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DEVELOPMENT OF A MATHEMATICAL MODEL FOR RISK ATTITUDE ANALYSIS USING AN EGO-GRAM TEST

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Abstract. *A characteristic type has been typically used in examining a person's preference that stands out when he/she makes a decision. In general, a person's characteristic type is closely related with their risk attitudes. In this paper, we develop a new mathematical model that analyzes individual risk attitudes using an Ego-gram, which assesses a person's character with a score for various character types. To do this, we measure a risk appetite index by calculating an individual's weighted score of stability and profitability for 7 investment types by pairwise comparison of the AHP, where the scores of stability and profitability denote risk-averse tendency and risk-taking tendency, respectively. Based on both the scores of the individual risk appetite index and characteristic type, the principal component analysis is implemented, as well as the development of multi-regression models.*
Keywords: Risk attitude, Ego-gram test, Regression

1. **Introduction.** When people are faced with decisions, some people tend to make a decision from their subjective point of view, whereas others decide based on objective information and logic. This difference in decision making often is because of a person's different character type. Hence, it would be very helpful in people's decision-making to detect preferences based on a person's character type and predicting how and whether the detected preference works independently or in combination. There have been many studies regarding character type, most of which concluded that there is a significant effect of character type on decision making [1,2]. The risk attitude as well as character type has a significant effect on decision making [3,4]. Although there has been research on the relation between character type and risk attitude, most of it has dealt with the character type and risk attitude as categorical variables [5,6]. That method has a problem of ignoring the difference among the values in the same category. Hence, we score each of the risk attitude and character type to analyze the differences among the values in the same category. After that, we measure person's character type and risk attitude in order to analyze their relations and develop a mathematical model. Character types are measured by use of Ego-gram test that provides scores for each character type, which enables mathematical analysis. Individual risk attitudes are measured as follows. First, we have the weighted scores of stability and profitability by pairwise comparison in AHP among a seven-asset portfolio. The weighted scores are multiplied by the distribution ratio of the current status of a seven-asset portfolio, according to which we can classify individual risk attitudes. Analyzing both the scores of character type and risk attitude, through principal component analysis we find out the main factor of a character type that influences risk attitude, such as risk-taking, and risk-neutral. In addition, we develop a regression model that explains the relation between character type elements and individual risk attitudes.

The rest of this paper is composed as follows. In section 2, we explain two measurement methods for character type and risk attitude. In Section 3, we perform a statistical analysis of the data obtained by use of the two methods mentioned in the previous section. Finally, Section 4 summarizes the paper and presents an overview of future work.

2. Methodology.

2.1. **Character type examination.** In order to examine the participants' character types, an Ego-gram test was used, which included 50 questions, as summarized in Figure 1. In this paper, we used Ego-gram test rather than an MBTI that is commonly used for a character type test. The reasons are as follows. First, there are too many inapposite questions on the MBTI test. Second, a certificate or degree in psychology is needed to obtain the MBTI test sheets. In contrast, the Ego-gram test can be administered through the Internet, and hence diffusion problems can be easily dealt with later. Third, quantitative scores can be obtained for each character type, which allows it to be analyzed mathematically. The Ego-gram test is a method for a character type test that started from transaction analysis. Transaction analysis is a theory advocated by Eric Berne. In this test, it classifies character type into the parent (P), adult (A), and child (C) ego-states, and focuses on analyzing how these groups of people interact; that is, transactions [7]. The results of the test will be shifted to a grade list shown in Figure 2, in which the scores of each character type (CP, NP, A, FC, AC) are calculated. According to whether the score is high or low, each attribute of factor is classified into two character types, as shown in Table 1.

2.2. **Risk attitude test.** In this paper, we use the AHP method, rather than the lottery game, for measuring risk attitude. The AHP can measure an entity in a ratio scale for both qualitative and intangible decision making variables, as well as breaking down complex matters into smaller elements, which means problems can be solved by using simple pairwise comparison. The AHP is widely used in decision making fields because

Egogram Test

Mark the score for each article below.
Check the score according to your present behavior
(For those who want the psychological tests result, please leave your e-mail on a blank below. We will send you the result after thorough analysis.)

