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Asset Allocation Decision for Malaysia's Dc Pension Scheme: Application of Two Stage Alm Model

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Abstract: **This study aims to analyze the strategic asset allocation and matching assets/liability problem in Malaysia's defined contribution (DC) pension scheme-Employees Provident Fund (EPF). Stochastic asset liability management (ALM) model is employed to solve the asset allocation decision where assets and liabilities are considered simultaneously in the decision strategy. We then extend the analysis by incorporating integrated chance constraints (ICC) to minimize the event of underfunding along the planning horizon. The results show that, in respect to asset holding constraints, the EPF tends to hold government security in their asset allocation strategy. Moreover, the ICC risk constraint limits the ability of fund to maximize the expected terminal wealth and tends to reduce the gains of our ALM model.**

Index Terms— **The EPF; defined contribution; asset-liability management; stochastic modelling.**

I. INTRODUCTION

With a complicated and more volatile financial market, investment strategy is becoming vital to determine the performance of the pension system. Looking at the nature, the EPF implements DC pension scheme where 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. A prudent investment plan is crucial for institutional investors like pension funds in order to gain public trust. [1] argues that the 90% performance of investment strategy is derived from investment performance, and the other 10% is from active investment management. Pension fund managers will deal with challenges in short and medium term investment strategy such as low-interest rate investment, continuous increase in longevity and decline in fertility rate. These uncertainties have increased the need of the fund manager to methodologically develop a sound asset allocation strategy.

The mean-variance (MV) model was introduced by Markowitz in 1956 based on a static model for portfolio construction. This model has provided the fundamental basis for portfolio analysis as well as broadly accepted model in finance. Economic complexity and financial uncertainties have limited the role of the MV model to solve the portfolio optimisation problem.[2] 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, [3] 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 MV model was extended, and stochastic modelling was introduced to overcome the shortage of the model; for example, [4], who consider liability factors in a MV framework with a single period model, or [5] and [6] 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 considered in modelling the ALM problem, such as ignoring transaction costs. 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 [7]. 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 [8]. Other successful ALM models and stochastic programming have been proven in the pension system [9-12] [13]. The stochastic model requires the uncertainties be approximated using an appropriate model. The quality of the scenario generation is essential as it influences the performance of the stochastic programming model [14]. We have proposed models of developing scenarios of future cash flows for the EPF and the scenarios generated are similar to [15]. However, this study differs in terms of data set used as well as actuarial method used to develop liability streams. Cash flow generation for a pension fund consists of five main models i.e. member (population), asset returns, salary model, pre-retirement withdrawal and retirement withdrawal model. From these models, 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, 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 objective of this study is to propose a stochastic ALM model 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 two stage ALM model. Then we extend the model by the inclusion of the integrated chance constraints (ICC) to restrict the underfunding event with high probability to occur. This study will analyse the impact of ICC risk measure in our ALM model.

II. METHODOLOGY

The model used in this study is adopted from [15]. However, this study differs in terms of data set used as well as acturial method used to develop liability streams.The objective of the model in this study is to maximize expected terminal wealth at the end of planning horizon i.e.,

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

The notations of variables, coefficient and parameters in the ALM model are as follows;

I = Index of asset classes i = 0,1, …, N
T = Time index t = 0,1, …, T
S = Index of scenarios s = 0,1, …, S
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
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
Lt = Liability to be paid at time t
Pt s = Probability of scenario s at time t
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

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 [14]. The important model constraints in this model are as follows:

Wealth constraints- This constraint displays the amount of wealth at time t. 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.

$$W_t = \sum_{i=1}^{I} x_{i,t} + Q_t(1+r^l) - O_t(1+r^b) \qquad t = 1, \ldots, T \qquad (2)$$

Asset holding constraints- It describes holdings, purchases and sales of each asset over the 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.

$$x_{i,1}^S = x_{i0} + B_{i,1}^S - S_{i,1}^S; \text{ t=1 while,}$$

$$x_{i,t}^S = x_{i,t-1}(1+r_{i,t}^S) + B_{i,t}^S - S_{i,t}^S; \text{ t}\geq \qquad (3)$$

