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A TACTICAL ASSET ALLOCATION MODEL FOR INSURANCE COMPANY

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ABSTRACT

In this article, we offer a mathematical model of asset allocation that considers asset and liability management in insurance companies. The SAA guides the investment asset allocation process, which contains regulations regarding permitted investment instruments and the maximum allocation weight placed on the permitted investment instruments. Then it is formulated in the TAA in the form of tactics to determine the weight of the proper asset allocation placed on permitted investment instruments which we call the tactical asset allocation model (TAAM). TAAM consists of a reverse model shown to fulfill insurance companies' liabilities and a linear programming model (LPM) shown to optimize insurance companies' investment income. We show that the tactical asset allocation model is beneficial in increasing the confidence of investment managers in making decisions to determine the amount of

weight allocation for investment assets in a transparent and accountable manner, and the methodology can meet the ideal challenges in every investment decision between risk, return, and the company's liquidity capability. We computationally illustrate the robustness of the tactical asset allocation model using particular numerical examples

Keywords

Contribution/Originality: This study provides alternative decision-making for insurance industries and investment managers in determining the weight of the allocation of investment assets into the selected portfolio, whereas other researchers have never conducted this study.

INTRODUCTION

Social insurance in Indonesia is held on a national scale which the government established to provide social welfare for all people, and its participation is mandatory. Social insurance aims to provide essential protection to the entire community with minimal, cheap, and affordable premiums. That way, people can still get compensation if they experience an unexpected event such as an accident or illness. Just like insurance in general, a premium must be paid. So, participants, in this case, the public, must deposit premiums following applicable regulations. However, the mechanism is arranged so that it is lightening. Because the focus is on protecting and improving the community's welfare as much as possible, the premiums or contributions do not burden the participants.

The principle is to prioritize the values of gotong-royong, cooperation, and cross-subsidies to obtain optimal benefits. The company manages the premium collected with a safe and prudent principle in investment portfolio management. In recent years, social insurance has been in the news as several companies face the prospect of bankruptcy due to being severely underfunded and unable to pay claims. As a result, there is a need to develop models that take into account the projected cash flows of companies and manage investment portfolios appropriately so that they can meet the needs or obligations of the company to participants and optimize benefits to the company.

Insurance management is an example of asset and liability management[1], where the objective of the decision maker is to manage the capital invested into a set of assets to meet obligations at the minimum possible cost and optimize the benefits to the company. Corlosquet-Habart et al. (2015) show that management of the company's assets and liabilities is designed to achieve financial objectives for a certain level of risk and under predetermined limits. Asset and liability management has become a sophisticated modeling tool and facilitates the generation of relevant cash flow projections, business-centered accounting standards, and regular financial communications.

[1] Corlosquet-Habart et al. (2015) in recent years, the technique known as asset and liability management (ALM) has enjoyed remarkable popularity. Initially pioneered by English-speaking financial institutions during the 1970s as an actuarial and cash flow matching technique, ALM has grown into an essential framework for banks and insurance companies.

Asset and liability management results in recommendations on asset allocation (see, for instance, Corlosquet-Habart et al. (2015)). Fabozzi et al. (2011) show that asset allocation determines the portion or gives a certain weight to each investment instrument in the portfolio to balance risk and return. Asset allocation decisions include strategic asset allocation (SAA) and tactical asset allocation (TAA). SAA decisions reflect long-term investment goals and policies and determine the optimal allocation proportion of each asset class (bonds, equity, alternative investments) in the initial timeframe, which is the essential decision that controls total investment risk and meets investment return objectives. This topic has been widely studied (Koivu et al. 2009; Heinke 2021; Atkinson et al. 2019; Bisetti et al. 2017; Dächert et al. 2021; Zhou and Lao 2011; Al-Debei et al., 2021).

