that the highest percentage return on treasury for SSNIT is 28.84 percent in the year 2001 and a minimum percent value of 11.59 percent in the year 2011, while that of the market return is of a high of 28.94 percent in the year 2001 and low of 9.60 percent in the year 2006. The skewness statistics are all positive, indicating that the performances of the two treasury strategies were all toward the right side longer or fatter than the left side. Thus the loss through treasury operations for both strategies is less than that of the gains. It can be inferred that, the treasury operations for SSNIT and the market over the periods of study yielded a more positive return.

On making a more comparative analysis of the performance of SSNIT and the financial market, the study also based on the return on listed equity of these two groups and assessed the scenario. From figure 4.2, it is indicative that the returns on equity trends over the period of study are more

likely closer. Thus, strategies developed by the market and SSNIT yield an almost equal return on equity. There was similar movement of the equity returns of SSNIT and that of the stock market over the periods of study.

Figure 4. 2 Trend Analysis of the Performance of SSNIT with the Financial Market



Source: computation from Research Data, 2015

Table 4.2 below shows descriptive statistics, which are also given more information on the situation. The mean percentage return on equity from the table below shows that return on equity from SSNIT outperform than that of the market. Over the period SSNIT was able to make 35.5 percent of expected returns on equity while that of the market was able to yield 34.7 percent. The coefficient of variation of SSNIT returns on equity is 1.13 and that of the market is 1.53. Similarly shown from the percent return from Treasury bill, it can be assessed that the market activity toward return on equity is more risky than from the SSNIT. The standard deviation values of 53.34 percent and 40.16 percent which were respectively from the percentage return on

equity in the financial market and SSNIT shows the risk attached on these returns. The minimum return on equity from the market is -47 percent in the year 2009 and a maximum of 155 percent, in the year 2003 while that of SSNIT -30.35 percent in the year 2009 low and a high of 101.50 in the years 2004.

Table 4. 2 Descriptive statistics on percentage return on equity

Statistics	Equity_Market	Equity_SSNIT
Mean	34.77	35.55
Standard Deviation	53.34	40.16
CV	1.53	1.13
Kurtosis	0.99	-0.31
Skewness	0.72	0.08
Minimum	-47.00	-30.35
Maximum	155.00	101.50

Source: computation from Research Data, 2015

4.2 Designing a method for an optimum asset mix strategy for sustainable pension fund

Developing a method for asset mix that will provide to pension fund manager's good asset mix to well diversify the investment opportunity for a better yield is the main concern of the every fund manager. In this section the study provides an asset mix strategy using the stochastic programming approach based on market data received from 1990 to 2014 on asset returns and the wage growth rate.

The model used a stochastic simulation of asset returns and wage growth for a period of five years. Vector auto regression model was used to simulate random future asset returns and wage growth. Thirty-two random future asset returns and wage growth were simulated. The Stochastic-programming model is characterized by a complete set of decision. The decision

variables for the stochastic programming model is how much of the asset to buy, sell and hold for each time period under each scenario, and additional non-anticipativity constraints that force the model not to be clairvoyant by using information that is not yet available when making first- and second-stage decisions. This formulation is known as a “split-variable” formulation (Nielson & Consiglio, 2010). The (logically identical) first-stage variables are split up into one copy per scenario, and are then forced to be equal to each other with the additional constraints.

In the table 4.3, the study provides descriptive statistics for the time series data obtained. Wage is the rate of change in Ghanaian average wage level. Equity and treasury bills are the returns on Equity and 91-day Treasury bills respectively. It is shown that the wage growth over the period of study is increasing by 31.6% annually on average. Thus, the wage increment will cause high liability to the pension fund. The mean of the treasury bills and equity return are 25.9% and 31.5% respectively. This indicates that equity has a higher expected return than treasury bills. The standard deviation of the returns of Treasury bills is 11.6% and that of equity is 50.8%. It can be inferred that equity has higher risk than treasury bills.

Table 4. 3: Descriptive statistics on asset returns and Ghana’s wage growth rate, 1990 - 2014

Variables	Mean	Std. dev.	Skewness	Kurtosis
WAGE	0.316	0.288	1.647	5.190
TBILLS	0.259	0.116	0.439	-0.605
EQUITY	0.315	0.508	0.770	2.947

Source: computation from Research Data, 2015

The table below is a test of relationship between the variables under study thus, Treasury bills, Equity and Wage. From the correlation test, it may be inferred that, there is a weak correlation

amongst the variables. There is therefore an indication that the variables under study were of distinct features therefore less susceptible to the collinearity. The negative correlation indicates that an inverse relationship exists for these variables. Thus an increase in returns in wage causes a decrease in returns on equity and vice versa.

Table 4. 4 Correlations of Ghana’s asset classes, annually 1990 - 2014

	TBILLS	EQUITY	WAGE
TBILLS	1		
EQUITY	0.063	1	
WAGE	0.231	-0.215	1

Source: computation from Research Data, 2015

Table 4. 5 Coefficient of vector auto regression model for asset returns and wage growth for the Ghanaian market.

Wages _t	$= 0.0715 + 0.3217\text{wage}_{t-1} + 0.0755\text{equity}_{t-1} + 0.3167\text{tbills}_{t-1} + \epsilon_{1t}$
Equity _t	$= 0.2778 + 0.0652\text{equity}_{t-1} + 0.8906\text{tbills}_{t-1} + -0.5926\text{wage}_{t-1} + \epsilon_{2t}$
Tbill _t	$= 0.0507 + 0.7401\text{tbills}_{t-1} + 0.0195\text{equity}_{t-1} + 0.0284\text{wage}_{t-1} + \epsilon_{3t}$

Source: computation from Research Data, 2015

Table 4.5 shows the coefficient of the vector auto regression model using annual data for the period 1990 to 2014. It was found the coefficient of the lag of equity and wage were insignificant at 5% significance level. This means that equity and wage have no memory (Kouwenberg, 2001).

Table 4. 6 Variance - Covariance Matrix from VAR model

	Equity	T-bills	Wage
Equity	0.2461		
T-bills	-0.0015	0.0065	
Wage	-0.0018	0.0003	0.053

Source: computation from Research Data, 2015

Table 4.6 shows the variance covariance matrix from the Vector Auto regression model.

