THE DESIGN OF A DECISION SUPPORT SYSTEM FOR THE SELECTION OF BANKING INVESTMENT PRODUCTS USING THE ANALYTICAL HIERARCHY PROCESS

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ABSTRACT

Currently there are various banking investment products such as bonds, mutual funds, stocks, and foreign exchange. Each of these products has different characteristics. Unfortunately, not all potential investors get the information and are able to determine the suitable product. The variables used as the determinants of suitable banking investment products were the amount of capital, risk-return, liquidity, the investor's experience, and investment period. These factors are multi-criteria. The purpose of this research was to produce a decision support system that was able to help potential investors determine the most suitable banking investment products. The Analytical Hierarchy Process (AHP) method was considered appropriate for providing multi-criteria decisions. As a result, the compatibility of the AHP method to help the investors solve the problem could be observed.

Keywords *:decision support system, financial investment products, Analytical Hierarchy Process (AHP)*

INTRODUCTION

Economic conditions change over time. As an alternative to seek for the income and the financial security, people make some investments, in the form of banking products or in the form of goods. Several types of the banking investment products available are savings, deposits, mutual funds, foreign exchange, and stocks. While the goods investment can be in the form of lands, houses, or golds. This research was limited to the banking investment products.

Each type of banking investment products has distinct advantages and risks. The capital required to own each of these investment products is also varied. This often becomes an obstacle for people who want to invest, especially for the newbie investors.

There are several factors that can help someone in determining the appropriate banking investment product. First is the amount of the capital needed. Each banking investment product requires a varied capital. The amount of the capital is relative to the different levels of society. For example, for the middle to lower class, 100 million Rupiah is a large amount; meanwhile for the upper middle class, this number is considered as a small one.

The second determining factor is the level of risks and results obtained. The greater the risk is, the greater the profit will be obtained. The lower the risk is, the lower the income will be.

The next factor is the liquidity or the convenience of withdrawing the funds. This is usually also related to the investment period. Some investment products require a certain period of investing time. In addition, there are some specific procedures that must be done to withdraw the funds. In the other words, the withdrawal cannot be done anytime the investor wants to.

Based on these factors, the experienced investors will easy in determining the most appropriate banking investment products for them. However, the newbie investors can be confusing because the criteria are interconnected. To overcome this confusion, researchers tried to make a decision support system in order to help the investors determine the banking investment products which were in accordance with the characteristics of potential investors.

The Analytical Hierarchy Process (AHP) method was used as the determinant, since it allows multi-criteria selection with different levels of importance. Based on these variables, a decision support system that could help people, especially the newbie investors, determine the banking investment products which best suited the needs and the characters of its users was expected to be embodied.

LITERATURE REVIEW

INVESTMENT

Investing is an action of placing some funds at the present time in order to gain some profits in the future (Halim, 2005: 4). According to Fahmi and Hadi (2009: 7), there are two categories of investing: fixed-assets investing involving tangible assets such as houses and gold, and financial investing that generally involves assets in written contracts such as stocks and bonds.

DECISION SUPPORT SYSTEM

The Decision Support System (DSS) is defined as a computer-based system consisting of three interacting components: a language system (a mechanism for communicating between users and other DSS components), a knowledge system (a repository of problem domain knowledge that exists in the DSS as data or as a procedure), and the problem-processing system (the relationship between the other two components, consisting of one or more common problem manipulation skills required for decision making) (Turban, 2005: 104). The purpose of making the Decision Support System is to help someone make decisions.

Decision Support System (DSS) is developed by three components:

Database System

Model Base

Software System

ANALYTICAL HIERARCHY PROCESS (AHP)

The Analytical Hierarchy Process (AHP) is a decision support model developed by Thomas L. Saaty. This decision support model will describe complex multi-factor or multi-criteria problems into a hierarchy. According to Saaty, the hierarchy is defined as a representation of a complex problem in a multi-level structure where the first level is the goal, followed by the factor level, criteria, sub criteria, and so on down to the last level of the alternative. With a hierarchy, a complex problem can be broken down into groups that are then organized into a hierarchical form so that the problem will seem more structured and systematic.

In the Analytical Hierarchy Process (AHP) method, the following steps are done:

Defining the problem and determining the desired solution.

In this stage, the researchers tried to determine the problem to solve in a clear, detailed and easier way. From the existing problems, the researchers tried to find the solutions that might be suitable for the problem. The solutions of the problem may be more than one. These solutions would be further developed in the next stage.

