Malaysia's Pension System: Performance and Strategies for Improvement

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Declaration of Originality

I certify that this thesisdoes not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

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On: 28th November 2018

Foreword

First and foremost, I would like to thank my principal supervisor, Professor Kevin Daly, for his guidance and encouragement to undertake research in an area that went beyond my initial belief in what I could achieve. He was always helpful and supportive throughout the course of this research. My co-supervisor, Dr Anil V. Mishra also has my thanks for encouraging me to strive for the PhD. Also, Dr Terry Sloan for his guidance on matters of funding and administration.

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Abstract

Population ageing and economic uncertainties made many question the extent to which current pension systems are able to provide adequate pension savings that can at least maintain standards of living during the retirement period. Much focus on pension issues and challenges has centred on developed nations rather than developing countries. In general, the framework of pension systems in developed countries are expected to be different in terms of policy and regulation than pension system practices in developing countries. As a project largely contributing to the literature for developing countries, this thesis seeks to explore the performance of the Malaysian pension system and investment strategy of Malaysia's defined contribution pension scheme known as the Employees Provident Fund (EPF). This thesis is composed of three parts.

The first part of this thesis explores the development and evolution of pension system in both developed and developing countries as well as analysing the performance and experiences in both nations. This analysis has particular importance to Malaysia as it enhances understanding on pension practices and reform experiences from these nations. Moreover, this understanding offers a vast opportunity of learning in the effort to reform existing Malaysia's pension system. The second part of this thesis presents the performance of a pension system, primarily for the EPF. Faced with financial markets that are more complicated and more volatile, the necessity for an optimal investment strategy made by the EPF is greater than ever as it affects net benefits for the EPF. Therefore, this study explores the investment strategy for the EPF in an attempt to establish an adequate and sustainable pension system, which is essential in influencing pension fund performance. As the analysis of investment strategy for pension strategy associated with a long-term investment planning horizon, EPF's regulations as well as future liability commitments, the stochastic ALM model is essential to match the asset and liability cash flows with a high degree of probability. Finally, this thesis extends the investment analysis through analysing the impact of alternative assets on the EPF's strategy. We incorporate international assets in the existing model and the investment performance for the strategy with and without international assets are compared. From investment analysis, international asset enhances the EPF performance thus may lead the EPF to distribute higher dividend rate.

Moreover, this study also shows an inverse relationship between dividend distributed to the members and expected terminal wealth. It depicts that the higher dividend distributed to its members, the lowest expected terminal wealth generated due to less funds available for reinvestment activities.

The significant of this study are: i) based on lesson from others country's experiences, this thesis provides a comprehensive documentation analysis that gives a greater understanding of Malaysia's pension system performance and future directions of the system towards preparing the nation for the ageing population; ii) with different policies and regulations from other country practices, this study develops the investment model methodologically tailored to the EPF case. iii) we extend a well-established TSP study for the EPF done by Hussin (2012) considering alternative international assets for the EPF context. Here, we provide new evidence of optimal investment strategy for the EPF after taking into account international diversification.

Acknowledgement

Some of the research in this thesis has been previously published or presented at international conferences. I duly acknowledge referee and conference participants' comments and suggestions which have greatly helped this thesis.

Research papers presented at conferences:

Reviewing the financial soundness of Malaysia's Employees Provident Fund. Paper presented at the International Conference on Economic, Management and Corporate Social Responsibility, December 2016, Kuala Lumpur, Malaysia.

The Sustainability of Malaysia's Pension System: Implementation of Deterministic Linear Programming. Paper presented at the 6th International Conference on Global Optimisation and its Application, November 2017, Malacca, Malaysia.

Asset Allocation Decision for Malaysia's DC Pension Scheme: Application of Two Stage ALM Model. Paper presented at the International Conference of Managerial Finance and Economics (ICMFE-18), 1st June 2018, Kuala Lumpur, Malaysia

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List of Abbreviations

ALM	Asset Liability Management
ARMA	Autoregressive-moving-average
CBA	Capital-based Approach
CCP	Chance Constraints Programming
DB	Defined Benefit
DC	Defined Contribution
DTSP	Domestic Two-stage Stochastic Programming
EPF	Employees Provident Fund
EQMAS	Equity Malaysia
EQJAP	Equity Japan
EQSIN	Equity Singapore
EQUSA	Equity United States of America
FTSP	Foreign Two-stage Stochastic Programming
GARCH	Generalised Autoregressive Conditional Heteroscedasticity
GDP	Gross Domestic Product
ILO	International Labour Organization
LCH	Life Cycle Hypothesis
LTAT	The Armed Forces Fund
MSCI	Morgan Stanley Composite Index
MGS1	Malaysian Government Security with 1 year maturity
MGS10	Malaysian Government Security with10 year maturity
MMI	Money Market Instrument
MV	Mean-Variance Framework
NE	New Entrants
OECD	Economic Co-operation and Development
OLG	Overlapping Generation Model
PAYG	Pay-as-you-go
PROP	Property Index
RBA	Redistributive-based Approach
RM	Ringgit Malaysia
SOCSO	Social Security Organisation

SP	Stochastic Programming
TSP	Two-stage Stochastic Programming
VAR	Vector Autoregressive
VECM	Vector Error Correction Model

Chapter 1 – Introduction: Justification, goals and thesis structure

> One of the greatest accomplishments of medical science in the 20th century is the dramatic increase in the life expectancy of the individual. However, the continuous rise in life expectancy has led to a growing concern about imbalances in the age structure, most notably, the increase in the proportion of the old age group.

(Teixeira, Renuga Nagarajan, & Silva, 2017)

1.1 Introduction

The above quote illustrates the concern of the new challenges posed by countries' population imbalance as a result of the advancement in medical technology and knowledge. In stark contrast to the benefit of health quality improvement—attributed to increased longevity and reduced fertility—the number of pensioners is rising while the workforce population is shrinking. Such a discourse on population ageing negates much of the ability of the current pension system to provide adequate savings in a sustainable manner, and consequently change pension system's landscape across the world.

Bettendorf and Heijdra (2006) highlighted the common belief that demographic changes have a remarkable and long-lasting economic impact on the world as a whole and on individual countries. By emphasising the impact of demographic shock on macroeconomic and welfare impacts, Bettendorf and Heijdra (2006) have revealed that population ageing significantly influences capital accumulation, household consumption, aggregate output, economic growth, and intergenerational welfare effect. In the 2013, the World Bank reported that the global demographic landscape was projected to change dramatically when an older group (aged 60 and above) is expected to double from 841 million in 2013 to more than 2 billion in 2050 (www.worldbank.org). In Asia, the number of ageing groups is expected to grow faster compared to European and Western countries. This concern has been discussed by several sources such as Donghyun; Park and Estrada (2012), and the United Nations (2015). According to United Nation's Population Division in 2015, it was projected that the older age group in Asia and Africa to dominate between 64% and 66% of their total population in 2030. Interestingly, Europe and the United States had an advanced economy before experiencing ageing society. For example, South Korea has a high per capita income, degree of ubranisation rate and industrialisation. We categorise this country under characteristic of 'getting rich before getting old'. By contrast, emerging countries are expected to be getting old before getting rich. With a low per capita income, it places more pressure on governments to support pensions in both the state (public) pension and private pension, as well as healthcare expenditure.

One of the concerns raised with respect to ageing people is the sustainability of the existing systems resulting from the demographic imbalance between the number who contribute to the system and the number who receive benefits (Bielecki, Goraus, Hagemejar, & Tyrowicz, 2015). In addition to this, some scholars discussed the ageing population implication from the perspective of economic as a whole (Courbage & Liedtke, 2012; Jackson, 2012; Kenichiro; Kashiwase, Masashiro; Nozaki, & Kiichi; Tokuoka, 2012; Panzaru, 2015). Jackson (2012), for example, argues that, in addition to the fiscal burden, the demographic transition may influence all aspects, including rates of savings and investments, rates of employment and productivity growth.

In addition to an ageing group, economic uncertainty and complexity in financial markets have hindered the pension systems ability to provide sustainability and an adequate pension fund to its members. Unsurprisingly, economic uncertainty not only effects the existing pension system, it may also negatively influence the impact on pension reform. Ionescu (2013), for example, highlighted that a financial crisis negatively affects pre-financing pension schemes and seriously diminishes the public's confidence in a public system to provide appropriate and sustainable pension benefits. Ionescu also suggests that vulnerability of private pension schemes to the volatility of financial markets need more cautious promotion by policymakers. Indeed, due to economic crises, the myth that shifting the existing pension system from PAYG to a private pension scheme would increase the levels of national savings is ambiguous and the impact of this reform is not inclusive.

Malaysia is not spared from the ageing population crisis. United Nation (2015) reported that there was one pensioner in Malaysia for every 12 workers in 2010 and with this number projected to increase to one pensioner been supported by five workers by 2040. The concern regarding the increase of this older group is that this group are more likely to be living in the poverty. Mahon, McNeill, and Heymann (2015) highlighted that about 6% of Malaysia's population is represented by those aged 60 and above with more than 30% from this group considered to be officially living below the poverty line. Meanwhile, from other sources, Suhaimi and Norma (2013) mentioned that, the household headed by the older group experience high poverty incidence, at 22.7%.

From another perspective, according to the Chief Executive Officer of the EPF, about 80% of the current population who will reach 55 years old (the time to withdraw) will not have sufficient retirement savings to survive at least at the poverty line after their retirement (TheEdge Markets, 2015)[1]. The key factors that trigger inadequate saving stem from pre-retirement withdrawal policy for reasons such as educational purposes, health, housing, etc. (Mohd, 2009) as well as low return gained from investment activities. Thus, beyond the pre-retirement withdrawal policy, another milestone for the development of sufficient pension saving is investment decision making. As the pension benefit is dependent on the contribution made during the working year and investment return, designing an appropriate investment strategy is critical to generating higher returns, which will thus boost the final savings among pension members. Apart from inadequate savings, one of the biggest changes from a demographic transition is the weakening of extended family, especially in developing countries (Asher & Bali, 2015; Park & Estrada, 2012). With an insufficient EPF saving, financial assistance from family members becomes a secondary income source during retirement time. Thus, it poses another pressure on the government to provide financial support in terms of health expenses as well as creating an income gap for the older group and necessitates the government to provide a formal pension system to fill this gap.

In view of this significant impact on the ageing population, the fundamental issue for a pension system in Malaysia is: can Malaysia's pension system, the EPF, fulfil the objectives of the pension system to provide adequate and sustainable pension benefits

[1] The Edge Markets (2015, March 13). Retrieved July 20, 2015, from http://www.theedgemarkets.com/article/malaysias-epf-says-80-workers-have-savings-below-poverty-line-they-turn-55

for Malaysians? Or in other words, will the future pensioner be able to support themselves with the retirement income available to them after taking into account the higher costs of living and inflation? Thus, from the context of Malaysia, the purpose of this thesis is to understand the challenges and risk management of the pension system, in order to help prevent the large-scale effects of societies' economic and social structure negatively affecting an ageing population. This goal will consider the current status and future direction for the pension system in Malaysia, as well as analysing investment decisions, which is essential in influencing pension fund performance. To begin our analysis on this issue, this chapter briefly discusses the fact, justification, and objectives of doing this study. In addition, the goals of this thesis are stated and an overview of the thesis structure is provided.

1.2 Justification for the Research

As the preceding section discusses, world governments, policymakers and non-government organisations are directing attention to the related issues of population ageing, income adequacy, and sustainability of the pension system. Indeed, the important issue of pension systems around the world can be seen from the perspective of the way the systems meet the needs of their members and strategies that ensure the policy will not burden younger generations and negatively affect economic growth (Hussin, 2012). The different nature of pension system and demographic structure in specific countries must take adaptive actions in order to administer it. As suggested by Mitchell (1993), pension systems differ across countries in terms of their practices, policies or regulations. She also argued that these structural differences imply that the economic effects on pension systems vary from one country to another. Therefore, country-specific study presents interesting pension practices and development. In this thesis we focus on Malaysia's pension system whereby current challenges and future directions are explored in an attempt to develop a robust pension system. We also believe that pension reform from other countries' experience become one of the most significant references in order to portray potential pension reforms for Malaysia. This encouraged the interest of this study to analyse the reforms performance across countries and to figure out the factors inspiring the countries to rehabilitate their pension system. Although there are remarkable concerns in regards to difficulties in designing adequate retirement income with sustainable way, there is still little evidence studying potential pension reforms for emerging countries. Ergo, this thesis is aiming to discuss this gap by focusing primarily on Malaysia case.

The challenge in designing an adequate and sustainable pension system inevitably relates to how critically the fund manager allocates wealth to the right financial assets under uncertainties. Consequently, it shows investment strategy is a critical factor for the pension system, as it impacted net cost for the DB scheme and net benefits for the DC pension scheme (Blake, 2000; Ionescu, 2013). Faced with financial markets that are more complicated and more volatile, the necessity for an optimal investment strategy made by the EPF is greater than ever. Moreover, investment decisions for pension system are dealing with long-term investment decision horizon, normally 30 to 40 years with the presence of policy constraints and uncertainty in future assets and the liabilities stream.

With a long-term investment planning horizon as well as EPF ’s rules and regulations consideration, the model develops in this thesis is a dynamic investment strategy with the aim to cater the EPF’s future commitment and liabilities. In order to solve this issue, the stochastic ALM model is essential to match the asset and liability cash flows with a high degree of probability. The importance and role of investment strategy using stochastic programming for Malaysia’s EPF is scarce in literature. Moreover, with different policies and regulations from other country practices, this study develops the investment model methodologically tailored to the EPF case. Besides, as stated by Thillainathan (2005), the EPF’s performance was limited by the nature of the scheme, regulations as well as under-developed financial market. One of the characteristics of the scheme allows the assets invested in the approved assets classes only. So, it limits the potential benefit of diversification. Looking at the EPF case, we empirically analyse benefits of international portfolio diversification in boosting the EPF performance which will affect the pension adequacy through distributing higher dividend to its members.

1.3 Objective of the Research

The main purpose of this study is to explore and analyse policy practice, as well as an optimal investment strategy that can provide adequate savings with a sustainable manner for Malaysia's pension system. The following research questions were formulated.

1. Malaysia established its pension systems in the 1950s for both government (civil servant pension scheme) and formal private sector workers (Employees Provident Fund). Changes in statistical trends indirectly have important implication to these two systems. Thus, in light of statistical change we will conduct in-depth analysis on; What is the performance of the current pension system in Malaysia? To what extent is pension reform required to develop a more decent pension system? The main argument being discussed in relation to pension crisis is that, is the government not well-prepared towards aging nation and pension shortfall? Following that, based on experiences from developed and developing countries, we are witnessing that pension system practices across countries face homogenous problems namely adequacy, sustainability, and coverage issue. Therefore, this research questions will explore the potential reform for Malaysia pension system based on the comparative perspective of pension practices and developments in developed and developing countries as deliberated in Chapter 2.

2. Since the final benefit of the EPF is determined by the contribution rate and return on investment, the investment strategy is crucial to increase the final benefit to its members. With more volatile return in the financial market as well as long-term investment strategy, allocating the available fund to accurate financial asset will maximize wealth and are critical decision to be made by the fund manager. Further criticism in managing pension funds was perceived misalignment between the EPF's objective's, which is maximizing wealth, and policy constraints exist in the system, which its aim to protect the EPF members. To that extent, we empirically analyse how do the EPF's fund managers manage the fund, in other words, what is the optimal investment strategy of the EPF with ex-ante policy constraints? In this context, it is noteworthy that developing methodologically a decent investment model will support to secure adequate and sustainable pension provision for the EPF.

3. The role of international diversification will influence pension fund performance (Pfau, 2009). Although the aim of pension investment constraints

to safeguard retiree's welfares, the EPF's policies and regulations, such as the limitation to hold certain assets, also has a remarkable impact on investment risk appetite of the fund managers thus indirectly control the behaviour of the EPF's investment strategy. However, broaden the asset diversification is believed will help the EPF to overcome limited available asset in the local financial market as well as improving the EPF's investment performance. Thus, the next question is, how does international portfolio diversification influences the EPF performance?

1.4 Scope of the Thesis and Methodology

1.4.1 Scope of the thesis.

As being studied in previous literature, it significantly indicates that the major concerns of facing pension system in both developed and developing countries are driven by longevity and economic uncertainty then followed by sustainability, adequacy and coverage issue in pension practices. Ergo, in order to find solutions for this issues, this thesis focuses on the Malaysian pension system and its major concerns that will be given particularly to the Employees Provident Fund (EPF). This then explains, the first part (in Chapter 2), whereby we take a holistic descriptive analysis to identify Malaysia's pension practice and issues and the following chapters are designed directly for the EPF. An investigation conducted into the following areas will be made to fulfil the objectives detailed above:

i. Pension practice differs across countries; however, most of the countries are facing homogenous problems such as pension fund sustainability, saving adequacy, and low coverage ratio. Thus, in developing a decent pension system, beyond the country-specific factors, this research explores pension practice and experience from developed and developing countries. Using documentation analysis and systematic reviews, relevance lessons are suggested for Malaysia's pension system practice.
ii. Another important area in the pension system is investment strategy, where it is a key factor to determine the performance of the pension fund. Investment strategy between investing locally and investing abroad are compared to analyse the potential benefit of international diversification. Moreover, in this

analysis, we include risk management constraints to minimise the shortfall during the investment horizon. This analysis is also subject to policies and relevant facts from the *EPF Act* 1991.

1.4.2 Methodology.

Considering the objective of the research, we divide this thesis into two major analyses. The first involves a systematic review analysing the performance of pension systems through scientifically documenting the pension system in Malaysia, as well as other countries using document analysis. Bowen (2009) argues that document analysis is a qualitative method that is reviewing or evaluating documents—both printed and electronic material.

The rationale of document analysis in this thesis is mentioned as follows:

- This analysis will provide historical insight into pension system development worldwide to understand the root problem of the pension system; this will provide a clear picture of tracking changes and development in the global pension system.

- This analysis will provide supplementary research data from other sources and information as reported from previous research and government reports.

While, for research questions (2) and (3), a stochastic asset liability management (ALM) model is employed to develop a portfolio optimisation model for the EPF. This analysis is divided into two areas. At the beginning, we solve the ALM problem by assuming that the EPF invests only in domestic markets, and we expend the model by incorporating international assets in the EPF portfolio using a stochastic programming model.

A stochastic ALM model is a model that considers asset and liability simultaneously with pre-determined constraints to achieve certain goals (Mitra & Medova, 2010). The ALM decision process involves the definition of a planning horizon that specifies the number of years and considers the policy and constraints existing in the system. The pension fund is typically considered a long-term investment, normally 30 to 40 years. Moreoever pension funds must follow financial and regulation constraints. Hence, in order to tackle these issues, we utilise stochastic ALM model. A stochastic ALM model relies on uncertainty approximated by a discrete set of scenarios organised in a time-series model. In this study, the decision process is supported by two unknown factors: assets and liability stream. For the asset scenario, we use vector autoregressive (VAR) to generate future returns asset classes, where, future liabilities factors are derived from two sub-models: population and salary. In the population model, the future status of the EPF members was determined using a Markov Chain model. Details of the scenario generation process will be discussed in Chapter 4. In this thesis, we employ two-stage stochastic programming (TSP) for solving the ALM model. We consider the EPF will allocate its assets in five broad asset classes in the domestic financial market and in three international assets. Table 1.1 shows the proxy of the asset used in this study.

Table 1.1: Asset proxy

Asset	Proxy
Malaysia Government Security 10 Years (MGS10)	Long-term government bond yield (risk free)
Malaysia Government Security 10 Years (MGS1)	Medium-term government bond yield (risk free)
Equity (KLCI)	MSCI price index
Money Market Instrument	Short term interest rate
Property	Annual percent change of property price indicators.
Japan Equity	MSCI index price
America Equity	MSCI index price
Singapore Equity	MSCI index price

To recapitulate, the related pension research is ongoing across both developed and developing countries. The contribution of this research complements existing and ongoing literature in the pension system. Pension reform in the European and developed countries regularly become the subject of research and little research has been done on Malaysia case especially on the investment strategy.

1.5 Finding of the Research

The findings from this research are divided into three sections. Firstly, we discuss the findings from the document and descriptive analysis. From this analysis we find that Malaysia's pension system is based on a single-tier system where the system is segregated based on working status. A public pension system was established specifically for public servants, while the EPF covers the formal working sector. Three major issues facing the Malaysian pension system are highlighted, namely coverage, sustainability and adequacy of the pension system.

For the public pension system, pension adequacy is not as crucial as the EPF, as benefits covered in the private pension scheme are limited and members are exposed to inflation and adequacy issues. Lump sum payments received at retirement age, as well as low financial literacy among Malaysians, will shrink the standard of living of the EPF’s members. To support that challenge, the government needs to provide basic facilities that can support this group to maintain their standard of living during the retirement phrase.

From the EPF performance itself, investment strategy plays a vital role in influencing the performance of the EPF. It is suggested by Asher (2000) that an active investment strategy influences 90% of pension performance. However, by enforcing integrated chance constraints in the model, we found that it reduces the performance of the model by reducing the expected terminal value. This finding is in line with Binsbergen and Brandt (2007) who studied the implication of policy constraints in the ALM model. Asher’s (2000) findings suggest that ex-ante policy constraints such as integrated change constraints and value at risk constraints minimise the performance of the ALM model.

Given the role of investment strategy with various dividend growths distributed to the EPF’s members, the finding shows that there is an inverse relationship between dividend and expected terminal wealth. The solution for this model depicts an increase in dividend distributed to the member, which drives the reduction in expected terminal wealth. While higher dividend rates increase a member's final benefit, it also reduces the available wealth that can be invested in the financial market for the next period, thus affecting the expected terminal wealth. Therefore, the decision of distribution policy is essential for the EPF to ensure financial soundness and funding stability in the future.

Finally, we extend the model by incorporating international equity in our model. The finding suggests that international equity enhances the performance of our TSP model. This suggests that the EPF needs to consider allocating its accumulated wealth in the international market. However, this model overlooks the role of economic performance, which may influence the performance of our model.

1.6 Limitation and Weaknesses of the Research

A limitation of this study is the availability of the data. This research relied heavily on the EPF annual report. Thus, this study can only analyse the performance of the EPF investment strategy based on aggregate performance the EPF member's age group as opposed to individual performance. Blake e. al. (2014) argue that optimal investment strategy is age-dependent strategy. This strategy involves switching from high weigh of equities at the young age to the high portion of bond towards retirement. However, due to data constraints, it limits our study to analyse either how members' age influences the choice of investment strategy as suggested in the investment life-cycle strategy.

Secondly, the model used in this study ignores the role of economic performance. As suggested by Siu (2011), economic environment, such as inflation and economic growth, influences the investment strategy directly and indirectly. Siu (2011) also argues that economic performance over a long period of the time influence prices of ordinary shares, the interest rate on the fixed asset, as well as influencing pension liability through inflation risk. Meanwhile, from a liability perspective, inflation affects ALM analysis through an indirect relationship between inflation and salary. Thus, taking into account the effect of economic performance may influence the result.

1.7 Organisation of this Thesis and Main Findings

The structure of the thesis as follows.

Chapter 2 documents the performance of Malaysia's pension system as well as pension practices in developed and emerging countries. Using document analysis, this chapter reports and analyses changes and developments in the global pension system. At the end of the chapter recommendations for pension reforms are suggested for Malaysia. In this chapter, we intend to classify pensions practices in developed and developing countries. The objective of this chapter is to provide a brief idea of pension issues in relation to sustainability, adequacy and coverage challenges; and how these challenges are handled.

In **Chapter 3**, we review the empirical and theoretical literature on portfolio optimisation for the pension system. A detailed methodology that consists of a two-stage stochastic programming model (TSP) and TSP with integrated chance constraint (ICC) are discussed, along with possible other limitations or constraints.

Chapter 4 discusses the process of scenario generations for both asset and liability streams. The scenarios generated in this thesis include asset returns, and the liability represents lump sum payments, pre-withdrawal retirement, and death payments, as well as a salary growth model for each group. From the salary model, contribution payments are generated for each age group.

Chapter 5 reports the result of the TSP model when we consider the EPF allocates all assets in the domestic market. We extend the TSP model by incorporating integrated chance constraints as a risk constraints model to analyse the new performance. At the end of the chapter, TSP and TSP-ICC models are compared and the implication is reported.

Chapter 6 considers that the EPF portfolio consists of domestic and international assets. Thus in this chapter, we present the results of DTSP, DTSP-ICC, FTSP, and FTSP-ICC models for the EPF after taking into account alternative international assets in its portfolio. Then, the domestic and international investment strategies are compared.

Chapter 7 analyses the stability of the generated scenarios using in-sample and out-of-sample analysis. Then, we extend the analysis by measuring the performance of the model using standard finance performance measures such as the Sharpe ratio, Treynor ratio, return-risk ratio, solvency ratio, and funding ratio.

Chapter 8 summarises the key findings from this study. Potential contributions and policy implications are discussed in this chapter. We also highlight significant topics of future research in this field.

Chapter 2 – Literature Review: A Review of Global Pension Systems: Lesson for Malaysia

Using document analysis, this chapter provides a systematic review of global pension systems to analyse their changes and development. We begin the analysis by reporting on the development, current state, and challenges faced by the Malaysian pension system, with a special focus on the EPF. In addition, we have undertaken a systematic literature review to provide a brief comparison between Malaysia and other developed and developing countries' pension performance to identify the current state of Malaysia's pension system relative to other countries. This study reveals that Malaysia has achieved remarkable results in providing aggregate financial protection to its citizens. Population ageing is still manageable in the current state. However, the system still has problems such as inadequate savings resulting from a low saving rate, and limited pension coverage. To deal with this issue and to manage expected challenges, pension system reform should be considered by the government in an effort to provide a decent pension system for its citizens. As for the EPF, investment strategy is a key factor to influence the performance of the scheme.

2.1 Introduction

The world has been hammered by a combination of demographic transitions and globalisation, as well as instability in investment returns that have made it difficult for pension systems to fulfil their policy commitments. The understanding of forming an effective pension system has become increasingly important, primarily in developing an adequate retirement income in a sustainable manner; because a combination of various facets of life, financial factors, and societal arguments affect the sustainability of current pension systems, and the prospect of their long-term feasibility (Bonoli, 2003; Brook, 2007; Park & Estrada, 2012).

Such sustainability and adequacy concern triggers interest among policymakers, academics and practitioners in analysing the implications of ageing in various contexts from its financial soundness, social implications and government expenses for social security. For instance, the rising proportion of elderly affects economic levels, which creates fiscal burdens to fulfilling pension commitments (Jackson, 2012; Madrid, 2000; Truglia, 2000); labour market distortion and productivity (Borsch-Supan, Ludwig, & Winter, 2006; Edwards, 2005; Harper, 2006; Peterson, 1999; Powell & G.Cook, 2009); and vulnerability of extended family (Park & Estrada, 2012; Thompson, 2007).

2.1.1 Demographic ageing and the economy.

Many questions remain about the relationship between population ageing and economic challenges. In terms of fiscal pressure, there is evidence that ageing has increased pension funding requirements, thus creating pressure on public pension expenditure. In Western European countries, for example, pension expenditure increased from 7% (of GDP) in 1980 to 9% (of GDP) in 1993 (Madrid, 2000). Kitao (2015) argues Japan is expected to raise its government expenditure on pensions in the magnitude of 30 to 40% of consumption if there is no change in policies or reforms. This result suggests that the impact of the increase of the number of pension receivers is significant to the economy and requires governments to re-examine the sustainability of their existing pension system.

Figure 2.1 details the projections of public expenditure on pensions between 2010 and 2050, for OECD countries and other selected countries. The figure shows that all countries are expected to confront an increase in pension expenditures. Figure 2.1 shows that there is a significant increase in the projection for Luxemburg, Argentina, Indonesia and South Africa in the next 40 years. Interestingly, three of these countries are developing countries where pension systems are not well-developed in terms of their coverage and governance issues.

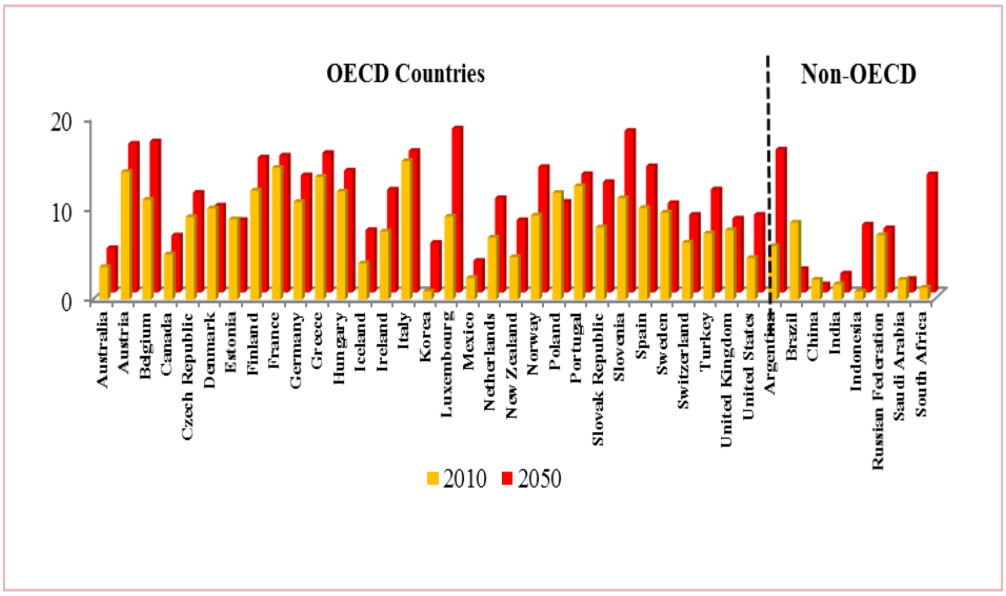

Figure 2.1: Projections of public expenditure on pensions, 2010–50 (% of GDP)

Source: Pension at a Glance 2013-OECD

In view of the relationship between the increased portion of older groups and economic performance, researchers have discussed in detail the possible impact of higher proportions of elderly populations at the micro- and macro-economic levels. Jackson (2012) argues that population ageing raises concerns about its impact on economic activities such as saving rates and investment, as well as employment rates along with productivity growth. Looking at the micro-economic point of view, the greater the proportion of the elderly in total population the greater the negative effect on productivity of the labour force, consumption and saving rates (Börsch-Supan, 2003; Courbage & Liedtke, 2012). Bloom et al. (2015) argue that the ability of older groups to work as effectively as young and middle aged workers are different, where this group is not as productive as younger workers thus tending to reduce overall output. Bloom et al. further argue that investment in education, training and health is essential to offset the negative impacts of an ageing population.

Another strand of micro-economic effect is consumption and saving behaviour. As stressed earlier, caring for older people requires huge expenses. From an individual perspective and theoretical point of view, Disney (1996) explained the relationship between demographic change and saving using the life-cycle hypothesis (LCH) of saving, established by Franco Modigliani. In general, individual will face three stages of life cycle: early working age, middle age and retirement stage. At the early working age, provided there exists a well-functioning capital market, individual tends to consume more than they receive due to low salary and family development. Then savings are expected to increase over middle ages as less commitments are required for consumption. At the end of it, LCH assumes that net wealth is maximised at retirement. This cycle is depicted in Figure 2.2. This theory suggests that a country with a high share of older groups tend to have lower household savings, thus aggregately affecting investment capital accumulation.

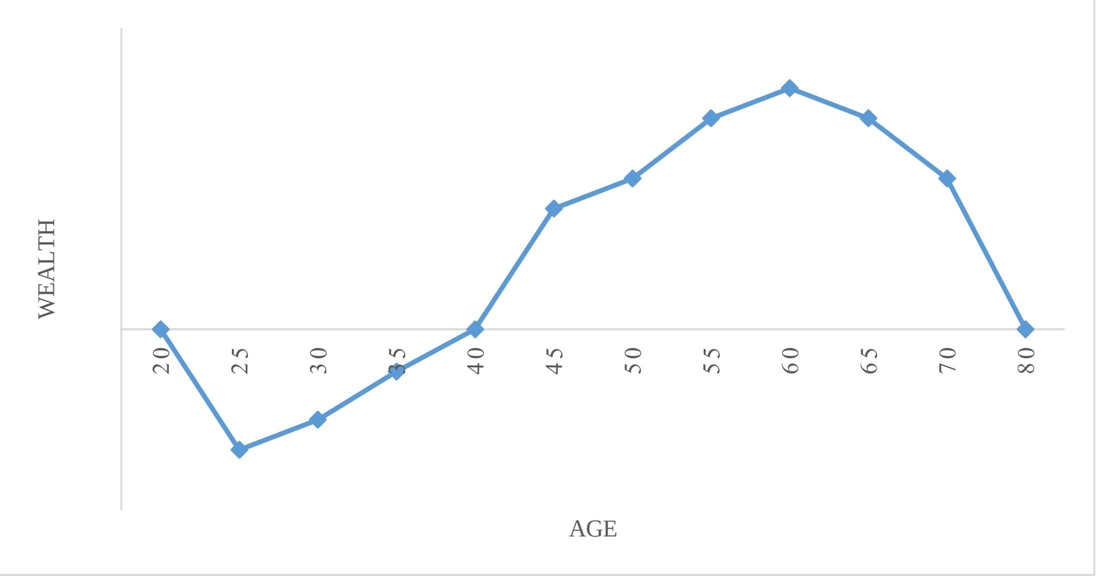

Figure 2.2: The life cycle hypothesis of saving

From a macro-economic point of view, previous literature argues that the combination of declining fertility rates and increasing lifespan reduces the active labour force, thus influencing the relative price of labour and capital (Börsch-Supan, 2003; Courbage & Liedtke, 2012). Hokenstad and Johansson (2001) elaborated this argument by mentioning that reducing the number of the young adult population and increasing a large portion of an older generation produces a worker shortage, thus affecting production productivity and economic growth. This requires companies to restructure their employment training, specifically for the older group. In response to the employee shortage problem, most developed countries inevitably need to confront immigrant pressure to support production activities (Peterson, 1999).