Budget constraints- it constraints represent the cash inflow (revenue) and cash outflow (expenses) of the pension fund.

$$\sum_{i=1}^{I}(1+\alpha)B_{i,1}^{S}+Q_{1}^{S}+L_{1}^{S}=V_{1}^{S}+\sum_{i=1}^{I}(1-\alpha)S_{i,1}^{S}+O_{1}^{S} \quad ; t=1 \qquad (4)$$

$$\sum_{i=1}^{I}(1+\alpha)B_{i,t}^{S}+Q_{t}^{S}-(1+rl_{t}^{S})Q_{t-1}^{S}+L_{t}^{S}=V_{t}^{S}+\sum_{i=1}^{I}(1-\alpha)S_{i,t}^{S}+O_{1}^{S}-(1+rb_{t}^{S})O_{t-1}^{S}$$
$$; t=2 \le t \le T\text{-}1 \qquad (5)$$

$$\sum_{i=1}^{I}(1+\alpha)B_{i,t}-(1+rl_{t})Q_{t-1}+L_{t}=V_{t}+\sum_{i=1}^{I}(1-\alpha)S_{i,t}-(1+rb_{t}^{S})O_{t-1}^{S} ; t=T \qquad (6)$$

Short sale constraints- We do not allow short sale activities

$$S_{i,1}^{S} \le \sum_{s=1}^{S} x_{i,0} \qquad (7)$$

$$S_{i,t}^{S} \le x_{i,t-1}^{S} \qquad (8)$$

Portfolio constraints- it refers to the minimum and maximum limit of the assets that can be held at time *t* 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.

$$l_i H_t^S \le x_{i,t}^s \ge u_i H_t^S \qquad (9)$$

Non-anticipativity constraints- it 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. To fulfil the objective of this model, two-stage stochastic ALM model engaged several simulation model with regards to the future assets and liability streams. 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. In this study, we employ two-stage stochastic programming (TSP) for solving the ALM model. As an overview, the summary of our model are as follows:

Objectives: *to maximize expected terminal wealth*
Decision variables: *amount of assets hold, sold and bought*.
Decision constraints: *wealth constraints, asset holding constraints, budget constraints, short sales constraints, portfolio and non-anticipavity constraints.*
Risk management constraints: *integrated chance constraints (ICC)*
Simulation models: *asset returns, population model, pre-withdrawal, lump sum pension benefits, salary model.*

III.DATA

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. we consider the EPF will invest in five asset classes: stocks, government bonds, short term bonds, money market, and property. These assets' proxy is illustrated in Table 1.

TABLE 1: 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.

IV. EMPERICAL RESULTS

All numerical results were obtained using AMPLDev with CPLEX solver. According to the EPF Act 1991, the EPF compulsorily distributes a yearly dividend of 2.5%. We assume that liability will have various dividend growths of 2.5%, 4%, 5% and 6%. Thus, the result of this analysis will

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be analyzed based on different dividend growth. In this analysis, we analyze 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). 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. Table 2 illustrates the expected terminal wealth and 1st stage asset allocation for each asset class with various dividend growths. From Table 2, the EPF tend to hold MGS10 and MGS1. The result is consistent with [16], 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 [17].

TABLE 2: Expected terminal wealth and 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

Next, we extend our TSP model by incorporating another risk constraint i.e. integrated chance constraint (ICC). This constraint has been used by [18], [19], and [15]. 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 1 shows the expected terminal wealth of TSP by incorporating ICC with the value λ=0.05 and γ =1.10. While Figure 2 depicts asset allocation for the EPF. Based on Figure 2, 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.