Table 4. 7 Lower Cholesky Decomposition Matrix from the VAR model

	Equity	T-bills	Wage
Equity	0.4961		
T-bills	-0.0029	0.0806	
Wage	-0.0037	0.0034	0.2302

Source: computation from Research Data, 2015

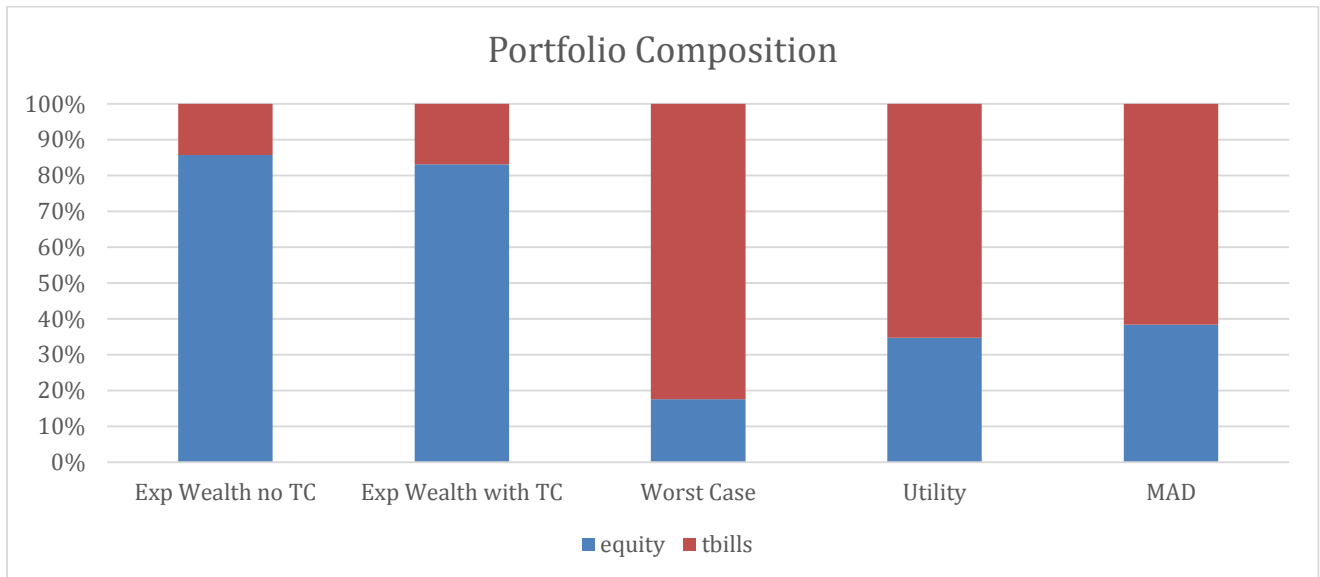
Table 4.7 shows the lower Cholesky decomposition matrix of the vector auto regression model.

Figure 4.3 below summarizes the optimal portfolios obtained by five objective models. The first objective implements the stochastic programme with non-anticipativity constraints and no transaction cost. The second model implements the same as the first model, but with transaction costs. The third model also maximizes the worst-case outcome where the wealth constraint is set equal to 1. The wealth is the ratio, cash available at the end of the financial planning period (T5) to final liability. This indicates that assets (cash) are constrained to be equal to liabilities. The fourth model maximizes the expected utility of the final wealth, using the logarithmic utility function.

The fifth model is a multi-stage formulation of the tracking Model with limits on maximum downside risk. In this case there is a constrain wealth which is not to be less than 1.1 – a constant benchmark by allowing a tolerance level of deviation of nine percent.

Figure 4.3 shows the optimum asset allocation at a transaction cost of one percent.

Figure 4. 3: Asset Allocation



Source: computation from Research Data, 2015

According to figure 4.3, for the first model, 85.7% of the fund value should be invested in Equity and 14.3% in Treasury bill. The first model is a risk neutral model. It does not consider the risk. Higher allocation went to Equity than the Treasury bill because Equity has higher expected returns than treasury bills.

For the second model, the initial investment indicates that 83.1% of the initial fund value should be put in Equity and 16.9% in Treasury bills. The objective of this model is to maximize expected wealth but the transaction costs reduce the rebalancing activity at stage T1. Risk isn't considered in this model so less was invested in Treasury bills since it is less risky and lesser-expected returns compared to equity.

The worst case Scenario is considered as absolute risk averse. With this model the optimum initial investment is 17.6% in equity and 82.4% into Treasury bills. This model is not just to maximize expected final wealth, but risk is also considered. The worst Case scenario with extreme risk averse is where the fund ratio (asset/final liability) is constrained to be equal to 1. Thus, in the worst-case situation liabilities should be equal to assets. Higher percentage of the initial fund value is put into treasury bills, which is less risky than equity.

The log Utility function is a risk averse utility function. The optimum asset allocation shows that 65.3% into Treasury bills and 34.7% into Treasury bills.

With the last model, which is the mean absolute deviation, the optimum asset allocation is 38.4% in equity and 61.6% in bonds.

Among the five objective functions, models three, four and five have risk being considered (risk averse), whereas the first two models did not consider the risk (risk neutral). It was found that the optimum asset allocation for the last three models (Worst Case Scenario, log Utility and Mean Absolute Deviation) has a higher allocation in Treasury bills than Equity. The first two models, on the other hand, are risk neutral also, had higher allocation to equity than Treasury bills. The risk averse models allocate more in less risky asset (Treasury bills) than a risky asset (Equity). The risk neutral models allocate more in risky assets than less risky asset. This is consistent with the findings of Nielsen and Zenois (1994).

Table 4.8 shows the optimal expected final wealth of all the five models. The expected final wealth is the average of wealth (i.e. the ratio of asset to liabilities) at the end of the financial planning period under all scenarios.

Table 4. 8: Expected Final Wealth

Exp Wealth with no TC	9.333
Exp Wealth with TC	8.981
Worst Case	1.295
Utility	1.932
MAD	8.679

Source: computation from Research Data, 2015

From table 4.8, the expected wealth model with no transaction cost got the highest objective value of 9.333. This means that the final asset at the end of the fifth period will be 9.333 times more than liabilities. The least objective value is the worst-case scenario of 1.295. Among the risk averse models, the mean absolute deviation got the highest objective value of 8.679. The mean absolute deviation is therefore recommended since it considers risk and has higher expected final wealth among the models that considered risk. It is not surprising that Expected wealth with no transaction cost has highest objective value since the model is traded at zero cost and also do not consider the risk. Also from figure 4.3, shows the transaction cost with no transaction cost got the highest allocation to equity. Equity has higher expected returns than treasury bills refer (table 4.3). It can also be observed that, the final wealth value of each model is greater than more. This implies that the scheme would be capable of paying pension benefits promised when due despite the risk preference of the investor. It is therefore proven that stochastic programming model if adopted would ensure the sustainability of the SSNIT pension scheme.

Table 4.9 shows purchases of assets for the mean absolute deviation model at a transaction cost of one percent of all the thirty-two scenarios at each time period. The non-anticipativity constraints equalize the optimal decision under each scenario. Purchases occur at time t_0, t_1, t_2, t_3 and t_4 .