2.1.2 Population ageing and social structure.

Alongside the economic impact, demographic transition has changed demographic characteristics in terms of age distribution, size, and family structure. Such changes have important implications for socio-economic inequalities. Social and economic changes—such as sociocultural change, urbanisation and industrialisation—primarily in Asia, have weakened informal family-based old age support arrangements creating a gap in old age pension support (Park, 2009). Traditionally, parents will stay with their children in the same household. However, due to urbanisation and job factors, the younger group prefers to stay at the city near to where they are working; thus weakening extended families, which places pressure on the government to take care of the older group because family support becomes a central motor of intergenerational transfers of income to old age (Mohd, Azman, Sulaiman, & Baba, 2010). Given the weakening of the extended family, we can expect the emergence of income inequality or redistributive issues. According to Dong, Tang, and Wei (2017), a demographic change would affect the aggregate income inequality of the total economy if only this inequality differs across age groups. They also suggest that if the income inequality rise results from demographic change, population policy, the social welfare system, and intergenerational transfer payment policy should be considered to overcome this issue. This will require the government to allocate huge amounts of money to deal with this issue by providing social security benefits for the elderly to support existing pension provisions thus minimising the gap of distributive issue.

Finally, Bloom et al. (2015) highlighted five major economic concerns regarding population ageing: i) reducing productivity among older people, which creates less output; ii) older groups have high consumption and thus tend to reduce savings and investment capital; iii) increase the demand of pension schemes; iv) disease and disability among older groups represents substantial loss to national production, thus affecting workforce and capital accumulation; and v) massive fiscal burden required for health and long-term care system. In response to these concerns, countries around the world are re-examining their pension systems through pension reform. The next sections will discuss the broad literature on pension reforms, and understanding the fundamentals and challenges of the pension system in both emerging and industrialised countries. Prior to that, Malaysian pension practice is discussed first. Then, based on pension practices in developed and developing countries, we suggest a lesson for Malaysia's potential reform.

2.2 Malaysia's Pension System and Challenges

Malaysia implemented a single-tier pension system where the pension is segregated based upon employment criteria. In other words, different pension plans cover different groups of employees. Generally, pension systems in Malaysia can be classified into two broad groups: social security and social insurance where the former refers to retirement programs such as the EPF, civil pension, and the Armed Forces fund. While the latter provides work-related compensation such as SOCSO and social pensions.

According to Mohd (2009), social protection programs were introduced in Malaysia in the 1800s with the introduction of the Penang Municipal Provident Fund in 1889 to provide retirement income for employees. However, the formal pension operating in Malaysia was introduced by the British in 1945. The EPF is a mandatory defined contribution scheme where the benefit of the scheme is undefined while the contribution is pre-determined. This scheme is governed under the *Employees Provident Fund Act*, 1951 and then amended to the *Employee Provident Fund Act*, 1991. It is a national compulsory retirement saving for private sectors and non-pensionable public sector employees (Tolos, Wang, Zhang, & Shand, 2014). The objective of the EPF in Malaysia is to provide post-retirement securities for formal private workers through monthly savings from participants. Therefore, the end benefit is not guaranteed and participants receive the retirement benefit based on contribution and return earned from investment. According to current policy, members of the EPF can withdraw a proportion of their savings at the age 50 and the remaining at 55.

The second pension system is the civil service pension scheme, which is designed specifically for public servants and they are not required to contribute to their pension benefit. In addition to annuity pension benefits, civil servants are also paid a lump sum payment, which is known as a gratuity or '*golden handshake'*. These benefits are financed by three income sources: allocation from the federal government (5% of its annual emolument budget), a contribution from a lower level government (17.5% of the salaries of the pensionable employee), and investment income generated from an accumulated balance in the retirement fund (Asher, 2012). As for minimising the impact of population ageing and globalisation, statutory retirement ages for public servants has been raised several times: from 55 to 56 years in October 2001; from 56 to 58 in July 2008; and from 58 to 60 in January 2012 (Tolos et al., 2014).

Another pension system is designed for military personnel. The Armed Forces (LTAT) fund was established in 1972 under an Act of Parliament. Like the EPF, LTAT is a DC scheme with both employee and government (as an employer) contributing 10% and 15% of employee's monthly salary respectively. This scheme covers disability and survivors' benefits if any unexpected event occurs during service. The members of this scheme are eligible to withdraw the full amount of benefit at the age of 50 years.

2.2.1 Pension challenges.

Fifty-three percent of Malaysia's labour force is covered under the EPF scheme. As previously stated, under this scheme, final pension benefits rely on the contributions made by individuals and returns gained from investment. In a world where financial markets have become seemingly increasingly complicated and more volatile, it directly and indirectly affects the investment returns during the accumulation period, thus dragging this institution into pension "*crisis*".

One of the main challenges faced by the EPF is the ability to provide a significant coverage for labour forces. The concept of pension coverage, as suggested by Asher and Bali (2015), can be defined from three perspectives: the number of workers enrolled in the pension program; risk covered by the system; and adequacy of the pension system to mitigate poverty. From the first perspective, the EPF is open only to the Malaysian citizen. Moreover, this scheme is designed for private sectors and non-pensionable public sector employees and ignores the informal sector—such as the self-employed and farmers—for whom it is not compulsory to join this pension scheme. As a result, more than 2.7 million self-employed Malaysians in 2009 have no specific scheme targeted for them (Asher, 2012). The OECD (2013) reports that 53.5% of the total labour force in Malaysia is covered by the EPF, which is lower than Singapore and Hong Kong, which implemented the same pension system (provident fund). Table 2.1 shows membership of a mandatory pension scheme by population and labour force for selected countries. Under coverage issue, it is also interesting to highlight the statistic of the uncovered labour force in Malaysia. Holzmann (2015) argues that about 37% of the total labour force are without formal coverage. Table 2.2 shows the estimated labour force coverage with a special focus on Malaysia.

Table 2.1: Membership of mandatory pension scheme by population and labour force

Country	Year	Members **('000)**	Percentage of population aged 15 to 65	Percentage of labour force
Malaysia	2010	6,400	28.1%	53.5%
China	2010	268,200	27.7%	33.5%
Hong Kong	2009	2,921.8	55.4%	78.9%
Indonesia	2010	12,979.5	8.0%	11.0%
Philippines	2011	10,163	17.5%	26.3%
Singapore	2012	1,790	64.0%	84.0%
Thailand	2009	8,537.5	17.7%	22.5%
Vietnam	2010	10,585.5	17.3%	20.7%
India	2006	44,404	6.4%	10.3%
Sri Lanka	2006	2,032	14.9%	24.1%

Source: Pension at a Glance Asia/Pacific 2013, OECD

Table 2.2: Estimated pension coverage rate in Malaysia

Coverage status	Coverage (Thousands)	% of total
Mandatorily covered		
EPF actives	6039	52
Public pension scheme active	1200	10
Uncovered		
Own account workers	1917	17
Unpaid family workers	500	5
Others(including foreign workers)	1861	16
Total	11517	100

Source: Holzmann (2015)

From the second perspective, in addition to lower membership coverage, the EPF does not cover longevity risk and health benefits risk. Unlike a civil pension scheme, EPF's members are responsible for their pension benefit with the risks borne by the employee. This means that under the EPF scheme, employees are exposed to inflation, interest rates, and longevity risks. As a result, these risks raise the adequacy issue among the EPF's because caring for an ageing population requires more financial support, primarily for health care.

The second challenge of the EPF relates to the ability of the EPF to provide an adequate pension benefit to maintain the standard of living during retirement. Blake (2000) argues that the level of pension saving is a more vital issue than the type of pension system, and inadequate pension saving is seen as the major obstacle to establishing a decent pension system. Thus, pension adequacy has become a major concern among policymakers, so as to ensure that the current pension system can maintain a standard of living of the population after retirement. The most widely used measure of pension adequacy is replacement ratio. The ratio is defined as the individual net pension entitlement divided by net pre-retirement earnings, taking into account personal income taxes and social security contributions paid by workers and pensioners (https://data.oecd.org/pension/net-pension-replacement-rates.htm). This ratio depicts the effectiveness of a pension system in providing retirement income to replace earnings during the retirement period.

The level of effective replacement ratio has been discussed in previous studies. Park and Estrada (2013) mention that the standard replacement rate suggested by pension experts is between 66% to 75%, whereas Mohd (2009), in line with Lee's study, states that adequacy replacement benefits is defined as 50% replacement rate of final drawdown salary. However, according to the OECD (2013), the current gross replacement rate for Malaysia is 35.1%, which is lower than the suggested rate. Table 2.3 illustrates the gross replacement rate for selected Asian countries.

Table 2.3: Gross replacement ratio for selected Asian countries

Country	Gross Replacement Ratio	Country	Gross Replacement Ratio
China	77.9	Sri Lanka	45.9
Vietnam	67.3	Singapore	38.5
Pakistan	65.9	Malaysia	35.1
India	55.8	Philippines	37.7
Thailand	47.1	Indonesia	14.1

Source: OECD (2013)

Looking at the level of pension savings among the EPF's members, the EPF's annual report for the financial year 2013/2014 shows that about 68% of all members aged 54 years old have savings less than RM50,000 (approximately US$14,305)[2] before retirement at age 55 years old. In addition to this, from the same year, it is reported that on average each member who retires at the age of 55 will receive RM180,152. Considering life expectancy and pension benefits are distributed on an annuity basis, each retired member will receive about RM750.63 per month until 75 years of old and they will be living in poverty (poverty income is average monthly income of less than RM760 for Peninsular Malaysia, RM1,050 in Sabah, and RM950 in Sarawak).[3] This means that the adequacy issue is crucial for the pension system in Malaysia and the EPF is unable to provide adequate savings for members due to several factors, such as increased life expectancy, very low average household income (Suhaimi & Norma, 2013), pre-retirement withdrawal, and low investment return (Mohd, 2009).

As previously mentioned, the final retirement benefit of the EPF fundamentally relies on the financial skills of fund managers. Therefore, an efficient fund manager managing a members' fund is essential to gain higher expected returns that can be channelled into the individual's account for their retirement. Financial management issues such as asset allocation, investment management and diversification become a significant issue for the EPF, in order to generate a good investment, thus generating

[2] As stated by Bank Negara Malaysia (Central Bank of Malaysia) dated 31 December 2014 (RM1 = US$0.2861).
[3] Definition of poverty line income (2014) retrieved from http://etp.pemandu.gov.my/

an adequate pension benefit. This is supported by Asher (2001) who argues that 90% of investment performance is explained by asset allocation, while active investment management contributes to the remaining 10%. Besides the duration of investment, net real return and other costs account for the majority of pension performance (Asher & Bali, 2015).

Under the *EPF Act*, the fund is permitted to invest in only approved investments such as Malaysia Government Security (MGS), debenture loans, money market instrument, equity, and property. In an attempt to protect members' savings in the long-term, the EPF is required to allocate at least 70% in MGS from its investments; at the same time, it is restricted from investing more than 25% in equity. However, in 1991 the *EPF Act* has been revised and these statutes have changed. The government allows for more diversification in their investment strategy when the portion of MGS considerably declined in line with economic growth in the mid-1990s, and privatisation of certain infrastructures and other services were untaken by the government (Asher, 2001; Thillainathan, 2005). Thus, the share of MGS dropped from 73.6% in 1991 to 26.5% in 2011. On the other hand, equity allocation increased from 2.1% to 35.6% for the same periods. Table 2.4 presents the asset allocations of the EPF investment from 2007 to 2011.

Table 2.4: Asset allocations of the EPF investment

Year	Type of Investment	MGS	Loans and Bonds	Equities	MMI	Property	Total Investment
2007	RM Billion	112.9	112.8	66.3	19.3	1.776	313
	Share (%)	36.08	36.03	21.17	6.15	0.57	100
2008	RM Billion	110.6	122.8	87.9	19	1.6	342
	Share (%)	32.35	35.9	25.71	5.56	0.47	100
2009	RM Billion	114.1	131.9	100.4	23.2	1.6	371.3
	Share (%)	30.73	35.55	27.05	6.25	0.42	100
2010	RM Billion	118.5	142.6	153.5	23.9	1.9	440.5
	Share (%)	26.9	32.37	34.85	5.45	0.4	100
2011	RM Billion	124.6	160.7	167.2	14.9	1.82	469.219
	Share (%)	26.55	34.25	35.64	3.18	0.39	100

Source: EPF's annual report (various year)

With an effort to gain more returns for pension savings, in 1996 the EPF launched an investment withdrawal scheme allowing members, who have more than RM50,000 savings in their Account I, to invest the excess funds into alternative assets through a fund manager institution approved by the Ministry of Finance; the return gained from the investment would not be allowed to be withdrawn before the member reaches the pre-determined retirement age of 55 (Jidwin, Tuyon, & Ali, 2011). However, as reported by Mingguan Malaysia dated 6 August 2006, EPF members suffered losses of about RM600 millions of their savings, which they withdrew for investment in the unit trust. Members who withdraw for investment schemes and who have inefficient knowledge of investment strategy are more exposed to market risks. Jidwin et al. (2011) conducted survey on EPF's members invetsed in unit trust and they found that the performance of unit trust investment were inconclusive. While there were members gained return of 10%, there were also possibilities that the members' earning fall below the 2.5% guaranteed minimum return for the EPF, and also possibilities for members to generate higher returns than the average performance of EPF investment of 5%. Jidwin et al. (2011) also claim that the performance of members' investment is influenced by the level of knowledge of unit trust investment and the role played by the financial consultant.

The diagnosis of the Malaysian Pension system, focusing on the EPF, clearly shows that coverage, adequacy and sustainability are amongst the main problems faced by the EPF, which makes pension reform essential. The failure of the government to design a more robust pension system will drag Malaysia into a crisis that requires substantial public expenditure to support both public and private pensions, as well as health care.

2.3 Global Pension Practice and Reform

In general, the pension system is a primary initiative offered by the government as a financial security for the ageing group. Pension system practices vary across countries (Holzmann, 2000), and have been defined in numerous forms by current researchers based upon the objectives of its inception. The Table 2.5 shows the definitions of the system by previous authors.

Table 2.5: Definitions of the pension system

Author(s) and year published	Definition
Mitchell and Smith (1991)	Pension system is an income promise that represents a claim to a future income stream payable after leaving his or her employer.
Blake (2000)	He defines the pension scheme as a long-term saving program to transfer resources from the young to the old or from the youth to the elderly.
Friedberg and Webb (2005)	They describe pensions as a form of compensation deferred until a worker leaves his or her job.
Grech (2014)	He explains that at the beginning, the role of the pension system was more like deferred payment for preferred workers (primarily, civil servants) than seen as a social benefit for the masses.

Looking at Table 2.5, it can be stated that the pension system was established according to goals that needed to be solved by policymakers. However, turning to the objectives of the system, Bar (2002) and Bar and Diamond (2009) argue that the inception of the system is triggered by individual and policy objectives where the former refers to smooth the consumption during retirement, as well as an insurance from longevity and inflation risks, while the latter represents the role played by the pension system to fight poverty and to be medium of the income distribution. In respect to these objectives, we suggest that despite the various definitions, the objectives of the systems are same: to provide income during the retirement period to avoid poverty and smoothing consumption at old age. The variation of definitions also implies that pension system practices vary across countries (Holzmann, 2000). Despite these structural differences across countries, it is believed that all pension systems are facing similar issues which are notably population ageing, high unemployment rate, and changing economic structure (Mitchell, 1993).

From a historical point of view, the pension system was established based on two major common practices: Bismarckian social security, and the Beveridgean social system. The Bismarckian system was introduced by German Chancellor, Bismarck, in 1884. This model is related to employment and represents deferred salary. Under the Bismarckian model, the aim is to provide protection from disability due to an accident at work and sickness (Thane, 2006). The benefits of this model are mainly based on the employer/employees contribution record with the main concern of this system being income maintenance for employees (Bonoli, 1997). This model influenced European countries to develop an old age secure system (Orenstein, 2003). By contrast, the Beveridgean social system was developed to prevent poverty. The benefits of this system are a flat rate and is funded via general taxation.

From another viewpoint, some authors defined the system in response to its features. Kietlińska and Piotrowska-Marczak (2004), for example, distinguish the pension system as a redistributive-based approach (RBA) and a capital-based approach (CBA). The former refers to a system where benefits for retirees are funded by an active working generation, while the latter suggests that pension benefits are determined based on contributions paid during the entire working period. These contributions are then invested in the money market to secure and increase the saving value in the pension account. RBA consists of a public pay as you go (PAYG) pension scheme, whereas CBA entails a defined benefit (DB) and defined contribution (DB) scheme. Another classification of pension practices are funded and unfunded pension schemes; DB and DC schemes; private and public systems; occupational and personal pension plans; and mandatory and voluntary membership (Holzmann, 2000; Robert, 1994; Yermo, 2002).

As stressed in previous sections, the evolution of demographic and economic factors trigger pension reform throughout the world. In addition to these factors, a single-tier model is believed insufficient to provide an adequate and sustainable pension benefit. Thus, the World Bank since 1994 has been promoting multi-pillar pension provisions comprising state pension schemes, insurance programs, private pensions and voluntary pension savings (Holzmann, 2000; Orenstein, 2003; Tolos et al., 2014). The multi-pillar pension system has been promoted as an effort to diversify a retirement income source for individual retirees where each pillar has a specific social target with different methods of financing. Figure 2.3 details the idea of a multi-pillar pension system suggested by the World Bank.

Prior to the World Bank's multi-pillar model, the International Labour Organization (ILO) played a vital role in reshaping global pension programs. The main principle of the pension program from the perspective of the ILO is to fight poverty and equality considerations (Tolos et al., 2014). The ILO, as stated in the ILO's Declaration of Philadelphia in 1944, promotes the idea of a unified, national pension system, central social security, as well as providing a specified set of benefits, which consider disability and old-age pension protection. Meanwhile, the Geneva Association introduced a four-pillar program by improvising the World Bank's multi-pillar program. Through this program, the Geneva Association promotes modernisation of social security by greater integration of private insurance through the complementary development of the second and third pillars. Moreover, this program aims to encourage retirees to continue to work on a part-time basis to supplement their income from the first three pillars. According to the Geneva Association (2012, p. 19), as cited by Tolos et al. (2014), the encouragement to work after retirement is based on a future need for working life to be extended in a flexible manner, mostly on a part-time basis to support their retirement income. The multi-pillar model suggested by the ILO and Geneva Convention are summarised in Table 2.6.

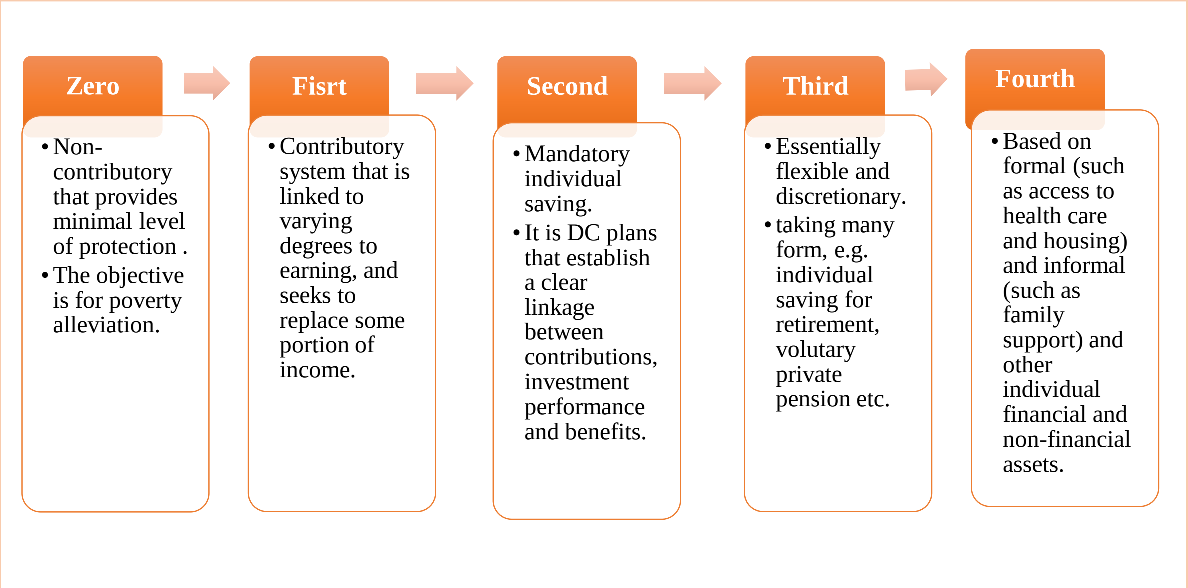

Figure 2.3: World Bank's **m**ulti-**p**illars system

Source: Author's compilation from Holzmann (2012), Tolos et al (2014).

Table 2.6: Multi-pillar pension system by ILO and Geneva Association

	ILO	Geneva Association
1st Pillar	Anti-poverty tier, means tested and financed from general revenue.	Compulsory PAYG
2nd Pillar	PAYG, DB, mandatory and publicly managed.	Occupational pension and fully funded.
3rd Pillar	DC scheme and mandatory.	Individual saving including personal pension and insurance
4th Pillar	DC scheme and voluntary.	Income from part time job after retirement.

Source: Tolos (2014).

As the role of a pension system becomes more complex resulting from population ageing and financial factors, these have pushed dozens of countries to overhaul their pension system to ensure the system remains sustainable, as well as achieving another target such as poverty alleviation, savings and capital acceleration. In the next section, we explore in greater detail the nature and experience of pension reform among developed and developing countries.

2.4 An Outline of Pension Reform

Over the past several decades, the world has witnessed pension reform initiatives in various ways, such as parametric reform, systemic reform, regulatory reform through changes in investment regulations, and administrative reform (Schwarz, 2006). Hur (2010) argues that the direction of pension transition involves four approaches: from a PAYG plan to a funded plan, from a DB to DC, from publicly managed to privately managed, and from a singular to the multi-pillar scheme. Hur (2010) also mentions that these reform directions have not always run fully parallel with one another.

However, rather than focusing on the detailed information of the reforms, it is more common to categorise reforms into two broad approaches: parametric reform and systematic reform. Parametric reform changed the underlying rule of existing pension systems such as retirement age, contribution rate, and pension benefit. Whereas, systematic reform requires policymakers and governments to overhaul the whole existing pension system, such as shifting from an unfunded DB scheme to a funded DC pension scheme.

A substantial part of the literature discusses the key factors of pension reform, such as population ageing (Bongaarts, 2004; Madrid, 2005), economic development and globalisation (Brook, 2007; Jackson, 2012; Mesa-Lago, 2002), boosting financial and capital markets (Ferreiro & Serrano, 2011), and global agenda played by the world organisation, such as the World Bank and ILO (Brown, 2008; Holzman, 2012; Tolos et al., 2014). In response to these factors, there are also many studies that assess the outcome before and after the reform was initiated. Fehr, Sterkeby, and Thøgersen (2003), for example, studied the effect of pension reform proposals in Germany; Ionescu (2013) compared the effect of pension reform between EU and Romania; and Kitao (2015) focused on Japan.

Having reviewed the reforms made across the world, country-specific studies present interesting outcomes of the reforms effect. Miyazaki (2014), for example, examines the impact of an increasing retirement age on economic variables in Japan. Using an overlapping generational (OLG) model, he finds that the initiative to increase retirement age does not necessarily boost aggregate output and this reform is effective only for the short-term. In the long run, he suggests the government increase tax or reduce the social benefit index to sustain the current system. By contrast, using the data from China, Zeng (2011) argues that an increased pension age will reduce pension benefits in China. These two findings imply that the same reforms may have different outcomes due to country-specific factors. This also suggests that a countries that consider reform in pension system have to take into account their country-specific objectives such as minising financial burden of pension system and solving labour shortage. Clark, Munnell, and Orszag (2006) assert that the reform initiative be targeted towards maintaining a standard of living rather than income replacement because the cost of the pension will be accompanied by rapidly rising healthcare costs of the ageing population Meanwhile, Ionescu (2013) highlights that fundamental pension reform must ensure long-term financial viability and adequate levels of savings to avoid poverty. Table 2.7 explains the different objectives of pension reform.

Table 2.7: Pension reform objectives

	Author and Year published	Country/ Region Setting	Reform's Objective(s)
1	Clark et al. (2006)	OECD	To maintain the standard of living of the retiree.
2	Madrid (2000)	OECD	Pension reform is not only to solve the financial problem of the current pension system but also assists countries to compete in increasingly and highly volatile environments.
3	Holzmann (2000)	World	Key primary concerns of the World Bank to developing pension policy is divided from four factors: (1) short-term financing and long-term financial viability; (2) economic growth; (3) adequacy and other redistributive issues; and (4) political risk and sustainability.
4	Bar and Diamond (2009)	World	The main objective of pension reform is to fulfil the role of the pension system—consumption smoothing, poverty relief and redistribution—in response to demographic changes and declining labour-force participation of older male workers.
5	Ferreiro and Serrano (2011)		Three key drives of pension reform: attain higher rate of return, stimulate economic growth through the growth of investment resulting from private saving, and impossibility to keep current system due to dramatic effect of population ageing.
6	Song (2009)	Russia and China	The idea of reform was to overcome the problem of PAYG, which has limited coverage, inequality across sectors, lack of probability, and unsustainable financing.
7	Holzman (2012)	Central and Eastern Europe	Arguing that pension reform consists of basic and intermediate objectives. For basic objectives, the reform is taken for poverty alleviation and consumption smoothing. Meanwhile, intermediate objectives focus on old age pension issues such as coverage, adequacy, affordability, sustainability, robustness and distribution.
8	Mavlutova and Titova (2014)	Latvia	The goal of pension reform is to create a financially stable and efficient pension scheme based on individual social security contributions.
9	Wang, Beland, and Zhang (2014)	China	The aim is to reduce the financial burden of pension system.
10	Ionescu (2013)	Romania	Highlights fundamental pension reform is to ensure long-term financial viability and adequate level of savings to avoid poverty.
11	Bonoli (2003)	Western Europe	Other than population ageing, pension reforms are also is adapted as a result of demand for new forms of employment and with the requirement of an internalised capital market.

Table 2.7 reveals that in most cases the reform's objectives lay in developing a sustainable pension fund to provide adequate pension savings. Working on these objectives most studies have highlighted three fundamental challenges to developing a pension system: i) coverage issue, pension adequacy, financial stability and affordability; ii) economic efficiency and administrative efficiency; and iii) security. The next section describes pension reform experiences for both developed and developing countries from the perspective of parametric and systematic pension reform. The next point in this section discusses the challenges of sustainability and performance concern among developed countries.

2.4.1 Pension reform in developed countries.

Financial pressure in social-security programs across OECD countries resulting from an ageing population has been discussed since the 1960s (Holzmann, 1988). Holzmann (1988) shows the proportion of older people aged 65 and over has increased remarkably in OECD countries since the 1950s, especially in Greece, Italy, Japan, and Scandinavian countries. Again, pension system sustainability becomes a major concern among industrialised countries. Asher and Bali (2015) define sustainability from narrow and broader perspectives where the former requires the pension system to balance long-term assets and liabilities, while the latter suggests sustainability as an assessment of fiscal burden currently and in the future, adequate levels against longevity, inflation, and survivor's risks and near-universal coverage under the pension system among the country's population.

Spurred by the approaching ageing transition, policymakers and academics sounded the alarm about the sustainability of current pension systems to fulfil its promises. Higher projected public pension spending was seen as clear evidence that current systems are likely not sustainable. This occurs when the number of pension receivers is higher than the number of pension contributors. It is explained by the increase in the dependency ratio in industrialised countries. In Canada, for example, the dependency ratio is expected to increase by 130% from 1960 to 2050. Meanwhile, Japan's aged population is expected to increase by 190% for the same period (Hviding & Merette, 1998). The OECD (2015) notes that, as expected, the old age dependency ratio will double in the next 45 years on average in OECD countries as depicted in Figure 2.3. Figure 2.4 depicts that the dependency ratio among OECD countries is expected to increase for the next 45 years where Japan, Spain, and Korea Japan record the highest old-age dependency ratios.

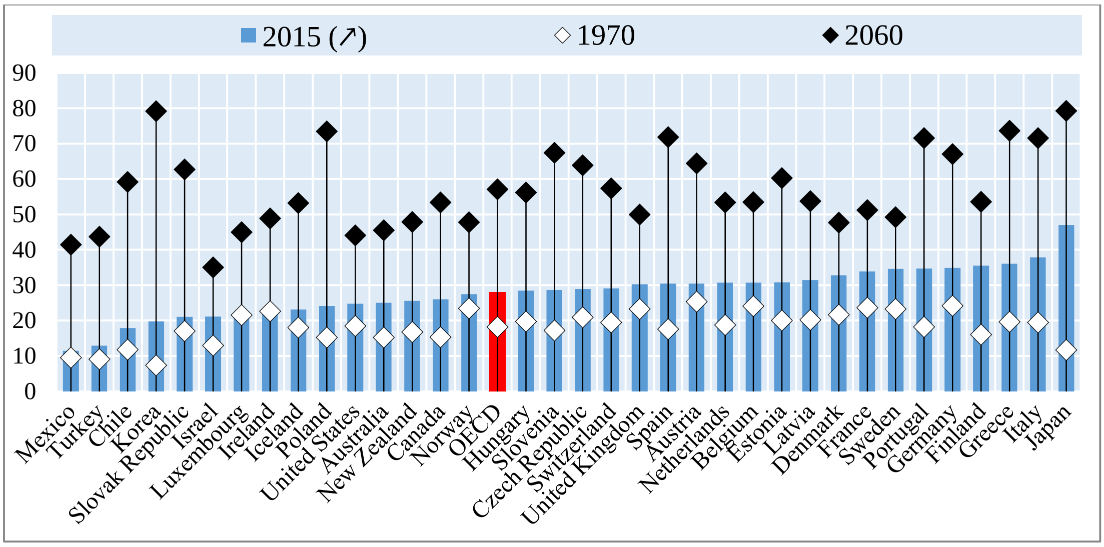

Figure 2.4: Projection of the old-age dependency ratio for the next 45 Years

Source: Society at Glance (2015)

The effect of unsustainable pension systems creates welfare and economic problems. As reported by the OECD (2015), pension expenditure is projected to increase from 9% in 2014 to 10.1% on average in OECD countries. Furthermore, looking at the dependency ratio, Kitao (2015), who is studying pension reform in Japan, suggests that without any reforms, Japan will be required to increase its tax rate by 48% in 2080 to finance pension benefits. Although demographic transition affects the sustainability of current pension system, it should not be over-highlighted as a factor that demands pension system adjustment because other factors such as economic uncertainty and volatility in financial market may also encouraged to pension reforms.

One of the key challenges of the PAYG pension system was the promise by the government or pension provider of higher pension benefits. However, in many industrialised countries, the declining fertility rate has led to a reduction of the main contributing age group into the PAYG system. In addition, unfunded pension schemes, together with generous pension benefits, exacerbate the system. Some countries, including Germany and Finland, offered up to 60 to 70% of final salary as benefits during retirement (Madrid, 2000). Thus, one of the common reform of achieving sustainability in pension system is reducing replacement rate. However, the efficiency of this reform varies. Even reducing the replacement ratio may bring a positive impact to economic growth, it also would limit the pension's role in alleviating old age poverty (Kashiwase et al., 2012).

Another common reform in the parametric approach is increasing the statutory retirement age. Increasing the minimum retirement age may enlarge the contribution base while preserving adequacy for those who are able to work longer (OECD, 2015). However, this reform is theoretically controversial (Fanti, 2014). On one side, Karam, Muir, Pereira, and Tuladhar (2010) argue that such reform has a positive impact on growth both short- and long-term as a result of rising consumption and boosting aggregate investing due to lower government debt. In another study, Kashiwase, Nozaki, and Tokuoka (2012) suggested that an increase in the minimum pension age in Japan would have a positive impact on economic growth and would be fair in sharing the burden of fiscal adjustment between young and old rather than cutting the replacement rate where it is believed it would undermine the pension role in alleviating old age poverty. Isleifsson (2012) studies the implication of four reforms: discounted rate change; increased retirement age; change in life expectancy; and incidence of disability on pension imbalance. The results show that increased retirement age has a positive impact on pension imbalance. This result is consistent with Zeng (2011) who mentions that, comparing several alternative reforms, the effect of the increased retirement age is much earlier than possible change in the fertility policy or faster mortality trend. Moreover, using data from advanced small economies, Heijdra and Romp (2009) suggest that increasing the early retirement age provides the lowest cost policy measure to combat the adverse effect of the various demographic shocks.

Miyazaki (2014), by contrast, argues that increasing the retirement age has a limited effect on aggregate output. Using the OLG model for Japan, he asserted that increasing the retirement age does not increase aggregate output, and raising the retirement age can only help Japan's pension crisis in the short run. He suggests that government should increase tax, as well as decrease social security to sustain current pension security. In addition to this, Fanti (2014), argue that for the case of PAYG pension plans, that reduction of retirement age may be more favourable for economic growth and pension payment when a country has sufficiently high capital.

Another interesting approach considered by developed countries to deal with sustainable issues is introducing a new system through systematic reform. As stressed before, this reform requires countries to shift their existing unfunded plan towards partially or fully funded pension plans. In essence, there have been two approaches to systematic reform: those are shifting unfunded PAYG to a fully private pension system; and the introduction of a multi-pillar system as inspired by the World Bank. The idea of implementing this reform is to address the issue of savings, intergenerational equity and capital market formation, which PAYG fails to achieve (Holzmann, 2000).

According to Brook (2007), until 2005 more than 25 governments around the world had implemented some form of market-oriented reform or “privatisation”. The success of Latin America’s pension reform encouraged OECD countries to transform their pension system and received considerable support from the World Bank. Theoretically, it is believed that shifting the system to a funded system will generate positive impacts through a higher rate of domestic savings, the development of national capital markets, as well as higher economic growth. This is supported by the finding from Hviding and Merette (1998). Using the OLG model for eight OECD countries, they found that private pension systems can reduce the fiscal burden of future pension liabilities and increase national savings along with future potential output.