Creating a hierarchical structure that begins with the main purpose.

After setting the main objective as the top level, a lower hierarchy level was being developed. It consisted of the suitable criteria for considering or assessing the researchers' given alternatives and determining them. Each criterion has a different intensity.

Creating a pairwise comparison matrix that describes the effects of each element against the upper level criteria.

The matrix is simple. It has a strong position for the consistency framework. Furthermore, it obtains other information that may be required with all possible comparisons and is able to analyze the overall priority sensitivity for any changes in the consideration. The matrix approach reflects the multiple aspects of the priority which are dominating and being dominated. The comparisons are made based on the judgment from the decision makers by assessing the importance of an element over the other elements. To begin the pairwise comparison process a criterion is selected from the topmost level of the hierarchy, K for example, and then the elements which are going to be compared are taken from the lower level, for examples: E1, E2, E3, E4, E5.

Defining the pairwise comparisons so that the total judgments will be $n \times [(n-1) / 2]$

The result of comparing each element will be in the form of a number from 1 to 9 that shows the comparison of the importance of an element. The result then is then loaded on cells corresponding to the element being compared.

Calculating the eigen values and test their consistency. If it is not consistent then the data retrieval is repeated.

Repeating step 3, 4, dan 5 for every hierarchy level.

Calculating the eigen vector from every pairwise comparison matrix which will be the weight of each element for the determination process.

The calculation is done by summing the value of each column of the matrix, dividing each value of the column by the total of the corresponding columns to obtain the normalization of the matrix, and summing the values of each row and dividing them by the number of elements to obtain the average number.

Checking the hierarchical consistency.

The Analytical Hierarchy Process measures the ratio of consistency by looking at the consistency index. The consistency expected is the one near perfect in order to produce a decision that is close to valid. Although it is difficult to achieve the perfection, the consistency ratio is expected to be less than or equal to 10%.

RESEARCH METHODOLOGY

The stages of the research process include several stages:

Data Collection

The data were obtained through the interviews with one of the banks to get theinformation of the types of banking investment products, the data criteria, and the investment risk profile. The supporting theories were obtained through the literature studies.

Requirement Analysis

Based on the data obtained, a requirement analysis that includes the functional requirements of the system to be built, the software requirements, and the hardware requirements was conducted. Based on the data obtained, the decision support system method that best meets the users' needs was determined.

System Design and Implementation

Based on the results of the analysis, a design of the system was built. The next stage was the implementation of the design into the system which was built using a particular application. In addition, the method of decision support system was also being applied into the application.

System Testing and Evaluation

Once the system had been successfully established, the internal and external test phase were performed for the users. The results of these trials were then evaluated in order to draw the conclusions and provide developing advices for further research.

RESULTS AND DISCUSSION

CALCULATION OF ALTERNATIVE WEIGHT

Based on the results of data collection, the users of the system built were the public and the administrator of the program as the determinant of the criteria. The criteria used to determine the outcome of the decision were the amount of the capital, the ratio between the risks and the results obtained, the liquidity, the investors' experiences, and the investment period. The alternative decision results, the banking investment products that were being offered, included the bonds, equity funds, mixed mutual funds, fixed-income mutual funds, money-market mutual funds, and foreign exchange.

Before conducting the test to get the appropriate result of the banking investment product suggestions, users filled in the risk profile used to determine the level of risk acceptance. The results of this test were used as additional filters in determining the investment products. The testing was done by filling out the questionnaire, then the total number of answers will be summed. The result was then matched against the risk profile table that had been determined in value from a particular bank.

Table 1. Risk Profile and Investment Product

Total Value	Risk Profile	Suitable Product
<=11	*Conservative* (1)	Savings, Deposit
12-19	*Moderate* (2)	
20-28	*Balanced*(3)	Foreign Exchange
29-35	*Growth* (4)	Bonds
36-40	*Aggressive*(5)	Share Mutual Funds, Mixed Mutual Funds, Fixed Income

		Mutual Funds, Money Market Mutual Funds

The values used in the calculation of the alternative weighting were obtained from the questionnaire filled by the bank. The questionnaire used a 9 point Likert scale. This assessment was used to facilitate the bank in filling the criteria. While the one needed for the AHP process was the Pairwise Comparison.