Table 4. 9: Purchase of Asset at each time period under all scenarios

	t0	t0	t1	t1	t2	t2	t3	t3	t4	t4
	equity	tbills	equity	tbills	equity	tbills	equity	tbills	equity	tbills
S1	38	62	0	29	0	0	12	0	41	0
S2	38	62	0	17	0	0	12	0	40	0
S3	38	62	34	0	0	211	0	0	262	0
S4	38	62	60	0	0	211	0	0	262	0
S5	38	62	67	0	0	0	0	0	0	0
S6	38	62	61	0	0	179	169	0	0	0
S7	38	62	59	0	0	0	0	0	0	0
S8	38	62	61	0	0	0	0	384	442	0
S9	38	62	0	48	0	0	124	0	0	212
S10	38	62	0	45	130	0	0	0	0	0
S11	38	62	0	24	143	0	0	198	231	0
S12	38	62	59	0	0	0	0	214	0	0
S13	38	62	69	0	0	270	287	0	0	0
S14	38	62	0	34	0	0	105	0	0	0
S15	38	62	0	31	0	0	0	0	155	0
S16	38	62	0	72	184	0	0	0	0	0
S17	38	62	0	34	135	0	0	165	205	0
S18	38	62	0	81	0	0	0	0	0	0
S19	38	62	64	0	0	117	0	0	0	0
S20	38	62	70	0	0	0	0	0	0	0
S21	38	62	0	17	112	0	0	0	0	0
S22	38	62	0	43	0	0	114	0	0	0
S23	38	62	0	30	117	0	0	0	0	0
S24	38	62	62	0	0	0	0	331	0	0
S25	38	62	0	0	65	0	0	0	0	0
S26	38	62	0	32	0	0	136	0	0	0
S27	38	62	0	21	0	0	0	0	0	0
S28	38	62	66	0	0	0	0	379	400	0
S29	38	62	63	0	0	0	0	0	0	0
S30	38	62	59	0	0	0	0	0	0	298
S31	38	62	67	0	0	0	0	0	0	0
S32	38	62	63	0	0	183	223	0	0	0

Source: computation from Research Data, 2015

According to table 4.9, thirty eight and sixty two percent of the fund value should be used to purchase equity and treasury bills respectively for all the scenarios at the initial period. How

much of an asset to be purchase change as the period change depending on which scenario will be realized. For instance, for scenario one the investor (SSNIT) should use thirty eight percent of the fund value to purchase equity and the rest (62%) to purchase treasury bills. The investor should invest twenty nine percent in treasury and nothing in equity in the following year. For the third year, the investor should not buy neither equity nor treasury bills. Also for the fourth year (t3) the investor should invest twelve percent of the fund value in equity and nothing in treasury bills. At the firth year (t4), the investor should invest forty one percent of the fund value in equity and nothing in treasury bills. A purchase is made after pension benefits due are paid.

Table 4.10 shows sales of assets for the mean deviation model at a transaction cost of one percent for all the thirty-two scenarios at each time period. Sales occur at t1, t2, t3, t4 and t5. The non-anticipativity constraints are active only at t1.

Table 4. 10: Sale of Asset at each time period under all scenarios

	t1	t1	t2	t2	t3	t3	t4	t4	t5	t5
	equity	tbills	equity	tbills	equity	tbills	Equity	tbills	equity	tbills
S1	60	0	0	12	0	25	0	53	90	0
S2	28	0	0	34	0	59	0	72	91	0
S3	0	77	228	0	0	44	0	295	437	0
S4	0	71	228	0	0	20	0	295	264	0
S5	0	79	15	0	20	0	21	0	294	0
S6	0	72	195	0	0	189	16	0	266	0
S7	0	69	13	0	20	0	25	0	395	0
S8	0	72	13	0	408	0	0	470	636	0
S9	59	0	0	14	0	145	238	0	0	272
S10	56	0	0	146	22	0	27	0	513	0
S11	37	0	0	165	234	0	0	277	435	0
S12	0	69	14	0	237	0	27	0	0	397
S13	0	82	288	0	0	313	24	0	1028	0
S14	45	0	0	14	0	125	20	0	276	0
S15	42	0	0	17	0	28	0	186	205	0
S16	84	0	0	204	28	0	29	0	566	0
S17	45	0	0	154	195	0	0	247	361	0
S18	93	0	0	18	0	25	0	29	0	303
S19	0	76	132	0	0	19	0	21	0	147
S20	0	82	18	0	28	0	30	0	831	0
S21	29	0	0	131	24	0	28	0	377	0
S22	53	0	0	14	0	133	18	0	223	0
S23	41	0	0	134	25	0	30	0	427	0
S24	0	73	15	0	357	0	0	26	0	419
S25	0	11	0	82	24	0	28	0	437	0
S26	43	0	0	17	0	163	29	0	407	0
S27	33	0	0	17	0	26	0	35	0	227
S28	0	78	16	0	408	0	0	432	569	0
S29	0	74	15	0	25	0	30	0	907	0
S30	0	70	14	0	21	0	325	0	0	350
S31	0	80	17	0	25	0	27	0	568	0
S32	0	75	200	0	0	250	32	0	563	0

Source: computation from Research Data, 2015

The table 4.10 shows how much of individual financial asset is to be purchased at each time period under all the thirty-two scenarios. For scenario one (S1) the investor should sell sixty

percent of the amount invested in equity only. The fund value varies as the time changes due to changes in the asset returns and liability.

Table 4.11 shows the final wealth ratio at the end of the financial planning period at a transaction cost of one percent for the mean absolute deviation model.

Table 4. 11: Wealth for all the scenarios under mean deviation model

S1	1.01	S9	4.46	S17	11.43	S25	8.68
S2	1.26	S10	9.97	S18	6.13	S26	8.55
S3	9.48	S11	21.33	S19	2.07	S27	5.31
S4	4.19	S12	7.05	S20	20.40	S28	11.67
S5	4.66	S13	19.79	S21	7.74	S29	20.58
S6	3.76	S14	4.12	S22	3.16	S30	5.77
S7	6.59	S15	4.07	S23	9.25	S31	11.52
S8	10.7	S16	13.47	S24	7.35	S32	12.24

Source: computation from Research Data, 2015

It can be seen from table 4.11 that the objective values under all the scenarios are above 1. This implies irrespective of which scenario that occurs, the assets are going to be more than the liabilities at the end of the financial planning period. Therefore, the stochastic programming model especially the mean absolute deviation if adopted would make the scheme capable of paying benefits promised.