In contrast, numerous studies analysed the effectiveness of private pension systems in ensuring pension sustainability over the long run. Several studies showed that private pension schemes would lead to income inequality among older people because private pension systems raise distributional issues (Arza, 2008; Goudswaard & Caminada, 2010). The concept of transforming to a private pension system is still being debated, since the impact is unclear and evidence that privatisation brings economic benefit remains ambiguous (Madrid, 2005). Moreover, financial crisis and financial instability negatively influence the performance of pension privatization and affect confidence among the public. Ionescu (2013) concluded that private pensions was not the best way to maintain a standard of living for retirees. Ionescu (2013) also argues that the income of most retirees in EU countries is still provided by the PAYG system, and private pensions offer supplementary incomes to pensioners. Therefore, to sustain this problem, several countries implemented minor changes in their current pension system instead of changing the whole system (Miyazaki, 2014).

2.4.2 Pension reform in developing countries.

This sub-section presents challenges in reforming the system for developing countries. We detail the five major challenges that make developing countries' needs unique when compared to developed countries. Those challenges are: sustainability, coverage, pension adequacy, governance, and family structure. This sub-section will also touch on challenges rather than reform experience because reforming pension systems in both developed and developing countries is alike, namely through systematic and parametric reforms.

2.4.3 Sustainability.

One of the major concerns in developing countries is that most of these countries do not yet have a mature and well-functioning pension system (Park & Estrada, 2012). Park and Estrada (2012) also argued that the developing Asian pension system relies heavily on defined benefits pensions. With the continuous increase in the older group (pensioners), a DB scheme is expected to be unsustainable in the long run. A single-tier pension scheme is believed to lead to unsustainable pension reform, especially in a PAYG or DB scheme. For the case of South East Asia, Asher and Bali (2015) argued that a financing–mix approach is an alternative that can be considered for individuals to diversify sources of income to meet their retirement needs. This is in line with a multi-pillar social approach as suggested by the World Bank. In addition to that, in order to support sustainability of a pension system, financial and capital market development plays a significant role. In studying pension systems in ASEAN countries, Singapore, for example, introduced mandatory annuitisation for members of the Central Provident Fund (CPF) when they reach retirement age where the premiums are determined based on commercial instead of social insurance principles (Asher & Bali, 2015). This implies that premiums vary according to age, where the premium will increase as the age increases.

2.4.4 Coverage.

Coverage is one of the main challenges of the pension system. Unlike developed countries, the challenge of pension reforms is domination of the informal labour market. Moreover, Asher (2000) asserted that formal coverage of old age protection was less developed in Southeast Asia in relation to its economic development. The existing pension system covers a limited group of employees such as government servants and formal workers. Most of the pension systems in developing countries ignore informal workers such as farmers and part-time workers.

Pension coverage is not limited to the number of people or workers who enrol in the pension program, but it also must take into account the risk and benefits covered in the system and the adequacy of the system in providing a replacement rate that not only covers the inflation risk but also mitigates old-age income poverty, as well as to smooth consumption (Asher & Bali, 2015). Figure 2.5 displays the active coverage of pension systems for selected countries. Figure 2.5 clearly shows that the coverage ratio in lower income or developing countries (oval) have lower pension coverage, and high-income countries (rectangle) have a high population covered by the pension system. This figure suggests that coverage issue is a primary issue among developing countries. One of the common reforms to encourage informal workers to be covered by the system is the inception of a voluntary pension system. However, in order to encourage this group to participate in this system, Hu and Stewart (2009) argue that the government needs to provide a monetary incentive such as tax benefits. However, monetary benefits, like tax benefits, are seen as unable to encourage citizens in the informal sector to participate in a voluntary scheme because most of the rural informal groups do not pay tax or have too low income to participate in the scheme. Alternatively, Hu and Stewart (2009) suggest that financial literacy and financial knowledge are important to raise public awareness of pension knowledge. Furthermore, government’s initiative is essential to support this low income group maintaining their standard of living through social security program.

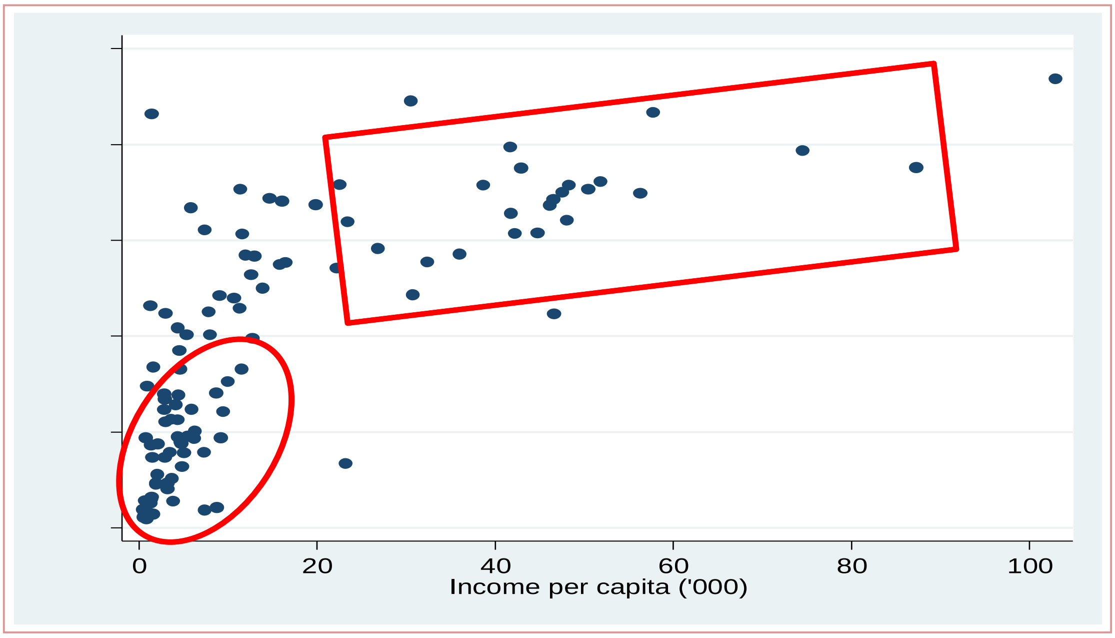

Figure 2.5: The active coverage ratio (No. of active contributor/working-age population)

Source: Author's calculation

2.4.5 Pension adequacy.

The next challenge is pension adequacy. It is fundamental to a pension system to ensure that the current pension system can maintain a standard of living of the population upon retirement. One of the main obstacles to establishing a decent pension system is inadequate pension savings during ones working life; even the type of pension scheme matters, but the level of pension savings matters most of all (Blake, 2000). Changing from a DB to DC pension scheme requires individuals to be responsible for their retirement savings. In developing countries, extra challenges of the adequacy of pension savings have arisen when the population are not financially ready for their retirement (Bloom & McKinnon, 2010; Wang et al., 2014). According to Wang et al. (2014), as stated by Lu (2013), there were more than 18 million poor elderly people in China in 2011. The performance of a pension system to provide an adequate pension saving is disputable. The benefits of the private pension scheme are subject to economic performance and capital market development. Under this system, appreciation of pension funds and future benefits relied heavily on financial market functions. Yet Song (2009) has studied pension reform in Russia and China and found that the challenge of pension reform in both of these countries is immature capital markets. As a result, without a supportive capital market, the objective to boost pension benefits is questionable. Thus, pension reform together with capital market reforms should maximise the effect of pension reforms. Having dealt with adequacy issues, Park (2009) suggests that the fund manager needs to maximise the return from assets they manage through a decent investment strategy. He also highlighted that development of domestic capital and financial markets is required to support the fund manager to generate higher returns.

Nevertheless, there is a tendency that the fund provider may not be able to improve investment returns in a pension system, thus affecting the final benefits of the system. An alternative source of income is essential to ensure the standard of living is maintained during the retirement period. These alternative sources may include individual savings, or government expenditure on social security. As suggested by Asher and Bali (2015), when the existing pension scheme cannot provide adequate savings, the role of government to provide social-finance transfer to targeted individuals with below certain pension benefit levels is required to protect them from falling into poverty in retirement age.

2.4.6 Governance.

Governance issues occur in both developed and developing countries. However, governance problems are more serious in developing countries due to ineffective governance systems, which weakens the effectiveness of provident and pension fund organisation (Asher & Bali, 2015). According to Stewart and Yermo (2009), a DC contribution contract is more exposed to governance challenges emerging from the absence of trustee arrangement. Meanwhile, Holzmann, MacArthur, and Sin (2000) asserted that governments have taken advantage of the situation and conditions of non-transparency to address policy objectives that do not match the fund's purpose of old-age income protection, which adversely affects the efficiency of translating savings into investments. Indonesia, for example, has used provident fund assets to support the exchange value of its currency, and ease the passage of bills in parliament. Park (2009) stressed that governance and regulations are vital to promote operational efficiency as well as transparency of any pension system. It is important to secure the interest of the members of pension funds.

2.4.7 Family structure.

Another noteworthy challenge for many developing countries is that economic development and population transition have weakened informal family-based old age support. Social and economic changes—such as sociocultural change, urbanisation and industrialisation—occur in most developing countries and result in children moving to cities for a better life, which leads to the deterioration of family support as an income source for the elderly. Park (2009) claimed in his working paper that Asian citizens have traditionally relied heavily on their children to take care of their material needs in their old age and the weakening of informal family support must be fulfilled by developing a formal pension system. In addition to this, Masud and Haron (2008) compared income differences among elderly in regional Malaysia and they found that in most regions the elderly still relied on their child for support compared to the youngest generation, which were concerned for their future pension savings.

In addition to this challenge, developing countries face the same problem where their population were not ready, in terms of financial support, to live in retirement period thus, escalating poor group among the older population. The development of socio-economics in developing countries, such as per capita income, degree of industrialisation, urbanisation and social security, are relatively lower than developed countries. Park and Estrada (2012), and Ja'afar and Daly (2016) depicted this situation as the phenomenon where Asian populations are getting old before getting rich.

2.5 Lesson for Malaysia

This section is going to discuss the lesson that can be taken from reform experiences in both developed and developing countries, which might be useful for Malaysia. Based on the previous study, Malaysia is not spared from a "*pension crisis*" due to an ageing population and economic uncertainty. Malaysia's pension problem may differ with what was happening in the developed countries. However, as stated by Park and Estrada (2008) the most common feature of a pension system in developing countries is their population getting old before getting rich. Therefore, this phenomenon leads to inadequate savings during their retirement time.

In general, two factors will determine the effectiveness of a pension system when taking into account factors of globalisation and an ageing population, i.e. financial sustainability of the pension system and income adequacy received by the pensioner during retirement. From the context defined contribution, as implemented by the EPF, financial sustainability is not a crucial problem because pension benefits are subject to the contribution made by members and return on investment generated from the accumulated contribution. However, from the income adequacy point of view, DC does not guarantee that any pension benefit will create an adequate pension income. The EPF, as stated by Ja'afar and Daly (2016), failed to provide an adequate pension benefit to its members. After taking into account financial risk, mortality risk and longevity risk, Ja'afar and Daly (2016) suggested that the investment decision should be a central concern for the government in considering reforms for the EPF.

Adequacy consideration is one of the major issues when developing a decent pension system and pension saving levels are a more important issue than the type of pension system. Based on the data from OECD in 2013[4], the replacement rate for the EPF was 35.1%, which was lower than the average replacement rate for South Asia (42%), and East Asia (44%). Meanwhile, the EPF annual report for 2014 reported that more than 60% of the EPF members aged 54 years old had savings less than RM50,000. This implies that, with a lifespan rising and without well-managed pension savings, a tendency to see the elderly group getting poorer is higher, which requires the government to allocate a certain portion of public spending to protect this group. To deal with this issue, it is recommended to consider extending the statutory age. Currently, the EPF member is allowed to withdraw a full pension benefit at age 55. However, for a government servant, the statutory retirement age is 60 years old; thus increasing the withdrawal age from 56 to 60 years old will minimise the potential of "income lost" after retirement among older people. Moreover, financial planning and financial literacy awareness is important to future retirees, especially how to manage their pension savings during the decumulation period.

[4] The data were taken from Pension at a Glance Asia/Pacific 2013, OECD (www.oecd.org/publications/pensions-at-a-glance-asia-pacific-23090766.htm)

Another concern for the Malaysian pension system is coverage level. There is a significant coverage gap in Malaysia, primarily on old-age protection. Similar to other developing countries, the formal pension system (the EPF) only covers formal private workers. Meanwhile, informal workers, such as farmers and self-employed, are not mandated to contribute into the EPF. As reported by Holzmann (2015), only 52% of the labour force are covered by the EPF, 10% covered by the public pension fund and 37% are without formal coverage. Therefore, we believe that the initiative taken by the government to introduce a private retirement scheme (PRS) in 2012, as voluntary supplement saving for both employed and self-employed, is a good start to prepare future retirees with good retirement savings. However, monetary incentives are probably important to encourage citizens to participate in this scheme.

While Malaysia's population is still at the median age, Malaysia has room to prepare and develop a more decent pension system; thus avoiding any potential future problems. Moreover, in an effort to transform its economy into a high income nation by 2020, social and old age protection needs to be considered as complementary factors to achieve a high-income nation in a sustainable manner. Failing to develop adequate savings among the population exposes the Malaysian Government to increased spending on social protection expenditure in the future. From the perspective of the EPF, adequate saving is subject to the contribution made by members and return obtained from invested assets in financial markets. Therefore, it is important to identify the investment strategy and the optimal contribution that generates benefits at least at the poverty line (i.e. RM950). Although there is a study discussing investment strategy for the EPF (see Hussin, 2012), the potential benefit of international diversification for the EPF is not well explored due to regulation restriction of asset holding. Thus, this thesis will fill the gap by proposing investment strategy for the EPF after taking into account the inclusion of international stock in the portfolio decision strategy.

Finally, Table 2.8 summarises the challenges and potential reform or potential initiative that can be taken by Malaysia to prepare the country for population ageing.

Table 2.8: Potential reform for Malaysia's pension system

Challenge	Potential Reform/action
Pension Adequacy	• Government needs to consider increasing the retirement age for the EPF members from 56 to 60-years-old, which is in line with the statutory retirement age for the public service pension scheme. This will increase saving accumulation. • Improve return from assets managed by the EPF. Investment strategy is essential for the EPF, and asset allocation decision may improve investment performance. • Developing a financing-mix approach or multi-pillar scheme to support a single-tier approach through government expenditure on social security for retirees who have a low retirement income.
Pension coverage	• Extensive campaign on the benefit of private retirement schemes (PRS) to all citizens, especially in the informal sector. • Improving financial knowledge and financial literacy among citizens regarding the awareness of retirement readiness.
Pension sustainability	• Considering the implementation of an annuity based approach instead of lump sum benefit payout. This will ensure that EPF members receive a continuous benefit after retirement.

2.6 Conclusion

The key issues of retirement and pension system; adequacy, sustainability and coverage, have preoccupied researchers as evident in the above literatures. It is clearly showing that the entire issue of retirement planning will require policymakers and academia to review the direct and indirect impacts of continuous longevity increase, the decline in fertility rate as well as a consistent low-interest rate environment on the performance of pension system in order to provide retirees with an adequate and sustainable pension saving. In this chapter, we provided a snapshot of pension system practices and experiences from the perspective of both industrialised and developing countries. The lessons from these countries are used as a milestone in this thesis to identify the main problem to be tackled by policymakers in the EPF case. Pension's adequacy and their future sustainability are a central concern among policymakers regardless of if they are for developed or developing countries to be able to fulfil the objective of the pension system.

Even though the population in Malaysia is relatively young, preparation towards an ageing population should be considered now because without any action an ageing population will create economic and financial problems. In addition, as Malaysia wishes to be an advanced and high-income country by 2020, older income security is important. With a single-tier pension system, it is believed that Malaysia will be exposed to the phenomenon of "getting poor at retirement age" because of inadequate savings, high cost of living, and the abolishment of extended family. Therefore, the issue of pension readiness should be a central concern for the Malaysian Government, with the intention to reduce the government burden in providing social expenditure in the future.

Chapter 3: Asset Liability Management (ALM) for the EPF

A pension typically faces two types of risk, namely the rate of return on reserves is in general stochastic and actual benefits of the members (investment risk) and reserve covering their future benefits (actuarial risk) …. By choosing its investment policy and the level of reinsurance the pension fund is able to influence risks.
(Müller, 1985)

3.1 Introduction

The above quote clearly highlights that investment policy is crucial for the pension system. According to Asher (2000), 90% of the performance of investment strategy are derived from investment performance, and the other 10% are from active investment management. In light of this, this chapter addresses optimal decision making for the pension system by considering assets and liabilities simultaneously for asset allocation decisions. Various models suggested in the previous literature are discussed to enhance our understanding of the development of an optimisation model in this field, including static mean-variance model, and stochastic modelling in the ALM model. Then, we define the mathematical framework for modelling optimal decision making in the DC pension scheme in Malaysia known as the EPF. We consider a two-stage programming model (TSP) for different alternative assets in the investment strategy. We also incorporate integrated chance constraint (ICC) as solvency risk management in our TSP model.

3.2 Portfolio Optimisation

In the pension investment strategy, the fund manager confronts with challenges for short and medium term strategy namely, low-interest rate environment, continuous increase in longevity and decline in fertility rate (Pagnoncelli, Cifuentes, & Denis, 2017). Asset allocation is a central issue in financial management. A prudent investment plan is crucial for institutional investors like pension funds in order to gain public trust in their scheme. Asher (2000) argues that investment performance significantly influence the investment strategy taken by investor compared to active investment management.

One of the most frequent issues raised among the fund manager is how to allocate the fund in different asset classes with different times. In a world where financial markets are more complicated and volatile than ever before, optimisation problems deal with making decisions under uncertainties. Moreover, institutional investors such as pension funds or insurance companies, have long-term investment planning horizons. In respect to this, the main concern among fund managers is to make a decision of optimisation for the pension system, which are often influenced by the uncertainties and longer period decision. The uncertainties in pension fund investment policy consist of future interest rates, prepayment, external cash-flow, and liabilities (Dupačová, 1999). The pension fund is inevitably confronted with these risks in determining asset allocation and controlling future flows between assets and liabilities.

Thus, uncertainties have increased the need of the fund manager to methodologically develop a sound asset allocation strategy. As the preceding paragraph discussed, in addition to financial risk fund managers need to consider liability factors when developing an investment strategy that relate to future benefit payments. Alestalo and Puttonen (2006) supported the argument from Chernoff (2003), who mentioned that the correct way to maximise the pension's return is to match pension assets against pension liabilities. Using regression analysis, Alestalo and Puttonen (2006) found that asset allocation in the Finish pension system is influenced by a liability structure.

The associated debates of the impact of investment strategy on pension fund performance has been recognised and explored (Asher, 2000; Guan & Liang, 2015; Pflug & Świętanowski, 1999). Turning to the type of pension plan, both DB and DC schemes have different objectives in dealing with the investment strategy. DB for example, utilises the investment strategy to minimise the cost of providing the benefits through minimising the contribution rate made to the system. By contrast, as the final benefits are not determined, the fund manager in DC needs to maximise the return from assets they manage through a decent investment strategy. It is important to gain trust from the public. The DC plan fixed the contribution in advance and the benefits of the fund relied profoundly on terminal wealth at the retirement age which is subject to the economic behaviour of the account (Guan & Liang, 2015). Thus, from the context of the DC plan, an efficient pension strategy during an accumulation period is vital to ensure a decent saving for personal living after retirement.

Two main approaches have commonly been used to develop an optimal investment-plan for the pension system. One approach is a mean-variance (MV) model that was introduced by Markowitz in 1956. This model is based on a static model for portfolio construction. It is the most widely used technique by practitioners. This framework suggests that investors may gain optimal investment strategy through minimising variance or standard deviation of the portfolio return, subject to given mean return. The model also highlights that portfolio risks can be minimised via a well-diversified portfolio of individual stock.

In general, this model has provided the fundamental basis for portfolio analysis as well as broadly accepted in model in finance. Economic complexity and financial uncertainties have limited the role of the MV model to solve the portfolio optimisation problem. The underlying assumptions of this model are rather strict where it assumes the return has a multivariate normal distribution or investor's preference can be represented by some utility function over the means and variance of the portfolio returns. Then this model generates the efficient frontier to show an optimal combination of asset allocation for a given risk and return without a single suggested action (Rachev & Tokat, 2000). It is supported by Papi and Sbaraglia (2006) mentioning that the underlying assumptions are strict such as normal returns, single periods, and generate an efficient frontier rather than a single point of optimal decision.

In another study, Huang (2010) argued that a classical MV model suffers from two pitfalls: deterministic and single-period characteristic. According to him, prediction of expected return involves volatility and cross correlation of the asset; thus, an MV approach is very sensitive to a single-point forecast. While, in the long term, by considering liability factors, it is not suitable to retain the same weight of asset allocation for the whole period.

In response to these limitations, the static one period MV model is not able to provide a realistic description for strategic asset allocation decisions. According to Toukourou and Francois (2015), an optimisation approach should be dynamic instead of static or a single-period model. However, due to limitations, the MV model was extended, and stochastic modelling was introduced to overcome the shortage of the model; for example, Sharpe and Tint (1990), who consider liability factors in a MV framework with a single period model, or Chiu and Li (2006) and Chiu and Wong (2014) solving optimisation problems using stochastic modelling with multi-period MV-ALM setting. Although a MV framework has been extended to cope with a dynamic investment strategy, there are still other factors that are not taken into account in modelling the ALM problem, such as ignoring transaction costs.

Further work on extending an MV model was done by Merton (1969). He extended the MV framework by introducing a utility based approach with continuous setting. This approach suggests optimal wealth proportion is allocated to the risky asset based on the Merton Ratio where the allocation of a risky asset is constant. For example, a pension fund must allocate 60% of its fund in stock, and the rest should be in other assets. However, Siu (2011) argued that the Merton model might be inappropriate to solve a long-term asset allocation problem. He also suggested two key factors in modelling an asset allocation problem: changes in macro- (micro-) economic conditions over a long period of time and inflation risk that may affect liabilities direct and indirectly (see, Siu 2011).

The use of the ALM framework has a long tradition in the pension fund. The ALM model is also known as liability driven investment (LDI). It is a mathematical tool that is employed to address the integrated management of assets and liabilities simultaneously. At the beginning, the ALM framework started with the construction portfolio of fixed-income securities using immunisation and deterministic methods (Toukourou & Francois, 2015). According to this method, future payments are deterministic and assumed to be certain while deciding if the allocation bond income is sufficient to cover liability payments in each period. This model however faces difficulty to handle uncertainties (Toukourou & Francois, 2015).

The next approach of the optimal investment plan is a dynamic model where the model allows for different decisions at a different point in time, which may be contingent upon the state of the world at the time of decision making. From the context of the pension system, with the limitation to deal with the long-term horizon and regulation constraints, a stochastic model has emerged to solve the ALM problem. Stochastic ALM is a risk-management approach where asset and liability are considered simultaneously in the decision model (Mitra & Medova, 2010). In addition, the model must also consider the pension policies and all relevant data such as civil statutory age, mortality ratio and pre-retirement withdrawal provisions to determine the optimal investment decision for the specific planning horizon. Most of the existing literature agreed that stochastic modelling is more efficient in solving ALM problems.

This method is relatively close to industry practise, with one of the most common references in the literature is the application of the stochastic ALM model in the Russell-Yasuda Kasai Model by Carino and Ziemba (1998). Other successful ALM models and stochastic programming have been proven in the pension system (Dupačová & Polívka, 2009; Hilli et al., 2006; Kouwenberg, 2001; Kouwenberg & Zenios, 2008) (Kosmidou & Zopounidis, 2001). The stochastic model requires the uncertainties be approximated using an appropriate model. These uncertainties are normally modelled by a scenario tree with a finite number of states of the world at each time. The quality of the scenario generation is essential as it influences the performance of the stochastic programming model (Pflug & Świętanowski, 1999).

To sum up our discussion, to achieve a more sound and profitable investment strategy, considering assets and liabilities simultaneously are essential and the stochastic ALM model has proven very useful to handle this objective. There is remarkable literature on modelling and optimisation of portfolio asset allocation strategies for pension fund management. Table 3.1 summarises the literature discussing portfolio allocation strategy.

Table 3.1: Asset allocation approach for the pension fund

Method	Author(s)	Explanation(s)
Mean-variance model	Markowitz (1952)	One period and static model and failed to capture the multi-period problem and ignores market frictions, such as transaction cost.
Stochastic mean-variance framework	Sharpe and Tint (1990)	Introduced a single period surplus optimisation framework when liability factors are considered in the model.
Deterministic linear programming, stochastic two-stages programming.	Chwaiger, Lucas, and Mitra (2010)	This study analyses four investment strategies for the pension system: deterministic model, stochastic TSP, chance constraint and integrated chance constraint. Stochastic programming is superior than deterministic model.

3.3 Formulation of Stochastic Model

In general practice, a pension system is responsible for collecting contributions from employers and/or employees, to pay pension benefits to retired members and to invest the available funds in the financial market. Investment policies in the pension system involve optimising a given objective while ensuring that the fund is adequate enough to meet its liabilities as well as satisfying regulatory frameworks. The effect of a prudent strategy will maximise investment return and in turn this return will be distributed to the pension members in the form of a dividend. As a result, it increases the final benefit among members as well as boosts members' trust in the system. However, country-specific policies and regulations are something to bear in mind when determining an investment model, as these policies differ across countries.

Given the objective to maximise the wealth of the fund, this thesis employs stochastic modelling to solve an ALM model for the EPF. In this section, we describe the classical architecture of the stochastic multi-period model. We consider an *ex-ante* decision-making problem, where a decision is made before future data which determines when the model parameters are revealed. In other words, at each time *t*, decision making is allowed to be made based on actual knowledge of parameters where the corresponding parameters are known during each period. In this thesis, we consider the stochastic programming problem in the form of a two-stage recourse problem in discrete stages, as suggested by (Hussin, 2012; Schwaiger, Lucas, & Mitra, 2010). That is, the decision process of our stochastic ALM model is based on the following process:

decide		observe		decide		observe		decide		observe
X_0	$\rightsquigarrow$	ω_1	$\rightsquigarrow$	X_1 ...	$\rightsquigarrow$	... ω_{T-1}	$\rightsquigarrow$	X_{T-1}	$\rightsquigarrow$	ω_T

As mentioned before, optimisation in stochastic modelling addresses the problem of finding a decision that incorporates uncertainties in the form of probability distribution of some parameters, as well as subjected to some constraints. Uncertainty is described by the random variable ω. We introduce a mathematical formulation of stochastic programming with a two-stage problem. The recourse model of TSP can be represented by the following equation:

$$Z = min/\max c'x + E_{\omega}Q(x,w) \quad (3.1)$$

Subject to $\quad Ax = b, \quad x \geq 0$

where,

$$Q(x,w) = min\, f(\omega)y = d(\omega) + B(\omega)x \quad (3.2)$$

Subject to $\quad D(\omega)y = d(\omega) + B(\omega)x$

$$x \geq 0$$

The goal is to minimise/maximise the sum of the first stage cost $c'x$ and the expected second stage $E_{\omega}Q(x,w)$. In problem (3.1) $Q(x,w)$ is the optimal value of the second stage problem. The matrix A and the vector b are known with certainty. Meanwhile, the function $Q(x, w)$, is a recourse function that is defined by equation (3.2). $D(\omega)$ represents the recourse matrix or technology matrix, the right side $d(\omega)$ and $f(\omega)$ is the objective function coefficient. $B(\omega)$ is the inter stage linking matrix. The TSP with recourse decision separates the decision into first stage and second stage. At the first stage, the decision x is made before the random variables are observed and are anticipative. At the second stage, decision $y(\omega)$ is made after the random variables have been observed are adaptive. They are constrained by decisions made at the first-stage and depends on the realisation of the random vector (Kouwenberg & Zenios, 2008).

The decision vector lies between the first and second stage, and can be explained by the scenario tree as shown by *x* in Figure 3.1. If for any feasible value of the first stage variable *x*, there exists a feasible solution in recourse variables y^{ω} for the scenario ω then the corresponding problem is known as a two-stage stochastic program with relatively complete recourse.

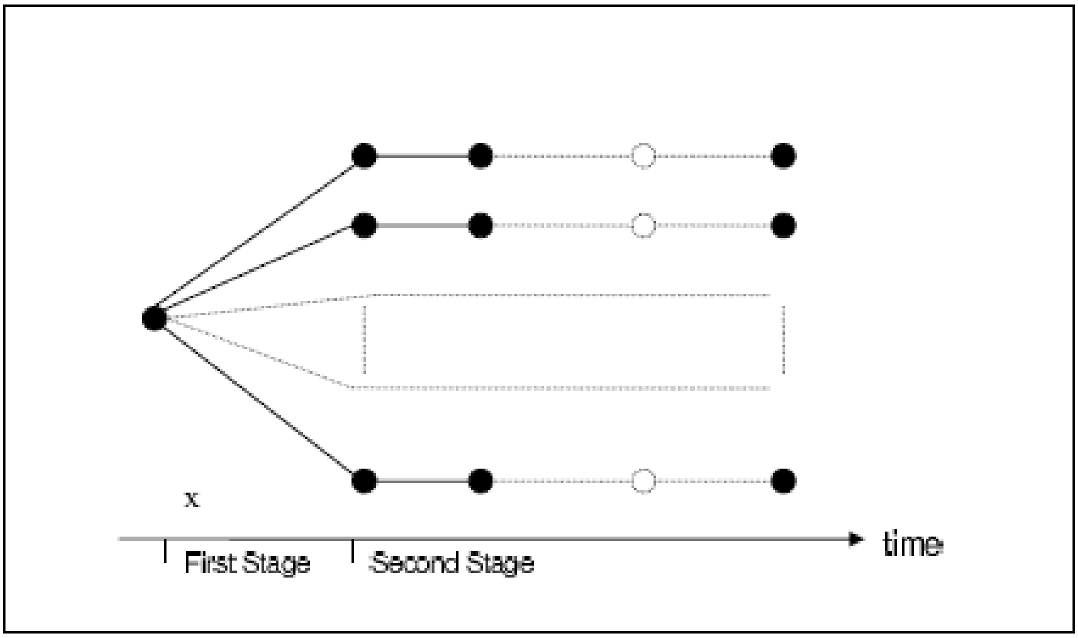

Figure 3.1: Two-stage event tree

TSP can be extended to a multistage recourse program (MSP) by considering a more complex dynamic setting. Instead of having the two decisions *x* and $y(\omega)$, the model can be considered to have decisions $x_0, x_1, \ldots, x_T$ that will be taken at the stage t = 1,2,

.., *T*. Bear in mind, the term "stage" does not necessarily represent "time periods", even these concepts coincide in many applications. We consider "stage" as a level where new information is provided.

3.4 Chance Constraint Programming (CCP)

TSP can be extended by incorporating chance constraint programming. CCP is one of the risk management constraints taken in the investment strategy. This constraint serves as a tool for modelling risk and risk aversion in SP. Several risk constraints have been applied in the ALM study, such as Value at Risk (*VaR*) constraint and Conditional Value at Risk (*CVaR*) constraints (Bosch-Princep, Devolder, & Dominguez-Fabian, 2002; Erik & Stanislav, 2001); and Chance constraints programming (CCP) (Dert, 1995).

CCP is a qualitative risk constraint first introduced by Charnes and Cooper in 1958 for production planning (Schwaiger et al., 2010). In CCP, β represents the probability of satisfying the constraint. Dert (1995), in his PhD study, incorporated binary variables in an ALM model to count the number of times a certain event happens. In his thesis, he developed unknown factors using scenarios. Since the uncertainty is modelled through scenarios, a binary variable is introduced to formulate the CC explicitly. His model minimises the cost of funding while ensuring the stability of contributions and ability to make payments timely with an acceptable level of insolvency risk.

Similar to the work of Schwaiger et al. (2010), CCP can be formulated based on the probability distribution of states of the world that follows from the scenarios. It can be written as follows:

$$P(h(x,\xi) \geq 0) \geq \beta \tag{3.3}$$

where P represents "probability", x is the decision vector, ξ is the random vector and $\beta \in \{0,1\}$ in the reliability level. In our study, we introduce CCP to ensure that the value of asset at time t is not lower than the value of liability at time t with high reliability $A_{t+1} \geq \gamma L_{t+1}$. We describe the CCP model as follows:

$$P(A_{t+1} - \gamma L_{t+1} \geq 0) \geq \beta_t \qquad t = 1,..,T\text{-}1 \qquad (3.4)$$

Where β_t $(0 \leq \beta \leq 1)$ represents the reliability level of satisfying a constraint that applies to all time periods *t= 1…T* and scenario *s= 1…S*. Meanwhile, γ is a level of meeting the liabilities to satisfy the constraint. According to Hussin (2012), CCP is modelled by considering additional binary variables that count the number of times when constraint is violated.

$$M\delta_{t+1}^{S} \geq \gamma L_{t+1}^{S} - A_{t+1}^{A}, \qquad t = 1...T\text{-}1 \qquad (3.5)$$

$$\pi_s \sum_{s=1}^{S} \delta_{t+1}^{S} \leq 1 - \beta_{t+1}, \qquad t = 1...T\text{-}1 \qquad (3.6)$$

$$\delta_{t+1}^{S} \in \{0,1\}, \qquad t = 1...T\text{-}1 \qquad (3.7)$$

β represents reliability level at time t; $0 \leq \beta \leq 1$ and can be user defined or assumed to be constant over time.

δ_{t+1}^{S} represents a binary decision where $\delta_{t+1}^{S} \in \{0,1\}$

γ represents level of meeting liabilities

M represents sufficiently large numbers for the chance constraint.