	Strong denial 1pt	denial 2pt	medium 3pt	affirmation 4pt	Strong affirmation 5pt
1. Good at praising others					
2. Feel uncomfortable until you clearly distinguish right and wrong					
3. Tender and lack of determination					
4. Bright and mischievous					
5. Calm and steady					
6. Urgent and impetuous					
7. Put emphasis on empathy					

FIGURE 1. Ego-gram test survey

Egogram Grade List

(1) Transcribe your answer score on square room.
(2) Sum each of article's score and write on total.

NO.	Ego-state					NO.	Ego-state				
	CP	NP	A	FC	AC		CP	NP	A	FC	AC
1	■		■	■	■	27	■	■	■		■
2		■	■	■	■	28		■	■	■	■
3	■	■	■	■		29	■	■	■	■	
⋮	■	■	■	■	■	⋮	■	■	■	■	■
24		■	■	■	■	50		■	■	■	■
25	■		■	■	■	*Total*	CP	NP	A	FC	AC
26	■		■	■	■						

FIGURE 2. Ego-gram test score sheet

TABLE 1. Attribute of each characteristic type factor

Factor	Attribute	High	Low
CP	Criticism	Obstinate	Cordial
NP	Emotion	Good-hearted	Closed
A	Fact	Logical and rational	Reality awareness is distorted
FC	Fervor	Strong curiosity	Suppress feeling
AC	Adjustment	Pliable to others	Stand up point

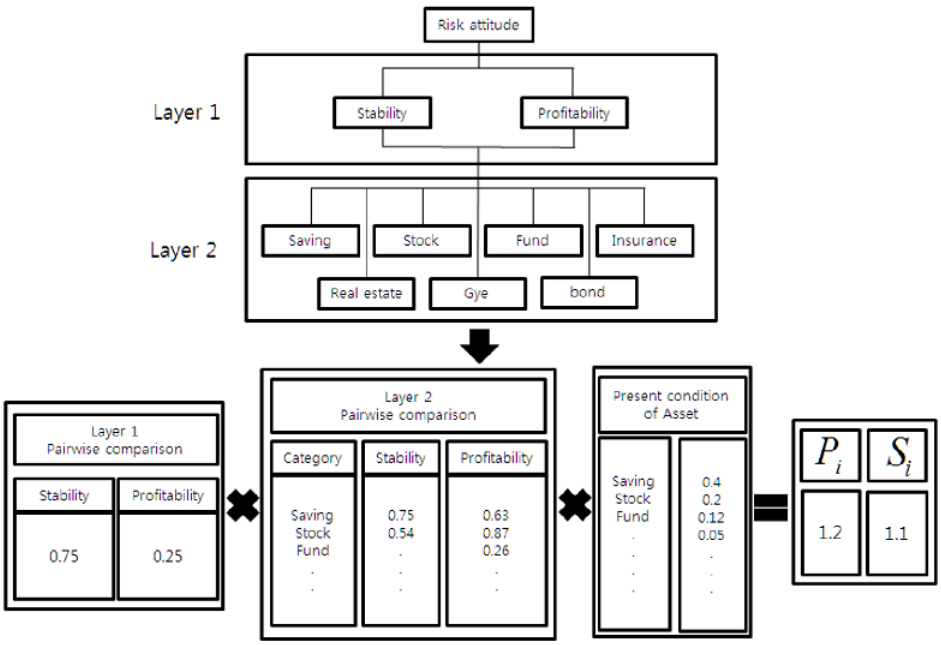

FIGURE 3. An example of calculating weighted score of stability and profitability

of its simplicity, accuracy, convenience, and generality. Furthermore, studies about its theoretical structure are ongoing [8].