4.3 Model Robustness

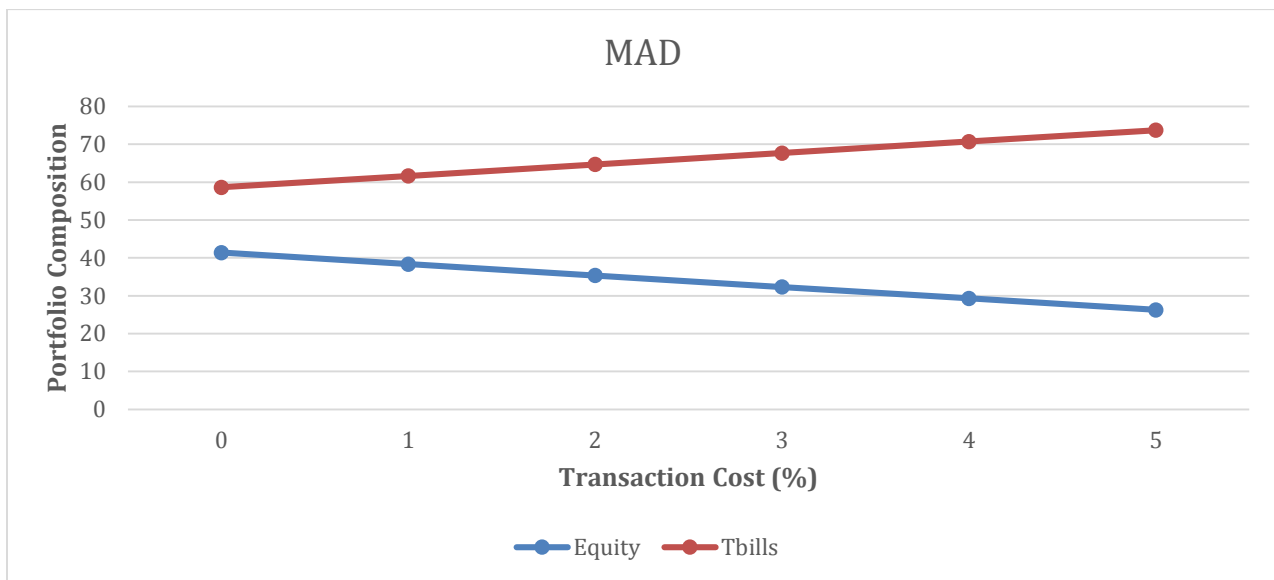
An investigation made in this section is on the model robustness, thus how sensitive the model is to its parameters. The transaction cost is varied in order to observe its effect on the initial portfolio allocation and the objective function value.

4.3.1 Varying the Transaction Cost

The reaction of the model to changes in the transaction cost is important for the practical use of the model (Nielsen & Zenois, 1994). The transaction cost was varied from zero to five percent and the result was that, as the transaction cost varies, so as the initial portfolio allocation and the objective function values also.

Figure 4.4 shows how sensitive the optimum asset allocation of the mean absolute deviation model to changes in transaction cost

Figure 4. 4: MAD Transaction Cost Sensitivity Analysis



Source: computation from Research Data, 2015

According to figure 4.4, as the transaction cost increases the optimal asset allocation for the treasury bills increase and that of equity decreases.

Table 4.11 shows the effect of transaction cost of the final wealth for the all the objective function models.

Table 4. 12: Expected Final Wealth Transaction Cost Sensitivity Analysis

Transaction Cost	0	1%	2%	3%	4%	5%
Exp Wealth with TC	9.333	9.271	8.920	8.585	8.269	7.971
Worst Case	1.341	1.295	1.250	1.205	1.161	1.118
Utility	1.971	1.932	1.894	1.856	1.818	1.780
MAD	9.032	8.679	8.33	7.999	7.682	7.376

Source: computation from Research Data, 2015

According to table 4.12, it can be inferred that, as the transaction cost increases, the final wealth also decreases for all the objective function values. This shows an inverse relationship between transaction cost and the final wealth.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter presents the summary of the entire study and focuses on the findings, conclusion drawn from the findings and recommendations. The chapter also outlines recommendations for further studies in the area of asset/liability management of defined benefit pension scheme.

5.1 Summary of the Study

The aim of this research is to find a method for the optimum asset allocation that will ensure the likelihood of the SSNIT pension scheme to meet its contractual obligation. The study employed a stochastic programming model for the optimal asset allocation and Vector Auto Regression model for the generation of scenarios. The data were collected from SSNIT, Bank of Ghana and Ghana Stock exchange.

The study considered a closed cohort pension scheme whose members are aged between fifteen and sixty years. It first investigated SSNIT investment returns in relation to that of the market returns statistically, then used trend analysis and descriptive statistics to investigate how well SSNIT performed for the period of 2001 to 2013 in the market with regards to equity and treasury bills.

To solve the optimum asset allocation generated, stochastic scenarios were first generated. A Vector Auto Regression (VAR) model was to generate thirty-two stochastic scenarios for asset returns (equity and treasury bills) and wages for a period of five years. The first scenario was for a period of forty-five years in order to estimate the liability of the pension scheme. The scenarios

were generated from the coefficient of the VAR model, normal random numbers, Cholesky decomposition and residual covariance matrix.

The optimal asset allocation for different risk preferences was also generated. The risk preferences are risk neutral and risk averse. For the risk averse, three models were obtained; that are the worst case scenario, log utility function and the mean absolute deviation. The risk neutral is to maximise expected wealth with transaction cost and maximise transaction cost with no transaction cost.

To check the robustness of the model, investigation was made in relation to the effects of varying the transaction cost on the initial optimal asset allocation and the final wealth.

It was however not clear whether SSNIT has performed better or worse than the market based on the trend analysis. Next, was the computation of the coefficient of variation of the returns on equity and treasury bills for both the financial market and SSNIT. The findings were that, SSNIT performed better in both the treasury bills and the stock market during the period of study based on the coefficient of variation values of the investment returns and the optimal allocation for models for the risk averse had a higher allocation to treasury bills than equity. Also the risk neutral models had higher asset allocation to equity than treasury bills. The final wealth values for the risk neutral are higher than that of the risk averse model. Among the risk averse models, the mean absolute deviation got the highest final wealth value.

Furthermore, the optimal asset allocation varied as transaction cost varied. On the level of the mean absolute deviation, as the transaction cost increases, the allocation to treasury bills increases and equity falls. Also, as expected as the transaction cost increases the final wealth decreases.

5.2 Conclusion

The research was successful at meeting its stated objectives. It was shown that SSNIT investment returns on treasury bills and the equity performed better than that of the market. It was also found the portfolio composition of the risk averse model has more of treasury bills than equity. On the other hand the portfolio composition of the risk neutral model has more of equity than treasury bills. The optimal final wealth values for risk neutral models are higher than that of the risk averse model. This is because the risk neutral models have higher allocation to equity than the risk averse model. Equity has higher expected return than treasury bills according table 4.3. Regardless of the risk preference (i.e risk averse models or risk neutral) used, it was found that the final wealth (the ratio of asset to liability) was greater than one. The final wealth greater than one implies that the pension would be capable of paying its liabilities when due. This study therefore concludes that the stochastic programming model if adopted by the SSNIT pension scheme as the method for the optimal asset mix would make it sustainable. Also, the model is sensitive to transaction cost. Varying the transaction cost affects the optimal asset allocation and the final wealth.