Even CCP, previously effective as a risk management tool, has drawbacks. CCP only considers the qualitative aspect of the risk, such as underfunding levels or minimising cost of the fund, where the objective is focussed upon whether the constraint is satisfied or not (Schwaiger et al., 2010; Toukourou & Francois, 2015). In other words, this model considers the probability of the constraint without the amount of the constraints. However, to get a better approach, risk constraint should be able to control the quantitative aspect of the fail such as size of the underfunding. In light to this, integrated chance constraint has been proposed.

3.5 Integrated Chance Constraint (ICC) Program

An alternative to including underfunding constraints is to use the ICC model. The model was introduced by Haneveld (1985) with the aim of not only considering the probability of underfunding, but also the amount of underfunding along the investment planning horizon (Schwaiger et al., 2010). Since the CCP is the quantitative model by appointing probability of a deficit without the amount of deficits, the introduction of ICC enhances the CCP model by considering both the probability and the amount of underfunding together.

As with the CCP, ICC employs the same sets, parameters and variables as the TSP model. We derive an ICC model based on the notation by Schwaiger et al. (2010). However, we introduce a new parameter λ with $0 \leq \lambda \leq 1$ to the maximum allowed shortage at each time period. Another new parameter is *shortage* to measure the amount of shortfall at each time period in each scenario.

According to Schwaiger et al. (2010) individual ICC risk constraint is defined as:

$$\mathrm{E}_{\omega}[\eta_i(x,\omega)^-] \leq \kappa_i \qquad \kappa_i \geq 0 \qquad (3.8)$$

Joint CCP are defined as:

$$\mathrm{E}_{\omega}[\max_{i \in I} \eta_i(x,\omega)^-] \leq \kappa_i \qquad \kappa_i \geq 0 \qquad (3.9)$$

where κ_i and κ represent the defined maximum allowed expected shortfall. As mentioned before, ICC considers the quantitative value of underfunding in the EPF. This model does not require a binary variable and can be written as:

$$H_t^S - \gamma L_t^S + shortage_t^s \geq 0 \qquad (3.10)$$

$$\pi_s \sum_{s=1}^{S} shortage_t^s \leq \lambda \pi_s \sum_{s=1}^{S} L_t^s \qquad (3.11)$$

This constraint allows us to measure the shortage between assets value (H_t^s) with liability at each time period as shown in equation (3.10), and then we include a new constraint, pre-specified λ, to endure the expected value of the shortage to be equal or less than λ of liabilities. This is shown in equation (3.11)

3.6 ALM Model for the EPF

In this thesis, we introduce a linear two-stage stochastic problem for asset liability management of the EPF. The key decision variables of the ALM model are $x_{i,t}^{S}$, $S_{i,t}^{S}$, $B_{i,t}^{S}$, which represent the amount of wealth invested in asset *i*, and bought and sell at time *t*. Other notations of variables, coefficient and parameters in the ALM model are presented in Table 3.2.

Table 3.2: Notation summary

Descriptions
<u>Model indices</u> I = Index of asset classes $i = 0,1, \ldots, N$ T = Time index $t = 0,1, \ldots, T$ S = Index of scenarios $s = 0,1, \ldots, S$
<u>Decision variables</u> W_T^S = Total wealth at the end of planning horizon $x_{i,t}^{S}$ = Total asset held at time t and scenario *s* $S_{i,t}^{S}$ = Total asset sold at time t and scenario *s* $B_{i,t}^{S}$ = Total asset bought at time t and scenario *s*
<u>Deterministic parameters</u> x_{i0} = Initial holding allocated at each asset *i* l_i = Lower bound of the assets *i* as the fraction of the total assets u_i = Upper bound of the assets *i* as the fraction of the total assets α = Transaction costs L_t = Liability to be paid at time *t* $P_{t\,s}$ = Probability of scenario *s* at time *t*
<u>Random variables</u> r_s = Random return on assets class rb_t^S = Cost of borrowing at time *t* rl_t^S = Cost of lending at time *t*

3.6.1 Objective function.

Objective(s) function for a dynamic asset allocation strategy varies and depends upon the goal of the fund manager; such as maximising expected utility of final wealth (Zenios, 1995); maximising expected terminal wealth Hussin (2012); (Pflug & Świętanowski, 1999); aiming to maximise expected terminal wealth; minimising cost of funding for DB scheme (Dert, 1995); and maximising expected terminal wealth, as well as minimising expected shortfall (Kouwenberg, 2001). The objective function in this study is to maximise the expected wealth in the planning horizon *T*.

$$Maximize \sum_{s=1}^{S} W_T^S \times r_s \tag{3.12}$$

3.6.2 Decision constraints.

One of the constraints that need to be taken into account by the fund is the presence of legal and policy constraints in deriving the decision process. The objectives of these constraints is to control or minimise the risk of losses, which adversely affect future pensioners (Pflug & Świętanowski, 1999).

3.6.3 Wealth constraints.

This constraint displays the amount of wealth at time *t*. The wealth is derived by summing up assets held and the amount of cash lent including lending rate received minus the amount of cash borrowed (if required) together with borrowing rate. This constraint is described by the following equation:

$$W_t = \sum_{i=1}^{I} x_{i,t} + Q_t(1+r^l) - O_t(1+r^b) \quad \text{t = 1, …, T} \tag{3.13}$$

3.6.4 Asset holding constraints.

The second constraint is asset holding, which describes holdings, purchases and sales of each asset over the time. The asset holding constraint can be written as follows:

$$x_{i,1}^S = x_{i0} + B_{i,1}^S - S_{i,1}^S \qquad t=1 \tag{3.14}$$

$$x_{i,t}^S = x_{i,t-1}(1+r_{i,t}^S) + B_{i,t}^S - S_{i,t}^S \qquad t \geq 2 \tag{3.15}$$

The amount of the asset held at time *t* is derived from the amount of assets held in the previous time (*t-1*) and its return plus the amount of assets bought minus the amount of assets sold. The initial holdings in each asset are denoted by x_{i0} and are assumed to be known. It means that at time *t=1*, the amount of assets held are equal to initial holdings, which is taken from the EPF's annual report in 2014.

3.6.5 Budget constraints.

Budget constraints represent the cash inflow (revenue) and cash outflow (expenses) of the pension fund and ensure that the cash outflow never exceeds the cash inflow. At t =1, we describe budget constraints as follows:

$$\sum_{i=1}^{I}(1+\alpha)B_{i,1}^{S}+Q_{1}^{S}+L_{1}^{S}=V_{1}^{S}+\sum_{i=1}^{I}(1-\alpha)S_{i,1}^{S}+O_{1}^{S};$$

t = 1 (3.16)

$$\sum_{i=1}^{I}(1+\alpha)B_{i,t}^{S}+Q_{t}^{S}-(1+rl_{t}^{S})Q_{t-1}^{S}+L_{t}^{S}=V_{t}^{S}+\sum_{i=1}^{I}(1-\alpha)S_{i,t}^{S}+O_{1}^{S}-(1+rb_{t}^{S})O_{t-1}^{S};$$

$t=2 \leq t \leq T\text{-}1$ (3.17)

$$\sum_{i=1}^{I}(1+\alpha)B_{i,t}-(1+rl_{t})Q_{t-1}+L_{t}=V_{t}+\sum_{i=1}^{I}(1-\alpha)S_{i,t}-(1+rb_{t}^{S})O_{t-1}^{S}$$

t=T (3.18)

This constraint is developed based on three different investment planning periods. Equation (3.16) represents cash balance at time period 1. Equation (3.17) represents cash balance constraint for time period $2 \leq t \geq T\text{-}1$. In these periods, previous amounts of cash borrowing and its borrowing rate, as well as cash of lending with lending rate, are incorporated. While for *t=T* borrowing and lending activities are not allowed as described in (3.18).

3.6.6 Short sale constraints.

In this study, we do not allow short sale activities. Thus, we restrict our model by deciding that the amount of assets sold must be less than the amount of assets held in the last period. The equation can be written as;

$$S_{i,1}^{S} \leq \sum_{s=1}^{S} x_{i,0} \qquad (3.19)$$

$$S_{i,t}^{S} \leq x_{i,t-1}^{S} \qquad (3.20)$$

3.6.7 Portfolio constraints.

This constraint refers to the restriction stated in the *EPF Act* 1991. The constraints are normally stated in lower bound and upper bound limits where the fund can be placed at each asset. Those limits are expressed as a proportion of the total wealth of the pension fund;

$$l_i H_t^S \leq x_{i,t}^s \geq u_i H_t^S \qquad t = 1 \ldots, T, i=1 \ldots, I, s=1 \ldots, S \qquad (3.21)$$

where l_i represents lower bound or minimum bound of portfolio weight of asset held while u_i refers to upper bound or maximum limit of the assets that can be held. As mentioned by Hussin (2012), under the *EPF Act* 1991, the lower and upper bound in the specific asset is stated in the following table:

Table 3.3: Upper and lower bound for each asset class

Asset class	Lower bound (%)	Upper bound (%)
Money market instrument (MMI)	5	25
Bond and loan	15	35
Equity	5	25
Malaysian Government Securities with 10 year (MGS10)	15	45
Property	0.1	5

Source: Hussin (2012)

3.6.8 Non-anticipativity constraints.

A non-anticipativity constraint explains that a decision at any given stage does not depend on the future realisation of the random event but only the observed part of the scenario. In other words, it ensures that scenarios with identical values of the uncertainties parameters in stage *t* must yield the same decision up to that period.

$$x_{i,1}^{S} = x_{i,1}^{1} \qquad s = 2 \ldots, \mathrm{S} \tag{3.22}$$

$$B_{i,1}^{S} = B_{i,1}^{1} \qquad s = 2 \ldots, \mathrm{S} \tag{3.23}$$

$$S_{i,1}^{S} = S_{i,1}^{1} \qquad s = 2 \ldots, \mathrm{S} \tag{3.24}$$

Based on (3.10) and (3.11), we incorporate the ICC constraint in the TSP model.

$$H_t^S - \gamma L_t^S + shortage_t^s \geq 0 \tag{3.10}$$

$$\pi_s \sum_{s=1}^{S} shortage_t^s \leq \lambda \pi_s \sum_{s=1}^{S} L_t^s \tag{3.11}$$

From equation (3.11), the expected value of shortage should be equal to or less than pre-specified λ while maximising the terminal wealth. In our study, we assume the λ is 5% of liabilities, as suggested by Hussin (2012).

3.7 Modelling Uncertainties

The scenario generation process is a key fundamental for stochastic programming. As mentioned earlier, the main concern of investment and financial problem is the ability to make the right decision under uncertainty with more than one-time period. According to Dupačová (1999), three elements need to be considered in decision making under uncertainties: firstly, is to determine the goal of the strategy, which includes the uncertainties identification that we want to hedge, constraints involved as well as its discretisation; secondly, is developing the model; and the final step is a generation of the data input. In line with this suggestion, our ALM model consists of three processes before an optimisation decision is obtained. The first two elements have been discussed and explained in this chapter, and the last element is going to be discussed in the next chapter. Therefore, to build a decision model, the following steps are applied in this study.

a. ***Identifying the optimisation objective*** – The objective function of the stochastic modelling is dependent on pension scheme types and the target to be achieved by the policymaker, such as maximising utility wealth or minimising costs or both. The advantage of using the stochastic programming is that it can handle more than one objective.

b. ***Defining the constraints in formulation of the model*** – Constraint refers to the limit needed to comply in making the decision. The constraints of the pension fund are normally dependent upon the policy and regulation and the specific objective that needs to be achieved by the fund managers.

c. ***Developing future assets and liabilities cash flow*** – Since both future assets and liabilities are unknown, the stochastic model is applied. Under stochastic programming, uncertainties or unknown factors are modelled as a random and discrete model with a finite planning horizon (Dupačová & Polívka, 2009). The details about cash flow model for the EPF are explained in Chapter 4.

To apply the stochastic ALM model, the above three important elements must be designed carefully. As informed previously, ALM will manage the cash inflow (asset part) and cash outflow (liabilities part) simultaneously to achieve the pre-determined objectives at the end of the time horizon T. The decision is adjusted at discrete time points where the fund managers assess the prevailing market conditions and the composition of the existing portfolio at the beginning of each time period (Kouwenberg, 2001) to achieve the objective function.

As suggested by Dupačová and Polívka (2009) and Pflug and Świętanowski (1999), the efficiency of stochastic modelling has relied primarily on the quality and reliability of the scenarios generated to represent unknown factors. Stochastic ALM programming for this model is dealt with two uncertain factors: future asset price and future claims of liabilities. In addition to manage savings for retirement, the EPF also plays an alternative function where it allows the members pre-retirement withdrawal benefits for education, buying property, health and performing the pilgrimage. Thus, in modelling liability factors, both the retirement withdrawal and pre-retirement benefit must be considered in this model. In the next chapter, we develop five uncertain factors for our TSP model: asset return; population model; salary model; pre-withdrawal claim model; and final retirement claim model.

3.8 Summary of the Stochastic Programming of ALM for the EPF

Objective function

$$Maximize \sum_{s=1}^{S} W_T^S \times r_s$$

Wealth constraint

$$W_t = \sum_{i=1}^{I} x_{i,t} + Q_t(1+r^l) - O_t(1+r^b)$$

Cash balance constraint

$$\sum_{i=1}^{I}(1+\alpha)B_{i,1}^S + Q_1^S + L_1 = V_1 + \sum_{i=1}^{I}(1-\alpha)S_{i,1}^S + O_1^S$$

$$\sum_{i=1}^{I}(1+\alpha)B_{i,t}^S + Q_t^S - (1+rl_t^S)Q_{t-1}^S + L_t = V_t + \sum_{i=1}^{I}(1-\alpha)S_{i,t}^S + O_1^S - (1+rb_t^S)O_{t-1}^S$$

$$\sum_{i=1}^{I}(1+\alpha)B_{i,t} - (1+rl_t)Q_{t-1} + L_t = V_t + \sum_{i=1}^{I}(1-\alpha)S_{i,t} - (1+rb_t^S)O_{t-1}^S$$

Asset holding constraint

$$x_{i,1}^S = x_{i0} + B_{i,1}^S - S_{i,1}^S$$

$$x_{i,t}^S = x_{i,t-1}(1+r_{i,t}^S) + B_{i,t}^S - S_{i,t}^S$$

Short sales constraint

$$S_{i,1}^S \leq \sum_{s=1}^{S} x_{i,0}$$

$$S_{i,t}^S \leq x_{i,t-1}^S$$

Inventory constraint

$$l_i H_t^S \leq x_{i,t}^s \geq u_i H_t^S$$

Non-anticipativity constraints

$$x_{i,1}^S = x_{i,1}^1$$

$$B_{i,1}^S = B_{i,1}^1$$

$$S_{i,1}^S = S_{i,1}^1$$

The chance constraint

$$M\delta_{t+1}^S \geq \gamma L_{t+1}^S - A_{t+1}^A$$

$$\pi_s \sum_{s=1}^{S} \delta_{t+1}^S \leq 1 - \beta_{t+1}$$

The integrated chance constraints

$$H_t^S - \gamma L_t^S + shortage_t^s \geq 0$$

$$\pi_s \sum_{s=1}^{S} shortage_t^s \leq \lambda \pi_s \sum_{s=1}^{S} L_t^s$$

3.9 Conclusion

This chapter detailed the modelling ALM that will be employed in Chapters 5 and 6 to solve asset allocation problems with various constraints for the EPF. The ALM analysis starts with a two-stage stochastic programming model (TSP). After deriving optimal asset allocation with TSP, we introduce risk control, to ensure that the EPF is able to meet its obligation in the future, by incorporating a chance constraints program and integrated chance constrains program (ICC). The main benefit of the stochastic model is its computational efficiency. Although ALM models have proven to be effective on a different set of applications and have produced best results in this thesis, the weaknes of the model is that our models are using deterministic projection for the future EPF's liabilities. The use of the stochastic model for liability streams may generate more scenarios so that the results are more efficient to solve sustainability and adequacy problem for the EPF case.

Prior to modelling ALM for the EPF, this chapter discussed the development of a portfolio optimisation model for the pension system based on previous studies related to this field. Although the model resembles those presented in the literature, statutory restrictions and policy implemented in the EPF made this model unique and tailored specifically for the EPF. The next chapter presents cash flow scenario generation for the EPF taking into account all relevant factors that may influence the EPF.

Chapter 4: Modelling and Simulation of the EPF's Cash Flow with Uncertainties

The financial sustainability of a pension scheme depends not only on the time-length of the benefits to be paid, subject to longevity risk, but also the correct qualification of the contributions to be received.

(Maccioni, 2011)

Financial soundness and financial stability are two major concerns for pension providers and governments. In recent years, with the increase of life expectancy together with the decrease of fertility and mortality rates, pension systems seem to be imbalanced with more benefit receivers than contributors (Bielecki et al., 2015). In addition, the instability of investment return put more pressure on the system to provide an adequate pension system with sustainable manners. In respect to this, two factors need to be considered to develop a decent pension system: future cash flows; and an optimal investment strategy. This is supported by Pflug and Świętanowski (1999) and Asher (2000) mentioning that investment strategy significantly influences the performance of the pension system. Indeed, projecting future cash flows are a fundamental element in the stochastic investment strategy for the pension system. Pension system soundness depends on the benefits to be paid as well as on the correct projection of the contribution to be received by the system. A prior study by Change and Cheng (2002) stated that projection of future cash flows using appropriate stochastic modelling is important and crucial for pension system evaluation. In this respect, this chapter develops the pension system cash flow analysis based on Malaysia's specific policy and regulation, as well as all relevant data associated with the scheme. The concern of this chapter is placed on the stochastic cash flows in both asset and liability. In order to pursue this research, we develop two streams of future cash flows: future asset cash flows and future liability cash flows. For the asset projection, a Vector Autoregressive Model (VAR) with lag zero (0) is employed to generate asset returns. While, liabilities are derived from several sub-models including population model, salary model, pension benefits model. We derive the projected aggregate cash flows to an open population pension system where new a entrant is considered. The study provides the stochastic structure of future cash flows for the

EPF where the data generated are used for the investment analysis in the following chapter.

Keywords: VAR, financial soundness, stochastic simulation

4.1 Introduction

When determining the stochastic portfolio optimisation problem, the analysis needs to consider the question of how future uncertain factors cash flow streams are derived and simulated. Appropriate stochastic modelling is essential and crucial to derive future uncertain factors as it may influence the performance of stochastic decision making (Dupačová & Polívka, 2009; Pflug & Świętanowski, 1999). For this reason, stochastic programming models are used to handle these uncertainties. Two important aspects of projection cash flows for a pension system are member's salary projection and future members’ status. These two factors are used to derive the contribution for the pension system and pension benefit payments paid to eligible members. Very generally, in modelling unknown future liabilities and payment benefits, Kouwenberg (2001) suggests that we need to consider two steps, estimating the future status of current participants and forecasting the future salary, for each participant.

Looking at the population model, plenty of studies have been conducted to derive a dynamic population model, such as Janssen and Manca (1997), Khorasanee (1997), Mettler (2005), and Aro and Pennanen (2014). The focus of deriving the dynamic population model is to develop future members’ status in various behaviours such as inactive members, dead, disabled and retired, at the next period. To set up the population behaviour, a Markov chain framework has been widely used in previous studies. Mettler (2005), for example, using a Markov model, developed the dynamics pension fund’s population based on both a closed and open system.[5] In his study, Mettler described the future status of the plan based on death, disability and old age. While Janssen and Manca (1997) derived a population model using a non-homogenous semi-Markovianity process. In a recent study, Markov’s chain process has broadly been used in various perspectives such as policyholder behaviour in life

[5] Mettler (2005) defined an open system model as a system that allows for resignation and new recruitment to be covered by the system while a closed system does not allow new entrants to the system and without staff turnover.

insurance (Buchardt, Møller, & Schmidt, 2015), and military personnel (Zais & Zhang, 2016). Since pension system practice differs between countries, in modelling future pension population models, we need to follow policy and rules, as well as all relevant data, which may affect the system such as civil statutory age, mortality rate, unemployment rate and survival ratio.

The next uncertain factor is the contribution made by the employer and employees into the fund. This contribution is influenced by the level of income or salary. Therefore, prior to deriving a contribution model, a salary model needs to be developed first. This model is developed based upon assumption where there is an increment in the salary model, and this increment is influenced by seniority of the employee, productivity and inflation rate (Schwaiger et al., 2010); Winklevoss (1982). Combining the salary, population, and cash flow models for the EPF generates encompassing total contribution, pre-retirement withdrawal and benefit payments.

This chapter contributes to the existing literature due to three innovations. Firstly, a study on Malaysia's pension system using stochastic is very rare and only Hussin (2012) in her thesis employed a similar investment strategy. Thus, analysis from this chapter aims to fill the gap in the literature, specifically stochastic modelling for developing countries like Malaysia. The second contribution of this chapter is that the model used in this paper is tailored to Malaysia. In light of this, the model has a uniqueness factor in terms of a Malaysian perspective. In addition, from a practitioners' perspective, this study contributes to the fund managers' understanding regarding the derivation and development of current active members as well as the projection of future cash flow using an appropriate stochastic model. Given the objective to develop a sound pension system, the projection of benefits to be paid as well as contribution from future active members are important for the fund.

The findings from this study differs from the previous literature from several perspectives. Firstly, it is modelled specifically for the EPF. These projections take into account the EPF's policies and regulations, which depend on demographic factors, legislative environment and the EPF members' behaviour. Therefore, even in many respects, the model resembles those presented in the literature, but it has unique features stemming from the statutory restriction of Malaysia's pension system, the *EPF Act* 1991.

4.2 Literature on Scenario Generation

To support a stochastic pension investment strategy, projecting uncertainties, assets, and liabilities factors are prerequisite to solving the investment model. Prior studies paid particular attention to describing the projection of uncertain factors that consist of investment returns, future cash flows for both assets and liabilities, and statutory restrictions (Hilli et al., 2006; Pflug & Świętanowski, 1999). Again, the performance of stochastic investment strategy is dependent heavily on the quality and accuracy of the random model to represent both uncertain assets and liabilities (Boender, 1997; Dupačová & Polívka, 2009; Hilli et al., 2006; Pflug & Świętanowski, 1999). To deal with uncertain factors, a probability distribution is assigned to these factors which is then incorporated into an appropriate model.

We describe the generated future uncertainties factor as scenarios and according to Brauers and Webber (1988), scenarios are a description of a possible state of an organisation's future environment, considering possible development of relevant interdependent factors of the environment. Meanwhile, according to the Casual Actuarial Society (1999) as mentioned by Bosch-Princep et al. (2002), scenario is a process of a projecting of group variable behaviour that may soundly influence the evolution of an insurance or pension fund. Generally, liabilities factors are driven by macroeconomic variables and actuarial prediction whereas economic variables influence the financial market and determine security prices on the asset models (Kouwenberg & Zenios, 2008). By contrast, Boender (1997) argues that asset and liability are affected by the same economic factors, such as wages growth, while inflation is crucial for cash flow and long-run return on equity and bond.

There is already substaintial research documenting the technique of scenario generation to derive uncertain factors. From the broad model, it can be divided into a deterministic or stochastic model. At the beginning of optimisation analysis in the pension system, the models were developed based on deterministic methods. These methods suggest that future cash flows are estimated and assumed to be certain. From the perspective of an ALM model, under the deterministic model, wealth is mainly allocated to the bonds, which are considered risk-free (Toukourou & Francois, 2015). This model is normally based on immunisation and cash-flow matching (Schwaiger et al., 2010).

However, this method has been proven inefficient to deal with the complexity of uncertain factors. Thus, the problem of uncertainty is handled by stochastic modelling. Stochastic modelling is dealing with unknown factors by appointing them with the probability of that factor occurring. The validity of stochastic programming in financial planning was first recognised by Bradley and Crane (1972).[6] The contribution of stochastic programming has been proven by previous studies such as Carino and Ziemba (1998), Dert (1995), Hoyland and Wallace (2001), and Schwaiger et al. (2010). In the context of asset liability management, stochastic programming became a prominent decision support tool in financial planning in the 1990s (Kouwenberg & Zenios, 2008). A previous empirical study by Hilli et al. (2006) indicates the stochastic programming model outperforms traditional static fixed-mix strategies. Taking into consideration the long-term projection with many uncertainties factors, stochastic is believed to be a powerful tool to help fund managers develop an optimal investment strategy. A stochastic modelling program deals with making decisions under uncertainty, which requires rigorous scenarios as an input to perform optimisation decision policies.

The review of existing literature on the scenario generation of future cash flows reveal that there are significant studies discussing the development of these scenarios. Kouwenberg (2001) utilises a VAR model to estimate future economic scenarios. This method uses sampling from the error distribution of the estimated VAR model to generate thousands of scenarios. The success of a VAR model has been proven by Carino and Ziemba (1998) in the Russell-Yasuda Kasai Model. Meanwhile, Boender (1997) mentions scenario generation of an ALM model are generated in two steps; generating scenarios of the economic environment using a VAR model and the second step is determining the status of current and future members' status in each node of scenarios using a Push Markov Model. Furthermore, the simulation can be done through a sampling model (i.e. Bootstrap, Monte Carlo and Markov Chain); statistical

[6] This is stated in the study by Kouwenberg and Zenios (2008).

(such as moment matching, regression methods); simulation (such as classical Brownian motion); and hybrid approach (such as a combination of simulation and optimisation approach) (Beraldi, De Simone, & Violi, 2010; Di Domenica, Lucas, Mitra, & Valente, 2009).

However, Mitra (2008) suggests that the sampling method is the simplest method to develop the scenario tree, where it uses historical data to model the sample randomly. More specifically, Di Domenica et al. (2009) suggest several steps of generating the scenario. Those steps are:

- Selecting an appropriate model to describe stochastic parameters such as econometric model and time series (VAR, VECM, ARMA, GARCH).
- Calibration of model parameters using historical data.
- Generation of data path from chosen model. Using statistical approximation (property matching) or sampling (random sampling or bootstrapping), the data path can be generated by performing the discretisation of the distribution.
- Constructing scenario tree with desired properties.

Scenarios generated from the pre-specified model are normally represented by scenario trees, as depicted in Figure 4.1. Each level in the tree represents a different time point and all nodes for a particular time point represent the possible scenarios for that time point.

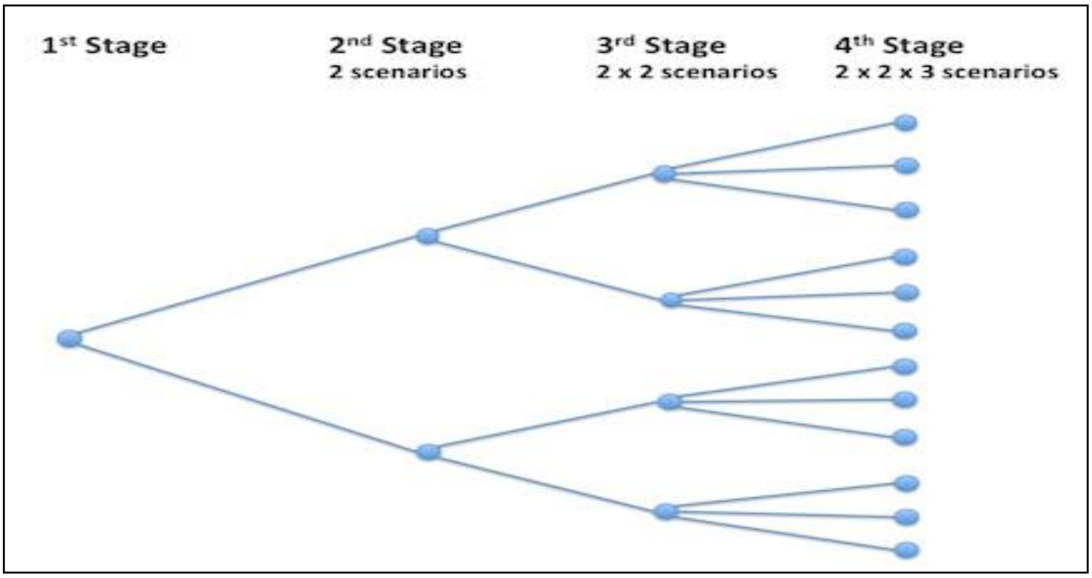

Figure 4.1: Multistage scenario trees

At stage 1, the node is known as a mother node and normally has a single node, and the following stages have child nodes where each node does not need to match the number of child nodes in another stage. In addition, the different levels or stages do not necessarily represent the same time gaps. Looking at Figure 4.1, stage 1 represents year 0, stage 2 can represent year 2, stage 3 may represent years 3 to 5 and, stage 4 represents year 10.

Before generating tree scenarios, several assumptions of our scenario trees, such as how many stages are needed in our scenarios tree decision and number of branches or output at each stage of our tree, are determined. Kouwenberg (2001) and Toukourou and Francois (2015), for example, developed a five-stage tree model with a branching structure of 10-6-6-4-4. Meanwhile, in this study, we develop two-stage scenario trees, applied by Schwaiger et al. (2010) and Hussin (2012).

Studies on the generating of scenarios have been debated for decades but it still becomes a significant topic in this field. In order to model futures scenarios of assets and returns, the valuation technique may differ from one country to another due to the nature of pension systems resulting from different practices and policies (Kouwenberg & Zenios, 2008). In addition to that, in modelling scenario generation, three main criterion are used to explain the quality of scenario generation i.e. correctness, accuracy and consistency (Zenios, 2005). In these responses, this chapter aims to formulate asset and liability streams projection for the EPF using the stochastic model based upon previous research suggestions. More specifically, in this chapter, we will construct scenario generations for assets and liabilities with respect to statutory restrictions for Malaysia's EPF.

4.3 Modelling Uncertainties

Cash flows generated for this study are based upon all relevant information that may affect the EPF. Scenarios of assets return and liabilities streams are modelled separately. Using stochastic modelling and simulation process, five sub-models are developed to derive the EPF's cash flows.

a) **The EPF's member model** analyses the projection of members' development in terms of their age group and status (active, inactive, death and retiree). It is generated by a series of transition probabilities from one status to another. In general, this model can be done using a Markov-model.

b) **The salary model** is used to model cash flow projections. We employ the salary model to generate the future value of the contribution from employee and employers. For the case of the EPF, worker and employer contributions are compulsory (11% from employee and 12% contributed by the employer) to the EPF. The contributions are made by active members only.

c) **The lump sum liability model** projects the lump sum payment to be paid to members at retirement age and to next of kin due to death for both active and inactive members. The value of payments is subject to the EPF's member model.

d) **The pre-retirement withdrawal model** is a model to develop the obligation of the EPF to the active members for allowable withdrawal before retirement age. According to the *EPF Act* 1991, a member can withdraw up to 30% of their savings (in Account II) before the statutory retirement age (55 years old) for reasons such as education, buying a house, health and investment.

e) **The asset return model** represents the plausible future return of asset classes where the EPF use their assets to invest in. In this thesis, we assume the EPF invests its assets in eight asset classes: Malaysian Government bond for 10 years (MGS10); Malaysian Government bond for 1 year (MGS1); domestic stock; property; in the money market; and in international equity from three countries.

4.3.1 Generating scenario for liabilities.

Using the technique of Mettler (2005) and Hussin (2012), the EPF's liabilities are generated based on regulations applied in the EPF scheme. To avoid any misconception, liabilities generated in this chapter are considered as cash outflow where the EPF needs to pay members. As suggested by Kouwenberg (2001), modelling the future status of the current participant is important before estimating future payment benefits.

To generate the scenario for unknown future liabilities and payment benefits, two steps need to be considered; namely: (i) estimating the future status of the current participant such as active and retired, and (ii) forecasting the future salary of each participant (Kouwenberg, 2001). To do this, Kouwenberg used a Markov model to differentiate participant status based on retired and working status in the future. Jensen (1966) was among the first to use this model for disability problems in a pension fund. Other studies on such a model include Mettler (2005) and Hussin (2012).

We begin our liability model by developing a population model for the EPF. Prior to population generation, Mettler (2005) argues that it is essential to identify the feature of the system, whether it is an open or closed system. According to him, an open pension system is defined as the eligibility of the new employee to be insured in the existing pension fund, or in other words, an existing pension system opens their scheme to new entrants. Instead, a closed population model refers to the pension scheme that does not open to new members. For modelling the liability factors, we develop assumptions that coincide with the policy and regulation of the EPF as follows.

a) With reference to legal working age, a population is allowed to start working at age 16 and entitled to be covered under the EPF scheme, and can claim the full pension benefit at age 56.
b) The EPF implements an open pension system where a new participant can join the scheme at any age. According to Hussin (2012), who studied the EPF's population model, new entrants are considered new employees, and existing members who left the scheme and return become an active participant again.
c) Members are allowed to make pre-retirement withdrawal from Account II for an approved reason such as education, housing, health, pilgrimage, and investment before reaching the mandatory retirement age. However, in this chapter, we only consider pre-retirement for education, housing and health in the analysis due to data constraints.
d) The liability model is based on age groups and we develop seven age groups from 16 to 56, i.e. (16–25), (26–30), (31–35), (36–40), (41–50) and (51–56), similar to Hussin (2012). In this study we assume that there is a common rate of changing group where only 80% of members will remain with the same age

group while another 20% will move into a new age group annually. We do not distinguish between male and female members in this study.

e) We assume that about 3% of current active members will be inactive in the following years for all states.

f) We also consider five states of group members' behaviour: new entrant (NE); active members (A); inactive members (I); retiree (R); and die (D). So, we develop future members based on this behaviour. Figure 4.2 tells us that there is the probability that active group members at current time t will shift (transit) to other states at the time $t+1$.

