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The Analysis Level of Optimism that Influence Investor's Risk Tolerance in Asset Allocation

(Analisis Tahap Optimisme yang Mempengaruhi Toleransi Risiko Pelabur dalam Peruntukan Saham)

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ABSTRACT

Investor's risk of tolerance level has been widely categorized into three types, namely, risk averse, risk seeker and risk neutral. Nevertheless, in assessing the risk of a particular asset, investors that fall under the same risk tolerance classification may have different levels of optimism. It is thus beneficial to complement types of investor's risk of tolerance with level of optimism. In this study, a fuzzy asset allocation model that satisfy heterogeneous investor's risk of tolerance with regards to investor's level of optimism is proposed. Enhancing Fuzzy Inferences System (FIS) with cooperation of optimism level, this study obtains a flexible fuzzy allocation model which is based on heterogeneous types of investor's risk of tolerance combined with various level of optimism. Empirical evidence on 30 Malaysian shares employing the model developed shows that the proposed model successfully able to differentiate various combinations of investor's risk of tolerance level and investor's level of optimism. Furthermore, model is able to determine asset allocation and priority shares for each combination accordingly. In conclusion, it is shown that employing the proposed model allows investor to make beneficial investment decision according to his combined risk tolerance and level of optimism.

Keywords: Fuzzy asset allocation; fuzzy inference system; heterogeneous investor's risk of tolerance; investor's level of optimism

ABSTRAK

Tahap toleransi risiko pelabur sering dikategorikan kepada tiga jenis iaitu, kehindaran risiko, pencari risiko dan risiko neutral. Walau bagaimanapun, dalam menilai risiko sesuatu saham tertentu, pelabur yang tergolong dalam pengelasan toleransi risiko yang sama mungkin mempunyai tahap optimisme yang berbeza. Oleh itu, adalah penting untuk melengkapkan jenis toleransi risiko pelabur dengan tahap optimisme. Dalam kajian ini, satu model peruntukan saham kabur yang memenuhi tahap toleransi risiko pelabur yang heterogen berdasarkan tahap optimisme pelabur dicadangkan. Dengan meningkatkan Sistem Penaakulan Kabur (FIS) dengan kerjasama tahap optimisme, kajian ini memperoleh model peruntukan kabur yang fleksibel berdasarkan jenis toleransi risiko pelabur yang berbeza digabungkan dengan pelbagai tahap optimisme. Bukti empirik terhadap 30 saham Malaysia menggunakan model yang dibangunkan menunjukkan bahawa model yang dicadangkan berjaya membezakan pelbagai gabungan tahap toleransi risiko pelabur dan tahap optimisme pelabur. Tambahan pula, model ini mampu menentukan peruntukan saham dan saham keutamaan bagi setiap gabungan. Kesimpulannya, telah ditunjukkan bahawa penggunaan model yang dicadangkan membolehkan pelabur membuat keputusan yang bermanfaat berdasarkan gabungan antara toleransi risiko dan tahap optimisme pelabur.

Kata kunci: Peruntukan saham kabur; sistem penaakulan kabur; toleransi risiko pelabur heterogen; tahap optimisme pelabur

Introduction

In real financial market, investors are heterogeneous in risk tolerance (risk averse, risk neutral and risk seeker. Viewing the same share analyses for asset allocation, some investors perceive it to be risk averse while some may not be. The willingness to accept the risk varies among investors (Ahn et al. 2014; Bhattacharjee 2017; Wen, He & Chen 2014; Yao & Rabbani 2021). Investors have different risk preferences which are influenced by their behaviors in asset allocation decisions (Gong, Min & Yu 2022; Huang et al. 2021).

Asset allocations refers to an investment strategy where the risk and return components of share is adjusted through manipulation of its investment percentage that is in accordance with investor's risk of tolerance (Chen & Huang 2009; Xing, Cambria & Welsch 2018). This strategy has been first implemented by Markowitz (1952) utilizing the risk and return components in selection of share for efficient portfolio optimization (Jaaman, Weng & Isa 2013). This works consider the risk averse type of investors focuses on maximizing the return subject to the risk as the constraint (Markowitz 1952). Considering asset allocation decision only from the perspective of risk averse is inadequate to mimic the actual investor risk of tolerance (Chen & Huang 2009; Gong, Min & Yu 2022; Huang et al. 2021; Kiliçman & Sivalingam 2010; Leungo 2010; Mirnoori & Shariati 2012; Mohd Amin & Jaaman 2023; Tsaur 2013; Van Staden, Dang & Forsyth 2021). Furthermore, the model cannot solely satisfy practical concern of real financial market which involves high uncertainty problem due to changes in economic, social, politic and investor's psychology in which affected the share trading and cannot be solved using probability theory (Gong, Min & Yu 2022).

The presence of uncertainty in investment and ambiguous investor's willingness to accept risk, have significantly affected the assets to be allocated (Bhattacharjee 2017; Gong, Min & Yu 2022; Yao & Rabbani 2021). Many scholars focuses on fuzzy set theory which suitable and efficient in handling uncertainty and ambiguous that are inherent nature of any financial market.

The nature of investor decision is influenced by the level of optimism when making decision on investment (Jouini & Napp 2007). Optimism can boost investor's confidence in making investment decision and able to more proactive approach in managing risks. However, most of the established models do not consider various level of optimism in asset allocation evaluation and thus are inefficient in managing asset allocation more accurately. This research proposed fuzzy model for asset allocation that capable to distinctively express investors' vague preferences which existing asset allocation methods fail to capture.