In this paper, as shown in Figure 3, we perform pairwise comparison among 7 investment types (savings, stocks, funds, insurance, real estate, gye, and bonds) for stability and profitability according to the following two steps. First, we can calculate the weighted score of each investment type by multiplying values of layer 1 obtained after pairwise comparison between stability and profitability by those of layer 2 after pairwise comparison among 7 investment types. Second, we obtain P_i and S_i, where $P_i(S_i)$ represents a final score gained after multiplying a weighted score of profitability (stability) obtained in the first step by the distribution ratio of current holdings of a relevant risk asset. Note, by i we denote a random participant from the total number of participants N $(N = 1, 2, \cdots, n)$. Hence, we can define both scores of risk-loving RL_i and risk-averse RA_i as follows, respectively.

$$\left\{ \begin{array}{ll} RL_i = \dfrac{P_i - S_i}{P_i}, & \text{if } P_i > S_i \\ RA_i = \dfrac{S_i - P_i}{S_i}, & \text{otherwise} \end{array} \right\}, \; i \in N \, (N = 1, 2, \cdots, n). \tag{1}$$

Furthermore, we define

$$RL^* = \min_{i \in N} \left\{ RL_{(i)} | \max R^2_{RL} \right\}, \tag{2}$$

$$RA^* = \min_{i \in N} \{ RA_{(i)} | \max R^2_{RA} \}, \tag{3}$$

where R^2_{RL} (R^2_{RA}) refers to coefficient of determination R^2 of regression analysis of risk-loving and risk-averse participants' risk attitude, satisfying the condition of $p - value \leq 0.1$. Thus, the scores of risk-loving and risk-averse for each participant are shown in Figure 4, so we can finally classify the three types of individual risk attitudes as follows. If $RL^* < RL_i$, then risk-loving, and if $RA_i > RA^*$, then risk-averse, or else (if $RL^* > RL_i$ or $RA^* > RA_i$) risk-neutral.

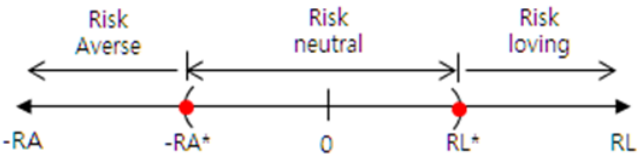

FIGURE 4. Risk attitude classification graph

3. **Result Analysis.** In this paper, in order to identify relations between the characteristic type and risk attitude, we measure risk attitude gained from AHP (Figure 3) and characteristic type factors from the Ego-gram test, and then perform a regression analysis as well as a principal component analysis.

3.1. **Principal component analysis.** Prior to identifying the relations between risk attitude and character types, we perform principal component analysis using SPSS statistical analysis software in order to clarify the correlation between the factors of character type and in order to find the leading factors. The results of the principal component analysis of the risk-loving participants' characteristic type factors are as follows. We extracted two principal components, components 1 and 2 shown in equations below, where the level of significance is 0.1 and power of explanation is 69%. The component matrix of component 1 and component 2 can be expressed as follows.

$$\text{component } 1 = 0.489\text{CP} + 0.767\text{NP} + 0.282\text{A} + 0.768\text{FC} + 0.568\text{AC}$$

$$\text{component } 2 = 0.699\text{CP} - 0.273\text{NP} + 0.835\text{A} - 0.029\text{FC} - 0.609\text{AC}$$

In component 1, the coefficients of all factors except factor "A" are greater than 0.5. In component 2, "A" and "CP" have a positive correlation, whereas "AC" has a negative correlation. As "CP" gets higher, people show a critical character type; as "A" gets higher people tend to show rational characteristic; and people are more pliable as "AC" gets higher. In total, we see that risk-loving people are shown to be less critical, rational, and pliable.

Next, the result of principal component analysis of risk-neutral participants' characteristic type is as follows. We have extracted two principal components, components 1 and 2, as shown in the equations below; the power of explanation is 57%. However, the level of significance is not good, indicating 0.67. The component matrix of component 1 and component 2 can be described as follows.

$$\text{component } 1 = 0.264\text{CP} + 0.649\text{NP} + 0.775\text{A} + 0.517\text{FC} - 0.548\text{AC}$$
$$\text{component } 2 = 0.879\text{CP} - 0.543\text{NP} + 0.328\text{A} - 0.243\text{FC} + 0.014\text{AC}$$

In component 1, the coefficients of all factors except factor "CP" are greater than 0.5. In component 2, "CP" has a positive correlation, whereas "NP" has a negative correlation. If we look at a character type, people are more critical as "CP" gets higher, as well as people are more tolerant as "NP" gets higher. In general, we see that risk-neutral attitude people are shown to be critical and not tolerant. The reason why the significance level is not meaningful is that risk-neutral people are not partial compared with risk-lovers.