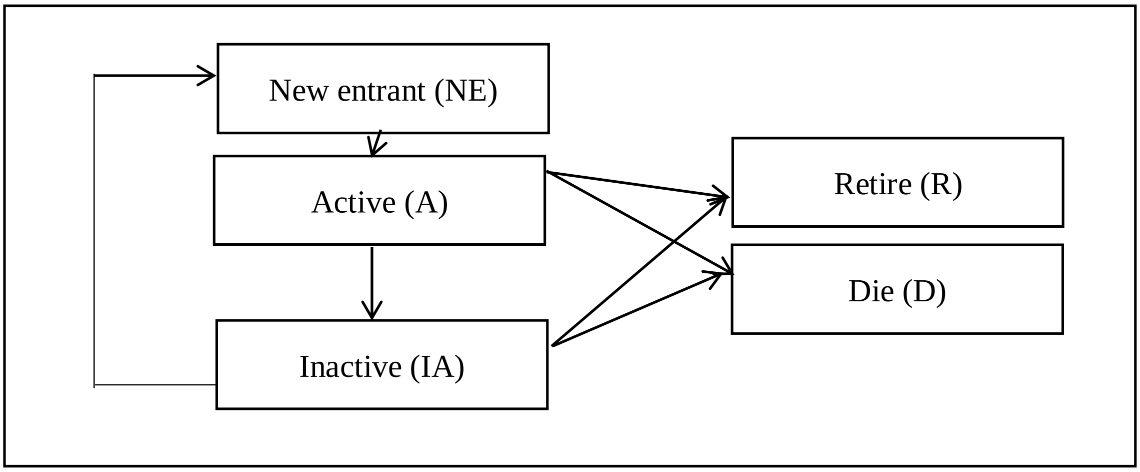

Figure 4.2: Simple model of the behaviour of EPF's members

Again, we develop a liability scenario projecting the value of future obligations and generate a future cash flow stream, which will be employed for the ALM model. Therefore, modelling liability is essential because it will determine the value of future expected cash outflows. We proceed our population analysis by identifying member's status using all relevant data.

4.3.2 Active member.

Active members refer to members who actively make a contribution to the EPF. We model the possibility of the current member remaining an active member based on the survival ratio obtained from Malaysian Abridged life tables. We also assume that 80% of members of the specific age group will remain within the same group for the next period and another 20% will move to the next age group. Thus, we model an active member model as follows:

$$A_t = 0.8 \times [\omega (A_{(t-1)})] \qquad (4.1)$$

where;

$A_{(t,i)}$ = projection of active member at states i at time t

ω = survivor ratio

$A_{(t-1)}$ = actual active member at states i at time t-1

4.3.3 Death member.

In this study we assume a death member for each state as a person from active and inactive states who have died (Hussin, 2012). For the dead participant, we project the probability of death for every year and for each age group. In order to model this plausibility, we employ mortality probabilities from Malaysian Abridged life tables which consist of the one-year death probabilities for every age group. We denote φ as a mortality probability. We model the probability of death for the EPF using the following equation:

$$D_{i,t} = \varphi(A_{t,i}) \qquad (4.2)$$

where;

$D_{t,i}$ = projection of member who died at time *t*

φ = mortality ratio

$A_{t,i}$ = actual active member at states *i* at time *t*

4.3.4 Inactive member (IA).

An inactive member refers to a member who has stopped contributing to the EPF. Inactive members will occur at any age group. As stated previously, we assume that 3% of the currently active members will become inactive in the following years. We believe that they become inactive due to disability. Therefore, inactive members for the EPF for each group are modelled based on the following equation:

$$IA_{i,t} = 0.03\ X\ (A_{t-1,i}) \qquad (4.3)$$

where

IA = inactive members for state i at time t

$A_{t-1,i}$ = active members for state i at time t

4.3.5 New entrant.

We consider there is a new entrant at the specific age group. For the sake of simplicity, we assume new entry will occur at ages 16–25, 31–35, 41–45, and 51–55. At the age of 21 we assume an entry age that 20% of the total active member will join, while for 31 and 51 the new entrant rate is 15% and 10% respectively.

Next, we continue population analysis by approximating possible transitions from one state to another stage where active members at the initial time become retired, inactive or dead. We consider death and retired as an absorbing state where once members are classified in the dead and/or retired group, they cannot move into other groups. The transition from one state to another is measured by the probabilities of transition from state i to state j at time t. Jones (2005) defines transition matrixes P_{ij} as a matrix of probabilities showing the likelihood of one state remaining unchanged or moving to any other state. In this study, probability transitions are measured using the following formula as suggested by Jones (2005):

$$P_{ij} = \frac{n_{ij}}{\sum_j n_{ij}} \tag{4.4}$$

We denote P_{ij} as a probability of members in a certain age group being in state j in the period t given that they were in state *i* in the period *t-1*. Therefore, according to Jones (2005), the transition probability from any given state *i* is equal to the proportion of individuals that started in state i and ended in state j as a proportion of all individuals in that started in state *i*. Table 4.1 shows the observed transition for the initial year for this analysis i.e. 2013–2014.

Table 4.1: Relative frequencies for transition (2013–2014)

	Active	Unemployed	Retired	Die
Active	0.925	0.029	0.032	0.014
Unemployed	0.557	0.029	0.4	0.014
Retired	0	0	0.908	0.092
Die	0	0	0	1

4.3.6 Salary model.

Once the population model is generated, we then calculate a benefit paid to the members subject to the employee's salary. Thus, in this section, we develop a salary model for the EPF members based on the methodology used in the previous study, see Winklevoss (1982) and Schwaiger et al. (2010). Based on these studies, salary increment is due to merit (seniority), labour productivity, and inflation. We generate the salary function sx for a group of participants at age group x as follows:

$$s_x = s_y \frac{(SS)_x}{(SS)_y} [(1 + I)(1 + P)]^{x-y} \tag{4.5}$$

where

y The entry age of the members

x The age of the members, x> y

(SS) The merit salary scale at age x

s_y The entry age Ringgit Malaysia (RM) salary

I The inflation rate

P The productivity rate (we assume 1.5%)

On average, the inflation rate in Malaysia from 1992 to 2014 was 2.75%. However, for the sake of simplicity, in this study, we assume an inflation rate of 3%. We also assume that the productivity rate is 1.5%. Meanwhile, we employ a salary scale from Winklevoss (1993) to solve our salary function.

4.3.7 A generic model for asset scenario generation.

At first glance, a pension system has two sources of funds to pay its liability: return from assets invested in financial markets and contributions from the employer and/or employees. For the EPF, contributions are compulsorily made by employee and employer where the current contribution rate is 23%. Employees contribute 11% of their salary to the EPF and another 12% is supported by the employer. The rate of the contribution made by a member has changed since its inception for several reasons, including saving targeted and policy targeted. Figure 4.3 depicts the contribution rate for the EPF.

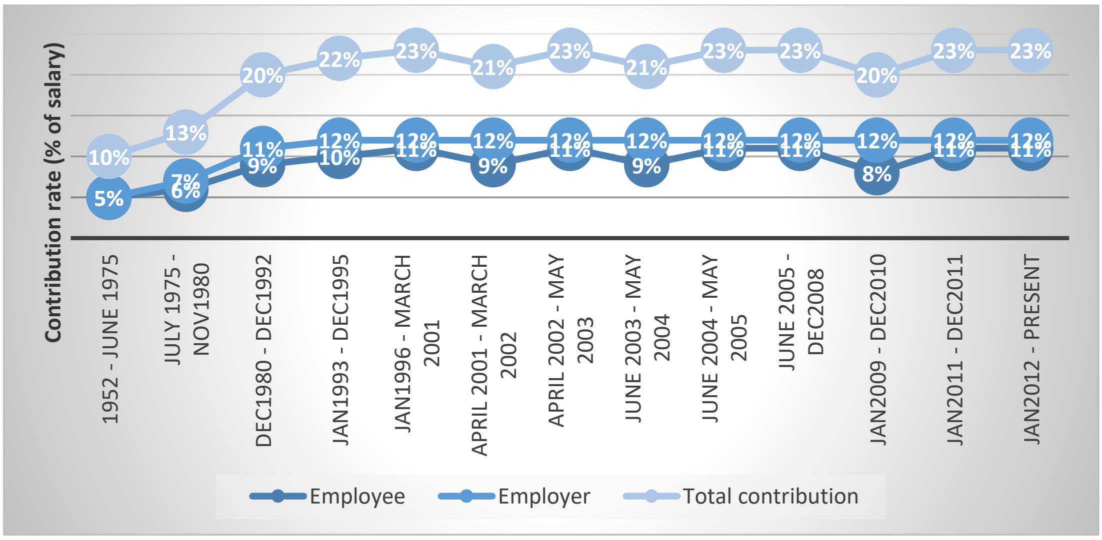

Figure 4.3: Contribution rates of the EPF for employee and employer

Source: EPF annual report (2014)

Meanwhile, investment return refers to a return that has been generated from the allocation over assets classes. Under the *EPF Act*, the fund is permitted to invest only in approved investments such as Malaysia Government Security (MGS), debenture loan, money market instruments, equity, and property. In an attempt to protect members' savings in the long term, the EPF was required to allocate at least 70% in MGS from its investments; at the same time, it was restricted from investing more than 25% in equity. However, under the *EPF Act* revisions, these statutes have changed. The government allowed for more diversification in their investment strategy when the portion of MGS considerably declined in line with economic growth in the mid-1990s, and privatisation of certain infrastructures and other services were undertaken by the government (Asher, 2000; Thillainathan, 2005).The share of MGS, thus dropped from 73.6% in 1991 to 26.5% in 2011. On the other hand, equity allocation increased from 2.1% to 35.6% for the same period.

Note that, in this study, we focus on two dynamic investment strategies that can maximise expected terminal wealth, subject to policy constraints and liability obligation: domestic investment strategy and international dynamic investment strategy. For the first strategy, we consider the EPF will invest in five asset classes: stocks, government bonds, bonds, money market, and property. These assets' proxy is illustrated in Table 4.2. This study uses historical data covering 1992 to 2014 and are obtained from various reliable sources such as DataStream, Kuala Lumpur stock index, Bank Negara Malaysia (Central Bank of Malaysia) and the EPF's annual reports. These historical data then are employed to project future asset returns known as scenarios.

Table 4.2: Asset proxy for domestic investment

Asset	Proxy
Malaysia Government Security 10 Years (MGS10)	Long-term government bond yield (risk free)
Malaysia Government Security 10 Years (MGS1)	Medium-term government bond yield (risk free)
Equity (KLCI)	MSCI Malaysia
Money Market Instrument	Short-term interest rate
Property	Annual percent change of property price indicators.

In the context of an international dynamic investment strategy, in addition to domestic asset classes, we consider three asset categories, namely the United States composite index, Japan stock index, and Singapore stock index. The objective of this analysis is to provide a quantitative assessment for our model after considering international portfolio diversification. Table 4.3 depicts the proxy for international stock index.

Table 4.3: Proxy for alternative assets

Asset	Proxy
International Fund	MSCI USA MSCI Japan MSCI Singapore

In modelling future realisation of asset return, we employ VAR. Sim first introduced the VAR model in 1980. The model depicts a relationship between the previous value and the present value of the variables in the model, which are then jointly used to forecast future value (Hussin, 2012). However, in the context of the ALM study, it is believed that Dert (1995), Carino and Ziemba (1998), and Kouwenberg (2001) were among the first to use VAR in scenario generation. In this chapter, we generate return scenarios for domestic asset classes, which consist of domestic equity, government bonds (maturity of 1 and 10 years), property index, and money market instrument. These returns are donated as $r_{i,t}^{s}$ where i denotes the asset class and t and s represent time and scenario respectively. For equity return, annual MSCI Malaysia indices are obtained from DataStream covering the period 1992 to 2014. Then we calculate annual return, using the following equation:

$$r_{klci,t} = ln\left(\frac{Price_t}{Price_{t-1}}\right) \quad (4.6)$$

$Price_t$ is price index for the current year and $Price_{t-1}$ is a price index for the previous year. Meanwhile, returns for other assets such as money market instrument, Malaysia Government Security (MGS), and property index returns are taken directly from the Monthly Statistical Bulletin, Bank Negara Malaysia (www.bnm.gov.my) before converting them into ln form. Figure 4.4 depicts a plot of annual return for five asset classes.

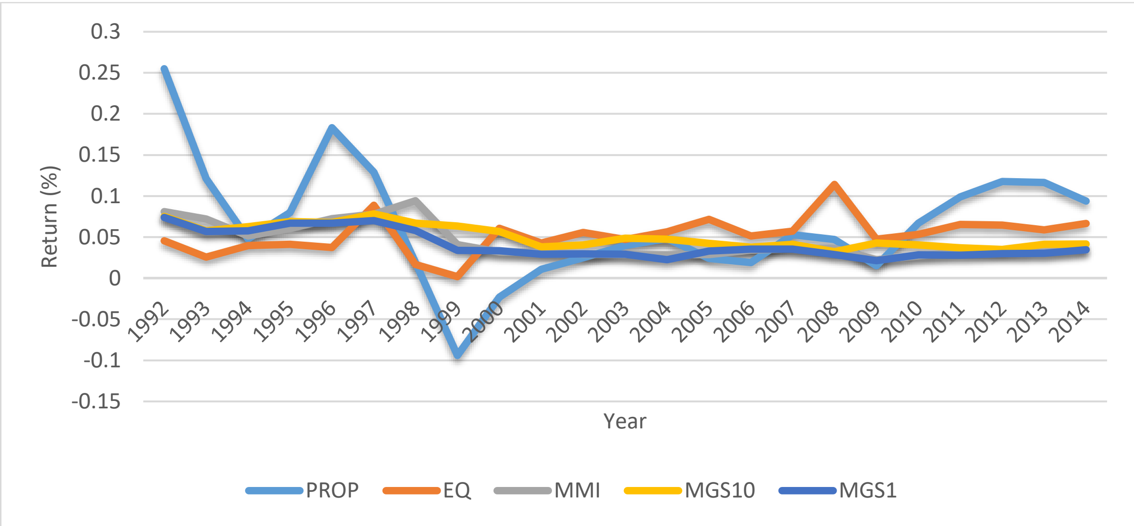

Figure 4.4: Historical annual return of Assets from 1991 to 2014

Sources: Bank Negara Malaysia and DataStream

Table 4.4 displays a descriptive statistic of the time series for five asset classes. The value of mean and standard deviation for MSCI Malaysia shows a higher return and is in line with higher risk compared to other asset classes, whereas, both government bonds offer a lower return with lower risks. It is because government bonds can be considered a riskless instrument since the returns are guaranteed by the government.

Table 4.4 presents the summary statistic of the following return series: Property (PROP), Malaysian Government Security mature at 10 years (MGS10) and at 1 year (MGS1), Kuala Lumpur stock (EQ), and Malaysia money market (MMI). All series are stated in log-return on a yearly basis covering the period 1992 to 2014.

Table 4.4: Summary statistic

	PROP	***EQ***	***MMI***	***MGS10***	***MGS1***
Mean	0.0608	0.0565	0.042986	0.0493	0.0397
Standard Error	0.0139	0.0250	0.0041	0.0028	0.0034
Median	0.0472	0.0487	0.0338	0.0420	0.0330
Standard Deviation	0.0665	0.1197	0.0199	0.0133	0.0161
Kurtosis	1.5769	3.7559	0.0081	-1.0554	-0.7765

Next, we proceed the analysis using a VAR model. The VAR model represents the relationship between the continuous returns on assets given as described in (4.7). The following zero lags VAR model is used to describe the dynamic of the return vector $R = [r_{EQ,t}, r_{MGS10,t}, r_{MGS1,t}, r_{PROP,t}, r_{MMI,t}]$, where $r_{klci,t}$, $r_{mgs10.t}$, $r_{mgs1,t}$, $r_{prop,t}$, $r_{mmi,t}$ denotes the vector return of five asset classes used in this study: Kuala Lumpur stock index, Malaysia Government Bond for 10 years, Malaysia Government Bond for 1 year, property index and money market instrument respectively. Value of *r* represents mean return of each assets or constant value of VAR model.

$$R_t = \mu + \Omega(R_{t-1} - \mu) + \mu_t \qquad t=1.....T \quad \mu_t \sim N(0,\Sigma) \qquad (4.7)$$

$$R_t = ln(1+R_{it}) \qquad (4.8)$$

This relationship of the EPF's asset return can be expressed in the matrix form as follows:

$$\begin{bmatrix} r_{klci,t} \\ r_{mgs10.t} \\ r_{mgs1,t} \\ r_{prop,t} \\ r_{mmi,t} \end{bmatrix} = A + B \begin{bmatrix} r_{klci,t} \\ r_{mgs10.t} \\ r_{mgs1,t} \\ r_{prop,t} \\ r_{mmi,t} \end{bmatrix} + \varepsilon_t \quad \text{with } \varepsilon_t \sim MNV(0, \Sigma) \tag{4.9}$$

In generating a more stable and not spurious predictability of return, Kouwenberg (1998) suggests not to use a lagged variable to model the returns for assets such as stock, real estate and bond. Therefore, the scenario of future returns projections in this study are modelled based on an unrestricted VAR without a lagged variable. Table 4.5 displays the VAR model for each asset.

Table 4.5: Coefficient of the vector autoregressive model for asset return for the EPF

$\mathbf{ln(1 + EQ_t)}$	= 0.0565+ ε_t
$\mathbf{ln(1 + MGS1_t)}$	= 0.0397+ ε_t
$\mathbf{ln(1 + MGS10_t)}$	= 0.0493+ ε_t
$\mathbf{ln(1 + MMI_t)}$	= 0.0430+ ε_t
$\mathbf{ln(1 + PROP_t)}$	= 0.0608+ ε_t

Note: The values represent estimated value which will be used to generate return scenarios.

From VAR analysis, the estimated residual matrix is decomposed by means of the Cholesky matrix (C). Cholesky decomposition is used to estimate the value of ε_t. Hussin (2012) mentioned that the Cholesky decomposition is a process to unfold the normal equation in linear least squares problem. We apply Cholesky of the covariance matrix of the residual that are characterised by being $N(0, \Sigma)$ to be decomposed into residual $N(0,1)$. Table 4.6 depicts a covariance matrix of the residual for five asset classes in the Malaysian market.

Table 4.6: Covariance matrix of residual of VAR model

	MMI	MGS1	KLCI	MGS10	PROP
MMI	0.00030	0.00029	-0.00055	0.00022	0.00061
MGS1	0.00029	0.00026	-0.00032	0.00019	0.00059
KLCI	-0.00055	-0.00032	0.01433	-0.00022	0.00009
MGS10	0.00022	0.00019	-0.00022	0.00018	0.00023
PROP	0.00061	0.00059	-0.00009	0.00023	0.00443

The estimated value of $\boldsymbol{\varepsilon_t}$ are projected using a Monte Carlo simulation, which has been done in Excel. Table 4.7 represents a Cholesky decomposition that has been generated from variance-covariance matrix of VAR residual. By multiplying the Cholesky decomposition and a vector random number from a standard normal distribution of ε**,** values are then used to project future returns for each asset by recursively solving the equation in Table 4.5. In our case, we generate 200 scenarios and probabilities to generate each scenario, which is equivalent to 0.005 or $\frac{1}{200}$. Graphically, the processes of generating an asset return scenario are explained in Figure 4.5.

Table 4.7: Cholesky decomposition

	MMI	MGS1	KLCI	MGS10	PROP
MMI	0.01990	0.00000	0.00000	0.00000	0.0000
MGS1	0.01477	0.00630	0.00000	0.00000	0.0000
KLCI	-0.02769	0.01477	0.11553	0.00000	0.0000
MGS10	0.01101	0.00371	0.00026	0.00656	0.0000
PROP	0.03080	0.02124	0.00387	-0.02819	0.04710

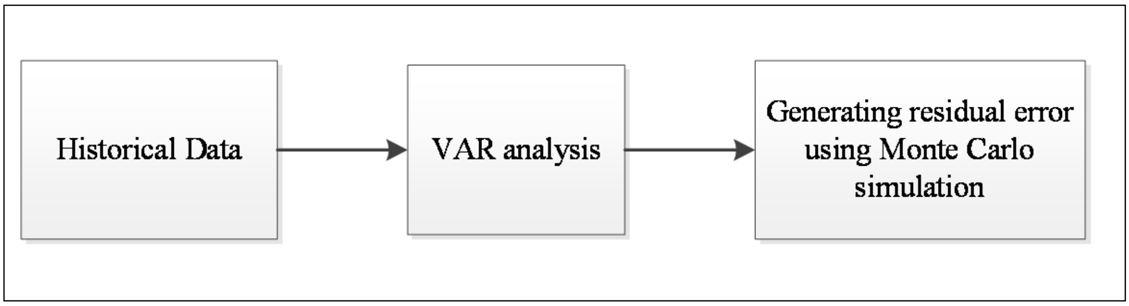

Figure 4.5: Processes of generating asset returns scenario

4.4 Cash Flow Formation

As stated earlier in this chapter, the projection of future EPF's cash flows is dependent upon the future status of current participants and future salary of participants (Kouwenberg, 2001). The *EPF Act* 1991 states that the EPF is required to pay a minimum 2.5% dividend every year to every participant. Based on this statutory requirement, the fund value for every member is estimated to grow and we assume it will grow at ranges 2.5%, 4%, 5%, and 6%. This dividend growth is employed to calculate lump sum payments to the active and inactive retiree. Payment benefit for the EPF can be differentiated into three broad categories i.e. contribution, payment to pre-withdrawal claim, to the retiree with lump sum payment, and payment made if participant dies before reaching retirement age. In general practice, the cash flows are modelled as illustrated in equation 4.10.

$$F'(t) = F(t) + IR\,(t) + C_s(t) - B(t) \qquad (4.10)$$

This equation shows that the increase of fund asset, $F'(t)$, or wealth of the EPF is generated from the investment return, $IR\,(t)$, plus contribution, $C_s(t)$, less benefit paid at time t, $B(t)$. However, looking at the EPF's practise and policy, cash flows are derived using the following equation:

$$F'(t) = F(t) + IR\,(t) + C_s(t) - PR_s(t) - LPA_{s,t} \text{-} LPI_{s,t} - PD_{s,t} \qquad (4.11)$$

where $PR_s(t)$ represents pre-retirement claim at time t, scenario s, $LPA_{s,t}$ is the lump sum payment made to retired active members, $LPI_{s,t}$ is the lump sum payment made to retired inactive members and, $PD_{s,t}$ the lump sum payment made to dead members.

4.4.1 Contribution.

The contribution rate is a proportion of salary determined by the government and needs to be contributed by employers and active employees during the accumulation phrase. In the case of the EPF, the total contribution rate is 23% of annual salary where 11% is paid by the employee while 13% is contributed by the employer. Using the salary function generated in (4.12), as well as population model, we derive the following contribution model;

$$C = S_t \times 0.23 \times A_t \qquad (4.13)$$

Where $C_s(t)$ represents contribution at time t, scenario s, S_t annual salary at time t and A_t represents active member at time t.

4.4.2 Pre-retirement withdrawal payment.

The EPF allows its members to withdraw up to 30% of total wealth (Account II) for statutory reasons such as for education, health, pilgrimage, and housing financing. However, due to data limitation, we develop pre-withdrawal claims for health, housing and education withdrawal. We combine the annual pre-withdrawal (health, housing and education withdrawal) in order to develop pre-withdrawal claims. From historical data, we found that on average, annual pre-withdrawal claims account for 13% of total contributions. Thus, we assume the current pre-withdrawal claim will occur at the same portion as shown in (4.14).

$$PR \quad (t) = 0.13\, X\, C \quad (t) \qquad (4.14)$$

4.4.3 Lump sum payment.

Lump sum payment consists of payment of commitment to be paid to active and inactive members who will retire at aged 56 years old and to whom are dead before retirement age. In line with the statutory minimum guaranteed dividend, we consider that the member's fund will grow every year with different growth rates, and in our case we assume the fund will increase by 2.5%, 4%, 5%, and 6%. As a result, the equation for pension payment to active-, inactive-member and dead member is modelled as (4.8), (4.9) and (4.10) accordingly.

$$LPA_t = ARA_{t-1}\,X\,(1+G)X\,ATR_t \tag{4.15}$$

$$LPI_t = ARI_{t-1}\,X\,(1+G)X\,LPI_t \tag{4.16}$$

$$PD_t = ADP_{t-1}X\,(1+G)\,X\,D_t \tag{4.17}$$

where ARA_{t-1} refers to precalculated average lump sum paid for active participants who retired, ARI_{t-1} represents precalculated average lump sum paid at retirement for inactive participants, ADP_{t-1} is precalculated average lump sum paid to participants due to death and, G denotes dividend growth distributed to the members.

4.5 Conclusion

In this particular chapter, we have proposed models of developing scenarios of future cash flows for the EPF and the scenarios generated are similar to Hussin's (2012). Nonetheless, this study differs in terms of data set used as well as acturail method used to develop liability streams. Cash flow generation for a pension fund consists of five main models i.e. member (population), asset return, salary, pre-retirement withdrawal and retirement withdrawal model. From these models, it can be seen that cash inflow and outflow generated represents the claims and payment paid to both active and inactive members. In an attempt to generate more realistic scenarios, factors such as regulations and policy constraints, as well as Malaysia's demographic facts such as-legal working age, minimum dividend, new entrant assumption, and survival ratio, were considered to enable these cash-flows projections will be the best outcome to forecast the EPF's future cash flows. The output from this chapter will become an input for TSP in the following chapters.

Chapter 5: An ALM Stochastic Investment Strategy for the Employees Provident Fund (EPF)

5.1 Introduction

With a complicated and more volatile financial market, investment strategy is becoming vital to the performance of the EPF. The EPF manages vast amounts of assets and liabilities, and deals with a long-term planning horizon. In this respect, future assets and liabilities projections are crucial for the EPF to design its investment strategies and risk profiles. Considering long-term investment strategy horizon together with future unknown asset and liability stream, we develop stochastic asset liability management (ALM) as a decision tool to achieve the goal and to meet the obligation of the EPF. Thus, this study proposes two-stage stochastic programming (TSP) for the EPF. Using assets and liability scenarios data generated in the previous chapter, we solve asset allocation strategy for the EPF based on a two-stage stochastic programming model, with special attention for modelling integrated change constraints (ICC) to minimise the risk of underfunding. This chapter reports the result of investment strategy in a stochastic ALM model based on aggregate asset classes such as stock index, bonds and property.

5.2 The Model

The model for this study is based on simulation analysis and there are two uncertain streams in the future, asset stream and liability stream. An asset stream consists of asset returns and contributions received from members. While the liabilities streams represent pre-withdrawal retirement, withdrawal retirement, and death payment. Scenario generation methods are explained in Chapter 4. According to the *EPF Act* 1991, the EPF compulsorily distributes a yearly dividend of 2.5% and on average, the EPF has distributed 5.5% dividend to its members for the past 15 years (2000-2015) with the highest dividend was in 2014, namely 6.75%[7]. Based on these historical data, we assume that liability will have various dividend growths of 2.5%, 4%, 5% and 6%.

[7] The data were taken from http://www.kwsp.gov.my/portal/en/about-epf/investment-highlights/dividend-rates/dividend-rates.

Similar to other pension systems, the EPF is responsible for collecting premiums (contribution), paying pension benefits (pre-retirement and retirement withdrawal) and investing available wealth in the financial market. In this chapter, we analyse the performance of investment strategy when the EPF invests in the five broad asset classes, government bonds, loans and bonds, equity, property, and money market instrument with 45-year investment planning horizon (*T=45*). We used 2014 data as the based year for this analysis.

The period chosen in this analysis is aligned with previous studies as the strategy encompasses a long term planning horizon with the presence of policy constraints and uncertainty in future assets and the liabilities stream (for example, see Pflug and Swietanowski, 1999; Schwaiger, Lucas and Mitra, 2010). In response to the long term planning horizon, forecasting uncertain future assets and liabilities flows are essential to ensure the system is able to fulfil all promised payment in the long run. Siu (2011), for example, suggests that insurance company and pension fund manage their assets and liabilities over a long period between 30 to 40 years. The static one period Mean-Variance (MV) model is not able to provide a realistic description for strategic asset allocation decisions for pension fund. According to Toukourou and Francois (2015), an optimisation approach should be dynamic instead of static or a single-period model. So, in this study we employ stochastic ALM model to solve asset allocation decision for the EPF. The stochastic ALM model was successfully proven to overcome the limitation of classical single period MV model to handle long term planning horizon with several policies or fund constraints. Schwaiger, Lucas and Mitra (2010), for example, solved pension fund investment analysis for a time period of 45 years where the finding suggests that stochastic modelling has an advantage in dealing with uncertainty and hedging against possible future deficit.

We begin ALM with a recourse model by solving asset allocation problems with uncertainty based upon the TSP model. Then, we expand the model with the presence of risk management by introducing ICC in TSP. The models for the EPF, as discussed in Chapter 3, are employed and the summary of the models are as follows:

The objective function for our model is maximising expected terminal wealth at the end of the planning horizon.

$$Maximize \sum_{s=1}^{S} W_T^S \times r_s \qquad (5.1)$$

<u>Model indices</u>

i = Asset classes $i = 0,1, \ldots, I, I=5$

T = Time index $t = 0,1, \ldots, T, T= 45$

S = Index of scenarios $s = 0,1, \ldots, S, S=200$

<u>Decision variables</u>

W_T^S = Total wealth at the end of planning horizon

$x_{i,t}^S$ = Total asset held at time t and scenario *s*

$S_{i,t}^S$ = Total asset sold at time t and scenario *s*

$B_{i,t}^S$ = Total asset bought at time t and scenario *s*

<u>Deterministic parameters</u>

x_{i0} = Initial holding allocated at each asset *i*

l_i = Lower bound of the assets *i* as the fraction of the total assets

u_i = Upper bound of the assets *i* as the fraction of the total assets

α = Transaction costs

L_t = Liability to be paid at time *t*

$P_{t\,s}$ = Probability of scenario *s* at time *t*

<u>Random variables</u>

r_s = Random return on assets class

rb_t^S = Cost of borrowing at time *t*

rl_t^S = Cost of lending at time *t*

5.2.1 Wealth constraint.

Wealth constraint at time t and scenario s is equal to the total asset held and the lent cash amount paid back, including the lending rate minus the amount borrowed and the borrowing rate. Borrowing rate and lending rate are assumed as MMI's return at time t scenarios s minus 0.05 for lending rate while, MMI's return at time t and scenario s plus 0.05[8] for the borrowing rate at time t and scenario s .

$$W_t = \sum_{i=1}^{I} x_{i,t} + Q_t(1+r^l) - O_t(1+r^b) \quad \text{t = 1,..., T} \tag{5.1}$$

5.2.2 Asset holding constraint.

This constraint refers to asset rebalance over time. Assets holding is derived from amount hold at time t-1 and asset return *i*, plus the asset *i* bought minus asset *i* sold at time t. At time t=1, the asset held is equal to the initial holding plus asset bought at time 1 minus asset sold at time 1.

$$x_{i,1}^S = x_{i0} + B_{i,1}^S - S_{i,1}^S \tag{5.3}$$

$$x_{i,t}^S = x_{i,t-1}(1+r_{i,t}^S) + B_{i,t}^S - S_{i,t}^S \tag{5.4}$$

5.2.3 Cash balance constraint.

Cash balance constraint ensures that cash outflows must be equal to cash inflows. We describe this model by the amount invested in the purchase of the new assets plus asset lent (reinvest surplus cash) and all the liabilities equal to the contribution (from employer and employees) plus any cash generated asset sold and amount of cash borrowed (if required). This research is closely related to the recent study on the EPF's investment strategy conducted by Hussin (2012). Based on the study, she employed transaction costs at 2%. Therefore, in our analysis, we consider both the selling and buying costs are $(1-\alpha)$ and $(1+\alpha)$ where α = 2% which are aligned with the rate that had been used by Hussin (2012). Selling and buying activities are not allowed at the end of the planning horizon (*T*=45). Selling and buying activities are not allowed at the end of the planning horizon (*T*=45).

$$\sum_{i=1}^{I}(1+\alpha)B_{i,1}^S + Q_1^S + L_1 = V_1 + \sum_{i=1}^{I}(1-\alpha)S_{i,1}^S + O_1^S \tag{5.5}$$

$$\sum_{i=1}^{I}(1+\alpha)B_{i,t}^S + Q_t^S - (1+rl_t^S)Q_{t-1}^S + L_t = V_t + \sum_{i=1}^{I}(1-\alpha)S_{i,t}^S + O_1^S - (1+rb_t^S)O_{t-1}^S \tag{5.6}$$

[8] As suggested by Hussin (2012).

$$\sum_{i=1}^{I}(1+\alpha)B_{i,t}-(1+rl_t)Q_{t-1}+L_t=V_t+\sum_{i=1}^{I}(1-\alpha)S_{i,t}-(1+rb_t^S)O_{t-1}^S \qquad (5.7)$$

5.2.4 Short sales constraint.

Short sales are not allowed in this analysis thus, in essence t the amount of asset sold must be less than the amount of assets held in the last time of period.

$$S_{i,1}^S \le \sum_{s=1}^{S} x_{i,0} \qquad (5.8)$$

$$S_{i,t}^S \le x_{i,t-1}^S \qquad (5.9)$$

5.2.5 Inventory constraint.

This constraint tells us that the amount of asset held at time t and scenario s must not exceed the upper bound and lower bound as stated in the *EPF Act*.

$$l_i H_t^S \le x_{i,t}^s \ge u_i H_t^S \qquad (5.10)$$

5.2.6 Non-anticipativity constraints.

Since the decision at the given stage does not depend upon future realisation of the random events, we incorporate this constraint to ensure that the same variables will take the same decision if they share the same node in a scenario tree. We consider that the investment decision at t=1 as the first decision variable.

$$x_{i,1}^S = x_{i,1}^1 \qquad (5.11)$$

$$B_{i,1}^S = B_{i,1}^1 \qquad (5.12)$$

$$S_{i,1}^S = S_{i,1}^1 \qquad (5.13)$$

5.2.7 The chance constraint and the integrated chance constraints.

We introduce both CC and ICC to limit the percentage and the amount of shortage in this model. However, in this study we only consider ICC in our analysis.