While TAA is a rebalancing of strategic asset portfolios to increase excess returns in the investment term of the plan by locking or reducing short and medium-term investment losses based on ensuring the implementation of long-term investment objectives. This topic has been widely studied (Høyland and Wallace 2008; Ho et al. 2010; Louton et al. 2015; Kim and Kang 2015; Cloutier et al. 2017; Ardia et al. 2019; Yang et al. 2019; Bellu and Conversano 2020; Al-masaeed et al., 2021). The literature shows that asset allocation decisions, especially SAA decisions, have a significant role in the investment management process, both qualitative and quantitative analysis (Al-Shammari, 2021).

This research focuses on TAA decisions that consider the management of insurance companies' assets and liabilities by placing funds in permitted investment instruments and the weight of their allocation on them. In fulfilling a particular insurance company's liability, the funding source must also be sure to achieve the company's security. So the first investment fund is placed in a fixed-income investment portfolio. A fixed-income portfolio is an investment portfolio that is certain to provide (certain) income, and the nominal amount of funds invested will not decrease in value (see, for example, Stewart et al. 2019; Fabozzi and Markowitz 2011; Hwang et al. 2013; Andrino and Leal 2018; Schwaiger and Mitra 2010; Consiglio et al. 2010; Kritzman and Thomas 2004). Furthermore, if there are remaining investment funds, these funds can be placed in financial investment instruments that are traded with high returns but with high risks. The goal is to optimize investment returns or benefits to companies sourced from uncertain funding (see, for example, O, Jangmin, et al. 2005; Chorafas 2004; Chen et al. 2014), which we call a non-fixed-income portfolio.

Linear programming has an excellent track record of achieving profit optimization for revenue maximization, operational efficiency, and cost savings. Moreover, Anderson et al. (2013) argue that investment managers can use linear programs and extensions to determine investments. Dantzig and Thapa (2003) show that linear programming is a mathematical optimization tool used to solve a wide variety of decision-making problems requiring the allocation of scarce resources. To optimize the return on investment using a linear programming procedure using variables and parameters linked together by algebraic expressions

reflecting the decision maker's goal for maximum profit and specific constraints on the types of alternatives to be considered. The algebraic procedure of the simplex method works on all linear programs, regardless of the number of variables. Moreover, several commercial solvers, such as Frontline System (supplier of EXCEL SOLVER), can solve problems of thousands of variables and ten times the number of constraints in numerical example (see, for instance, Slater and Curwin 2013; Brandimarte 2011). We expect the tactical asset allocation model to become the method of choice for solving large-scale insurance companies' problems.

The rest of the article is organized as follows. In the "strategic asset allocation (SAA)" section, we present the investment limits set by the regulator in managing the investment portfolio of insurance companies. In the section "tactical asset allocation model (TAAM)," we show how a TAA strategy takes into account the management of insurance companies assets and liabilities by placing funds in permitted investment instruments and the weight of their allocation on investment instruments allowed in the SAA. In the section "numerical example", we report the results of our numerical experiments with investment assets and describe the robustness of the TAAM solution. In the "Concluding remarks" section, we include some concluding remarks.

Strategic Asset Allocation (SAA or Constraints)

Yu et al. (2010) show that SAA decision reflects long-term investment objectives and policy as a constraint determines to optimize allocation proportions of each asset class (bonds, equities, alternative investment) in the initial term, which is the most critical decision that controls total investment risk and meets investment return objectives. Regulations for insurance companies vary from country to country. SAA provides guidelines for placing investment funds in a healthy portfolio to support the company's operations for investment managers. SAA provides guidelines for insurance investment managers to make two decisions, namely (1) placing investment assets in permitted investment instruments and (2) allocating investment assets with an ideal allocation weight and not exceeding the maximum allocation weight in the legal investment instruments.

Tactical Asset Allocation Model (TAAM)

The insurance company's investment policy, in general, is up to the SAA that the regulator has set. In its tactical, technical implementation, it does not have a tactical mathematical model to determine the amount of weight for allocating investment funds into each portfolio. In this section, we present a TAAM-based framework on investment portfolios for insurance companies. In managing their investment portfolios, insurance companies must be based on fulfilling the company's obligations and increasing optimal investment returns.