This paper is organised as follows. Next section presents the literature review and subsequently the methods of the proposed fuzzy model for asset allocation. After that, we cover the application of the proposed work on a case study of 30 Malaysia's shares. The discussion and conclusions are given in following sections, respectively.

Literature Review

As fuzzy approach is able to handle uncertainty and ambiguous situation, Leungo (2010) suggests the incorporation of fuzzy sets in the methodology of Markowitz model, known as the fuzzy based mean-variance method. Fuzzy asset allocation is further developed by Kiliçman and Sivalingam (2010) and Mirnoori and Shariati (2012) when all of them consider the risk seeker and risk averse type of investors in asset allocation evaluation.

Meanwhile, Kocadağlı and Keskin (2015) and Tsaur (2013) used fuzzy portfolio model and fuzzy goal programming method, respectively, for asset allocation purposes. However, this works consider all the three risk tolerance behavior with different predefined indicator values of risk tolerance such as descriptions of risk averse is 0.5, risk neutral is 1 and risk seeker is 2. This predefined indicator are also used by Huang et al. (2021), Lam et al. (2015), Lin et al. (2013), Turan et al. (2020), and Yao and Rabbani (2021) in defining risk tolerance behavior. This predefined indicator is based on the utility function in which the value larger than 1 reflects the risk seeker investor, less than 1 is risk averse and value of 1 is for risk neutral. Due to this, many scholar set different values to define risk tolerance behavior.

Investor with high preferences towards guaranteed gains, desiring to avoid risk as much as possible is referred as risk averse investor (Tsaur 2013; Wen, He & Chen 2014). Difference to risk seeker investors, who, more tolerance with risk, willing to accept high risk and aim for high return, while, risk neutral investor are those that are neither risk averse nor risk seeker, with mild concern and tolerance with risk (Safdari & Scannell 2005; Tsaur 2013; Wen, He & Chen 2014). The assumption of utility function of the rational investors are risk averse investor is not always true based on systematic biased in human psychology in which changes based on overconfidence and avoid regret (Tsaur 2013).

Due to this issues, Chen and Huang (2009), Kiliçman and Sivalingam (2010) and Mirnoori and Shariati (2012) has consider level of confidence with different investor risk tolerance behaviors in making decision on asset allocation. They consider four confidence level such as 0, 0.25, 0.5, 0.75 and 1 to evaluate each asset allocation for different risk tolerance behavior. Instead of using level of confidence, Mohamed, Mohamad and Samat (2009) and Ramli and Mohamad (2010) used level of optimism, $\lambda \in [1, 0]$ to differentiate investors risk of tolerance in managing asset allocation. According to Gong, Min and Yu (2022), Jouini and Napp (2007), Ramli and Mohamad (2010), and Zainol Abidin et al. (2020), investor decision is influenced by the level of optimism. Study done by Jouini and Napp (2007) shows that investor with low risk aversion is more optimist, investor with moderate risk aversion is neutral investors and investors with high risk aversion is pessimist investor in making decision on investment. However, most of the established works ignoring level of optimism in solving asset allocation problem. In general, optimistic investors are confidence that a decision goal is achievable and expecting the best in the best possible evaluation values, hence they may overestimate the decision outcomes (Gong, Min & Yu 2022; Li & Yi 2019). Pessimistic investors, in contrast, are often doubtful about level of achievement, making them more likely to underestimate the decision outcomes (Li & Yi 2019).

It will be very much subjective decision because one may think that investor A is risk seeker, but actually investor A may be less or much more risk seeker than what other thinks, or may be risk seeker to risk neutral category. As per particular investor, he/she may be risk averse with optimism level of λ=0.2 but actually he/she may be very risk averse with optimism level λ=0.4 and *vice versa*. Due to this, the effects of optimism level should be integrated into decision analysis process, especially when involve heavily on subjective judgments and decision outcomes such as in asset allocation problem. A comprehensive literature review comparing various assets performance using FIS can be found in Zainol Abidin et al. (2020), in shares performance evaluation by engaging Fuzzy Inference System (FIS) to cluster shares performance by considering heterogeneous investor's preferences. Their result shows that FIS successfully able to cluster shares performance according to inferior, stable, good, and aggressive performance and able to classify investor's preferences based on optimistic, neutral, and pessimistic investors. Thus, in this research, the FIS employed in Zainol Abidin et al. (2020) is further enhanced to consider investor's risk tolerance that influenced by level of optimism on which can be helpful in managing asset allocation more accurate and reliable. It also consider level of satisfaction as it does not done by any other scholar in handling asset allocation problem.

Methods

In the previous study Zainol Abidin et al. (2020) employed the FIS to solve the selection of shares based on evaluation of shares performance considering heterogeneous investors' preferences. Result obtained from the related work indicated that FIS has great capability to resolve share selection based on preferences. As FIS is able to deal with ambiguous and uncertainty situation, this study upgrade FIS with cooperation with level of optimism in assets allocation which also take into consider the heterogeneity in investor's risk tolerance. Hence, this proposed model are difference with the established model by considering all the three types of investor's risk of tolerance, engaging the investor's risk of tolerance with satisfaction's level and optimism's level. In this case, standard deviation and rate of return are used to define the linguistic inputs of Very High (VH), High (H), Moderate (M), Very Low (VL), and Low (L) to develop rule bases. Results obtained in the form of linguistic investor's risk tolerance with level of optimism are transformed into optimal percentage of asset to be allocated. Therefore, this study aims at fulfilling the following objectives: 1) To obtain detailed classification of investors' risk of tolerance by incorporating levels of optimism, and 2) To improve the interpretation of the aggregated defuzzified linguistic outputs of the FIS with optimism levels.