5.4. Limitation.

The scope of the study is SSNIT pension scheme tier 1. The study focused on the asset/ liability management of the pension fund by adopting a stochastic programming approach. The study also focused on the liability of the scheme arising from old age. The study focused on the investment policies that ensure that the scheme meets its liability.

The study is limited to only the tier one of the SSNIT pension Scheme due to availability of data.

In the valuation of liability, some studies considered old age pension, disability pension and survival pension. This study only considered old age pension. This is due to lack of data availability.

SSNIT invests in three broad classes of assets, which are; fixed income, equity and alternative investment. This study only looked at Treasury bill and listed equities. This can be attributed to lack of data accessibility.

5.3 Recommendation

The study provides a method for the optimum asset mix strategy that ensures financial safety of the SSNIT pension scheme and higher expected final wealth for a period five years. It clearly appears that SSNIT investment in treasury bills and equity has performed better compared with the market over the study period (2001 to 2013).

The first objective of the SSNIT investment policy is safety (SSNIT, 2013). Safety here means that the investment strategy should be in such a way that there will be enough funds to pay future liability. The study therefore recommends stochastic programming model as a method to be used for the asset mix strategy for the pension fund. This is recommended because the study found that irrespective of the risk preference of the investor (risk neutral and risk averse) the scheme would be capable of paying its liabilities hence ensure sustainability. Also among the five objective models under the stochastic programming model, the mean absolute deviation is recommended since it ensures safety and higher expected final wealth. This will ensure that the scheme will have the ability to meet its contractual obligation should any of the scenarios occur all things being equal for the next five years (2015 to 2019).

It was also found that transaction cost affects the expected final wealth negatively. An increase in transaction cost decreases the expected final wealth. Again, as SSNIT aims at maximising wealth, minimising transaction cost should be considered.

This study will help members of the pension scheme understand the risks and opportunities related to capital market investments and other major decisions and also assist SSNIT in their financial planning process so as to improve its investment and liability payment decisions and its overall risk management. The study will also help SSNIT pension scheme to reduce cost (money paid to consultants for the asset allocation) if the method recommended by this study is adopted. Again, the study has contributed to the existing literature since it is the first of its kind in the Ghanaian context, has enhanced the current researcher's experience and lays a foundation for further research in the area.

5.4 Recommendations for future studies

Future studies in the area of asset liability management of the defined pension scheme (SSNIT) can extend the valuation of liabilities by including survivor benefit, disability benefit and reduced pension. Also further studies can include more assets to make the investment portfolio more diversified. Future research studies can investigate the impact of transaction cost on expected final wealth and designing an asset allocation policy that minimizes transaction cost as an extension to this study. Also future research can focus on designing an asset allocation that will simultaneously minimize the contribution rate, downside risk and maximise the expected final wealth.

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APPENDIX

Table A. 1: Simulated Equity Returns for each period under all scenarios

Equity	T0	T1	T2	T3	T4		Equity	T0	T1	T2	T3	T4
S1	0.5688	-0.2460	-0.1880	0.1431	0.6674		S1	1.568751	0.753979	0.812046	1.143132	1.667439
S2	-0.2593	0.6077	-0.0136	0.1991	0.6812		S2	0.740726	1.607719	0.986383	1.199066	1.681163
S3	0.8260	1.1877	0.6251	0.2565	0.6727		S3	1.825968	2.18775	1.625128	1.256497	1.67265
S4	0.1523	1.1894	-0.0346	0.0449	0.0083		S4	1.152292	2.189356	0.965399	1.044946	1.008272
S5	0.1956	0.3180	0.4935	0.2043	0.5129		S5	1.195639	1.317959	1.493498	1.204285	1.512911
S6	0.4482	0.6771	-0.3072	0.4233	0.1852		S6	1.448201	1.677131	0.692823	1.423325	1.18523
S7	-0.1129	0.7919	0.5490	0.3601	0.4643		S7	0.887058	1.791908	1.549023	1.360076	1.464276
S8	0.5784	0.9245	0.8482	0.0294	0.4374		S8	1.578437	1.924543	1.848205	1.029399	1.437397
S9	0.5351	0.0644	-0.0197	0.9198	-0.3787		S9	1.535133	1.064395	0.980307	1.919759	0.621299
S10	0.4558	-0.0847	0.5416	0.7279	0.8337		S10	1.455849	0.91531	1.54161	1.727894	1.833683
S11	-0.0326	0.2867	0.6382	-0.4536	0.8838		S11	0.967442	1.28667	1.638203	0.546411	1.883779
S12	0.4709	0.7582	0.3580	0.3940	0.2207		S12	1.470872	1.758173	1.358004	1.394	1.220691
S13	0.2989	1.4203	-0.6917	1.3430	0.5835		S13	1.298904	2.42033	0.308321	2.342972	1.583453
S14	0.1659	-0.2706	0.1142	0.6649	0.7763		S14	1.165897	0.729353	1.114245	1.664936	1.776276
S15	0.1041	-0.2305	0.2573	-0.2583	0.3276		S15	1.104136	0.769456	1.257258	0.741655	1.327624
S16	1.1981	0.2321	0.5343	0.7169	0.3878		S16	2.198125	1.232089	1.534254	1.716891	1.387803
S17	0.1716	0.2973	0.4453	0.4000	0.7614		S17	1.171639	1.297348	1.445315	1.400009	1.761445
S18	1.4204	-0.6992	0.0349	-0.2886	0.0363		S18	2.420372	0.300786	1.034891	0.711429	1.036293
S19	0.1393	0.2228	0.0438	-0.1867	-0.1350		S19	1.139255	1.222796	1.043762	0.813304	0.865045
S20	0.4706	0.9915	0.2999	0.9837	0.6120		S20	1.470594	1.991459	1.299861	1.98372	1.61202
S21	-0.2421	-0.3372	0.5806	1.1405	0.2592		S21	0.757915	0.662826	1.580623	2.140494	1.259158
S22	0.3851	-0.6320	-0.2188	0.6321	0.3301		S22	1.38505	0.368047	0.781235	1.632056	1.330143
S23	0.0572	0.0739	0.5749	0.8913	0.5784		S23	1.057239	1.073876	1.574905	1.891256	1.578407
S24	0.9437	0.9891	0.3917	-0.3057	0.1144		S24	1.943729	1.98905	1.391683	0.694324	1.114369
S25	0.5040	0.2482	0.3011	0.6613	0.9116		S25	1.503973	1.248168	1.301083	1.661322	1.911635
S26	0.1143	0.0132	-0.4885	0.8030	0.8807		S26	1.114322	1.013202	0.511519	1.802959	1.880671
S27	-0.1496	-0.1654	0.1639	0.3296	0.3429		S27	0.850361	0.834644	1.163947	1.329554	1.342925
S28	0.4338	1.5117	0.4191	0.0793	0.4207		S28	1.433798	2.511705	1.419125	1.079302	1.420723
S29	0.6522	1.1032	0.4120	0.3368	1.2234		S29	1.652249	2.103165	1.411962	1.336827	2.223357
S30	0.4549	1.0260	0.2817	0.2502	-0.2316		S30	1.4549	2.026037	1.281743	1.25025	0.768416
S31	0.8626	0.2945	0.8770	0.2171	0.8064		S31	1.862557	1.294456	1.877043	1.217062	1.806423
S32	0.1525	0.8557	0.1325	0.4573	0.9157		S32	1.152487	1.855662	1.132452	1.457284	1.915665