To achieve this target, it is necessary to have tactics and formulas or mathematical models to determine the allocation of assets in an investment

portfolio that is more ideal and realistic. The SAA guides the investment asset allocation process, which contains regulations regarding permitted investment instruments and the maximum allocation weight placed on the permitted investment instruments. Then it is formulated in the TAA in the form of tactics/tactics to determine the weight of the ideal asset allocation placed on permitted investment instruments which we call the tactical asset allocation model (TAAM). TAAM consists of (1) reverse model and (2) linear programming model (LPM).

Reverse Model / Class division on portfolio

The nature of the core business of an insurance company is to manage risk with guaranteed coverage, and at any time a claim occurs. Therefore, the management of investment assets is based on the principle of prioritizing security with optimum yields and easy disbursement. So we set a "reverse model" (which we created) in which the weight allocation of investment assets in the investment portfolio is divided into two portfolio classes: the first is allocated to the fixed-income investment portfolio, and the second is to the non-fixed-income investment portfolio.

The amount of investment asset allocation in a fixed-income investment portfolio must at least be able to generate returns that can cover cash flow needs or the estimated Cash Flow deficit so that the proportion of determination of the amount of weight allocation for investment assets on fixed-income instruments can be determined dynamically where the amount of the results in order to meet the needs liquidity funds are as follows;

If the company is new, then it is to cover the total cash out of its operations $\sum_{i=1}^{n} COF$, covered first by cash inflows in the form of premiums $\sum_{i=1}^{n} \mathrm{P}\text{-}1$, the total cash out of operations is always more significant than the total premium as the first cash in from a newly established insurance company so that the cash flow deficit is met at a minimum by the investment returns of a fixed income investment portfolio r_{p} $(f\dot{\imath})$ with allocation weight W_{p} $(f\dot{\imath})$ at the expected benchmark interest rate $\mathcal{E}_{\mathrm{r}}$. Then the formula for determining the weight of the fixed income investment portfolio allocation is as follows;

$$\mathrm{W}_{\mathrm{p}}\,(f\dot{\imath}) \;=\; \left(\frac{(\sum_{i=1}^{n} \mathrm{P} \;-1) \;-\; (\sum_{i=1}^{n} COF)}{\mathcal{E}r}\right)$$

If there are remaining investment assets, they can be placed in a non-fixed-income investment portfolio whose investment instruments have high returns with high risk to optimize the investment portfolio's return performance. Therefore, the formula for determining the weight of the allocation of a non-fixed-income investment portfolio is as follows;

$$\mathrm{W}_{\mathrm{p}}\,(\mathfrak{n}f\dot{\imath}) = \;\; \mathcal{N}I - \left(\frac{(\sum_{i=1}^{n} \mathrm{P} \;-1) \;-\; (\sum_{i=1}^{n} COF)}{\mathcal{E}r}\right)$$

If the company has been established, then to cover cash out of operations $\sum_{i=1}^{n} COF$, can be funded from cash inflows in the form of investment returns from the previous period's fixed-income investment portfolio r_{p} $(f\dot{\imath})$ – 1 so that the cash

flow deficit is met at a minimum by the investment returns of a fixed-income investment portfolio r_{p} (fi) with allocation weight W_{p} (fi) at the expected benchmark interest rate $\mathcal{E}_{\mathrm{r}}$. Then the formula for determining the weight of the fixed income investment portfolio allocation is as follows;

$$\mathrm{W}_{\mathrm{p}}\,(f\mathrm{i}) \;=\; \left(\frac{(r_{\mathrm{p}}\,(f\mathrm{i})-1)\;-\;(\sum_{i=1}^{n} COF)}{\mathcal{E}r}\right)$$

If there are remaining investment assets, they can be placed in a non-fixed-income investment portfolio whose investment instruments have high returns with high risk to optimize the investment portfolio's return performance. Therefore, the formula for determining the weight of the allocation of a non-fixed-income investment portfolio is as follows;

$$\mathrm{W}_{\mathrm{p}}\,(\mathfrak{n}f\mathrm{i}) = \;\; \mathfrak{N}I - \left(\frac{(r_{\mathrm{p}}\,(f\mathrm{i})-1)\;-(\sum_{i=1}^{n} COF)}{\mathcal{E}r}\right)$$

The next step is determining the weight of the permitted allocated assets per investment instrument, namely (1) in the fixed-income investment portfolio. It is determined based on the rate of return, market absorption, and inflation. Then (2) the non-fixed-income investment portfolio to optimize the performance of the investment portfolio returns can be calculated using a linear programming model.