The flowchart of the proposed model is given as in Figure 1. Figure 1 shows the proposed asset allocation model divided into phases. Details of the phases involved are as follows.

Phase 1: Determination of input variables

This phase involves data collection, inputs identification and normalization of variables. The data on share prices is analyse using rate of returns and standard deviation variables, is given by the following definitions.

Definition 1 Rate of return, R_t

Rate of return, R_t, denotes the return on investment, S_i is closing price and S_{i+1} is next day closing price as shown in Equation (1) (Robiyanto 2018).

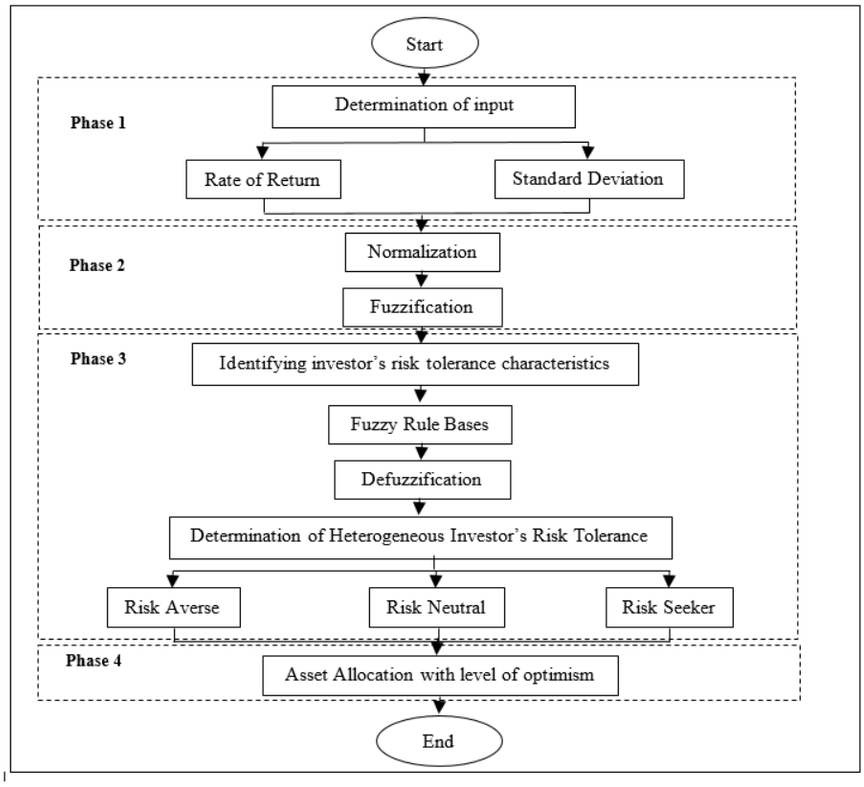

FIGURE 1. Flowchart of the novel proposed asset allocation model

$$R_i = \frac{S_{i+1} - S_i}{S_i} \tag{1}$$

High and positive value of return rates indicates high amount of profit gain in investment and otherwise it denotes loss of investment (Mirnoori & Shariati 2012).

Definition 2 Standard Deviation, S_t

Standard deviation, S_t, is used to measure the investment risk (Chen & Huang 2009). Standard deviation, S_i can be calculated using Equation (2), shown as follows:

$$S_t = \sqrt{\frac{\sum_{t=1}^{n} \left(R_t - \overline{R}_t\right)^2}{n-1}} \tag{2}$$

Phase 2: Normalization and Fuzzification

In this phase, normalization is used to ensure that all inputs variables are in standard form, where it is given by the following definition.

Definition 3 Normalization, ϖ_i

Normalization is a process of transforming return rates and standard deviation values into 0 to 1 using Equation (3) (Chen & Huang 2009).

$$\varpi_1' = \frac{\varpi_i - Min\left(\varpi_{i,j}\right)}{Max\left(\varpi_{i,j}\right) - Min\left(\varpi_{i,j}\right)} \tag{3}$$

The normalization for both $R_t^{'}$ and $S_t^{'}$ are shown as Equations (4) and (5).

$$R_t \rightarrow R_t^{'} \tag{4}$$

$$S_t \rightarrow S_t^{'} \tag{5}$$

where $R_t^{'} \in [0,1]$ and $S_t^{'} \in [0,1]$.

The normalization result are then transformed into linguistic terms of VH, H, M, L, and VL. The transformation of Equations (4) and (5) into linguistic triangular fuzzy numbers is shown by the following Equations (6) and (7), respectively.

$$R_t^{'} \rightarrow R_t^{*} = \left(a_{R_t^{*}}, b_{R_t^{*}}, c_{R_t^{*}}; 1\right) \tag{6}$$

$$S_t^{'} \rightarrow S_t^{*} = \left(a_{S_t^{*}}, b_{S_t^{*}}, c_{S_t^{*}}; 1\right) \tag{7}$$

where R_t^{*} and S_t^{*} are the linguistic triangular fuzzy numbers for the rate of return and standard deviation values, respectively.