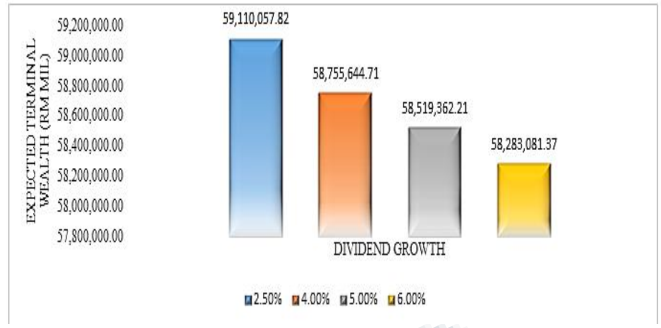

Figure 1: Expected terminal wealth and dividend growth with ICC risk constraint

Figure 2: 1st stage asset allocation for each asset class

V. CONCLUSION

In this paper, we attempt to analyse 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. Our results are encouraging for two reasons. Firstly, the influence of ex-ante risk constraints as a preventive action minimize the amount of fund shortage along the planning horizon. However, the effect of the inclusion of ICC in our model has limited the ability of the fund to maximise expected terminal wealth 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

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on the EPF to manage the fund which can generate higher return. As a return, 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. Thus, a prudent dividend decision is crucial in order to ensure the EPF retains its financial soundness.

REFERENCES

1. Asher, M.G., Pension reform, capital markets amd corporate governance in Malaysia. Journal of Financial Regulation and Compliance, 2000. 9(1): p. 30-37.

2. Papi, M. and S. Sbaraglia, Optimal asset–liability management with constraints: A dynamic programming approach. Applied Mathematics and Computation, 2006. 173(1): p. 306-349.

3. Huang, H.-C., Optimal Multiperiod Asset Allocation: Matching Assets to Liabilities in a Discrete Model. Journal of Risk and Insurance, 2010. 77(2): p. 451-472.

4. Sharpe, W.F. and L.G. Tint, Liabilities—A new approach. The journal of portfolio management, 1990. 16(2): p. 5-10.

5. Chiu, M.C. and D. Li, Asset and liability management under a continuous-time mean–variance optimization framework. Insurance: Mathematics and Economics, 2006. 39(3): p. 330-355.

6. Chiu, M.C. and H.Y. Wong, Mean–variance asset–liability management with asset correlation risk and insurance liabilities. Insurance: Mathematics and Economics, 2014. 59: p. 300-310.

7. Mitra, G. and E. Medova, Asset and liability management/liability-driven investment for pension funds. Journal of Asset Management, 2010. 11(2): p. 71-72.

8. Carino, D.R. and W.T. Ziemba, Formulation of the Russell-Yasuda Kasai Financial Planning Model. Operations Research, 1998. 46(4): p. 433-449.

9. Kouwenberg, R., Scenario generation and stochastic programming models for asset liability management. European Journal of Operational Research, 2001. 134(2): p. 279-292.

10. Kouwenberg, R. and S.A. Zenios, Chaper 6 - Stochastic programming models for asset liability management, in Handbook of Asset and Liability Management. 2008, North-Holland: San Diego. p. 253-303.

11. Dupačová, J. and J. Polívka, Asset-liability management for Czech pension funds using stochastic programming. Annals of Operations Research, 2009. 165(1): p. 5-28.

12. Hilli, P., et al., A stochastic programming model for asset liability management of a Finnish pension company. Annals of Operations Research, 2006. 152(1): p. 115.

13. Kosmidou, K. and C. Zopounidis, Bank asset liability management techniques: an overview, in Fuzzy Sets In Management, Economics And Marketing. 2001, World Scientific. p. 255-268.

14. Pflug, G. and A. Świętanowski, Dynamic asset allocation under uncertainty for pension fund management. Control and Cybernetics, 1999. 28: p. 755-777.

15. Hussin, S.A.S., Employees Provident Fund (EPF) Malaysia: generic models for asset and liability management under uncertainty, in Department of Mathematical Sciences. 2012, Brunel University.

16. Mohd, S. Provident Fund in Malaysia: Sustainability of Retirement Income Provision. in Proceedings of 3rd Asia-Pacific Business Reasearch Conference. 2013. Kuala Lumpur, Malaysia.

17. Asher, M.G., The Future of Retirement Protection in Southeast Asia. International Social Security Review, 1998. 51(1): p. 3-30.

18. Haneveld, W.K.K. and M.H. van der Vlerk, Integrated Chance Constraints: Reduced Forms and an Algorithm. Computational Management Science, 2006. 3(4): p. 245-269.

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19. Schwaiger, K., C. Lucas, and G. Mitra, Alternative decision models for liability-driven investment. Journal of Asset Management, 2010. 11(2): p. 178-193.