Linear Programming Model / Determination of Individual Portfolio Allocation

This study's instrument for non-fixed-income investment is investment placement in traded investment instruments. These instruments have a high-risk parallel/linear with the returns to be obtained. For this reason, determining the allocation weight per investment instrument is crucial in producing optimal returns. Determination of the amount of weight allocation per investment instrument with an LPM will provide a more precise and scientifically justified mix of weights per investment instrument for the portfolio with the most optimum results. In addition, it can minimize the risk of loss due to excess weight allocation on instruments experiencing potential loss. Dantzig and Thapa (2003) explain that linear programming is a mathematical optimization tool used to solve a wide variety of decision-making problems requiring the allocation of scarce resources. Furthermore, portfolio managers can use linear programming and its extensions to determine what investments to make.

Mathematical formulations use variables and parameters linked together by algebraic expressions that reflect the decision maker's goals and specific constraints on the types of alternatives to be considered. Decision goal $\mathrm{Z}(\mathfrak{n}f\mathrm{i})$ was obtained from the total yield between the expected interest rate per instrument Ern and asset allocation weights per instrument $\mathrm{W}n$. The purpose of the decision will be achieved after meeting the existing limitations, namely (1) the weight of asset allocation per instrument ≤ of the maximum allocation weight per instrument allowed, (2) the total weight of asset allocation per instrument $\sum_{\mathfrak{Q}=1}^{n}\mathrm{W}n \leq$ the weight of the allocation of a non-fixed-income investment portfolio $\mathrm{W}_{\mathrm{p}}\,(\mathfrak{n}f\mathrm{i})$, and (3) total investment risk per investment instrument with weighted allocation

$\sum_{\tilde{\omega}=1}^{n} (\sigma n \; x \, Wn) \leq$ fifty percent (50%) is defined as the probability of success or failure in trading a variable income investment portfolio. In the next step, the linear programming model will work using the simplex method algebraic procedure, regardless of the number of variables. With the help of a digital computer, namely an excel solver, the simplex method can be used to optimize income on a non-fixed-income investment portfolio with existing limitations.

Numerical Example and Discussion

In this section, we present a figure or illustration of a specific example in applying the TAAM consisting of (1) reverse model taking into account the nature of the insurance company's core business, which is to manage risk with guaranteed coverage and at any time a claim occurs. Investment fund management prioritizes security with optimum yields and easy disbursement. So the determination of the weight of the allocation of investment assets in the investment portfolio is divided into two categories: the first is allocated in the form of fixed-income investment, and the second is in the form of non-fixed-income investment formulated with a linear programming model. That is, determining the weight of the allocation becomes very important to produce optimal returns.

Regulatory Limits

We assume for a numerical example that the SAA contains guidelines for the placement of investment funds in permitted investment instruments and the maximum weight allocation for allowed instruments in the investment portfolio, as shown in Figure 1.