Figure 2 shows the sample of linguistic triangular fuzzy numbers, where μ_{α}, $\alpha = R_t^{*}, S_t^{*}$ is the membership function in the form of triangular ffuzzy number with *a* denotes as the minimum value, *c* is the maximum value and *b* ismodal value (Princy & Dhenakaran 2016; Shyamal & Pal 2007).

Phase 3: *Identifying Investor's Risk of Tolerance, Fuzzy Rule Bases, Defuzzification and Determination of Heterogeneous Investor's Risk Tolerance*

In the third phase, the processes on generating fuzzy rule bases by identifying the characteristic of investor's risk of tolerance, defuzzification and determination of heterogeneous investor's risk of tolerance are carried out. The rule bases are designed to complement the aggregation process of linguistic input variables in producing the linguistic output variable to depict heterogeneous investor's risk tolerance. The established definition of investor's risk of tolerance from Rinandiyana et al. (2020), Safdari and Scannell (2005), Tsaur (2013), Vlad and Surlura (2020), and Wen, He and Chen (2014) are used as benchmark in designing the fuzzy rule bases in this research work, characterized by IF-THEN rules. The process of designing the rule bases is generically given as follows.

IF R_t^{*} **AND** S_t^{*} **THEN** *investor risk tolerance is ...*

Classifying investor risk of tolerance obtained from the defuzzification process as a single value in which this value represents investor's risk of tolerance towards the shares based on risk and return measurements. Equation (8) shows the defuzzification formula (Andani 2013; Febriany, Agustina & Marwati 2017; Sutara & Kuswanto 2019).

$$z_i^{*} = \frac{\int_a^b z\mu(z)dz}{\int_a^b \mu(z)dz} \tag{8}$$

where z^{*} represents the defuzzification value.

Phase 4: Asset allocation with Level of Optimism

In the last phase, results obtained from Phase 3 are then analysed using the proposed fuzzy asset allocation model to determine the distribution of assets' percentages for all types of investors' risk tolerance by considering investor's level of optimism. The definition of the proposed model is given by the following Definition (4).

Definition 4 Fuzzy asset allocation model under influence of investor's risk tolerance and level of optimism

The proposed fuzzy asset allocation model is designed to obtain the distribution of asset allocation percentage under the influence of investor's risk of tolerance and their optimism level. Investor's level of optimism and asset allocation are shown in Equations (9) and (10).

$$q_{\lambda} = \alpha_t \lambda \tag{9}$$

$$\text{Asset Allocation} = \frac{q_{\lambda}}{\sum q_{\lambda}} \tag{10}$$

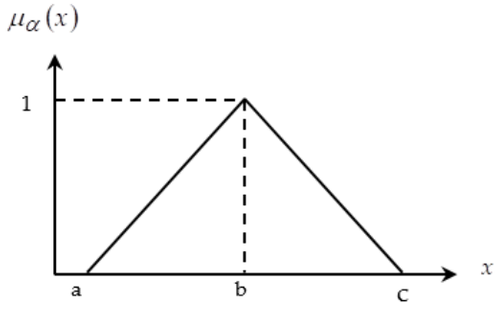

FIGURE 2. Triangular fuzzy number

where λ denotes the optimism level in which investor judgment are tested on three levels, namely as pessimistic judgement $(\lambda = 0.3)$, neutral $(\lambda = 0.7)$ and optimistic judgment $(\lambda = 1)$ based on Mohamed, Mohamad and Samat (2009). Meanwhile, α_t denotes investor's satisfaction level and q_λ indicates investor's risk of tolerance with optimism level.

MALAYSIA'S ASSET ALLOCATION CONSIDERING HETEROGENEOUS INVESTOR'S RISK OF TOLERANCE WITH OPTIMISM LEVEL

In this section, a case study of 30 Malaysia's share listed on Bursa Malaysia for the year 2017 until 2022 is analysed using the proposed model. Details of the application of the proposed model is given below.

Phase 1: Determination of input variables

This study used data of 30 top KLCI component shares from 20th November 2017 until 14th November 2022 collected from YahooFinance.

Phase 2: Normalization and Fuzzification

The normalised values of input variables were then transformed into five linguistic terms namely, VL, L, M, H, and VH. Meanwhile the output variable that describes the heterogeneous investor's risk of tolerance is classified as risk averse, risk neutral and risk seeker. The linguistic terms for input and output variables are shown in Table 1.

Phase 3: Fuzzy rule base development, FIS implementation and Defuzzification

Utilizing the five linguistic terms for the input variables and three linguistic terms for the output variables in phase 2, 25 rule bases are designed. The generic rule bases generated for each investor's risk tolerance are listed in Table 2.

Results in the form of heterogeneous investor's risk tolerance are presented in the following Figure 3 and Table 3.

Based on Figure 3, since the defuzzification value are maps into two α-cut, hence, there are two result of investor's risk of tolerance preferences are obtained. Table 3 shows that α-cut < 0.5 is risk averse investor with a low satisfaction level of 0.0040, while for α-cut > 0.5 is risk neutral investor with highly satisfied level of 0.9960 investing in Nestle Malaysia Bhd. The highest satisfaction level for α-cut < 0.5 shows that risk neutral investor will likely invest in Inari Amerton Bhd company giving on satisfaction level of 0.8330, while for α-cut > 0.5 risk neutral investors will be satisfied with Top Glove Corp Bhd, Hong Leong Financial Group Bhd and Nestle Malaysia Bhd with 0.9960 satisfaction level. Level of satisfaction shows that investor's is capable and satisfy to invest in that shares.