Source: computation from Research Data, 2015

Table A. 2: Simulated Treasury bills Returns for each period under each scenario

Tbills	T0	T1	T2	T3	T4		Tbills	T0	T1	T2	T3	T4
S1	0.133643	-0.02075	-0.08364	0.010609	0.091567		S1	1.133643	0.979251	0.916359	1.010609	1.091567
S2	0.329673	0.206471	0.323925	0.353944	0.318954		S2	1.329673	1.206471	1.323925	1.353944	1.318954
S3	0.254253	0.173556	0.282949	0.307687	0.302322		S3	1.254253	1.173556	1.282949	1.307687	1.302322
S4	0.148831	0.146479	0.166833	0.304899	0.268378		S4	1.148831	1.146479	1.166833	1.304899	1.268378
S5	0.274809	0.164231	0.105418	0.082685	0.077048		S5	1.274809	1.164231	1.105418	1.082685	1.077048
S6	0.165993	0.181078	0.054533	-0.08483	-0.1004		S6	1.165993	1.181078	1.054533	0.915165	0.899603
S7	0.118899	0.129197	0.293277	0.296031	0.288739		S7	1.118899	1.129197	1.293277	1.296031	1.288739
S8	0.164831	0.077783	0.200608	0.225213	0.220914		S8	1.164831	1.077783	1.200608	1.225213	1.220914
S9	0.239237	0.088794	0.204575	0.273898	0.283831		S9	1.239237	1.088794	1.204575	1.273898	1.283831
S10	0.185968	0.240379	0.240972	0.310657	0.344741		S10	1.185968	1.240379	1.240972	1.310657	1.344741
S11	0.439996	0.465274	0.385938	0.398557	0.26146		S11	1.439996	1.465274	1.385938	1.398557	1.26146
S12	0.122079	0.146714	0.256199	0.395793	0.329584		S12	1.122079	1.146714	1.256199	1.395793	1.329584
S13	0.323218	0.163706	0.162754	0.13544	0.213481		S13	1.323218	1.163706	1.162754	1.13544	1.213481
S14	0.161588	0.142756	0.167223	0.155591	0.205127		S14	1.161588	1.142756	1.167223	1.155591	1.205127
S15	0.198571	0.38329	0.43297	0.190089	0.226392		S15	1.198571	1.38329	1.43297	1.190089	1.226392
S16	0.308287	0.337285	0.251271	0.106718	0.296715		S16	1.308287	1.337285	1.251271	1.106718	1.296715
S17	0.252175	0.39347	0.383478	0.499186	0.381746		S17	1.252175	1.39347	1.383478	1.499186	1.381746
S18	0.261581	0.296313	0.210567	0.278535	0.310686		S18	1.261581	1.296313	1.210567	1.278535	1.310686
S19	0.226636	0.090443	0.174819	0.179907	0.244494		S19	1.226636	1.090443	1.174819	1.179907	1.244494
S20	0.33623	0.324051	0.266693	0.139257	0.188319		S20	1.33623	1.324051	1.266693	1.139257	1.188319
S21	0.311293	0.332315	0.212291	0.25129	0.20662		S21	1.311293	1.332315	1.212291	1.25129	1.20662
S22	0.151923	0.129283	0.161054	0.087547	0.208412		S22	1.151923	1.129283	1.161054	1.087547	1.208412
S23	0.21397	0.282609	0.332087	0.323534	0.361964		S23	1.21397	1.282609	1.332087	1.323534	1.361964
S24	0.177705	0.155651	0.235245	0.199913	0.128211		S24	1.177705	1.155651	1.235245	1.199913	1.128211
S25	0.225437	0.259955	0.236702	0.255294	0.292351		S25	1.225437	1.259955	1.236702	1.255294	1.292351
S26	0.237263	0.308734	0.307728	0.297773	0.300181		S26	1.237263	1.308734	1.307728	1.297773	1.300181
S27	0.288902	0.303287	0.34133	0.458919	0.508273		S27	1.288902	1.303287	1.34133	1.458919	1.508273
S28	0.261622	0.258179	0.229648	0.140305	0.185868		S28	1.261622	1.258179	1.229648	1.140305	1.185868
S29	0.199429	0.211153	0.309064	0.310163	0.40445		S29	1.199429	1.211153	1.309064	1.310163	1.40445
S30	0.130026	0.17949	0.18961	0.244585	0.175844		S30	1.130026	1.17949	1.18961	1.244585	1.175844
S31	0.289995	0.272943	0.193931	0.133933	0.134413		S31	1.289995	1.272943	1.193931	1.133933	1.134413
S32	0.210109	0.175832	0.365207	0.411283	0.337789		S32	1.210109	1.175832	1.365207	1.411283	1.337789