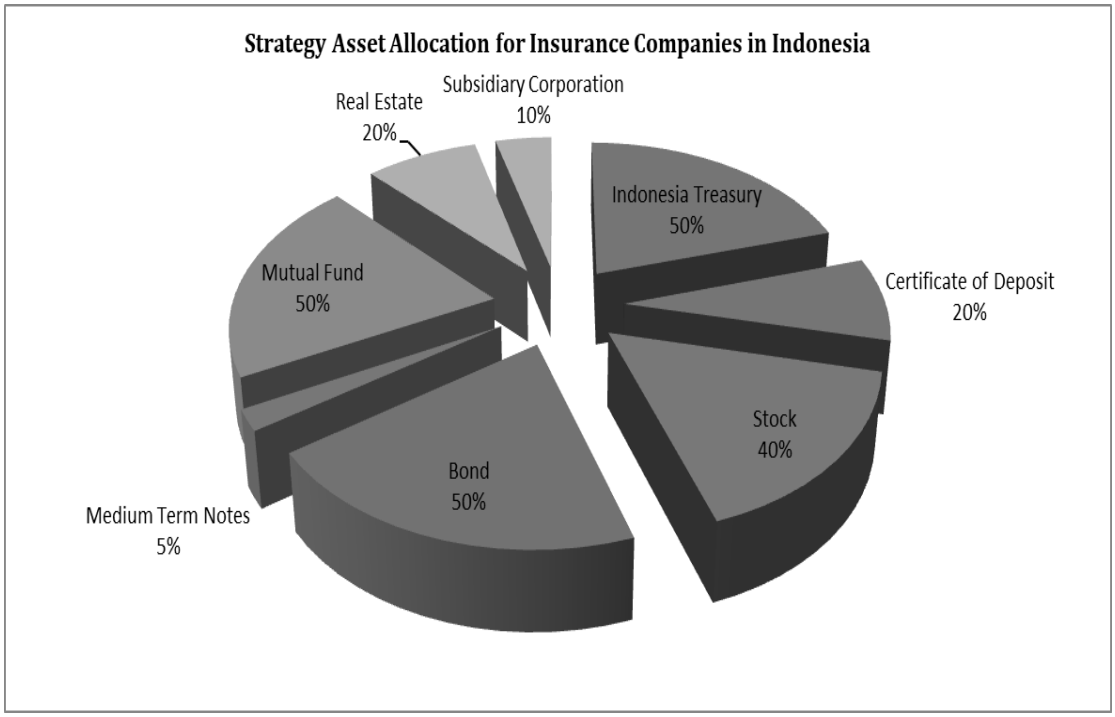

Figure 1. SAA for Insurance Companies in Indonesia
Sources: The Financial Services Authority in Indonesia

Tactics in determining Investment Asset Allocation Weight

Assume a company has an initial investment of $28.236.130. Investment managers who practice TAAM must first identify the cash inflows and outflows every month of the year, as shown in Table 1. Then calculate the difference between both to determine how many sources of funds are needed to cover the shortfall. The reverse model will calculate the amount of investment asset allocation in a fixed-income investment portfolio that must at least be able to generate returns that can cover the cash flow deficit so that the proportion of determination of the weight allocation of investment assets on fixed-income instruments can be determined dynamically where the amount of the results in order to meet funding needs liquidity in question. Then, if there are remaining investment funds, the funds can be placed in a non-fixed-income investment portfolio whose investment instruments have high returns with high risk to optimize the return performance of the investment portfolio, as shown in Table 2.

Table 1. Assumptions of Operational Cash flows of an Insurance Company (Monthly)

ACCOUNT	JAN	FEB	MAR	APR	MEI	JUN	JULY	AUG	SEP	OCT	NOV	DEC
CASH OUTFLOWS :												
CLAIM EXPENSES	427.180	238.162	212.043	255.689	263.594	274.248	292.462	332.328	349.855	282.152	264.281	244.348
CAPITAL EXPENDITURES	0	0	0	0	0	3.376	2.512	3.940	2.383	3.248	1.819	1.228
OPERATING EXPENSES	50.552	46.439	56.258	51.415	56.258	50.287	56.987	64.418	67.005	56.258	51.415	56.258
CASH INFLOWS :												
PREMIUMS	295.613	295.212	281.154	297.622	295.613	300.032	436.191	352.246	354.656	318.106	434.182	329.754
OTHER INCOMES	615	615	615	615	615	615	615	615	615	615	615	615
SURPLUS/DEFICIT CASHFLOW	(181.504)	11.226	13.468	(8.867)	(23.624)	(27.264)	84.845	(47.825)	(63.972)	(22.937)	117.282	28.535