TABLE 1. Linguistic terms and triangular fuzzy numbers for input and output variables

Input / Output	Linguistic Variables	Linguistic Values	Fuzzy Triangle Numbers
Input	Return, R_t^* Min = 0 Max = 1	VL	(0, 0, 0.1122)
		L	(0, 0.1122, 0.6333)
		M	(0.1122, 0.6333, 0.7462)
		H	(0.6333, 0.7462, 1)
		VH	(0.7462, 1, 1)
	Standard Deviation, S_t^* Min = 0 Max = 1	VL	(0, 0, 0.1667)
		L	(0, 0.1667, 0.3333)
		M	(0.1667, 0.3333, 0.6667)
		H	(0.3333, 0.6667, 1)
		VH	(0.6667, 1, 1)
Output	Risk Tolerance	Averse	(0, 0, 0.5)
		Neutral	(0, 0.5, 1)
		Seeker	(0.5, 1, 1)

TABLE 2. Rule bases

No		R^*		S^*		Risk Tolerance	Authors	Decriptions
1		VL		VL		Averse		
2				L		Averse		
3				M		Averse		
4				H		Averse		
5				VH		Averse		
6		L		VL		Averse		
7				L		Averse		
8				M		Averse		
9				H		Averse		
10				VH		Averse		
11		M		VL		Neutral		
12	IF		AND	L	THEN	Neutral		
13				M		Neutral		
14				H		Neutral		
15				VH		Neutral		
16		H		VL		Seeker		
17				L		Seeker		
18				M		Seeker		
19				H		Seeker		
20				VH		Seeker		
21		VH		VL		Seeker		
22				L		Seeker		
23				M		Seeker		
24				H		Seeker		
25				VH		Seeker		

- Tsaur (2013); Wen, He & Chen (2014)
  - High preference towards guarantee gains, instead of the uncertainty ones
  - Unwillingness to take risk / avoid risk
  - Less tolerance with risk
- Tsaur (2013); Vlad & Surlura (2020)
  - Insensitive with risk / mild concern on risk
  - Those that are neither risk averse nor risk seeker
  - Mild tolerance with risk
- Safdari & Scannell (2005), Tsaur (2013); Wen, He & Chen (2014); Rinandiyana et al. (2020)
  - Those who willing to accept high risk and aim for high return
  - More tolerance with risk

The level of satisfaction is not sufficient to indicate the investor's decision on investment. Investors may be satisfied with the performance of the shares but to invest in that shares, the nature and sentiment of the investors are need to be considered in term of optimise, neutral and pessimist investors. Investors judgment on pessimistic $(\lambda = 0.3)$, neutral $(\lambda = 0.7)$ and optimistic $(\lambda = 1)$ based on Mohamed, Mohamad and Samat (2009) are used to evaluate the behaviour of the investors. Table 4 shows the investor's risk of tolerance with level of optimism.

Based on Table 4, a very pessimist investor who is satisfied with Tenaga Nasional Bhd giving the highest level of optimism by 0.2016, while the neutral investor by 0.6972 for Top Glove Corp Bhd, Hong Leong Financial Group Bhd. and Nestle Malaysia Bhd. and a very optimise investor with 0.6640 level of optimist for Press Metal. Level of optimism shows that investor's confidence to invest in that shares in which will generate the best outcomes.

Phase 4: Asset Allocation

The utilisation of the proposed fuzzy asset allocation model in evaluating the asset allocation under the influence of heterogeneous investor's risk of tolerance and optimism level is carried out using Equation (10) as shown in Table 5.

Based on Table 5, the highest asset allocation for pessimist investor is 11.71% for Tenaga Nasional Bhd, neutral investor is 4.92% for Top Glove Bhd, Hong Leong Financial Group Bhd and Nestle Malaysia Bhd, while optimist investor will allocate their asset with 66.53% in Press Metal. Its shows that, risk averse investors prioritise Tenaga Nasional Bhd, risk neutral priorities Top Glove Bhd, Hong Leong Financial Group Bhd and Nestle Malaysia Bhd and risk seeker investors prioritise Press Metal in their investment decision.

TABLE 3. Result of investor's risk tolerance and level of satisfaction for the 30 shares

Shares	z^*	α-cut < 0.5		α-cut > 0.5	
		Investor	α-cut	Investor	α-cut
Nestle Malaysia	0.498	Averse	0.0040	Neutral	0.9960
Press Metal	0.832	Seeker	0.6640	Neutral	0.3360
Sime Darby	0.321	Averse	0.3580	Neutral	0.6420
Petronas Chemicals	0.491	Averse	0.0180	Neutral	0.9820
Public Banks Bhd	0.494	Averse	0.0120	Neutral	0.9880
IHH Healthcare	0.466	Averse	0.0680	Neutral	0.9320
RHB Bank Bhd	0.475	Averse	0.0500	Neutral	0.9500
Genting Malaysia	0.189	Neutral	0.3780	Averse	0.6220
PPB Group Bhd	0.475	Averse	0.0500	Neutral	0.9500
Digi.com Bhd	0.411	Averse	0.1780	Neutral	0.8220
Maxis Bhd	0.170	Neutral	0.3400	Averse	0.6600
Hong Leong Financial	0.487	Averse	0.0260	Neutral	0.9740
Malayan Banking Bhd	0.399	Averse	0.2020	Neutral	0.7980
Hong Leong Bank	0.498	Averse	0.0040	Neutral	0.9960
Kuala Lumpur Kepong	0.399	Averse	0.2020	Neutral	0.7980
Dialog Group	0.421	Averse	0.1580	Neutral	0.8420
Axiata Group Bhd	0.188	Neutral	0.3760	Averse	0.6240
Genting Bhd	0.189	Neutral	0.3780	Averse	0.6220
CIMB Group Holdings	0.427	Averse	0.1460	Neutral	0.8540
Inari Amerton Bhd	0.833	Neutral	0.6660	Seeker	0.3340
Tenaga Nasional Bhd	0.164	Neutral	0.3280	Averse	0.6720
Petronas Gas Bhd	0.440	Averse	0.1200	Neutral	0.8800
Petronas Dagangan Bhd	0.440	Averse	0.1200	Neutral	0.8800
MISC	0.448	Averse	0.1040	Neutral	0.8960
Telekom Malaysia	0.462	Averse	0.0760	Neutral	0.9240
Top Glove Corp Bhd	0.498	Averse	0.0040	Neutral	0.9960
Hartalega Holdings Bhd	0.181	Neutral	0.3620	Averse	0.6380