Source: computation from Research Data, 2015

Table A. 3: Simulated Wage Growth rate for each period under each scenario

Wage	T0	T1	T2	T3	T4		Wage	T0	T1	T2	T3	T4
S1	0.095119	0.003285	-0.06685	0.036714	0.126702		S1	1.095119	1.003285	0.933146	1.036714	1.126702
S2	0.291148	0.158551	0.337908	0.335948	0.299599		S2	1.291148	1.158551	1.337908	1.335948	1.299599
S3	0.215729	0.196314	0.354474	0.347722	0.309228		S3	1.215729	1.196314	1.354474	1.347722	1.309228
S4	0.110306	0.145181	0.234917	0.322043	0.257069		S4	1.110306	1.145181	1.234917	1.322043	1.257069
S5	0.236285	0.148964	0.118227	0.121227	0.109879		S5	1.236285	1.148964	1.118227	1.121227	1.109879
S6	0.127468	0.19414	0.093599	-0.07687	-0.04244		S6	1.127468	1.19414	1.093599	0.923131	0.957557
S7	0.080375	0.11692	0.338103	0.322623	0.299029		S7	1.080375	1.11692	1.338103	1.322623	1.299029
S8	0.126306	0.0983	0.269182	0.287611	0.232379		S8	1.126306	1.0983	1.269182	1.287611	1.232379
S9	0.200712	0.097197	0.219926	0.271498	0.319887		S9	1.200712	1.097197	1.219926	1.271498	1.319887
S10	0.147443	0.25127	0.228959	0.326972	0.37074		S10	1.147443	1.25127	1.228959	1.326972	1.37074
S11	0.401471	0.415706	0.347743	0.39374	0.203561		S11	1.401471	1.415706	1.347743	1.39374	1.203561
S12	0.083554	0.166764	0.306333	0.418056	0.32752		S12	1.083554	1.166764	1.306333	1.418056	1.32752
S13	0.284693	0.147929	0.237302	0.118161	0.28693		S13	1.284693	1.147929	1.237302	1.118161	1.28693
S14	0.123063	0.140559	0.153652	0.157083	0.243434		S14	1.123063	1.140559	1.153652	1.157083	1.243434
S15	0.160046	0.372816	0.387907	0.155771	0.197928		S15	1.160046	1.372816	1.387907	1.155771	1.197928
S16	0.269762	0.37388	0.251946	0.125002	0.349222		S16	1.269762	1.37388	1.251946	1.125002	1.349222
S17	0.21365	0.379803	0.365759	0.489876	0.357299		S17	1.21365	1.379803	1.365759	1.489876	1.357299
S18	0.223056	0.351451	0.169787	0.261955	0.274215		S18	1.223056	1.351451	1.169787	1.261955	1.274215
S19	0.188112	0.078285	0.192808	0.185714	0.233141		S19	1.188112	1.078285	1.192808	1.185714	1.233141
S20	0.297705	0.316208	0.298644	0.15156	0.2498		S20	1.297705	1.316208	1.298644	1.15156	1.2498
S21	0.272768	0.287751	0.157887	0.261094	0.261576		S21	1.272768	1.287751	1.157887	1.261094	1.261576
S22	0.113398	0.140635	0.132947	0.066904	0.247241		S22	1.113398	1.140635	1.132947	1.066904	1.247241
S23	0.175445	0.267501	0.315844	0.328615	0.392154		S23	1.175445	1.267501	1.315844	1.328615	1.392154
S24	0.13918	0.194978	0.302816	0.231906	0.115261		S24	1.13918	1.194978	1.302816	1.231906	1.115261
S25	0.186912	0.268406	0.240092	0.263193	0.319356		S25	1.186912	1.268406	1.240092	1.263193	1.319356
S26	0.198738	0.293794	0.284731	0.244409	0.311632		S26	1.198738	1.293794	1.284731	1.244409	1.311632
S27	0.250377	0.266822	0.302716	0.433188	0.480302		S27	1.250377	1.266822	1.302716	1.433188	1.480302
S28	0.223097	0.257985	0.301592	0.175848	0.203309		S28	1.223097	1.257985	1.301592	1.175848	1.203309
S29	0.160904	0.231305	0.370187	0.331793	0.410141		S29	1.160904	1.231305	1.370187	1.331793	1.410141
S30	0.091501	0.19761	0.249933	0.274228	0.187567		S30	1.091501	1.19761	1.249933	1.274228	1.187567
S31	0.25147	0.2931	0.201659	0.180972	0.163781		S31	1.25147	1.2931	1.201659	1.180972	1.163781
S32	0.171584	0.166568	0.40842	0.404677	0.328791		S32	1.171584	1.166568	1.40842	1.404677	1.328791

Source: computation from Research Data, 2015

Table A. 4: Simulated Liabilities for each year under each scenario

Total liab	T0	T1	T2	T3	T4
S1	509216199.6	602454056.5	665342435.5	635771243.2	697979563.8
S2	600367391.2	820218656.1	1298755859	1599240147	2025142440
S3	565298216.6	797480901.9	1278387847	1588033105	2025851269
S4	516278181.5	697196754.7	1018978515	1241673100	1520894187
S5	574856500.5	778867339.5	1030778087	1065259923	1152029715
S6	524258275.8	738240771.8	955494189.3	812995387.9	758552025.8
S7	502360416.5	661660302	1047843008	1277405926	1616889220
S8	523717779.9	678290917.6	1018853057	1209185368	1452010749
S9	558315662.7	722373650.1	1042958358	1222304669	1571986007
S10	533546335.1	787264651.1	1145064056	1400516404	1870578151
S11	651666272.4	1087917638	1735301003	2229221243	2614290853
S12	503838805.4	693221508.7	1071760266	1400837476	1812013100
S13	597365996.4	808635812.3	1184132714	1220397703	1530343637
S14	522210086.3	702361598.7	958974780.7	1022747245	1239149154
S15	539406722.9	873224914.3	1434360599	1528012442	1783570705
S16	590423217.4	956554317.6	1417316912	1469659908	1932114709
S17	564331663.1	918225184.4	1484208496	2038176322	2695565897
S18	568705532.8	906328143.4	1254769768	1459501408	1812090500
S19	552456722.3	702472518	991680552.3	1083798200	1302248540
S20	603416382.3	936567385.2	1439464307	1527862621	1860619232
S21	591820742.2	898710024	1231565083	1431533889	1759736309
S22	517716018.6	696363340.4	933721489.9	918204486.1	1115892169
S23	546567039.9	816938302.7	1272228877	1557976752	2113395114
S24	529704146.4	746432757.2	1150921411	1306832608	1420133772
S25	551898882.2	825496863.3	1211548883	1410611546	1813434698
S26	557398026.7	850409628.9	1293039978	1483104436	1895466933
S27	581409253.9	868550445.8	1339110744	1768953638	2551522195
S28	568724603.3	843674596.3	1299635803	1408541368	1651503413
S29	539805643.4	783791719	1271019482	1560219192	2143781913
S30	507533894.3	716767156	1060319009	1245318485	1441023413
S31	581917502.8	887342129.7	1261955804	1373664205	1557702242
S32	544771505.2	749414132.1	1249182550	1617331434	2094055225

Source: computation from Research Data, 2015

Table A. 5: Simulated Present Value of Liabilities for each year under each scenario