CC constraint:

$$M\delta_{t+1}^{S} \geq \gamma L_{t+1}^{S} - A_{t+1}^{A} \tag{5.14}$$

$$\pi_s \sum_{s=1}^{S} \delta_{t+1}^{S} \leq 1 - \beta_{t+1} \tag{5.15}$$

ICC constraint:

$$H_t^S - \gamma L_t^S + shortage_t^s \geq 0 \tag{5.16}$$

$$\pi_s \sum_{s=1}^{S} shortage_t^s \leq \lambda \pi_s \sum_{s=1}^{S} L_t^s \tag{5.17}$$

5.3 Data Source

We consider year 2014 as an initial time period for this study and the data were taken from the EPF 2014 annual report. The input used to generate the result is based on the data from Chapter 4, which consists of EPF's cash flows, asset returns, salary, and population model. It consists of 45 years of scenario generation.

5.4 Results

All numerical results were obtained using AMPLDev with CPLEX solver. As previously explained in Chapter 3, the main idea of this analysis is to solve asset allocation problems that can maximise expected terminal wealth, which is optimal in some sense, subject to a number of constraints relevant to the EPF case, as well as taking into account uncertainty in explicit ways. Thus, to achieve this objective, we employ TSP. The inclusion of the ICC constraint is to restrict the underfunding event with high probability to occur. Initially, we solve the ALM model without integrated chance constraint. It appears that for the optimal solution, the expected terminal value changes based on the dividend paid to the members. Of course, the optimal expected terminal value will decrease with the increasing percentage of dividend growth. The amount of dividend paid to the EPF members will affect the available amount to be invested in the market. Figure 5.1 illustrates the expected terminal wealth for TSP with various dividend growths:

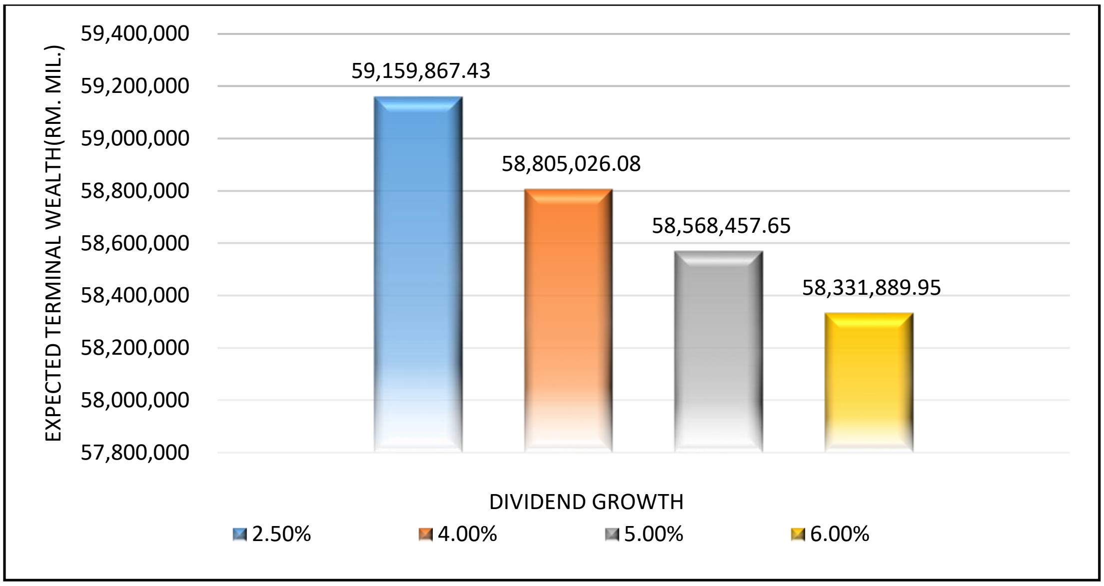

Figure 5.1: Expected terminal wealth (ETW) and dividend growth

Table 5.1: Expected terminal wealth and dividend growth for 1st stage asset allocation for each asset class

Dividend	Terminal wealth (RM Mil.)	Asset Allocation	MMI	MGS1	EQ	MGS10	PROP
2.50%	59,159,867.43	RM Mil.	32,608	159,900	163,040	266,753	29,859
		%	5.000	24.519	25.000	40.903	4.578
4.00%	58,805,026.08	RM Mil.	32,572	159,900	162,860	266,314	29,795
		%	5.000	24.546	25.000	40.881	4.574
5.00%	58,568,457.65	RM Mil.	32548	159900	162741	266021	29753
		%	5.000	24.564	25.000	40.866	4.571
6.00%	58,331,889.95	RM Mil.	32524	159900	162621	265729	29710
		%	5.000	24.582	25.000	40.851	4.567

From Table 5.1, the EPF tend to hold MGS10 and MGS1. The result is consistent with Mohd (2013), who mentioned that investing in MGS helped the fund to produce a good dividend to members. Moreover, this asset is traditionally considered risk-free and guaranteed rather than a higher return to the provident fund which exhibits higher volatility and risk (Asher, 1998).

Next, we extend our TSP model by incorporating another risk constraint i.e. integrated chance constraint (ICC). This constraint has been used by Haneveld and van der Vlerk (2006), Schwaiger et al. (2010), and Hussin (2012). This constraint suggests the model will not only consider the probability of underfunding but also consider the amount of underfunding through the planning horizon. The effect of the ICC on the first-stage decision i.e. on the asset mix and expected terminal wealth are discussed in the following paragraph. Figure 5.2 shows the expected terminal wealth of TSP by incorporating ICC with the value λ=0.05 and γ =1.10. While Figure 5.3 depicts asset allocation for the EPF. Based on Figure 5.3, the long-term government bond dominates asset allocation. Similar to the TSP result, the expected terminal wealth decreases as higher dividends are given to participants.

As mentioned in Chapter 3, in this model, we include ICC constraint to ensure expected shortfall will not be lower than 5% of the total liability. In response to this constraint, the ETW in the ICC model is relatively lower compared to the TSP model. In terms of asset weight, the result is similar to the TSP model where most of the asset is allocated in MGS10 in the first time period.

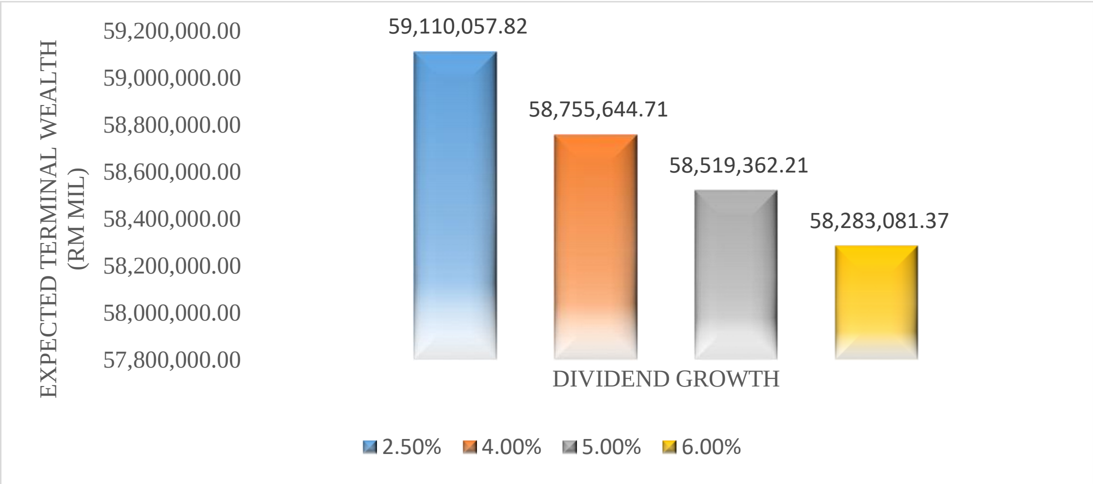

Figure 5.2: Expected terminal wealth and dividend growth with ICC risk constraint

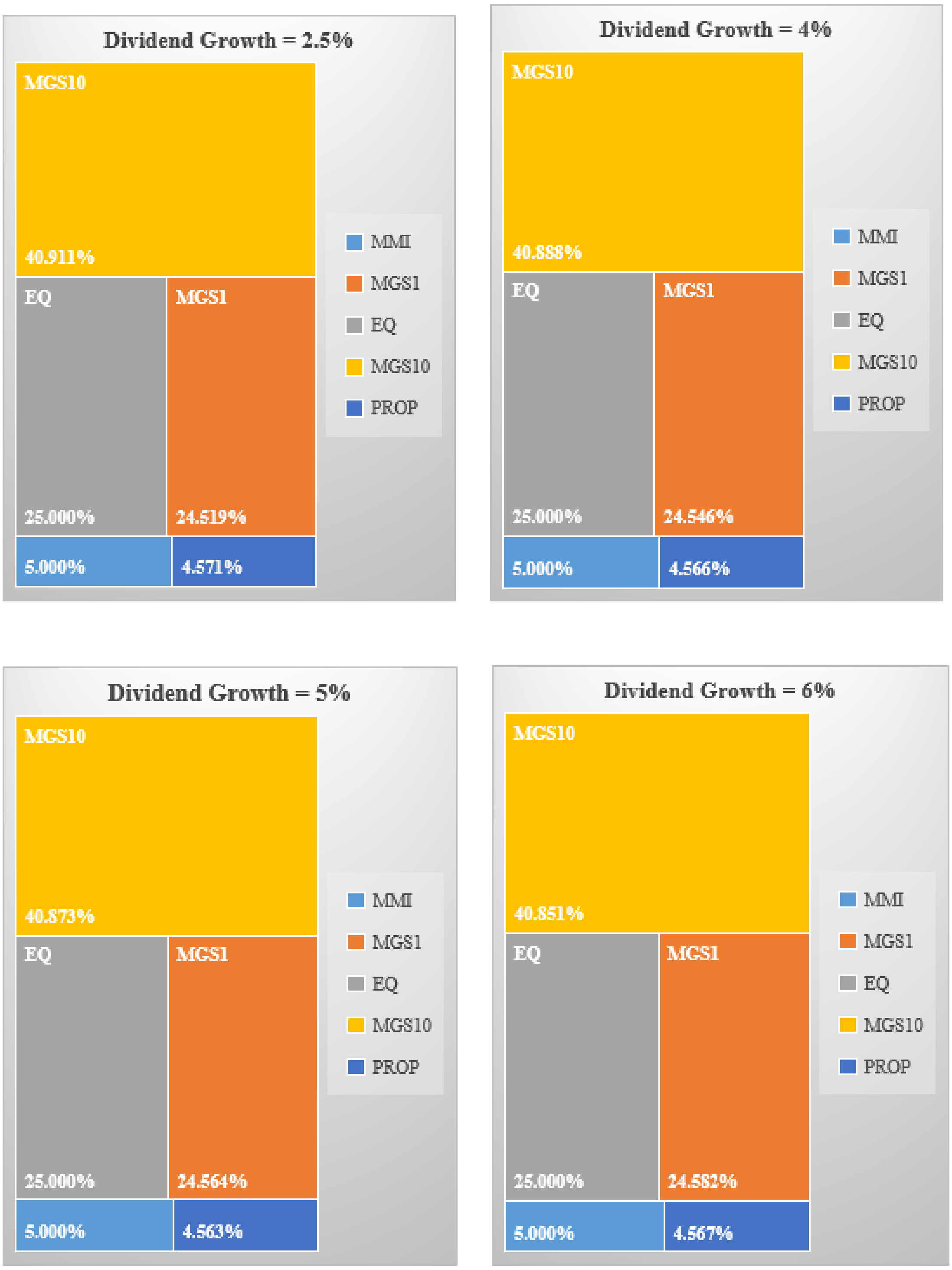

Figure 5.3: 1st stage asset allocation for each asset class

5.5 Conclusion

In this chapter, we analysed the investment strategy for the EPF using a two-stage stochastic ALM model. With the aim of maximising expected terminal wealth at the end of a planning horizon, we find that the EPF tends to hold government security in their asset allocation strategy. We introduce *ex-ante* risk constraint such as integrated chain constraint. This chapter has two chief implications of *ex-ante* constraints implemented in our ALM model. Firstly, the influence of *ex-ante* risk constraints as a preventive action minimize the amount of fund shortage along the planning horizon. Nonetheless, the effect of the inclusion of ICC in our model has limited the ability of the fund to maximise expected terminal wealth and and tends to decrease the gains to our stochastic ALM model. Based on the DC pension scheme, final benefits for the EPF's members are not only derived from monthly contribution, but also rely on the EPF to manage the fund which can generate higher return. As the consequent, members will get higher dividend to boost their pension saving adequacy. Thus, *ex-ante* risk constraints affect member's welfare. Secondly, based on the expected terminal wealth, we conclude that the dividend decision distributed to the members will also influence the gain of the dynamic investment. The dividend distributed to the EPF members has negative relationship with the expected terminal wealth. Hence, a prudent dividend decision is crucial in order to ensure the EPF retains its financial soundness.

In this study, we do not consider the sensitivity of the results to the level of economic performance. As suggested by Siu (2011), the economic performance may influence investment strategy from two ways. From asset perspective, economic performance over a long period of time influences share prices, and interest rate on the fixed asset. Meanwhile, from liability perspective, through inflation, economic performance affects investment analysis through relationship between inflation and salary. Therefore, it would be interesting to consider economic performance in investment strategy for the EPF because it may also influence dividend that will be distributed to its members.

Another limitation of this chapter suggested a direction for further research. The effect of regulation on the limit of certain assets that can be held leads to an inefficient portfolio decision strategy. Diversifying the domestic investment opportunity to international investments may bring further diversification benefits. In this regard, the next chapter discusses the role of the international portfolio in portfolio optimisation. Then, the performance of domestic TSP and international TSP are compared to analyse the benefit the EPF may gain from diversification.

Chapter 6: International Equity in an ALM Framework: The Case of Malaysia's EPF Investment Strategy

This chapter will discuss international portfolio diversification for the EPF. In addition to investing in the domestic financial market, this chapter evaluates the potential benefits of the inclusion of international assets in the EPF's portfolio. We employ the same method as in the previous chapter—two-stage stochastic programming (TSP)—in order to compare the investment performance between a domestic investment strategy and international diversification strategy. Uncertainty in this study represents future asset and liabilities and is normally appointed as scenarios with probability. We use a VAR model to re-model future asset return. Meanwhile we employ future liabilities treams data as discussed in Chapter 4. The objective of this analysis is to maximise the expected terminal value with an optimal manner, subject to policy constraints.

Keywords: International diversification, ALM, defined-contribution

6.1 Introduction

Triggered by a stuttering local equity market and the poor performance of the stock market, with RM8.05 billion impairment loss in 2015 with 73% contributed by the domestic market (www.malaysiainsider.com), initiative to invest abroad is seen as essential to improve the EPF's investment performance. Investing abroad is believed to improve investment performance as international markets are well-regulated with regulatory stability, as well as improving the potential of portfolio diversification across many asset classes and markets to offset volatility. However, from the context of emerging countries, pension funds are restricted to portfolio limits such as portfolio ceiling and international assets (Kumara & Pfau, 2011). Table 6.1 depicts portfolio limits for international investment and equity investment for emerging market pension funds,[9] with an integrated global capital market allowing investors to allocate funds internationally to reap the benefit of diversification. Theoretically, Markowitz, in

[9] The data are obtained from Kumara and Pfau (2011).

modern portfolio theory, suggests that portfolio diversification across asset classes with lower correlation of returns increases portfolio return for a given level of risk or even for lower risk. Moreover, foreign equities provide great diversification opportunities.[10]

Table 6.1: Portfolio limits on international investment and equity in emerging countries (as a percentage of investment portfolio)

Country	Limit on equity	Limit on International Assets
Turkey	100%	100%
Czech Rep	75%	100%
Chile	25%	60%
Columbia	40%	40%
Korea	Not Allowed	30%
Thailand	20%	10%
Philippines	30%	8%
China	40%	7%
Malaysia	**25%**	**7%**
Indonesia	14.8%	Not allowed
Sri Lanka	1.3%	Not allowed
India	Not allowed	Not allowed

Source: Kumara and Pfau (2011)

Based on Table 6.1, the pension funds in Turkey and the Czech Republic are the most liberal in terms of portfolio constraints on the international asset. On the other hand, India restricts its pension fund to allocate assets in both international asset and equity. In general, limitation to invest abroad is greater than the restriction on equities. This restriction influences the investment performance of the fund and retirement benefit. Furthermore, it makes a pension scheme inflexible and unable to accommodate rapid changes in financial conditions or structural change in financial markets (Kumara & Pfau, 2012). Thus, Roldos (2004) suggests that liberalisation in portfolio restriction affects the overall portfolio through flexibility given to the pension fund manager to decide allocation.

[10] This argument was made by Solnik (1974).

The literature has flourished in this field and includes extensive debate. Whether to invest globally is debated by researchers. As stated by Pfau (2009), Markowitz (1952) suggested that international portfolio diversification potentially increases returns and reduces risk through the selection of complementary assets with low cross-correlations because international assets are not exposed to the same country-specific shock as the domestic asset. Black and Litterman (1992) suggest that at any level of risk given, international diversification improves portfolio performance. Meanwhile, Asher (2008) argues that asset allocation in Asian countries is significantly influenced by tight government regulation, which does not benefit members. The pension fund is biased towards government securities and other domestic assets rather than using optimal asset allocation strategies (Kumara & Pfau, 2012).

In turn, Silva and de Oliveira (2011) investigate the role of international diversification in the Brazilian pension system. Using a static mean-variance framework, the study compares the investment strategy with and without allocation limits. The finding shows that investment strategy beyond the regulatory limit will increase the efficiency of asset allocation; and with allocation restriction, it restricts efficient frontiers. Pfau (2009) finds that incorporating international assets tends to improve the sustainability of the Pakistan pension system, as well as increase the expected return and decreasing volatility. Moreover, international diversification is not exposed to country-specific shock (Solnik & McLeavey, 2009). This is because, in the underdeveloped financial market, the prices are distorted and exposed to higher risks and potentially more frequent asset price bubbles.

However, proponents of restrictions on international assets argue that investing domestically may reduce the risk of financial outflows (Bodie & Merton, 2002). In addition, pension funds may become a low-cost source of government funding than borrowing funds from overseas, and investing in a local market may increase job opportunities for domestic workers, thus increasing economic growth (Kumara & Pfau, 2012).

From the context of Malaysia's EPF, with a massive amount of assets, approximately 60% of GDP, the domestic market is not enough to provide a good return, hence looking at interesting opportunities globally to counterbalance the impact of lower returns from the local equity market is required (www.thestar.com.my). Thus, this chapter investigates—under the stochastic ALM model—the portfolio allocation decision when international investment opportunities are taken into account. The next section discusses the process of generating asset returns for the EPF after including international equity. We use the same data for a future liability stream as explained in Chapter 4.

6.2 Asset Return Forecast

As stated earlier, we employ the same process, i.e. VAR model, to simulate future asset return scenarios. Instead of using five broad asset classes, we incorporate additional three international equities from Japan, Singapore and the USA in our asset classes. The assets proxy is illustrated in Table 6.2. This study again uses historical annual data covering 1992 to 2014 and are obtained from various reliable sources such as DataStream, Bank Negara Malaysia (Central Bank of Malaysia) and the EPF's annual reports.

Table 6.2: Asset proxy for international investment strategy

Asset	Proxy
Malaysia Government Security 10 Years (MGS10)	Long-term government bond yield (risk free)
Malaysia Government Security 10 Years (MGS1)	Medium-term government bond yield (risk free)
Equity (KLCI)	MSCI index price
Money Market Instrument	Short term interest rate
Property	Annual percent change of property price indicators.
Japan Equity	MSCI index price
The USA Equity	MSCI index price
Singapore Equity	MSCI index price

Table 6.3 presents the summary statistic of the following return series: Property (PROP), Malaysian Government Security mature at 10 years (MGS10) and at 1 year (MGS1), MSCI Malaysia (EQMAS), MSCI Singapore (EQSIN), MSCI Japan

(EQJAP), MSCI Unites State (EQUSA) and Malaysia Money Market (MMI). All series are stated in log-return on a yearly basis between 1992 and 2014.

Table 6.3: Summary statistic

	PROP	*EQMAS*	*EQSIN*	*EQUSA*	*EQJAP*	*MMI*	*MGS10*	*MGS1*
Mean	0.0608	0.0565	0.0810	-0.0509	0.0349	0.0430	0.0493	0.0397
Standard Error	0.0139	0.0250	0.0749	0.0470	0.0269	0.0041	0.0028	0.0034
Median	0.0472	0.0487	0.0270	-0.0357	0.0399	0.0338	0.0420	0.0330
Standard Deviation	0.0665	0.1197	0.3592	0.2256	0.1289	0.0199	0.0133	0.0161
Kurtosis	1.5769	3.7559	13.4163	2.5805	4.8831	0.0081	-1.0554	-0.7765

The scenario of future returns projections in this study are modelled based on an unrestricted VAR without lagged variable. Table 6.4 displays the VAR model for each asset.

Table 6.4: Coefficient of the vector autoregressive model

MMI	MGS1	EQMAS	EQSIN	EQUSA	EQJAP	MGS10	PROP
0.0430	0.0397	0.0565	0.0810	-0.0509	0.0349	0.0493	0.0608

Table 6.5: VAR equation with zero lag

$\ln(1 + \mathbf{MMI_t})$	= 0.0430+ ε_t
$\ln(1 + \mathbf{MGS1_t})$	= 0.0397+ ε_t
$\ln(1 + \mathbf{EQMAS_t})$	= 0.0565+ ε_t
$\ln(1 + \mathbf{EQSIN_t})$	=0.0810+ ε_t
$\ln(1 + \mathbf{EQUSA_t})$	=-0.0509+ ε_t
$\ln(1 + \mathbf{EQJAP_t})$	=0.0349+ ε_t
$\ln(1 + \mathbf{MGS10_t})$	= 0.0493+ ε_t
$\ln(1 + \mathbf{PROP_t})$	= 0.0608+ ε_t

The estimated value of $\boldsymbol{\varepsilon_t}$ are projected using a Monte Carlo simulation that was done in Excel. We apply a Cholesky factorisation of the variance-covariance matrix of residual that are characterised by *N(0,∑)* to be decomposed into residual *N(0,1).* By multiplying the Cholesky decomposition and a vector random number from a standard normal distribution of ε**,** values are then used to project the future return for each asset by recursively solving the equation in Table 6.5 in order to generate thousands of scenarios. In our case, we generate 200 scenarios and the probability to generate each scenario is equivalent 0.005 or $\frac{1}{200}$.

6.3 The Model

6.3.1 Data source.

We consider 2014 as the based year for this analysis and the data are taken from the EPF 2014 annual report. Asset streams consists of assets returns and contributions received from members. While the liabilities streams represent pre-withdrawal retirement, withdrawal retirement and death payment. Asset return data are the value of the scenario generated in a previous section from this chapter; and for the cash flows, liabilities and pre-retirement data aretken from the data generated in Chapter 4.

6.3.2 Model component.

In this section, we employ a TSP model for the EPF as described in Chapter 3. However, we extend the model by assuming that the EPF will expand their asset into three additional international equity, namely, MSCI Singapore, MSCI Japan, and MSCI USA. The objective of the model is to maximise the expected terminal value at the end of the planning horizon.

6.3.3 Objective function.

$$Maximize \sum_{s=1}^{S} W_T^S \times r_s \qquad (6.1)$$

<u>Model indices</u>

i	= Asset classes	$i = 0,1, \ldots, I, I=8$
T	= Time index	$t = 0,1, \ldots, T, T= 45$
S	= Index of scenarios	$s = 0,1, \ldots, S, S=200$

<u>Decision variables</u>

W_T^S = Total wealth at the end of planning horizon

$x_{i,t}^S$ = Total asset held at time t and scenario s

$S_{i,t}^S$ = Total asset sold at time t and scenario s

$B_{i,t}^S$ = Total asset bought at time t and scenario s

<u>Deterministic parameters</u>

x_{i0} = Initial holding allocated at each asset i

l_i = Lower bound of the assets i as the fraction of the total assets

u_i = Upper bound of the assets i as the fraction of the total assets

α = Transaction costs

L_t = Liability to be paid at time t

P_{ts} = Probability of scenario s at time t

Random variables

r_s = Random return on assets class

rb_t^s = Cost of borrowing at time *t*

rl_t^s = Cost of lending at time *t*

6.3.4 Wealth constraint.

This constraint suggests that the wealth at time *t* and scenarios *s* is derived from the total asset held and the lent cash amount paid back, including the lending rate minus the amount borrowed and the borrowing rate. We assume the lending rate at time t and scenario s as MMI's return at time t scenario s minus 0.05 and the borrowing rate at time t and scenario s as MMI's return at time t and scenario s plus 0.05.[11]

$$W_t = \sum_{i=1}^{I} x_{i,t} + Q_t(1+r^l) - O_t(1+r^b) \quad t = 1,\ldots, T \tag{6.2}$$

6.3.5 Asset holding constraint.

Asset holdings readjust the amount of assets held over time. The amount of asset held at time t is equivalent to asset holding at the previous time (*t-1*) with its return, plus the amount of asset bought minus the amount of asset sold. At the beginning of the planning horizon, the asset held is equal to initial holding plus asset bought at time *1* minus asset sold at time *1*.

$$x_{i,1}^S = x_{i0} + B_{i,1}^S - S_{i,1}^S \tag{6.3}$$

$$x_{i,t}^S = x_{i,t-1}(1+r_{i,t}^S) + B_{i,t}^S - S_{i,t}^S \tag{6.4}$$

6.3.6 Cash balance constraint.

This constraint describes the amount invested in the purchase of the new assets plus assets lent (reinvest surplus cash) and all liabilities must be equal to the contribution (from employer and employees), plus any cash generated assets sold and amount of

[11] As suggested by Hussin (2012).

cash borrowed (if required). We consider both the selling and buying costs are $(1-\alpha)$ and $(1+\alpha)$ where α = 2%. Selling and buying activities are not allowed at the end of the planning horizon (T=45).

$$\sum_{i=1}^{I}(1+\alpha)B_{i,1}^{S}+Q_{1}^{S}+L_{1}=V_{1}+\sum_{i=1}^{I}(1-\alpha)S_{i,1}^{S}+O_{1}^{S} \quad (6.5)$$

$$\sum_{i=1}^{I}(1+\alpha)B_{i,t}^{S}+Q_{t}^{S}-(1+rl_{t}^{S})Q_{t-1}^{S}+L_{t}=V_{t}+\sum_{i=1}^{I}(1-\alpha)S_{i,t}^{S}+O_{1}^{S}-(1+rb_{t}^{S})O_{t-1}^{S} \quad (6.6)$$

$$\sum_{i=1}^{I}(1+\alpha)B_{i,t}-(1+rl_{t})Q_{t-1}+L_{t}=V_{t}+\sum_{i=1}^{I}(1-\alpha)S_{i,t}-(1+rb_{t}^{S})O_{t-1}^{S} \quad (6.7)$$

6.3.7 Short sales constraint.

Short sales are not allowed in this analysis; thus it is important that the amount of asset sold must be less than the amount of assets held in the last time period.

$$S_{i,1}^{S}\le\sum_{s=1}^{S}x_{i,0} \quad (6.8)$$

$$S_{i,t}^{S}\le x_{i,t-1}^{S} \quad (6.9)$$

6.3.8 Inventory constraint.

This constraint tells us that the amount of assets held at time t and scenario s must not exceed the upper bound and lower bound as stated in the *EPF Act*.

$$l_{i}H_{t}^{S}\le x_{i,t}^{s}\ge u_{i}H_{t}^{S} \quad (6.10)$$

In this model, we consider that the EPF allows the fund to be invested in international financial markets. Therefore, we assume that the inventory constraints for this model are as follows.

Table 6.6: Upper and lower bound for each asset

Asset class	Lower bound (%)	Upper bound (%)
Money market instrument (MMI)*	5	25
Bond and loan *	15	35
Equity *	5	25
Malaysian Government Securities with 10 year (MGS10)*	15	45
Property*	0.1	5
MSCI Japan**	0.1	9
MSCI Singapore**	0.1	9
MSCI United States**	0.1	9

Note: * = Lower bound and upper bound of the amount assets held are based on the *EPF Act.*

** = Lower bound and upper bound are based on author's assumption

6.3.9 Non-anticipativity constraints.

Since the decision at the given stage does not depend upon future realisations of the random events, we incorporate this constraint to ensure that the same variables will take the same decision if they share the same node in a scenario tree. We consider that the investment decision at t=1 the first decision variable.

$$x_{i,1}^{S} = x_{i,1}^{1} \tag{6.11}$$

$$B_{i,1}^{S} = B_{i,1}^{1} \tag{6.12}$$

$$S_{i,1}^{S} = S_{i,1}^{1} \tag{6.13}$$

6.3.10 The chance constrained and the integrated chance constraint.

We introduce both CC and ICC to limit the percentage and the amount of shortage in this model. However, in this study we only consider ICC in our analysis.

CC constraint:

$$M\delta_{t+1}^{S} \geq \gamma L_{t+1}^{S} - A_{t+1}^{A} \qquad (6.14)$$

$$\pi_s \sum_{s=1}^{S} \delta_{t+1}^{S} \leq 1 - \beta_{t+1} \qquad (6.15)$$

ICC constraint:

$$H_t^S - \gamma L_t^S + shortage_t^s \geq 0 \qquad (6.16)$$

$$\pi_s \sum_{s=1}^{S} shortage_t^s \leq \lambda \pi_s \sum_{s=1}^{S} L_t^s \qquad (6.17)$$

6.4 Results

This section presents the main results from the application of our model after considering international equity in asset allocation decisions. The results are developed along three dimensions: the model of TSP, the results after incorporating ICC risk constraints, and the comparison of investment model for domestic two-stage stochastic programming (DTSP) and international two stage stochastic programming (FTSP).

Figure 6.1 illustrates the ETW for FTSP with various dividend growths. Of course, the optimal expected terminal value will decrease with increasing percentage of dividend growth. The inverse relationship between dividend growth and expected terminal wealth occur because the dividend paid to EPF members will affect the available amount to be invested in the market.

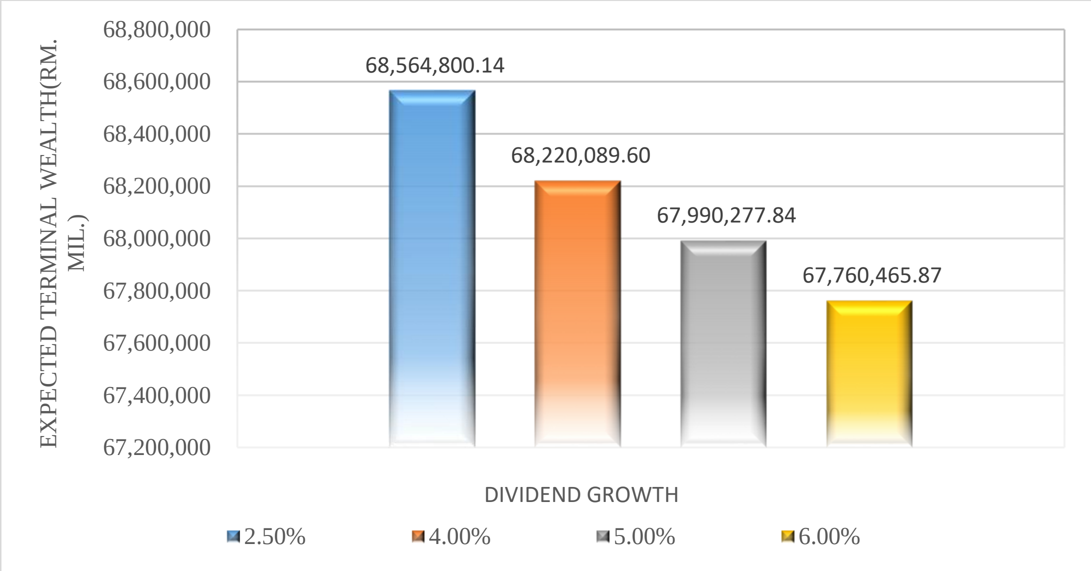

Figure 6.1: TSP model: Expected terminal wealth with various dividend growths

Next, we analyse the asset allocation decision. As the main concern is to analyse an optimal asset allocation strategy for the EPF, which can provide maximum expected wealth, Table 6.7 depicts the asset allocation first stage decision at time period one. As illustrated in Table 6.7, the wealth of the EPF is prominently allocated in the long-term Malaysian Government Bond. Even international asset and equity may provide a higher return, the decision model must still be subject to inventory constraint as stated in Table 6.6.

Table 6.7: TSP model with international asset: 1st asset allocation for each asset

Dividend	Terminal wealth (RM Mil.)	Asset allocation	MMI	MGS1	EQMAS	EQSIN	EQUSA	EQJAP	MGS10	PROP
2.50%	68,564,800.14	RM Mil.	63721.25	187663.21	261406.50	87576.16	62554.40	87576.16	440140.60	60449.76
		%	5.093266823	15.000	20.894	7.000	5.000	7.000	35.181	4.832
4.00%	68,220,089.60	RM Mil.	63658.15	187555.71	261893.99	87526.00	62518.57	87526.00	439313.01	60379.98
		%	5.091139143	15.000	20.945	7.000	5.000	7.000	35.135	4.829
5.00%	67,990,277.84	RM Mil.	63628.32	187484.05	262219.07	87492.56	62494.68	87492.56	438748.97	60333.46
		%	5.091	15.000	20.979	7.000	5.000	7.000	35.103	4.827
6.00%	67,760,465.87	RM Mil.	63561.08	187412.38	262543.89	87459.11	62470.79	87459.11	438222.58	60286.94
		%	5.087	15.000	21.013	7.000	5.000	7.000	35.074	4.825

Next, we consider the effect of the integrated chance constraints on the first-stage decision. Figures 6.2 and 6.3 show the results of ICC and asset allocation at stage one with the value λ=0.05 and γ=1.10 respectively. The result is consistent with DTSP where dividend growth inversely affects the expected terminal wealth.