TABLE 4. Result of investor's risk tolerance with level of optimism for the 30 shares

Shares	$\alpha < 0.5$	$\alpha > 0.5$	Pessimistic	Neutral	Optimistic
Nestle Malaysia	Averse	Neutral	0.0012	0.6972	
Press Metal	Seeker	Neutral		0.2352	0.6640
Sime Darby	Averse	Neutral	0.1074	0.4494	
Petronas Chemicals	Averse	Neutral	0.0054	0.6874	
Public Banks Bhd	Averse	Neutral	0.0036	0.6916	
IHH Healthcare	Averse	Neutral	0.0204	0.6524	
RHB Bank Bhd	Averse	Neutral	0.0150	0.6650	
Genting Malaysia	Neutral	Averse	0.1866	0.2646	
PPB Group Bhd	Averse	Neutral	0.0150	0.6650	
Digi.com Bhd	Averse	Neutral	0.0534	0.5754	
Maxis Bhd	Neutral	Averse	0.1980	0.2380	
Hong Leong Financial	Averse	Neutral	0.0078	0.6818	
Malayan Banking Bhd	Averse	Neutral	0.0606	0.5586	
Hong Leong Bank	Averse	Neutral	0.0012	0.6972	
Kuala Lumpur Kepong	Averse	Neutral	0.0606	0.5586	
Dialog Group	Averse	Neutral	0.0474	0.5894	
Axiata Group Bhd	Neutral	Averse	0.1872	0.2632	
Genting Bhd	Neutral	Averse	0.1866	0.2646	
CIMB Group Holdings	Averse	Neutral	0.0438	0.5978	
Inari Amerton Bhd	Neutral	Seeker		0.4662	0.3340
Tenaga Nasional Bhd	Neutral	Averse	0.2016	0.2296	
Petronas Gas Bhd	Averse	Neutral	0.0360	0.6160	
Petronas Dagangan Bhd	Averse	Neutral	0.0360	0.6160	
MISC	Averse	Neutral	0.0312	0.6272	
Telekom Malaysia	Averse	Neutral	0.0228	0.6468	
Top Glove Corp Bhd	Averse	Neutral	0.0012	0.6972	
Hartalega Holdings Bhd	Neutral	Averse	0.1914	0.2534	

TABLE 5. The result of asset allocation for each investor's risk tolerance

Shares	Asset allocation		
	Risk averse	Risk neutral	Risk seeker
Nestle Malaysia	0.07%	4.92%	
Press Metal		1.66%	66.53%
Sime Darby	6.24%	3.17%	
Petronas Chemicals	0.31%	4.85%	
Public Banks Bhd	0.21%	4.88%	
IHH Healthcare	1.19%	4.60%	
RHB Bank Bhd	0.87%	4.69%	
Genting Malaysia	10.84%	1.87%	
PPB Group Bhd	0.87%	4.69%	
Digi.com Bhd	3.10%	4.06%	
Maxis Bhd	11.50%	1.68%	
Hong Leong Financial	0.45%	4.81%	
Malayan Banking Bhd	3.52%	3.94%	
Hong Leong Bank	0.07%	4.92%	
Kuala Lumpur Kepong	3.52%	3.94%	
Dialog Group	2.75%	4.16%	
Axiata Group Bhd	10.87%	1.86%	
Genting Bhd	10.84%	1.87%	
CIMB Group Holdings	2.54%	4.21%	
Inari Amerton Bhd		3.29%	33.47%
Tenaga Nasional Bhd	11.71%	1.62%	
Petronas Gas Bhd	2.09%	4.34%	
Petronas Dagangan Bhd	2.09%	4.34%	
MISC	1.81%	4.42%	
Telekom Malaysia	1.32%	4.56%	
Top Glove Corp Bhd	0.07%	4.92%	
Hartalega Holdings Bhd	11.12%	1.79%	