Lastly, there is the result of the principal component analysis about the risk-averse participants' characteristic type. We have extracted two principal components, components 1 and 2, as shown in the equations below, where the level of significance is 0.0 and power of explanation is 62.7%. The component matrix of component 1 and component 2 can be expressed as follows.

$$\text{component } 1 = 0.733\text{CP} + 0.586\text{NP} + 0.731\text{A} + 0.568\text{FC} - 0.174\text{AC}$$
$$\text{component } 2 = -0.222\text{CP} + 0.644\text{NP} + 0.022\text{A} + 0.352\text{FC} + 0.882\text{AC}$$

In component 1, all factors except "AC" have positive correlations. In component 2, "NP" and "AC" have positive correlations. If we look through a characteristic type factor, people are more tolerant as "NP" gets higher and more pliable as "AC" gets higher. In total, risk-averse people are shown to be tolerant and pliable.

3.2. **Regression analysis.** We have implemented regression analysis to clarify relations between risk attitude gained by pair wise comparison and Ego-gram factors. The following is the result of regression analysis for risk-loving participants, where the level of significance is 0.007, and R^2 value is 0.57, which means it has a strong explanatory power. The equation below is the regression equation for risk taking.

$$RL = 3.77\text{FC} - 1.28\text{AC} - 2.11$$

This regression equation is composed of "FC" and "AC" that shows the highest eigenvalue in principal component analysis 1 and 2, respectively. In a characteristic type test, it can be said that the more curious and exploratory people are, the higher "FC" gets, as well as the more defiant people are, the lower "AC" gets. To conclude, people who are risk-loving are not only high in curiosity (FC) but also low in adjustment (AC).

The result of regression analysis for risk neutral participants is as follows. The equation below is the regression equation about risk-neutral, in which the value of R^2 is 0.541, hence showing it as favorable. However, the level of significance 0.270 represents that the regression model is not acceptable. The reason for that is that risk-neutral participants do not show special characteristics

$$RN = 1.49\text{CP} + 0.89\text{NP} - 1.27\text{A} - 1.28\text{AC} - 2.62$$

Lastly, the following are the results of regression analysis for risk-averse participants, in which the value of R^2 is 0.357, not having a strong explanatory power but it shows a favorable level of significance, 0.06. The equation below is the regression equation about being risk-averse.

$$RA = 2.19\text{CP} + 2.19\text{A} - 1.95\text{FC} - 17.072$$

From the results of regression analysis, we see that risk-averse people have a strong positive relation with "CP" and "A" but a strong negative relation with "FC". In a character type test, it is classified that people are critical when "CP" is high, with a rational attitude when "A" is high, and curious when "FC" is high. Thus, it can be said that risk-averse people tend to be critical (CP), rational (A), but less curious (FC).

4. **Conclusions.** We have investigated the participants' character types and risk attitudes by using an Ego-gram test and pairwise comparison of AHP, respectively, in order to mathematically analyze relations between the characteristic type and risk attitude. Using principal component analysis with those investigated results, we have successfully extracted the main factors of characteristic types that influence individual risk attitudes. Then we have developed a regression model that can explain and predict relations between the factors of the characteristic type and individual risk attitudes. In addition, the main results in this paper are as follows. First, strong risk-loving people are shown to be less critical (CP), emotional (A), curious (FC), and pliable (AC). Second, risk-neutral participants do not show any particular characteristics. Third, risk-averse participants are critical (CP), tolerant (NP), emotional (A), pliable (AC), and less curious (FC). Both risk lovers and risk averters are critical (CP) and rational (A), whereas risk lovers are curious (FC) and risk averters are pliable (AC).

The results of this paper are expected to be very useful in financial management where it needs to identify a customer's investment patterns to provide customized advices or consulting. It would be interesting to use another characteristic type test such as the MBTI instead of the Ego-gram test.

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