Table 2. Nine Point Likert Scale for Alternative Weighting

Alternative	Value
Bonds	3
Share Mutual Funds	5
Mixed Mutual Funds	5
Fixed Income Mutual Funds	5
Money Market Mutual Funds	8
Foreign Exchange	9

Therefore, the next step was converting the 9 point Likert scale data into the Saaty Pairwise Comparison. The data conversion was done by taking the value of the first alternative (L_i), the second alternative (L_j) then reducing L_i to L_j. If the yield of L_i with L_j was positive, then the calculation formula for the i pairwise comparison value to j (S_{ij}) could be seen in the following equation (1).

$$S_{ij} = (L_i - L_j \quad (1)$$

If the yield of L_i with L_j was negative then the calculation formula for the i pairwise compare value to j (S_{ij}) could be seen in equation (2).

$$S_{ij} = \frac{}{|L_i -} \quad (2)$$

Using the equations (1) and (2), the pairwise comparison value for capital criteria could be seen in Table 3 as follows.

Table 3. Pairwise Comparison for Alternative Weighting

Capital	Share Mutual Funds	Mixed Mutual Funds	Fixed Income Mutual Funds	Money Market Mutual Funds	Foreign Exchange	Bonds
Share Mutual Funds	1	1	1	0,25	0,2	3
Mixed Mutual Funds	1	1	1	0,25	0,2	3
Fixed Income Mutual Funds	1	1	1	0,25	0,2	3
Money Market Mutual Funds	4	4	4	1	0,5	6
Foreign Exchange	5	5	5	2	1	7
Bonds	0,333	0,333	0,333	0,167	0,143	1
TOTAL VALUE	12,333	12,333	12,333	3,917	2,243	23

After obtaining the pairwise comparison, the calculation was done to know the weight of each alternative for the criteria. First, the pairwise comparison table was normalized, which each value was divided by the number of values for each alternative. Then, the value of the

normalization result was calculated on average by summing each value to the side and dividing the sum by the number of alternatives (Equation 3).

$$Pi = \frac{\sum_{j:}^{n}}{} \quad (3)$$

i as the row, j as the column, S as the pairwise comparison value, J as the sum and n as the number of alternatives.

Table 4. Pairwise Comparison for Alternative Weighting with Priority Vector

Capital	Share MF	Mixed MF	Fixed Income MF	Money Market MF	Foreign Exchange	Bonds	Priority Vector
Share MF	1	1	1	0,25	0,2	3	0,088
Mixed MF	1	1	1	0,25	0,2	3	0,088
Fixed Income MF	1	1	1	0,25	0,2	3	0,088
Money Market MF	4	4	4	1	0,5	6	0,285
Foreign Exchange	5	5	5	2	1	7	0,413
Bonds	0,333	0,333	0,333	0,167	0,143	1	0,038
TOTAL VALUE	12,333	12,333	12,333	3,917	2,243	23	1

After finding the priority vector of each alternative, the Consistency Ratio was checked in order to determine whether the weight was eligible to be used or the value should be retrieved. The calculation of Consistency Ratio was done by calculating the Principal Eigen Value (Lmax) and Consistency Index (CI) first.

The formula for calculating the Principal Eigen Value and Consistency Index could be found in Equation (4) and (5).

$$L_{max} = \sum_{i=1,j=1}^{n,m}(P_i \, x \, J_j), \; where \; n \quad (4)$$

$$CI = \frac{L}{} \quad (5)$$

After obtaining L_{max} and CI values, the Consistency Ratio (CR) was calculated by dividing the Consistency Index with the Random Consistency Index (RI) (Equation 6). If the value of CR ≤ 10% then the value of the pairwise comparison was consistent and the weight was feasible to use. If the CR value> 10%, it meant that the value was inconsistent and needed to retrieve.

$$CR \quad (6)$$

Table 5. Random Consistency Index

	0	1	2	3	4	5
.I.	.52	.89	.11	.25	.35	.4	.45	.49	.51	.54	.56	.57	.58

The following was the calculation process along with the results of L_{max}, CI and CR for the capital criteria.

L_{max} = 0.088x12.333 + 0.088x12.333 + 0.088x12.333 + 0.285x3.917 + 0.413x2.243 + 0.038x23

= 6.176
CI = (6.176−6)/(6−1)
= 0.035
CR = 0.035/1.25
= 0.028
= 2.8%

Since the CR value was <10%, the pairwise comparison was consistent and weights could be used. The final result of the calculation of alternative weight could be seen in table 6.