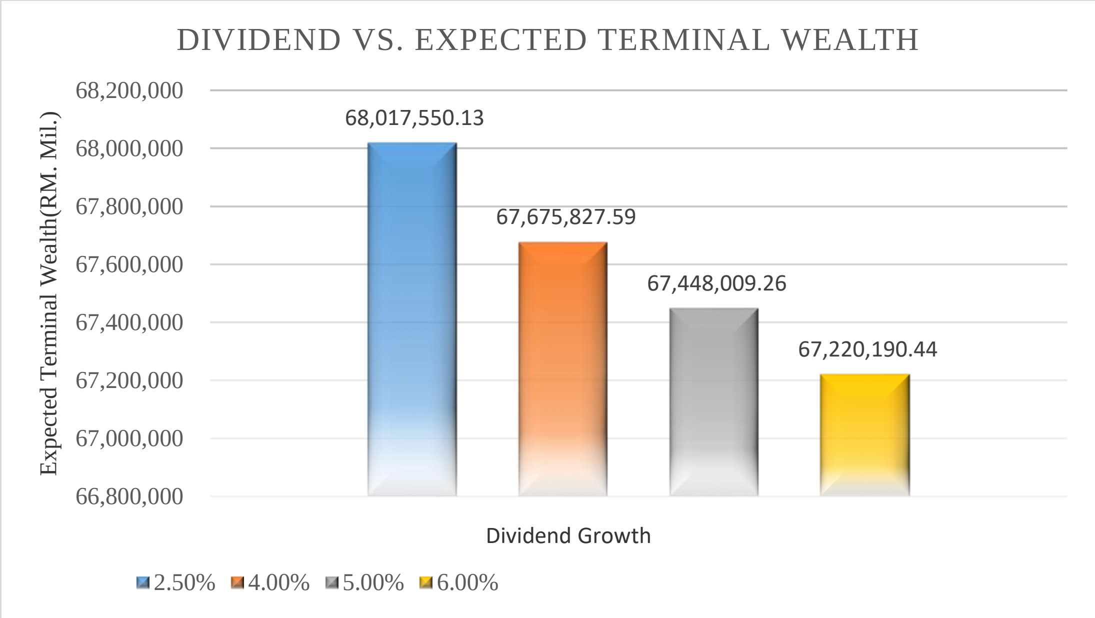

Figure 6.2: TSP model: expected terminal wealth and dividend growths with ICC risk constraint

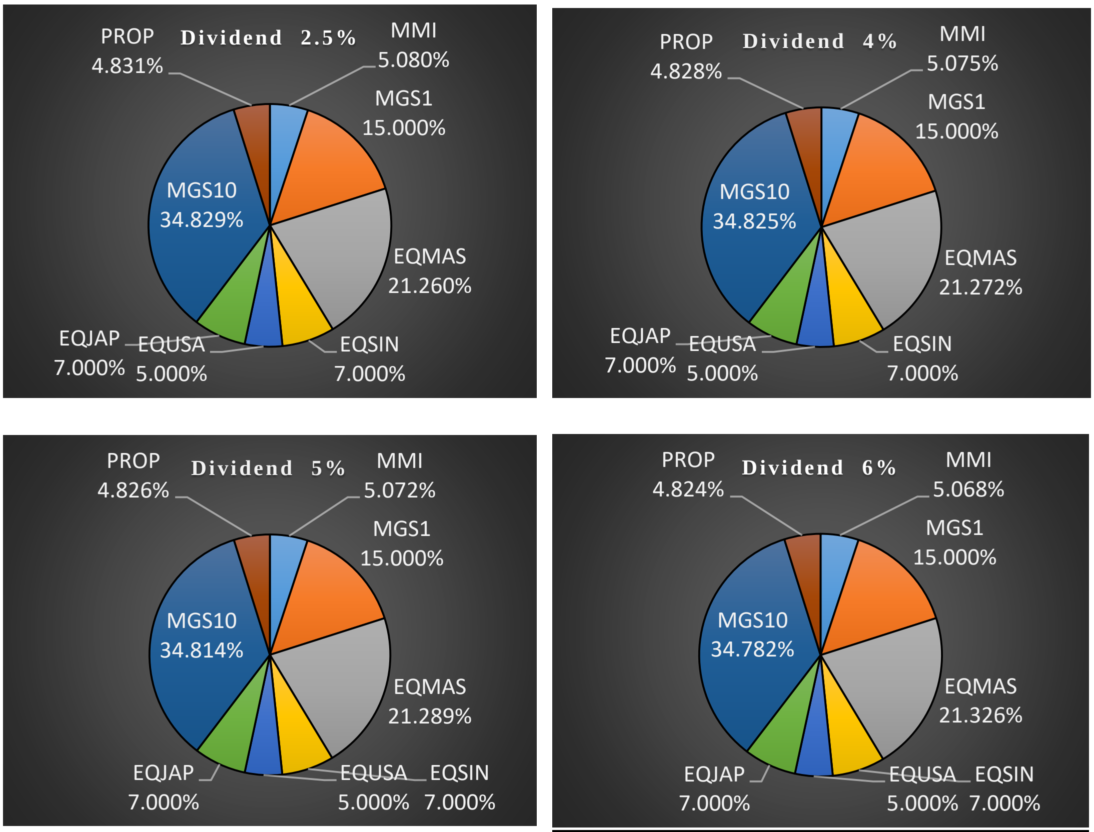

Figure 6.3: 1st stage asset allocation for each asset class

6.5 International Diversification Implication

In this section, investment strategies are compared between holding domestic assets and holding both domestic and international assets. First, we analyse the performance of both DTSP and FTSP with and without ICC constraint. It is displayed in Table 6.8.

Table 6.8: Expected terminal wealth for all investment strategies

Strategy	Investment Model	Dividend growth (%)			
		2.5	4	5	6
Domestic	DTSP	59,159,867.43	58,805,026.08	58,568,457.65	58,331,889.95
	DTSP-ICC	59,110,057.82	58,755,644.71	58,519,362.21	58,283,081.37
	Wealth loss (%)	-0.0842	-0.0840	-0.0838	-0.0837
International	FTSP	68,564,800.14	68,220,089.60	67,990,277.84	67,760,465.87
	FTSP-ICC	68,017,550.13	67,675,827.59	67,448,009.26	67,220,190.44
	Wealth loss (%)	-0.7982	-0.7978	-0.7976	-0.7973

In general, international investment strategy generates higher expected terminal value compared to the domestic investment strategy. In response to this higher return, we believe that the EPF can distribute higher dividends to its members improving final pension savings among members. We introduce the ICC constraint to avoid the fund from being underfunded or a shortage at the short run. This constraint allows the fund a shortage not more than 5% of total liabilities. However, this constraint inversely affects a fund manager's aim, which is to maximise terminal wealth. It can be shown from Table 6.7 that ICC creates wealth loss for both domestic and international investment strategies. Next, we summarise our results by comparing portfolio decisions for all models. Table 6.9 shows the portfolio weight for all ALM models at the first stage of our model. In terms of asset allocation decisions, there is a comparable shift in asset allocation for the EPF after incorporating international assets. Based on the asset allocation at the first stage, about 50% of wealth across the dividend growth was allocated to fixed income assets i.e. Malaysia Government bond with maturity 10 and 1 years. While, in terms of international assets, more wealth was allocated in Japan and Singapore Equity compared to investing in American Equity.

Overall, all empirical work indicates that when international equity is included in the model, it increases the performance of the investment strategy. It should be expected that international assets can maximise investment return; therefore increasing the possibility of higher dividends distributed to the EPF's members, thus reducing the issue of inadequate pension savings among EPF members.

Table 6.9: Portfolio weight for 1st stage ALM model for both domestic inventory constraint and international inventory constraint for the EPF

Investment Strategy	Dividend	Portfolio Weight							
		MMI	MGS1	EQMAS	EQSIN	EQUSA	EQJAP	MGS10	PROP
Domestic portfolio	2.50%	5.000	24.519	25.000	0.000	0.000	0.000	40.903	4.578
	4.00%	5.000	24.546	25.000	0.000	0.000	0.000	40.881	4.574
	5.00%	5.000	24.564	25.000	0.000	0.000	0.000	40.866	4.571
	6.00%	5.000	24.582	25.000	0.000	0.000	0.000	40.851	4.567
	2.50%	5.000	24.519	25.000	0.00	0.00	0.00	40.911	4.571
	4.00%	5.000	24.546	25.000	0.00	0.00	0.00	40.888	4.566
	5.00%	5.000	24.564	25.000	0.00	0.00	0.00	40.873	4.563
	6.00%	5.000	24.582	25.000	0.00	0.00	0.00	40.851	4.567
		MMI	MGS1	EQMAS	EQSIN	EQUSA	EQJAP	MGS10	PROP
International portfolio	2.50%	5.093	15.000	20.894	7.000	5.000	7.000	35.181	4.832
	4.00%	5.091	15.000	20.945	7.000	5.000	7.000	35.135	4.829
	5.00%	5.091	15.000	20.979	7.000	5.000	7.000	35.103	4.827
	6.00%	5.087	15.000	21.013	7.000	5.000	7.000	35.074	4.825
	2.50%	5.080	15.000	21.260	7.000	5.000	7.000	34.829	4.831
	4.00%	5.075	15.000	21.272	7.000	5.000	7.000	34.825	4.828
	5.00%	5.072	15.000	21.289	7.000	5.000	7.000	34.814	4.826
	6.00%	5.068	15.000	21.326	7.000	5.000	7.000	34.782	4.824

6.6 Conclusion

Although the investment of the EPF must be subjected to investment constraints on portfolio diversification, we cannot deny that international assets can potentially play a vital role in the investment efficiency. In fact, another topic that has gained substantial attention in the literature is home-bias versus international diversification investment strategy in the pension fund. Markowitz's MV framework suggested that international portfolio diversification potentially increases returns and reduces risk through the selection of complementary assets with low cross-correlations because international assets are not exposed to the same country-specific shock as the domestic asset. Furthermore, with a considerable amount of assets by the EPF, the domestic market is not efficient to generate a good return thus requires the EPF to consider allocating its assets in the global market. In this chapter we have presented the impact of international equity in asset allocation decisions. Using the model as stated in Chapter 5, we extended the model by incorporating international equity in the EPF asset allocation. In this chapter, we assume EPF invest in equity from Japan, Singapore and the USA. Using two stage stochastic ALM model, our empirical results suggest that international diversification increases the expected terminal wealth for all dividend growth. The finding suggests that investing abroad will enhance the performance of the investment strategy for the EPF. We also extend our TSP model by incorporating ICC risk constraints and suggest that ICC protects the fund from the underfunding risk. However, it also affects the performance of our model to maximize the expected terminal wealth.

Consequesntly, it is found that our results are encouraging for two main reasons. Firstly, the implementation of international inventory constraints influences the EPF's performance. The results indicate that international diversification improves the EPF's performance. So, with a higher expected terminal wealth generated from the international diversification investment strategy, the EPF may distribute the higher dividend to its members which affect members' saving adequacy upon retirement. Secondly, the implementation of *ex-ante* risk constraints such as inventory constraints, integrated chance constraints adversely influence the performance of our model. Following that, the next chapter will discuss the stability check and benchmarking of the model using in-sample and out-of-sample analysis.

Chapter 7: Validation of Results and Benchmarking

7.1 Introduction

This chapter will evaluate the performance of the results obtained from our model, domestic two-stage programming (DTSP), international two-stage programming (FTSP), and Integrated Chance Constraint (ICC), which are discussed in Chapters 5 and 6 respectively. As natural concern in stochastic modelling, the validity and performance of scenarios generated in this model are examined. This validity is deemed more an 'audit' of the ALM model that we have developed to ensure the accuracy of the model. As the quality of the sample influences the performance of our model, robustness tests are crucial and can be done by back-testing, simulation, and in- and out-sample stability testing. With the limited and short history data, historical backing testing is not allowed in this study (Dupačová & Polívka, 2009). This study applies to in- and out-sample tests to evaluate the stability of the scenario generated. Using the same methods as described in Chapter 4, a new set of larger scenario returns are generated for the out-of-sample models. Next, five evaluation techniques are introduced to measure the performance of the solution generated from the stability analysis. All of these models are compared based on financial ratios generated from the out-of-sample model.

7.2 Scenario Generation Quality Measure

The decision generated by our model in the previous two chapters are examined and evaluated using simulation performance analysis. We employ two evaluation techniques to interpret the solutions. We start with a brief literature review of evaluation methods for the ALM model.

Scenario generation quality is a key factor of our model performance. Hoyland and Wallace (2001) argued that the quality of scenario generation should be assessed based on the performance rather than theoretical property. They examine the quality of scenario generation based on in- and out-sample stability, and testing for bias. Zenios (1995) analyses the ALM model for fixed-income portfolio management. Based on the analyses, he finds the SP to perform well using both market data (historical back testing) and simulated data compared to a portfolio immunisation model and single periods. However, Dupačová and Polívka (2009) mentioned that historical back-testing analysis will not be efficient if there is limited historical data.

Kouwenberg (2001) developed a multistage stochastic programming ALM mode for a Dutch pension fund. Using rolling horizon simulations the model is tested to measure the performance of the simulation model compared to the fixed mix model. Based on the rolling horizon simulation analysis, the finding shows that the SP model dominates the fixed model and the trade-off between risk and costs are better in the SP model than in the fixed model.

7.3 Decision Evaluation

In this section, we discuss three common evaluations techniques: historical back-testing analysis, in-sample analysis, and out-of-sample analysis. However, in this study, we employ in- and out-of-sample analysis to measure the performance of our model.

a) Historical back testing analysis: This analysis is run using historical data. Using this model, the analysis shows what happens if it had been decided to implement them in the past. However, due to limited historical data, this analysis is not employed in this study.
b) In-sample testing analysis: This analysis tests how the model performs within the original input. Hussin (2012) defines in-sample stability as a distance of the objective function obtained by solving the same problem with different scenario trees (of the same size) generated with the same method. The model is tested to see the performance of the model perform within the original data input. It means that we compare scenario generation with itself. In this study, we solve a two-stage tree with 200 scenarios.

   Using this analysis, the optimal solution for the objective function is expected to not vary insignificantly from variation from the input. The set of scenario used to measure stability using in-sample analysis is 200 scenarios (as described in Chapter 4) with 2.5% growth dividend. We solve this analysis based on the following steps:

- Solve the model and fix the first stage decisions
- Use the first stage decisions and solve the remaining model based on recourse actions
- Compute the wealth.

c) Out-of-sample analysis: This method is similar to in-sample analysis. It differs from in-sample analysis when we use a new dataset instead of using already available data. We generate 1000 return scenarios using the same method of generation as described in Chapter 4. The growth model for this analysis is 2.5%. We solve this analysis based on the following steps:
    - Solve the model and fix the first stage decisions
    - Use the first stage decisions and solve the remaining model based on recourse actions
    - Compute the wealth
    - Compute risk-adjusted performance indices across the time periods.

7.4 Measuring Risk Adjusted Fund Performance

The performance of funds can be measured using several financial performance measurements such as the standard deviation of returns, the Sharpe ratio, Value at Risk, and the Treynor Ratio, Sortino ratio, funding, and solvency ratio. However, in this study we employ standard deviation analysis, Sharpe ratio, Sortino ratio, funding, and solvency ratio.

a) The standard deviation of return: depicts the standard deviation of excess return against the risk-free rate or some benchmark. This analysis suggests the higher the standard deviation, the higher the expected return for an investment and the more risk bearing the investors.

b) The Sharpe ratio: measures the excess return per unit of risk in the portfolio. To measure the performance, all models use the same benchmark of risk-free asset and the rational manager will choose the investment with the highest Sharpe ratio.

c) The Treynor ratio: similar to the Sharpe ratio, the Treynor ratio measures the excess return per unit risk. The higher the Treynor ratio, the better the performance of the fund strategy.

d) The Sortino ratio: a variation of the Sharpe ratio and taking into account downside risk. Unlike the Sharpe ratio, the Sortino ratio considers only those returns falling below a user-specified target, or pre-specified rate of return while the Sharpe ratio penalises both upsides as well as downside return deviation.

e) Value at risk: this performance measurement measures the least expected loss (relative to wealth) that will be expected given a confidence level.

f) Solvency ratio: refers to the ability of the fund to fulfil its long-term obligation. From the pension fund's view point, this ratio shows the ability of the fund to meet its obligation from its available assets.

g) Funding ratio: refers to the ability of the fund to cover all payment obligations. It derives from the ratio between fund's assets and fund's liabilities.

7.5 Computational Result

The following results present the performance of our stochastic modelling using in-sample and out-of-sample analysis. In this analysis, we use an investment strategy with 2.5% dividend growth for both the DTSP and FTSP models. We begin our result discussion with an in-sample analysis.

7.5.1 In-sample analysis.

Using a set of 200 scenarios (as described in Chapter 4) with 2.5% dividend growth. Figure 7.1 represents a histogram of expected terminal wealth for all four strategies. This graphic provides the frequency distribution of a terminal wealth from the in-sample analysis. The graph clearly shows that the expected terminal wealth is not a normal distribution and the expected terminal wealth is skewed to the right of the histograms.

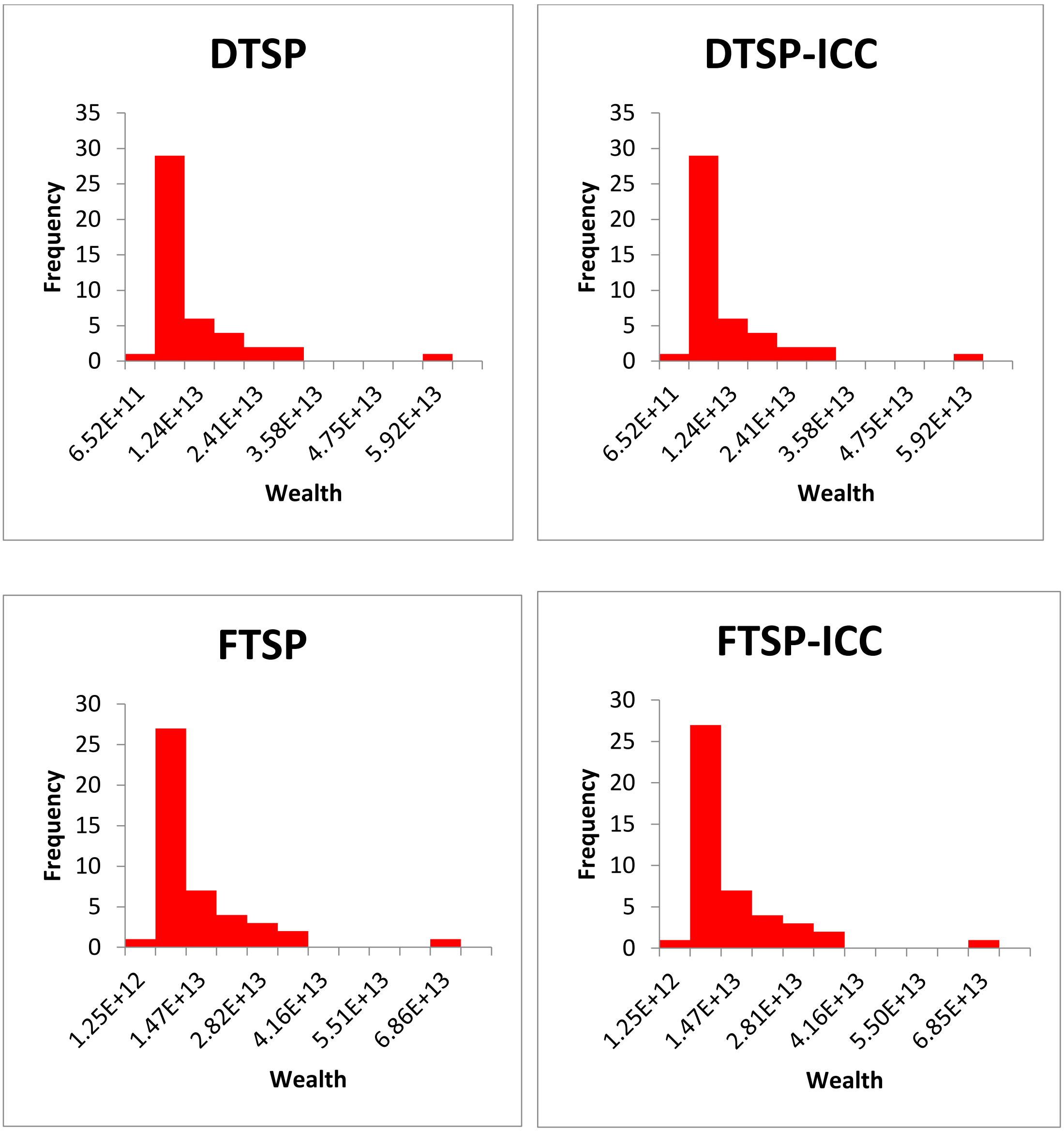

Figure 7.1: Expected wealth of four ALM strategies

Meanwhile, the results presented in Table 7.1 show the descriptive analysis of the wealth for the DTSP, DTSP-ICC, FTSP and, FTSP-ICC.

Table 7.1: Descriptive analysis for in-sample analysis

	DTSP	*DTSP-ICC*	*FTSP*	*FTSP-ICC*
Mean (mil.)	7461741.876	7461171.304	10019380.19	10014638.45
Minimum (mil.)	652159.9344	652159.9344	1251088.042	1251088.042
Maximum (mil.)	59159867.43	59152669.7	68564800.14	68482694.96
Standard deviation (mil.)	10410758.32	10410163.16	12149904.76	12138519.34
Kurtosis	13.32671508	13.32295503	11.56252005	11.54251483
Skewness	3.191035538	3.190687129	2.933773103	2.931249107
Range (mil.)	58507707.49	58500509.77	67313712.1	67231606.92

As seen from Table 7.1 the mean of the terminal wealth varies across the analysis. However, the wealth constraints for both DTSP-ICC and FTSP-ICC are lower than wealth generated by TSP. This study suggests that even risk constraints are preventive action to avoid underfunding in the EPF, it also reduces the terminal wealth. Meanwhile, the expected terminal value for FTSP is greater than DTSP. Moreover, all four models are skewed to the right and ICC constraints for both domestic and international are relatively less skewed.

Even ICC is used to minimise shortage in our model, it also effects the terminal wealth by reducing the expected terminal wealth. Thus, this risk constraint limits our model to achieve the objective of maximising the terminal wealth. Therefore, the ICC model was excluded from our sample analysis.

7.5.2 Out-of-sample analysis.

We generate 1000 sets of scenarios using the same process as in Chapter 4 for this analysis. Figure 7.2 shows terminal wealth for DTSP and FTSP for out-of-sample analysis. Meanwhile, Table 7.2 represents descriptive analysis for out-of-sample analysis.

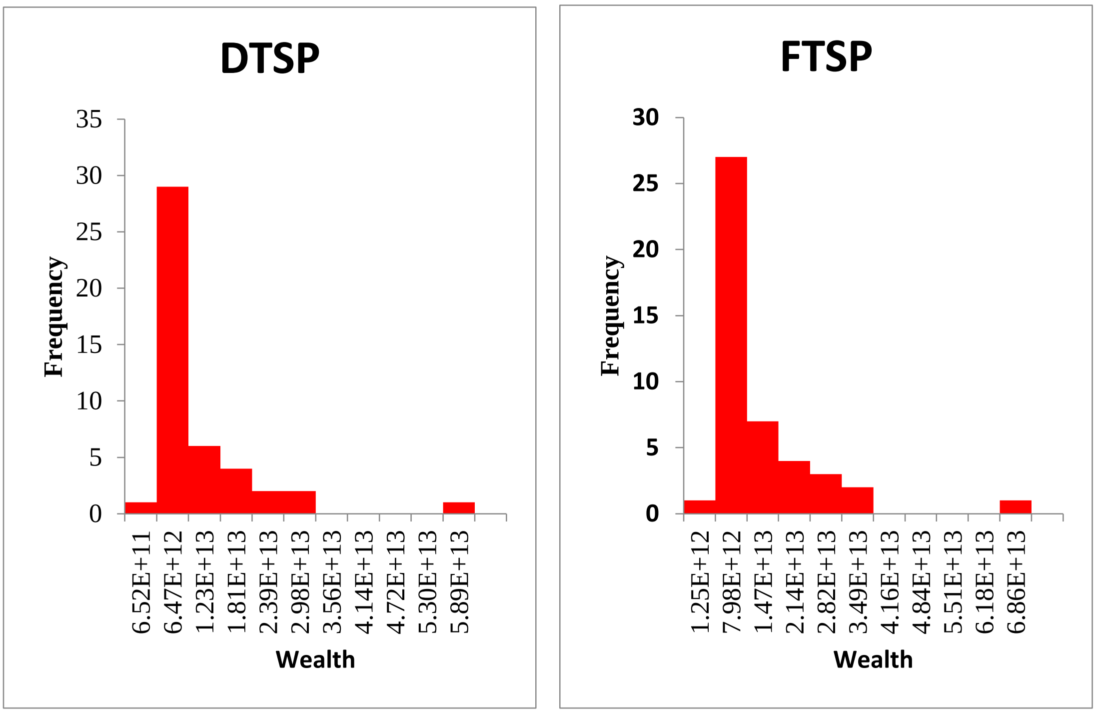

Figure 7.2: Histogram of terminal wealth distribution for DTSP and FTSP

Table 7.2: Descriptive analysis for out-of-sample analysis

	DTSP	*FTSP*
Mean (Mil.)	7451551.00	10019380.19
Minimum (Mil.)	652159.93	1251088.04
Maximum (Mil.)	58863685.95	68564800.14
Standard deviation (Mil.)	10371910.94	12149904.76
Kurtosis	13.21	11.56
Skewness	3.18	2.93
Range (Mil.)	58211526.01	67313712.10

As in the in-sample analysis, the out-of-sample histogram (in Figure 7.2) shows that the wealth value is skewed to the right. Meanwhile, from Table 7.2, the mean value for FTSP in the out-of-sample analysis is higher than mean values in the DTSP. Moreover, mean values between in- and out-of-sample analysis are seen to be comparable for both DTSP and FTSP.

7.6 Performance Measurement

This section discusses the comparison of performance measurement for all models that have been developed in this study. In this study, we consider out-of-sample scenarios and the wealth distribution to measure the performance of our model.

7.6.1 Standard deviation.

Figure 7.3 represents the standard deviations for domestic and international TSP for fund wealth over the next 45 years planning horizon.

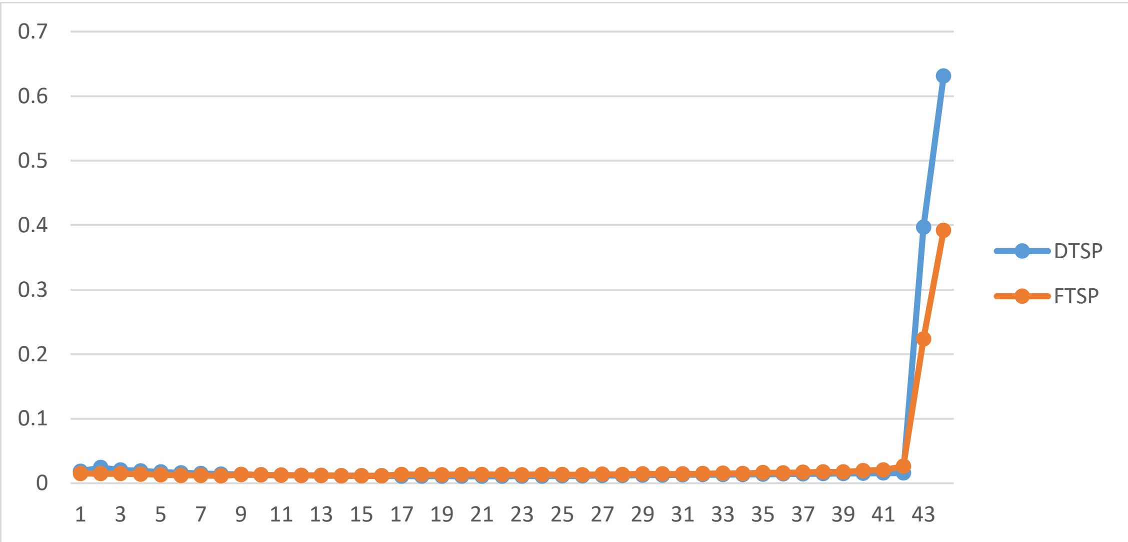

Figure 7.3: Standard deviation analysis for DTSP and FTSP

7.6.2 Sharp ratio (SR).

We measure the Sharp ratio based on the following formula.

$$S = \frac{\bar{d}}{\sigma_d} \tag{7.1}$$

where

$\bar{d}$ = the average of excess return expected value of the difference between return of the fund over the benchmark.

σ_d = is the standard deviation of the excess return of the fund over the benchmark

We derive $\overline{d}$ using the following equation:

$$\overline{d} = E[R_p - R_I] \tag{7.2}$$

R_p = return of the fund

R_I = 2.5% (considered as a benchmark, which is in line with minimum compulsory dividend paid to the members)

Then, we calculate SR at each time t using the following formula as suggested by Sharpe (1994) in the following equation.

$$S_{ht} = \frac{\overline{D_t}}{\sigma_{Dt}} \tag{7.3}$$

and

$$D_t = R_{pt} - R_{It}$$

$$\overline{D} = \frac{1}{t}\sum_{t\prime=1}^{T} D_{t\prime}$$

$$\sigma_{Dt} = \sqrt{\frac{\sum_{t'=1}^{t}(D_{t\prime} - \overline{D})^2}{t-1}} \tag{7.4}$$

where

R_{pt} = the expected return on the fund in the period t

R_{It} = the return on the benchmark portfolio in period t (2.5% for all t)

D_t = the expected excess return of the fund over the benchmark at time t period

$\overline{D}$ = the average value of D_t over the period

σ_{Dt} = standard deviation of excess return

Figure 7.4 shows the Sharpe ratio for DTSP and FTSP investment strategy for 45 years. As mentioned previously, the higher the ratio the better. This ratio represents direct comparison of the risk adjusted-performance of any two funds, regardless of their volatilities and their correlation (Hussin, 2012).

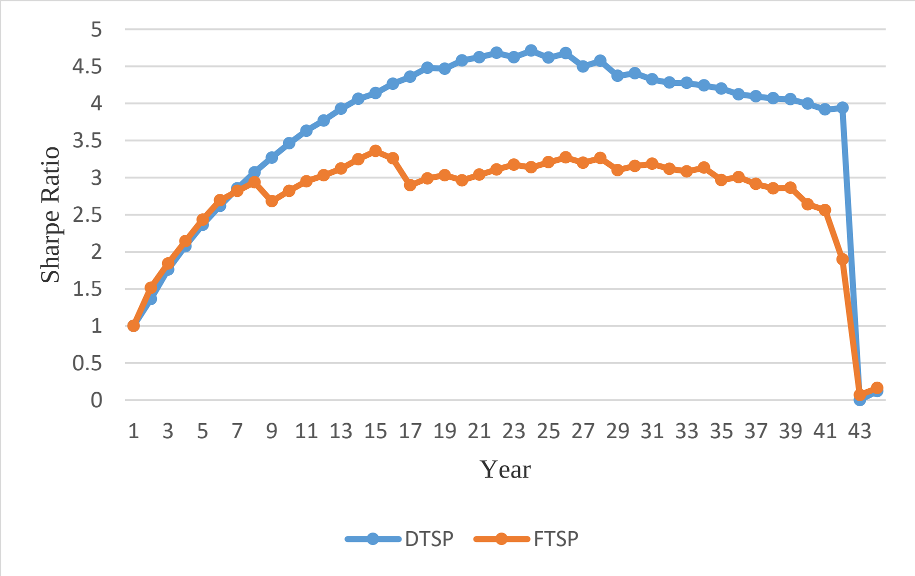

Figure 7.4: Sharpe ratio for fund wealth over the 45 years

7.6.3 Sortino ratio.

As suggested by Schwaiger et al. (2010) Sortino ratios are computed using a geometric mean return as follows:

$$S_{ht} = \frac{R_{pt} - R_{It}}{\sigma_{Dt}} \tag{7.5}$$

where

$$R_{Pt} = \left(\prod_{t'=1}^{t}(1 + R_{pt}\right))^{t} - 1$$

$$\sigma_{dt} = \sqrt{\frac{1}{t}\sum_{t'=1}^{t}(\min R_{pt} - R_{It}, 0))^2} \tag{7.6}$$

We consider σ_{dt} as downside deviation or target semi-deviation and the portfolio's return falls below the benchmarks will be penalised. In this study we consider 5% as a benchmark target return. Figure 7.5 depicts Sortino ratios for the EPF over 45 years.