Table 2. Simulation of Reverse Model in an Insurance Company

Month	Liability	Allocation weight of Fixed Income Portfolios	Allocation weight of Non-Fixed Income Portfolios	Access Fund
January	(181.504)	72,61%	27,38%	139.566
February	11.226	72,26%	27,73%	333.660
March	13.468	71,42%	28,57%	343.714
April	(8.867)	73,92%	26,08%	321.493
Mei	(23.624)	81,55%	18,44%	310.393
Jun	(27.264)	90,31%	9,68%	310.280
July	84.845	89,37%	10,62%	425.917
August	(47.825)	88,12%	11,87%	298.092
September	(63.972)	87,27%	12,72%	285.334
October	(22.937)	86,47%	13,53%	329.613
November	117.282	85,56%	14,43%	473.580
December	28.535	84,28%	15,71%	390.217

Calculating the TAAM mathematical model begins with identifying the insurance company's main outflows of funds, namely participant claims, capital expenditures, and operating expenses. The need for funds is financed by premiums and other income so that there will be a deficit or surplus of funds. In general, insurance companies will experience a deficit of funds. The typical funding source is investment returns to cover the deficit to avoid customer defaults. So the management of the investment portfolio must use TAAM. If there is a surplus, it is not only the weight of asset allocation in the fixed-income portfolio that is immediately changed/reduced. The asset shift depends on the situation, market absorption capacity, and long-term company needs. For this reason, the surplus of ideal funds is usually managed as an additional new investment. Therefore, the company's investment value continues to grow.

The non-fixed-income portfolio in this study is assumed to be an investment placed in the form of stocks, bonds, and mutual funds that are traded, where these instruments have a high risk in line with the returns to be obtained. For this reason, determining the weight of the allocation becomes very important to produce optimal returns. Determination of the number of allocation weights with an LPM will provide a mix of portfolio weights and is more precise and scientifically accountable with the most optimum results, as shown in Table 3. In addition, it can minimize the risk of losses due to excess determination of the allocation weight on instruments experiencing potential loss.

Table 3. Simulation of LPM in an Insurance Company

LPM Return of Individual Non-Fixed Income Portfolios			
Month	**Allocation Weight of Portfolios**		
	Stock	**Bond**	**Mutual Fund**
January	10,95%	13,69%	2,74%
February	11,29%	14,12%	2,82%
March	11,90%	14,87%	2,97%
April	10,43%	13,04%	2,61%
Mei	7,38%	9,22%	1,84%
Jun	3,87%	4,84%	0,97%
July	4,25%	5,31%	1,06%
August	4,75%	5,94%	1,19%
September	5,09%	6,36%	1,27%
October	5,41%	6,77%	1,35%
November	5,78%	7,22%	1,44%
December	6,29%	7,86%	1,57%

The TAAM application can allocate assets optimally and productively because it is supported by linear programming mathematical calculations, which can determine the most profitable allocation optimization without fear of violating

or exceeding the provisions in the SAA. In addition, TAAM provides solutions for investors regarding the distribution of individual portfolio risk to the overall portfolio. Fulfilling the needs of the company's funding sources, liquidity is guaranteed.

Concluding Remarks

The investment manager of an insurance company must not only select and assess the investment instruments permitted in the SAA but also determine the ideal amount of weight for the allocation of investment assets from risks and returns as well as the adequacy of the company in fulfilling its obligations. The tactical asset allocation model will significantly help increase the confidence of investment managers in making decisions to determine how much weight allocation of funds will be allocated to the investment instruments that have been selected. The use of a mathematical model in determining the amount of the allocation weight is transparent and accountable for its methodology and can meet the ideal challenges in every investment decision between risk, return, and the company's liquidity capability.

Of the three factors, the most decisive and able to balance risk and return is the amount of weight of asset allocation. Investment decisions in any form, made by experts or amateurs, are constantly faced with considerations of the risk of failure, the expected return, and the proportion of the allocated funds to be placed. Therefore we need a mathematical model that can be used to mix the weights of the investment portfolio allocation.

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