Table 6. Result of The Calculation for Alternative Weighting

Alternative x Criteria	Fund	Risk-return	Liquidity	Experience	Period
Share MF	0,088	0,345	0,125	0,214	0,107
Mixed MF	0,088	0,21	0,125	0,214	0,107
Fixed Income MF	0,088	0,128	0,125	0,214	0,107
Money Market MF	0,285	0,054	0,125	0,214	0,191
Foreign Exchange	0,413	0,054	0,375	0,071	0,425
Bonds	0,038	0,21	0,125	0,071	0,062

CALCULATION OF CRITERIA WEIGHT

The calculation of the criteria weight had the same steps as the calculation of the alternative weight. Each question posed to the user had 5 choices of answers with the values of 1, 3, 5, 7 and 9. These values were then converted into the pairwise comparison. The conversion of these values used the Equation (1) and (2).

Table 7. Nine Point Likert Scale for Criteria Weighting

Criteria	Value
Fund	7
Risk-return	5
Liquidity	3
Experience	9
Period	7

Table 8. Pairwise Comparison for Criteria Weighting

Criteria	Fund	Risk-return	Liquidity	Experience	Period
Fund	1	3	5	0,333	1
Risk-return	0,333	1	3	0,2	0,333
Liquidity	0,2	0,333	1	0,143	0,2
Experience	3	5	7	1	3
Period	1	3	5	0,333	1
TOTAL VALUE	5,533	12,333	21	2,01	5,533

Table 9. Pairwise Comparison for Criteria Weighting with Priority Vector

Criteria	Fund	Risk-return	Liquidity	Experience	Period	Priority Vector
Fund	1	3	5	0,333	1	0,202
Risk-return	0,333	1	3	0,2	0,333	0,089

Liquidity	0,2	0,333	1	0,143	0,2	0,044
Experience	3	5	7	1	3	0,464
Period	1	3	5	0,333	1	0,202
TOTAL VALUE	5,533	12,333	21	2,01	5,533	1

DETERMINATION OF DECISION SUPPORT SYSTEM RESULTS

The decision support system results was determined is by doing the matrix multiplication between the alternative weight and the criteria weight.

Alternative x Criteria	Fund	Risk-return	Liquidity	Experience	Period		Priority Vector
Share MF	0,088	0,345	0,125	0,214	0,107		0,202
Mixed MF	0,088	0,21	0,125	0,214	0,107		0,089
Fixed Income MF	0,088	0,128	0,125	0,214	0,107	x	0,044
Money Market MF	0,285	0,054	0,125	0,214	0,191		0,464
Foreign Exchange	0,413	0,054	0,375	0,071	0,425		0,202
Bonds	0,038	0,21	0,125	0,071	0,062		

Figure 1. Multiplication Between Criteria Weight and Alternative Weight

The multiplication result gave a new value for each alternative that showed the level of suitability between the existing alternatives and the level of importance of users' criteria.

Table 10. Result of Multiplication Between Criteria Weight and Alternative Weight

Investment Products	Result
Share MF	0,175
Mixed MF	0,163
Fixed Income MF	0,155
Money Market MF	0,206
Foreign Exchange	0,223
Bonds	0,077

The system then compared the user's risk profile with the risk profile table in Table 1. If the user's risk profile was greater than or equal to the recommended risk profile for the product, the rank did not change. However, if the user's risk profile was lower than the recommended risk profile for the product then the rank was placed at the lowest one. The result of this calculation was then applied to the development of the application.