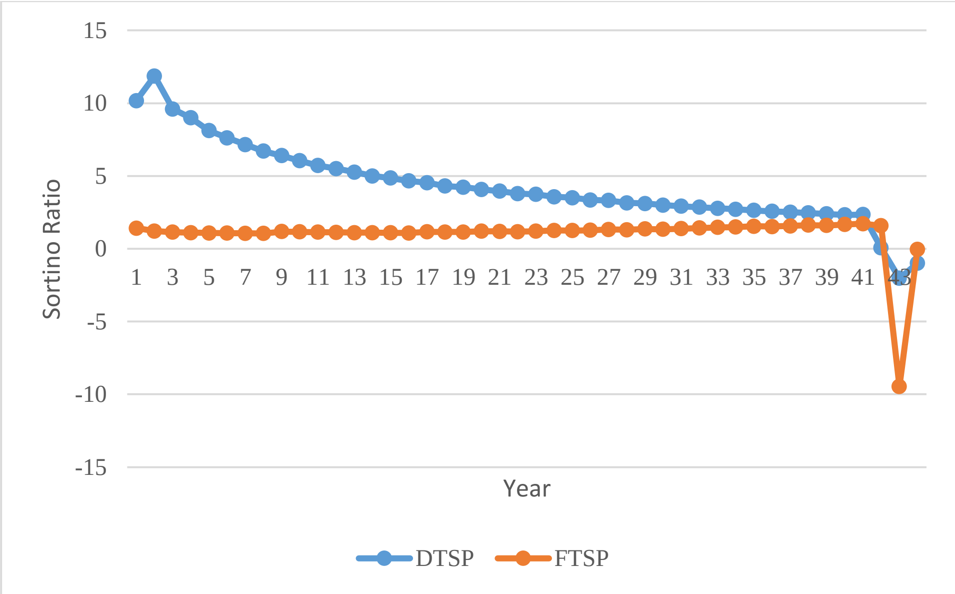

Figure 7.5: Sortino ratio for the EPF's fund over the 45 years

7.6.4 Solvency ratio.

Figure 7.6 depicts Solvency ratios for the EPF over 45 years. We derive this ratio as follows:

$$Solvency\ Ratio = \frac{(Asset\ net\ present\ value - Liability\ net\ present\ value)}{Liability\ net\ present\ value} \qquad (7.7)$$

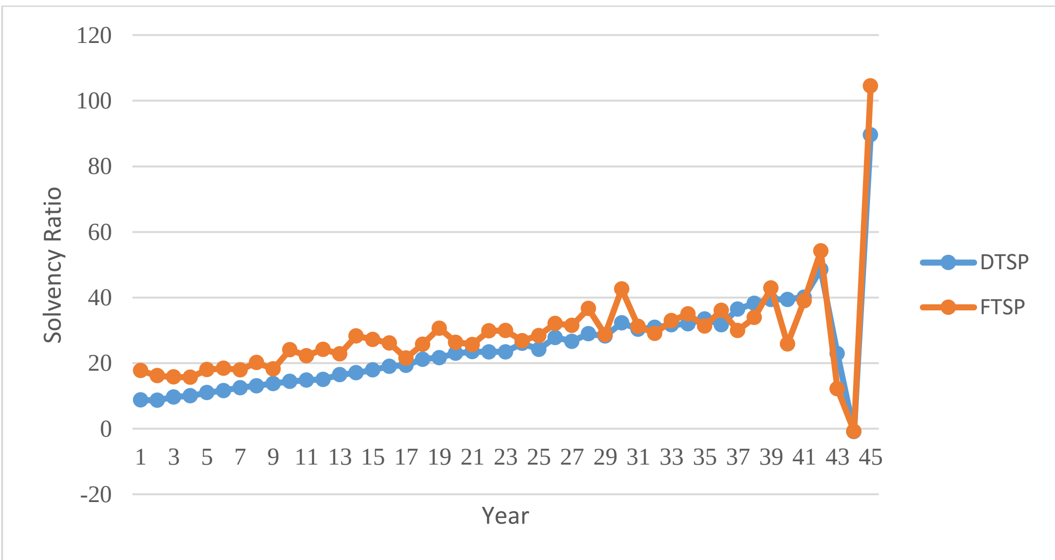

Figure 7.6: Solvency ratios for the EPF over 45 years

7.6.5 Funding ratio.

The funding ratio is derived from the ratio between fund's assets and fund's liabilities as in equation (7.8). Figure 7.7 depicts funding ratios for the EPF over 45 years.

$$FundingRatio = \ Asset\ net\ present\ value - Liability\ net\ present\ value \qquad (7.8)$$

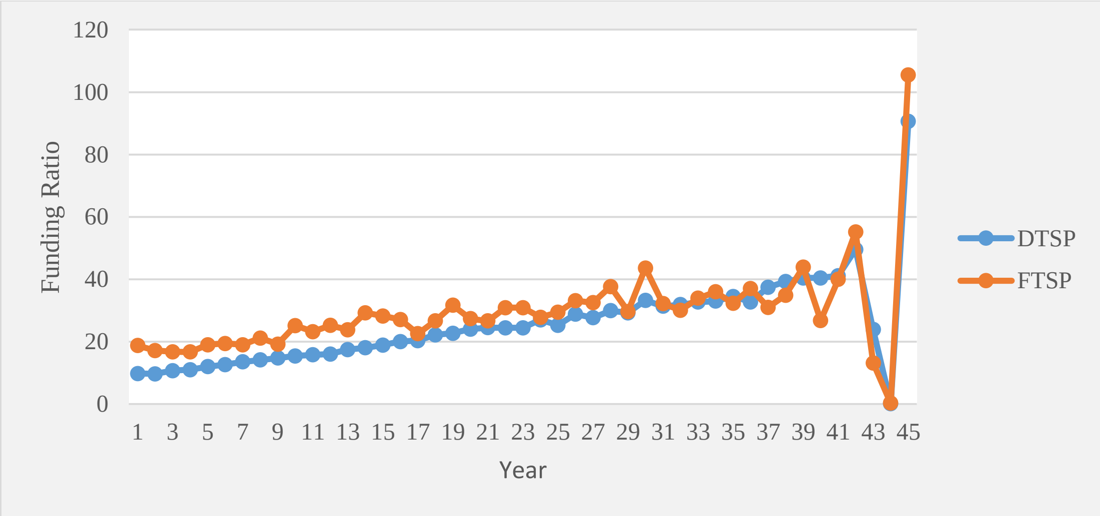

Figure 7.7: Funding ratios for the EPF over 45 years

7.7 Result Discussion

Standard deviation results show that both strategies have comparable standard deviation except for the last three years where DTSP is diverse from FTSP. The FTSP lead to superior expected terminal wealth value resulting from international diversification opportunities, which offers a lower risk than allocating wealth in the domestic financial market only.

Next, we compare the performance of the EPF investment strategy using Sharpe and Sortino ratios. From Figure 7.4 we can interpret that the DTSP gives a higher Sharpe ratio compared to FTSP over the years. This finding coincides with the domestic strategy that allocated about 50% of its wealth in a fixed asset that has a consistent and secure return. The result is consistent with Mohd (2013), who claimed that the investment in MGS helped the fund to produce good dividends to members. Moreover, this asset is traditionally considered risk-free and guaranteed rather than higher return to the provident fund that exhibits higher volatility and risk (Asher, 1998). For the

Sortino ratio, as shown in Figure 7.5, the result is still consistent with the Sharpe ratio, where the DTSP dominates the FTSP.

Figures 7.6 and 7.7 show solvency and funding ratios for both DTSP and FTSP. The funding ratio and solvency ratio for DTSP and FTSP are comparable and for the last four years of planning horizon the difference between the solvency and funding ratios for both strategies is very small.

By looking at the overall analysis, the result of the investment strategy is not consistent. The fact that DTSP is a better strategy than FTSP with respect to Sharpe and Sortino ratios. Meanwhile, looking at the solvency ratio, FTSP is slightly better than DTSP because, with the same liability stream, the FTSP is expected to generate more expected terminal wealth.

7.8 Conclusion

In this chapter, two evaluations were conducted. First, we described the simulation method to assess the stability of the simulation models using in-sample analysis as well as the out-of-sample analysis. We employed descriptive statistics and histograms that represent the distribution of terminal wealth to analyse the results for all SP and ICC for both domestic and international investment strategies.

This chapter also evaluated the performance of the results using standard ratio analysis: Sharpe ratio, Sortino ratio, solvency ratio and funding ratio, as well as standard deviation of return. Then, the decision strategies proposed in this study were evaluated and compared. Based on the objective of maximizing the expected terminal wealth, international investment strategy outperforms the domestic model using TSP. It suggests that the EPF has more diversification benefit if it expands its assets on international investment. This finding is in line with the finding from Pflug (1999) who promoted international diversification for the EPF for India and Pakistan.

Chapter 8: Conclusion, Policy Implication and Future Directions

8.1 Results discussion and research limitations

As the number of older population increases in Malaysia, the need for Malaysia to review its pension system arises on improving the existing pension system performance. The greatest concern of pension performance motivated by the increase of longevity, decrease in fertility rate as well as low investment returns environment placed pension system issue as a high priority in government agenda. Furthermore, financial support from extended family members for elderly affected as a result of urbanization, job factors, and demographic changes. Mohd et. al. (2010) in their study highlighted the major role of the extended family as an intergenerational transfer of income to the older generation. The weakening of this extended family places pressure on the government to provide a massive amount of social expenditure for the elderly to support existing pension provisions.

The present study considers three major concerns which motivate us to conduct this research. Firstly, the ability of current pension system to provide inclusive coverage for all workforce; the second concern is related to the capability of current pension systems to provide adequate pension benefits to its members; and the final issue is related to the performance of the EPF from the perspective of investment strategy which will influence adequacy and sustainability of the system. In order to analyse the performance of the current pension system, we used descriptive and documentation analysis. The documentation analysis has been useful in shaping our understanding of the development of pension practices across the world, including factors that triggered pension reforms and to understand root problem of pension system by providing historical insight into the system's development worldwide as well as providing supplementary research data from various sources of research and government reports. The following paragraphs review the findings of Chapter 2, evaluating the issue of Malaysia's pension system. In addition to analysing the current performance of Malaysia's pension system, development and experiences from both developed and developing countries were studied and compared. Then, based on experiences from both nations, lessons were taken as a cornerstone for Malaysia to develop a decent pension system that may at least maintain the standard of living of pensioners during their retirement period. Below are the potential reforms of initiatives can be considered by the government to prepare the country for population ageing:

- **The introduction of multi-pillar pension benefit**: Single-tier pension systems are believed to be insufficient to provide adequate savings for their citizens. In addition to the introduction of a zero pillar scheme, the introduction of voluntarily pension scheme, as a third pillar of the World Bank design, is essential to encourage informal worker participate in a pension system. For the case of Malaysia, only 53 percent of the labour force are covered by formal scheme. We believe that the initiative taken by the government to introduce private retirement scheme (PRS) in 2012, as a voluntary supplement to savings for both employed and self-employed, is a good agenda to prepare future retiree with a good retirement saving.

- **Increase retirement age for the formal private labour force**: At current practise, the EPF member is allowed to withdraw full pension benefit at age 55. However, for the government servant, the statutory retirement age is 60 years old. Thus, the consideration to increase the age that can make full withdrawal from 56 to 60 years old, will minimise the potential of "income lost" after retirement among older people.

- **Financial awareness concern**: Hu and Stewart (2009) suggest that financial literacy and financial knowledge are important to raise public awareness of pension knowledge. This awareness will encourage informal workers to participate in voluntarily pension scheme.

- **Considering annuity-based approach for the EPF members**: Currently, most of the EPF members prefer to receive their benefits in lump sum amount. However, as implemented in the CPF in Singapore, in addition to lump sum payment, some portion of the monthly contribution is allocated for annuity. Thus, during retirement, members will receive lump sum and monthly premium from pension annuity. This will ensure that EPF member will receive continuous benefit after retirement.

This research confirms that longevity, fertility rate as well as economic uncertainty matters for Malaysia's pension system. This first question aids on rethinking of pension reform for Malaysia. Based on the documentation analysis, we find that there are two key problems faced by Malaysia's pension system. First is the coverage issue. As discussed by Holzmann (2015), coverage refers to the number of employed covered by the system and types of benefits covered in the system. Types of employment covered under the formal pension system is relatively lower than other countries. This was contributed by the number of informal workers. Asher (2012) highlighted that more than 2.7 million work force in 2009 under self-employed workers with no specific scheme targeted for them. Initiatives undertaken by the government to introduce a voluntary private retirement scheme (PRS) are a good step to prepare the nation towards an ageing population. Even tax incentives given to the members, the number of informal workers involved in this scheme is still low. The low participation of self-employed workforce in the voluntary pension scheme is a common problem faced not only by developing countries but also by developed countries. Without a proper pension saving and lower participation from this group, future older generations are likely exposed to poverty during retirement age. In response to this, financial knowledge is important to encourage workers in the informal sector to participate in this scheme.

Another perspective of coverage issue is benefits provided by the scheme. The benefits offered by pension schemes have positive impact to improve pension adequacy amongst pensions members upon retirement. We find that coverage offered by both the public pension scheme and the EPF are different. For the public pension system, which applies a defined benefit scheme, it offers annuity benefits as well as a health benefit to its eligible members. Not just that, this scheme does not require the member to contribute to the pension system. Thus, this scheme does not affect the disposable income of its members. Meanwhile, the EPF is designed specifically for normal private workers. This scheme requires both employee and employer to contribute a pre-determined statutory percentage of monthly salary into the EPF. This saving is then managed by the EPF by investing it in the financial market. It tells us that the benefit of the EPF members is determined by the contribution and investment return. Additionally, this scheme does not cover health benefits. This means that under the

EPF scheme, employees are exposed to inflation, interest rates, and longevity risks. As a result, these risks raise the adequacy issue among the EPF's members because caring for an aging population requires more financial support, primarily for health care thus lead the older group to experience high poverty incidence due to inadequate saving and increase in lifespan. In response to lack of benefits offered by EPF, this study suggests the government to review the EPF policy to ensure members maintain the standard of living during accumulation and decumulation periods.

The second key issue to be highlighted for the Malaysia Government is the adequacy of the pension system to provide a decent pension benefit to its members. With inadequate pension savings, the government of Malaysia is exposed to providing more social expenses for the ageing population. In studying this concern, it is identified that there are three major factors that are contributing to adequacy problem. Firstly, Suhaimi and Norma (2013) highlighted that inadequate pension saving among the EPF members is contributed by low average household income. This will affect the amount of monthly contribution for pension saving. Therefore, it is important to ensure that the government play the role by providing social assistance for the retiree who have low retirement income to prepare future retirees with a sustainable standard of living. In granting adequate pension saving, we also suggest the government to consider increasing retirement age for the EPF members from 56 to 60 years old which is in line with the statutory retirement age for the public service scheme. The second factor contributed to inadequate pension saving among EPF's members upon retirement is pre-retirement withdrawal provision. Currently, the EPF plays multifunction roles namely as pension preparation and saving unit. Under the EPF Act, members are allowed to withdraw up to 30 % of total saving (allocated in Account II) to purchase the house, pay for education, performing Hajj etc. This provision, however, reduces the amount of final savings thus lead inadequate saving. Lastly, Mohd (2009) argued that low investment returns influence pension adequacy for the EPF. This implies that an efficient fund managers managing a members' wealth are crucial to gain higher expected returns so that can be channelled into the individual's account for their saving. The greatest concern with investment returns is related to assets allocation decision, investment management, and diversification opportunities because they improve investment performance. Since the key performance of a pension system is an investment strategy, the second question raised in this thesis is on modelling the investment strategy for the EPF. Using stochastic modelling with *ex-ante* risk constraints, this study compared the performance of the investment strategy without and with international equity. Investment strategy results has been discussed in Chapter 5, 6 and 7 whereby the study finds that incorporating international assets in an investment strategy increases expected terminal wealth.

We conclude that ex-ante constraints tend to decrease the gain of stochastic investment strategy. Removing the inventory constraint by allowing investing in the international equity increases the expected terminal wealth. However, when the ICC constraint introduced, it adversely affects the fund manager's objective thus reducing the wealth benefit from the investment strategy. On average, the impact of ICC constraint reduced the gain from dynamic investment by 0.08% for domestic strategy and 0.8% for the international strategy. Ergo, in terms of maximizing the objective function, the following conclusions are made:

1. Limitation of diversifying wealth towards international market tends to decrease the gain from investment strategy. As a result, this also may affect the welfare of the EPF's members through dividend distributed to members' account. International investment diversification benefits have been discussed in the prior studies where the finding of the studies support that international diversification tends to increase pension fund performance. This finding is in line with Silva and de Oliveira (2011) who investigate the role of international diversification in the Brazilian pension system. Using a static mean-variance framework, the study compares the investment strategy with and without asset holding limits. The finding shows that investment strategy beyond the regulatory limit will increase the efficiency of asset allocation; and with allocation restriction, it restricts efficient frontiers. In addition, Pfau (2009) found that incorporating international assets tends to improve the sustainability of the Pakistan pension system, as well as increase the expected return and decreasing volatility.

2. The role of ICC constraint as a preventive measure inversely affect fund manager's aim which is to maximize terminal wealth for both domestic and international model. However, this constraint tends to decrease the manager's

risk by ensuring that the fund is not underfunded or shortage at the short run. This will help the fund from borrowing to fulfil its obligation.

Based on the first stage of ALM model, it is about 50% of wealth (for all dividend growths) was allocated in fixed income assets i.e. Malaysia Government bond with maturity 10 and 1 years. While in terms of international assets, more wealth was allocated in Japan and Singapore Equity compared to investing in American Equity. Overall, all empirical work indicates that when international equity is included in the model, it increases the performance of the investment strategy. It should be expected that international assets can maximize investment return; therefore, increasing the possibility of higher dividends can be distributed to the EPF's members, thus reducing the issue of inadequate pension savings among EPF members.

The findings of this study may be limited by the following ways. With respect to our suggested reforms (in Chapter 2), the economic and social impacts of those reforms are not quantitatively discussed in this study. The impact of pension reforms vary across countries. Therefore, Bielecki et. al. (2015) argue that overlapping generation (OLG) model has widely been used to gauge the impact of the implemented or potential reforms on both the welfare and macroeconomic factors. Using this quantitative method, we are able to measure the effectiveness of our reform proposals.

For investment performance, our data are subjected to limits of the data availability. Firstly, this study relied primarily on limited available EPF annual report and the data reported were aggregate data instead of individual members' data. Blake, Wright and Zhang (2014) stressed on the contribution of stochastic "*lifestyling*" strategy to design an optimal investment strategy during accumulation phase. According to this strategy, risk preference in asset allocation strategy is age-dependent where the optimal allocation in equity is initially very high and continuously declines upon retirement. With respect to this limitation, this study is conducted to assess the EPF's investment performance based on the aggregate performance of members rather than individual age performance.

There is also limit in our model where we ignore the implication of global economic performance. Siu (2011) suggested that economic environment influence investment strategy directly and indirectly through inflation, economic growth, share prices as well as salary level. Therefore, taking into account the effect of those factors may influence our findings.

8.2 Novelty and Contribution

This thesis provides several contributions to the literature. Firstly, a comprehensive documentation analysis that gives a greater understanding of Malaysia's pension system performance and future direction of the system towards preparing the nation for an ageing population. The analysis provided an insightful and deep picture of Malaysia's pension system and pension development from developed and developing countries experience. We compared the performance and development of pension system practices in both developed and developing countries and then suggested the potential reform may be applied to Malaysia in order to develop a decent pension system.

Secondly, this study discussed and built future asset and liability streams specifically for the Malaysia EPF. We applied stochastic modelling to develop asset returns scenarios and actuarial techniques to develop a future population model based on relevant data to the EPF such as Malaysia lifetable, retirement age and retirement rate.

Finally, we applied a two-stage stochastic programming (TSP) model to analyse investment strategy for the EPF. However, in this thesis, we extend a well-established TSP study for the EPF done by Hussin (2012) considering alternative international assets for the EPF context. Here, we provided new evidence to EPF's investment strategy on the brand effect of alternative investment strategies.

Based on these three contributions, the study may have a positive impact from these three perspectives:

- Members of the EPF: One of the key factors to boost pension benefits is through effective investment strategy. Using stochastic modelling, this study compared the optimal pension investment-strategy with and without international diversification. With several alternative investment strategies, this study suggested an optimal investment strategy that can maximise return to the EPF's members thus boost pension benefits.

- The researchers: the accumulation of knowledge on how to provide a viable and sustainable pension scheme in emerging countries for members over their lifetime. Moreover, the model used in this study can be extended and applied to other institutional investor cases such as bank or university endowment in Malaysia.

- Government: from a policy implication point of view, this thesis may become a "blueprint" or reference for the government to develop a more decent pension system based on experience from developed and developing countries' practices. From an economic viewpoint, an optimal investment strategy will increase pension benefits to the future retirees, thus reducing government financial support on welfare or social networking expenses.

8.3 Further Research Directions

What are significant topics for future research in this field? First, this research can be extended by analysing the impact of alternative investment—mostly hedge fund, venture capital and Islamic instrument that may provide a new source for diversification benefits. From the modelling perspective, there is a need to run other alternative methods for a scenario generation model, especially for the population model. Instead of using a deterministic population model, the future study may apply a stochastic population model in the SP decision strategy.

Moreover, it would be interesting to extend the analysis by considering the relationship between economic performance and investment strategy for the EPF. Siu (2011) argues that economic performance over a long period of time influences prices of ordinary shares, the interest rate on the fixed asset, as well as influencing pension liability through inflation risk. Meanwhile, from the liability perspective, inflation affects ALM analysis through the indirect relationship between inflation and salary. Future research may also consider the fact that the results of pension reforms are not consistent and its impact on social and macroeconomic vary across countries. In Chapter 2, we identified some areas of reforms proposal could be considered in preparing the nation with the increase of elderly group. We need a better understanding of how these reforms would effectively minimise the impact of population aging and economic uncertainty. Thus, in order to develop a better conclusion of pension reforms impacts, the quantitative analysis should be considered for further investigation.

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Appendices

A.1 The ALM Model

This appendix includes the complete mathematical programming code for AMPLDeV which has been used in DTSP and FTSP.

```
param k
param tbuy
param tsell
param NS
param NA
param NT


#SETS
set assets;
set tp;

#SCENARIO
set scen=1..NS;
tree theTree:= twostage;

#RANDOM PARAMETERS
param return{ assets,tp, scen};
param b{t in tp, s in scen} := return[1,t,s] -0.05;
param c{t in tp, s in scen} := return[1,t,s] +0.05;

#PROBABILITIES
param Prob{scen}:=1/NS;

#PARAMETERS : VECTORS
param liabilities{tp};
param initialholdings{assets} ;
param salary{tp};
param preretirement{tp};
param lowbound {assets};
param upperbound {assets};

#VARIABLES
var amounthold{a in assets, t in tp, s in scen } >=0,
suffix stage if (t=1) then 1 else 2;
var amountbuy{ a in assets, t in tp, s in scen } >=0,
suffix stage if (t=1) then 1 else 2;
var amountsell{ a in assets, t in tp, s in scen } >=0,
suffix stage if (t=1) then 1 else 2;
var marketvalue{t in tp, s in scen} >=0, suffix stage if
(t=1) then 1 else 2;
```

```
var assetvalue{t in tp, s in scen}>=0, suffix stage if
(t=1) then 1 else 2;
var borrow{t in tp,s in scen}>=0, suffix stage if (t=1)
then 1 else 2;
var lend{t in tp,s in scen}>=0, suffix stage if (t=1)
then 1 else 2;
var expborrow {t in tp}>=0, suffix stage if (t=1) then 1
else 2;
var expecmktval{t in tp}>=0, suffix stage if (t=1) then 1
else 2;
var expecliab{t in tp}>=0, suffix stage if (t=1) then 1
else 2;

#OBJECTIVE
maximize wealth:sum{s in scen} marketvalue[NT,s]*Prob[s];

subject to
asetmarketvalue{s in scen}:
     marketvalue[1,s]=sum{a in assets}amounthold[a,1,s];

assetmarketvalue{t in 2..NT, s in scen}:
     marketvalue[t,s]=sum{a in
assets}amounthold[a,t,s]+(1+b[t,s])*lend[t-1,s]-borrow[t-
1,s]*(1+c[t,s]);


asetvalu1{t in tp,s in scen}:
     assetvalue[t,s]=sum {a in assets} amounthold[a,t,s];


assetholdings1{a in assets, s in scen}:
     amounthold[a,1,s]=initialholdings[a]+amountbuy[a,1,s
]- amountsell[a,1,s];

assetholdings2{a in assets,t in 2..NT, s in scen }:
     amounthold[a,t,s]=amounthold[a, t-
1,s]*(1+return[a,t,s])+amountbuy[a,t,s]-
amountsell[a,t,s];

cashbalance{s in scen}:
     sum{a in assets} amountbuy [a,1,s]*tbuy+lend[1,s]+
liabilities[1] +preretirement[1]=sum {a in
     assets}amountsell[a,1,s]*tsell+ (k*salary[1])
+borrow[1,s];
cashbalances{t in 2..44, s in scen}:
     sum{a in assets} amountbuy [a,t,s]*tbuy+
liabilities[t]+preretirement[t]+lend[t,s]-
(1+b[t,s])*lend[t-1,s]=sum {a in
     assets}amountsell[a,t,s]*tsell+(k*salary[t])+borrow[
t,s]-(1+c[t,s])*borrow[t-1,s];
cashbalancess{s in scen}:
```

```
     sum{a in assets} amountbuy [a,45,s]*tbuy+
liabilities[45] +preretirement[45] -
(1+b[45,s])*lend[44,s]=sum {a in
     assets}amountsell[a,45,s]*tsell+ (k*salary[45])-
(1+c[45,s])*borrow[44,s];


shortsaleconstraint{ a in assets,  s in scen}:
     amountsell[a,1,s]<=initialholdings[a];

shortsaleconstraints{ a in assets, t in 2..NT,s in scen}:
     amountsell[a,t,s]<=amounthold[a,t-1,s];

boundconstraints{a in assets, t in tp, s in scen}:
     marketvalue[t,s]*upperbound[a]>=amounthold[a,t,s];

boundconstraints2{a in assets, t in tp, s in scen}:
     amounthold[a,t,s]>=marketvalue[t,s]*lowbound[a];


# Non anticipativity constraints
NA1{a in assets, s in scen}:
     amounthold[a, 1, 1] = amounthold[a,1,s];
NA2{a in assets, s in scen}:
     amountbuy[a, 1, 1] = amountbuy[a,1,s];
NA3{a in assets, s in scen}:
     amountsell[a, 1, 1] = amountsell[a,1,s];

pmv{t in tp}:
     expecmktval[t]=sum{s in
scen}marketvalue[t,s]*Prob[s];

# Definition of expectations
epbr{t in tp}: expborrow [t]=sum{s in
scen}borrow[t,s]*Prob[s];

addinfo1{ t in tp}:
     expecliab[t]= liabilities[t]+preretirement[t]+sum{s
in scen}lend[t,s]*Prob[s];
```

A.2 The ALM Model with ICC Constraint

```
param k
param tbuy
param tsell
param NS
param NA
param NT
param gamma
param lamda


#SETS
set assets;
set tp;

#SCENARIO
set scen=1..NS;

#RANDOM PARAMETERS
param return{ assets,tp, scen};
param b{t in tp, s in scen} := return[1,t,s] -0.05;
param c{t in tp, s in scen} := return[1,t,s] +0.05;

#PROBABILITIES
param Prob{scen}:=1/NS;
tree theTree:= twostage;

#PARAMETERS : VECTORS
param liabilities{tp};
param initialholdings{assets} ;
param salary{tp};
param preretirement{tp};
param lowbound {assets};
param upperbound {assets};

#VARIABLES
var amounthold{a in assets, t in tp, s in scen } >=0,
suffix stage if (t=1) then 1 else 2;
var amountbuy{ a in assets, t in tp, s in scen } >=0,
suffix stage if (t=1) then 1 else 2;
var amountsell{ a in assets, t in tp, s in scen } >=0,
suffix stage if (t=1) then 1 else 2;
var marketvalue{t in tp, s in scen} >=0, suffix stage if
(t=1) then 1 else 2;
var assetvalue{t in tp, s in scen}>=0, suffix stage if
(t=1) then 1 else 2;
var borrow{t in tp,s in scen}>=0, suffix stage if (t=1)
then 1 else 2;
```

```
var lend{t in tp,s in scen}>=0, suffix stage if (t=1)
then 1 else 2;
var expborrow {t in tp}>=0, suffix stage if (t=1) then 1
else 2;
var shortage {t in tp, s in scen}>=0, suffix stage if
(t=1) then 1 else 2;
var expecliab{t in tp}>=0, suffix stage if (t=1) then 1
else 2;



#OBJECTIVE
maximize wealth:sum{s in scen} marketvalue[NT,s]*Prob[s];

subject to
asetmarketvalue{s in scen}:
     marketvalue[1,s]=sum{a in assets}amounthold[a,1,s];

assetmarketvalue{t in 2..NT, s in scen}:
     marketvalue[t,s]=sum{a in
assets}amounthold[a,t,s]+(1+b[t,s])*lend[t-1,s]-borrow[t-
1,s]*(1+c[t,s]);


asetvalu1{t in tp,s in scen}:
     assetvalue[t,s]=sum {a in assets} amounthold[a,t,s];


assetholdings1{a in assets, s in scen}:
     amounthold[a,1,s]=initialholdings[a]+amountbuy[a,1,s
]- amountsell[a,1,s];

assetholdings2{a in assets,t in 2..NT, s in scen }:
     amounthold[a,t,s]=amounthold[a, t-
1,s]*(1+return[a,t,s])+amountbuy[a,t,s]-
amountsell[a,t,s];

cashbalance{s in scen}:
     sum{a in assets} amountbuy [a,1,s]*tbuy+lend[1,s]+
liabilities[1] +preretirement[1]=sum {a in
     assets}amountsell[a,1,s]*tsell+ (k*salary[1])
+borrow[1,s];
cashbalances{t in 2..44, s in scen}:
     sum{a in assets} amountbuy [a,t,s]*tbuy+
liabilities[t]+preretirement[t]+lend[t,s]-
(1+b[t,s])*lend[t-1,s]=sum {a in
     assets}amountsell[a,t,s]*tsell+(k*salary[t])+borrow[
t,s]-(1+c[t,s])*borrow[t-1,s];
cashbalancess{s in scen}:
```

```
     sum{a in assets} amountbuy [a,45,s]*tbuy+
liabilities[45] +preretirement[45] -
(1+b[45,s])*lend[44,s]=sum {a in
     assets}amountsell[a,45,s]*tsell+ (k*salary[45])-
(1+c[45,s])*borrow[44,s];


shortsaleconstraint{ a in assets,  s in scen}:
     amountsell[a,1,s]<=initialholdings[a];

shortsaleconstraints{ a in assets, t in 2..NT,s in scen}:
     amountsell[a,t,s]<=amounthold[a,t-1,s];

boundconstraints{a in assets, t in tp, s in scen}:
     marketvalue[t,s]*upperbound[a]>=amounthold[a,t,s];

boundconstraints2{a in assets, t in tp, s in scen}:
     amounthold[a,t,s]>=marketvalue[t,s]*lowbound[a];


#ICC Constraint

c1{s in scen}:
shortage[1,s]>= -(sum{a in
assets}initialholdings[a]*(1+return[a,1,s])+k*salary[1])-
gamma*(preretirement[1]+liabilities[1]+sum{a in assets}
amountbuy [a,1,s]*tbuy+lend[1,s]);

c2{t in 2..NT,s in scen}:
   shortage [t,s]>=-(sum{a in assets}amounthold[a,t-
1,s]*(1+return[a,t,s])+k*salary[t])-
gamma*(preretirement[t]+liabilities[t]+sum{a in assets}
amountbuy [a,t,s]*tbuy+borrow[t,s]-(1+c[t,s])*borrow[t-
1,s]);

c3 {a in assets, s in scen} :
sum{s in scen} Prob[s]*shortage[1,s]<=lamda
*(preretirement[1]+liabilities[1]+sum{a in assets}
amountbuy [a,1,s]*tbuy+lend[1,s]);

c4{t in 2..NT,s in scen} :
   sum{s in scen} shortage[t,s]*Prob[s]<=lamda
*(preretirement[t]+liabilities[t]+sum{a in assets}
amountbuy [a,t,s]*tbuy+borrow[t,s]-(1+c[t,s])*borrow[t-
1,s]);

# Non anticipativity constraints
NA1{a in assets, s in scen}:
     amounthold[a, 1, 1] = amounthold[a,1,s];
NA2{a in assets, s in scen}:
     amountbuy[a, 1, 1] = amountbuy[a,1,s];
```

```
NA3{a in assets, s in scen}:
     amountsell[a, 1, 1] = amountsell[a,1,s];

# Definition of expectations
epbr{t in tp}: expborrow [t]=sum{s in
scen}borrow[t,s]*Prob[s];

 addinfo{s in scen}:
 expecliab[1]=preretirement[1]+liabilities[1]+lend[1,s];
 addinfo1{t in 2..NT,s in scen}:
    expecliab[t]=
preretirement[t]+liabilities[t]+(1+c[t,s])*borrow[t-1,s];
```

B.1 Average Salary by Age Group

Year 2014	Saving	Population	Average saving	% of average saving by age	Contribution	Contribution by age group	Average contribution (23%)	Monthly contribution	Wage
16-25	12,112,956,986	1,644,306	7366.607545	0.030272	57,178,000,000	1730900947	1,052.66	87.72	1000
26-30	37,207,307,993	1,337,610	27816.26034	0.092987		5316799583	3,974.85	331.24	1440.163
31-35	54,417,027,964	961,440	56599.50487	0.135997		7776010875	8,087.88	673.99	2930.391
36-40	70,067,775,543	772,644	90685.71754	0.17511		10012450238	12,958.69	1,079.89	4695.176
41-45	80,169,286,489	647,087	123892.5933	0.200355		11455922289	17,703.84	1,475.32	6414.433
46-50	80,635,726,589	542,427	148657.2877	0.201521		11522575016	21,242.63	1,770.22	7696.604
51-55	65,525,267,403	409,655	159952.3194	0.163758		9363341053	22,856.65	1,904.72	8281.395
Total	400,135,348,967	6,315,169	63360.98828	1		57178000000	9,054.07	754.51	3280.461

Note: Saving and population data were obtained from annual report 2014; total contribution in 2014 was obtained from BNM's monthly statistical bulletin; we consider minimum salary is RM1000.

C.1 Cholesky Decomposition for Eight Asset Classes

	MMI	MGS1	EQMAS	EQSIN	EQUSA	EQJAP	MGS10	PROP
MMI	0.0199	0	0	0	0	0	0	0
MGS1	0.014774	0.006303	0	0	0	0	0	0
EQMAS	-0.02769	0.014767	0.115526	0	0	0	0	0
EQSIN	-0.09096	-0.0186	0.236519	0.253956	0	0	0	0
EQUSA	0.076282	0.024274	-0.0794	-0.10464	0.165042	0	0	0
EQJAP	-0.00413	0.032358	0.017441	-0.01588	0.025126	0.119888	0	0
MGS10	0.011005	0.003714	0.000259	-0.00144	-0.00019	-0.00022	0.006392	0
PROP	0.030804	0.021243	0.00387	0.005704	0.006166	-0.02576	-0.02835	0.038406

Note: Asset classes consist of MMI, MGS1, EQMAS, EQJAP, EQSIN, EQUSA, MGS10, PROP