PV liability	T0	T1	T2	T3	T4	Sum
S1	509216199.6	489800045.9	439779520	341653241.6	T5	1780449007
S2	600367391.2	666844435.8	858454530.7	859405935.9	T6	2985072294
S3	565298216.6	648358456.8	844991637.2	853383451.9	T7	2912031762
S4	516278181.5	566826629.8	673526680.8	667255155.4	T8	2423886647
S5	574856500.5	633225479.2	681325988.1	572453551.2	T9	2461861519
S6	524258275.8	600195749.3	631564670.4	436890646.8	T10	2192909342
S7	502360416.5	537935204.8	692605597.5	686457401.3	T11	2419358620
S8	523717779.9	551456030.5	673443755.3	649796770.9	T12	2398414337
S9	558315662.7	587295650.4	689376930.6	656846871.9	T13	2491835116
S10	533546335.1	640052561.8	756866981.9	752614992.2	T14	2683080871
S11	651666272.4	884485884.3	1147003109	1197947645	T15	3881102912
S12	503838805.4	563594722.5	708414479.8	752787531.5	T16	2528635539
S13	597365996.4	657427489.6	782690670	655822099.1	T17	2693306255
S14	522210086.3	571025689.9	633865279.5	549607921.7	T18	2276708977
S15	539406722.9	709938954.7	948086852.9	821129312.8	T19	3018561843
S16	590423217.4	777686437	936821278.7	789771599.4	T20	3094702532
S17	564331663.1	746524540.1	981035426.6	1095283177	T21	3387174807
S18	568705532.8	736852149.1	829380507.1	784312584.7	T22	2919250774
S19	552456722.3	571115868.2	655483213	582415723	T23	2361471527
S20	603416382.3	761436898.5	951460313.2	821048801.5	T24	3137362395
S21	591820742.2	730658556	814042622.7	769283290.1	T25	2905805211
S22	517716018.6	566149057.2	617173303.3	493428324.3	T26	2194466703
S23	546567039.9	664177481.8	840920667.2	837231651	T27	2888896840
S24	529704146.4	606855900.1	760738589	702270827.2	T28	2599569463
S25	551898882.2	671135661.2	800812270.5	758039959.3	T29	2781886773
S26	557398026.7	691389942.1	854676435.5	796996472.6	T30	2900460877
S27	581409253.9	706138573.8	885128392.5	950607236.9	T31	3123283457
S28	568724603.3	685914305.8	859036158.3	756927479	T32	2870602547
S29	539805643.4	637229039.8	840121278.9	838436702.2	T33	2855592664
S30	507533894.3	582737525.1	700852012.2	669214126.6	T34	2460337558
S31	581917502.8	721416365.6	834130348.8	738185052.6	T35	2875649270
S32	544771505.2	609279782.1	825687455.2	869127902.5	T36	2848866645

Source: computation from Research Data, 2015

Table A. 6: Simulated Total Liabilities the scheme, final liabilities and initial fund value

Total Liability		Final Liab		fund Value
5944645728	S1	4164196720	S1	5170130000
5944645728	S2	2959573434	S2	5170130000
5944645728	S3	3032613965	S3	5170130000
5944645728	S4	3520759080	S4	5170130000
5944645728	S5	3482784209	S5	5170130000
5944645728	S6	3751736385	S6	5170130000
5944645728	S7	3525287107	S7	5170130000
5944645728	S8	3546231391	S8	5170130000
5944645728	S9	3452810612	S9	5170130000
5944645728	S10	3261564857	S10	5170130000
5944645728	S11	2063542816	S11	5170130000
5944645728	S12	3416010188	S12	5170130000
5944645728	S13	3251339472	S13	5170130000
5944645728	S14	3667936750	S14	5170130000
5944645728	S15	2926083884	S15	5170130000
5944645728	S16	2849943195	S16	5170130000
5944645728	S17	2557470920	S17	5170130000
5944645728	S18	3025394954	S18	5170130000
5944645728	S19	3583174201	S19	5170130000
5944645728	S20	2807283332	S20	5170130000
5944645728	S21	3038840517	S21	5170130000
5944645728	S22	3750179024	S22	5170130000
5944645728	S23	3055748888	S23	5170130000
5944645728	S24	3345076265	S24	5170130000
5944645728	S25	3162758954	S25	5170130000
5944645728	S26	3044184851	S26	5170130000
5944645728	S27	2821362270	S27	5170130000
5944645728	S28	3074043181	S28	5170130000
5944645728	S29	3089053063	S29	5170130000
5944645728	S30	3484308169	S30	5170130000
5944645728	S31	3068996458	S31	5170130000
5944645728	S32	3095779083	S32	5170130000

Source: computation from Research Data, 2015

Table A. 7 : Normalized final liability and liabilities in thousands

	final liab		liabilities	T0	T1	T2	T3	T4
S1	805.4337		S1	98.49195	116.5259	128.6897	122.9701	135.0023
S2	572.4369		S2	116.1223	158.6457	251.2037	309.323	391.7005
S3	586.5644		S3	109.3393	154.2477	247.2642	307.1554	391.8376
S4	680.9808		S4	99.85787	134.8509	197.0895	240.1628	294.1694
S5	673.6357		S5	111.188	150.6475	199.3718	206.0412	222.8241
S6	725.6561		S6	101.4014	142.7896	184.8105	157.2485	146.7182
S7	681.8566		S7	97.16592	127.9775	202.6725	247.0742	312.7367
S8	685.9076		S8	101.2968	131.1942	197.0653	233.8791	280.8461
S9	667.8383		S9	107.9887	139.7206	201.7277	236.4166	304.0515
S10	630.8477		S10	103.1979	152.2717	221.4768	270.8861	361.8049
S11	399.1278		S11	126.0445	210.4237	335.6397	431.1732	505.6528
S12	660.7204		S12	97.45186	134.082	207.2985	270.9482	350.4773
S13	628.87		S13	115.5418	156.4053	229.0335	236.0478	295.9971
S14	709.4477		S14	101.0052	135.8499	185.4837	197.8185	239.6747
S15	565.9594		S15	104.3314	168.8981	277.4322	295.5462	344.976
S16	551.2324		S16	114.1989	185.0155	274.1356	284.2598	373.7072
S17	494.6628		S17	109.1523	177.602	287.0737	394.2215	521.3729
S18	585.1681		S18	109.9983	175.3008	242.696	282.2949	350.4923
S19	693.053		S19	106.8555	135.8713	191.8096	209.6269	251.8793
S20	542.9812		S20	116.712	181.1497	278.4194	295.5173	359.8786
S21	587.7687		S21	114.4692	173.8274	238.2078	276.8855	340.366
S22	725.3549		S22	100.136	134.6897	180.5992	177.5979	215.8345
S23	591.0391		S23	105.7163	158.0112	246.0729	301.3419	408.7702
S24	647.0004		S24	102.4547	144.3741	222.6098	252.7659	274.6805
S25	611.7368		S25	106.7476	159.6666	234.3363	272.8387	350.7522
S26	588.8024		S26	107.8112	164.4852	250.0982	286.8602	366.6188
S27	545.7043		S27	112.4554	167.9939	259.0091	342.1488	493.5122
S28	594.5775		S28	110.002	163.1825	251.3739	272.4383	319.4317
S29	597.4807		S29	104.4085	151.6	245.839	301.7756	414.6476
S30	673.9305		S30	98.16656	138.6362	205.0856	240.8679	278.7209
S31	593.6014		S31	112.5537	171.6286	244.0859	265.6924	301.2888
S32	598.7817		S32	105.369	144.9507	241.6153	312.8222	405.0295

Source: computation from Research Data, 2015