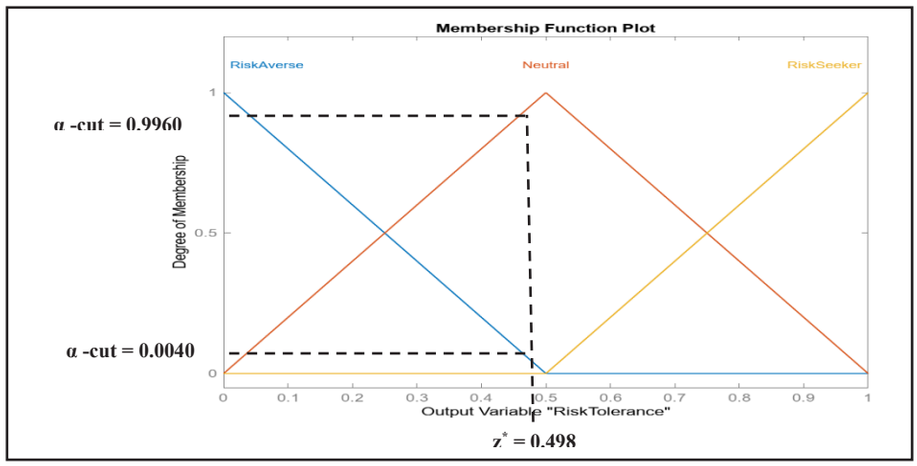

FIGURE 3. Mapping defuzzification value

DISCUSSIONS

As projected in the Method section, this study successfully enhanced method done by Zainol Abidin et al. (2020) by proposed model adopting FIS with cooperation of optimism level by developing fuzzy model for asset allocation that consider investor's risk of tolerance and level of optimism. The proposed model can determine asset allocation based investor level of tolerance, level of optimism as well as stock based on priority. The proposed model manages to highlight the importance of linguistic terms in categorizing the investors' risk of tolerance instead of predefined indicator to categorise investor's risk of tolerance where the linguistic terms prove to be more precise in describing the nature of heterogeneous investors as shown in Tables 1 and 2.

As shown in Table 3, heterogeneous investors based risk of tolerance, namely, risk averse, risk neutral and risk seeker, were presented. As exhibited, risk averse investor is someone who prefer to avoid risk as much as possible, risk seeker is willing to accept high risk in exchanged for possibility of higher rewards and risk neutral investor is someone who is mild concern with risk. Table 3 shows the difference between investor's risk of tolerance with difference investor's level of satisfaction towards the same shares. It shows that investors perceive the same value of the share, differently.

Level of satisfaction is more focuses on investors current conditions align with their desires, expectations and needs, while level of optimism refer to investor's attitude towards the future. Hence, level of satisfaction is not sufficient to describe investor's heterogeneity in asset allocation decision. Hence, Table 4 shows the investors with different level of risk tolerance with different level of optimism. The result shows that low risk aversion is more optimist, moderate risk aversion is risk neutral investor and high risk aversion is risk seeking investor in which align with the study done by Jouini and Napp (2007). It implies that different investors will act differently in making decision on selecting share to be allocated.

The proposed model generates percentages for asset allocation as shown in Table 5. The result shows the investor's share priority by indicating the percentage of asset allocation in accordance to determine with optimism level for each share and investor' level of tolerance. High percentage of allocation implies that the shares are preferred for investment purposes. Hence, the results shows that the proposed model has successfully achieved its aims at resolving the interaction between heterogeneous types of investor's risk of tolerance with their optimism level. The proposed model is a holistic model that can cover most of the real situation of investment in terms of asset allocation, heterogeneous behaviour, satisfaction level and optimism level.

Tambah

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Conclusions

This study presents a fuzzy model for asset allocation under the influence of heterogeneous investor's risk of tolerance and level of optimism by adopting the FIS. The proposed model manages to enhance method done by Zainol Abidin et al. (2020) by adopting FIS with cooperation level of optimism in asset allocation. This proposed model provides more flexible investors' risk of tolerance classification on shares than previous established research works by resolving the interaction between heterogeneous types of investor's risk of tolerance and optimism level. The efficiency of the proposed model is demonstrated where it successfully classifies 30 Malaysian's shares under the presence of heterogeneous investor's risk tolerance with regards to its optimism level, reliably diversifies allocation of assets and effectively determines share priority. Furthermore, this study enables investors to understand the uncertain situation on investment, selecting assets based on investor's risk of tolerance and allowing investors to make investment decision based on satisfaction level and optimism level. Empirical evidence shows that different investors perceive the same value of shares, differently. Even though the proposed model efficiently classifies each investor's risk of tolerance with respect to optimism level, it ignores the reliability of the investor's optimism level, hesitancy perspective on the investor's risk of tolerance and interpersonal uncertainty of the investors. In the future, this study can be improved further by incorporating other financial or economic variables that possibly have significant influences towards the presence of heterogeneous risk tolerance and optimism level.

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References

Ahn, D., Choi, S., Gale, D. & Kariv, S. 2014. Estimating ambiguity aversion in a portfolio choice experiment. *Quantitative Economics* 5(2): 195-223.

Andani, S.R. 2013. Fuzzy mamdani dalam menentukan tingkat keberhasilan dosen mengajar. *Seminar Nasional Informatika,* UPN 'Veteran' Yogyakarta, 18 Mei.

Bhattacharjee, S. 2017. A comparative analysis of impact of asset allocation on portfolio performance as medium term investments. *Journal of Management and Research* 11(3/4): 1-15.

Chen, L.H. & Huang, L. 2009. Portfolio optimization of equity mutual funds with fuzzy return rates and risks. *Expert Systems with Applications* 36(2): 3720-3727.

Febriany, N., Agustina, F. & Marwati, R. 2017. Aplikasi metode fuzzy mamdani dalam penentuan status gizi dan kebutuhan kalori harian balita menggunakan software MATLAB. *Jurnal Eureka Matika* 5(1): 84-96.

Gong, X., Min, L. & Yu, C. 2022. Multi-period portfolio selection under the coherent fuzzy environment with dynamic risk-tolerance and expected-return levels. *Applied Soft Computing* 114: 108104.