Figure 2. Admin Page in the Application

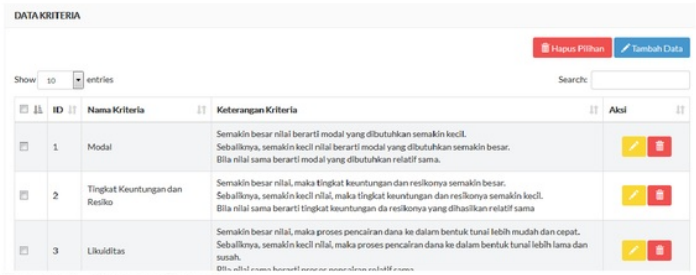

Figure 3. Criteria Data Page

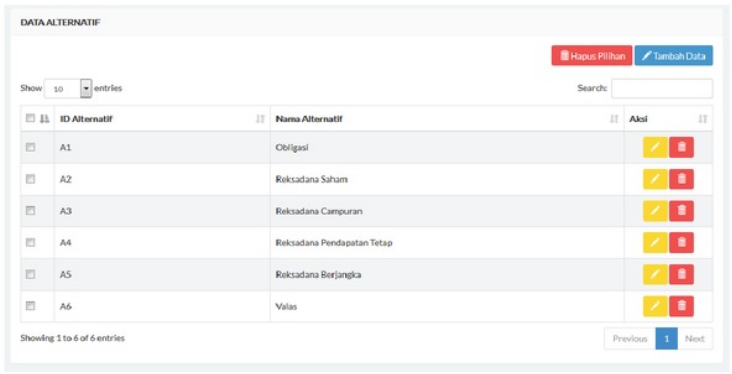

Figure 4. Investment Products Page

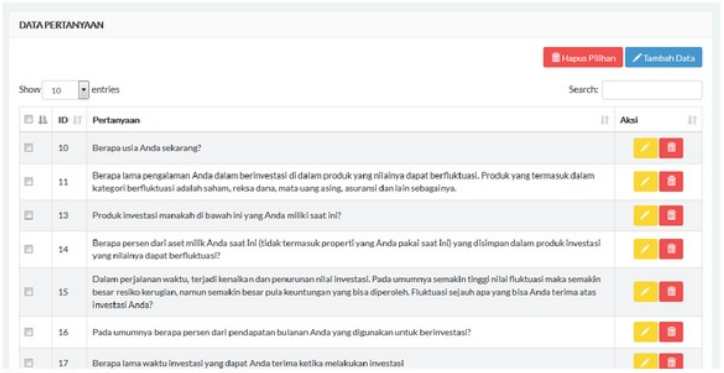

Figure 5. Questionnaire Page

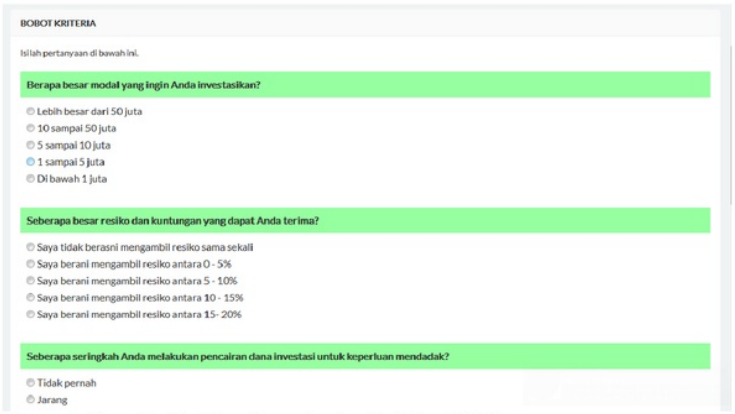

Figure 6. User Profile Questionnaire for Decision Making

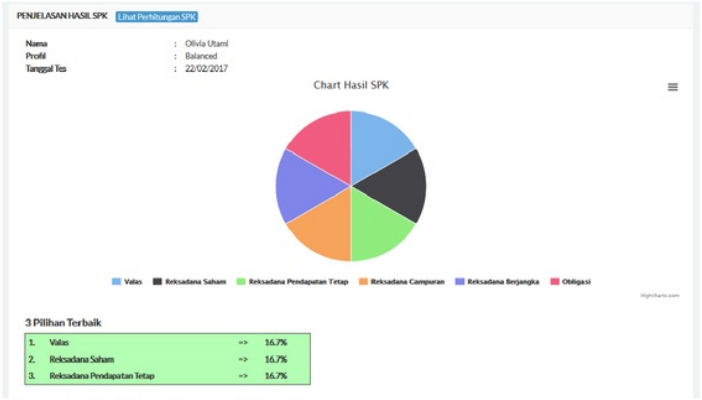

Figure 7. Decision Support Result

Before the application was tested, the user filled out a questionnaire in order to determine the level of user's knowledge about the investment (pre-test). After using the application, the user

filled out another questionnaire to find out the benefits the user obtained and to measure the develpoment of the user's knowledge toward the investments (post-test).

CONCLUSION

Based on the results of the trial and the users' evaluation, both from the public and from the bank, some conclusions could be drawn as follows:

The Analytical Hierarchy Process (AHP) method can be used in determining the banking investment products that suit the needs of users based on the criteria that have been used in this research.

Applications that have been made are able to help the public determine the banking investment products that are suitable with their needs.

The criteria used in the determination of investment products are varied for each bank because the available banking investment products are also varied.

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