Huang, X., Jiang, G., Gupta, P. & Mehlawat, M.K. 2021. A risk index model for uncertain portfolio selection with background risk. *Computers & Operations Research* 2021: 105331.

Jaaman, S.H., Weng, H.L. & Isa, Z. 2013. Risk measures and portfolio construction in different economic scenarios. *Sains Malaysiana* 42(6): 875-880.

Jouini, E. & Napp, C. 2007. Are more risk averse agents more optimistic? Insights from a rational expectations model. *Economics Letters* 101(1): 73-76.

Kiliçman, A. & Sivalingam, J. 2010. Portfolio optimization of equity mutual funds: Malaysian case study. *Adv. Fuzzy Syst.* 2010: 879453.

Kocadağlı, O. & Keskin, R. 2015. A novel portfolio selection model based on fuzzy goal programming with different importance and priorities. *Expert Systems with Applications* 42(20): 6898-6912.

Lam, W.S., Jaaman, S.H. & Ismail, H. 2015. The impact of human behaviour towards portfolio selection in Malaysia. *Procedia-Social and Behavioral Sciences* 172: 674-678.

Li, H.Q. & Yi, Z.H. 2019. Portfolio selection with coherent Investor's expectations under uncertainty. *Expert Systems with Applications* 133: 49-58.

Lin, P. C., Watada, J., & Wu, B. 2013. Risk assessment of a portfolio selection model based on a fuzzy statistical test. *IEICE Transactions on Information and Systems* 96(3): 579-588.

Leungo, E.A. 2010. Fuzzy mean-variance portfolio selection problems. *Advanced Modelling and Optimization* 12(3): 399-410.

Markowitz, H. 1952. Portfolio selection. *Journal of Finance* 7(1): 77-91.

Mirnoori, S.M. & Shariati, A. 2012. Fuzzy portfolio optimization using Chen and Huang model: Evidence from Iranian mutual funds. *Afr. J. Bus. Manag.* 6: 6608-6616.

Mohamed, Z., Mohamad, D. & Samat, O. 2009. A fuzzy approach to portfolio selection. *Sains Malaysiana* 38(6): 895-899.

Mohd Amin, F.A. & Jaaman, S.H. 2023. Pemeringkatan saham patuh syariah menggunakan pembuatan keputusan berbilang-kriterium: TOPSIS dan GRA. *Sains Malaysiana* 52(6): 1865-1877.

Princy, S. & Dhenakaran, S.S. 2016. Comparison of triangular and trapezoidal fuzzy membership function. *Journal of Computer Science and Engineering* 2(8): 46-51.

Ramli, N. & Mohamad, D. 2010. Fuzzy Jaccard with degree of optimism ranking index based on function principle approach. *Majlesi Journal of Electrical Engineering* 4(4): 9-15.

Rinandiyana, L.R., Fahmi, A.N. & Kusnandar, D.L. 2020. Experienced regret dan risk tolerance dalam membentuk perilaku perdagangan saham. *Forum Ekonomi* 22(1): 44-48.

Robiyanto, R. 2018. Performance evaluation of stock price indexes in the Indonesia stock exchange. *International Research Journal of Business Studies* 10(3): 173-182.

Safdari, C. & Scannell, N.J. 2005. Investment risk profiling utilizing business resource slack. *Journal of Business & Economics Research* 3(8). https://doi.org/10.19030/jber.v3i8.2794

Shyamal, A.K. & Pal, M. 2007. Triangular fuzzy matrices. *Iranian Journal of Fuzzy System* 4(1): 75-87.

Sutara, B. & Kuswanto, H. 2019. Analisa perbandingan fuzzy logic metode Tsukamoto, Sugeno, Mamdani dalam penentuan keluarga miskin. *Infotekmesin* 10(2): 75-86.

Turan, H.H., Atmis, M., Kosanoglu, F., Elsawah, S. & Ryan, M.J. 2020. A risk-averse simulation-based approach for a joint optimization of workforce capacity, spare part stocks and scheduling priorities in maintenance planning. *Reliability Engineering & System Safety* 204: 107199.

Tsaur, R.C. 2013. Fuzzy portfolio model with different investor risk attitudes. *European Journal of Operational Research* 227(2): 385-390.

Van Staden, P.M., Dang, D.M. & Forsyth, P.A. 2021. The surprising robustness of dynamic mean-variance portfolio optimization to model misspecification errors. *European Journal of Operational Research* 289(2): 774-792.

Vlad, C. & Surlaru, A.C.P. 2020. Empirical check of the return-risk tandem. *Ovidius University Annals, Economic Sciences Series* 20(1): 1070-1073.

Wen, F., He, Z. & Chen, X. 2014. Investors' risk preference characteristics and conditional skewness. *Mathematical Problems in Engineering* 2014: 814965.

Xing, F.Z., Cambria, E. & Welsch, R.E. 2018. Intelligent asset allocation via market sentiment views. *IEEE Computational Intelligence Magazine* 13(4): 25-34.

Yao, Z. & Rabbani, A.G. 2021. Association between investment risk tolerance and portfolio risk: The role of confidence level. *Journal of Behavioral and Experimental Finance* 30: 100482.

Zainol Abidin, S.N., Jaaman, S.H., Ismail, M. & Abu Bakar, A.S. 2020. Clustering stock performance considering investor preferences using a fuzzy inference system. *Symmetry* 12(7): 1148.

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