DOLLAR EQUIVALENCE: ALTERNATIVE APPROACH FOR MEASURING RISK PREFERENCE

Phatid Rongsirikul[1, *] and Arnond Sakworawich[2]

Abstract

This study proposes an alternative measure of people's risk preference based on Dollar Equivalence (DE). With reference to Probability Equivalence (PE) which is another, more well-known measurement for risk preference, DE can be considered to be the reverse of PE. In the context of DE, a certain amount of money should be stated by people when measuring their risk preference, while PE requires the subject to make a measure of probability. To illustrate and draw a conclusion on the effectiveness of DE, the study investigates the connection between financial knowledge, risk preference, and financial risk-taking behavior in situations of financial investment. This study relies on an online experiment where the results are taken from 446 participants who opted in, providing answers via a questionnaire. Furthermore, in order to create a control environment for the investment in which the external factor of risk warning can induce a change in a person's investment decision, an investment disclaimer or Risk Warning Statement (RWS) was randomly presented to roughly half of the participants. Comparison of the results for the two groups of people could then be used to show how the measures could gauge a shift in financial investment behavior.

Keywords: Risk Preference, Investment Behavior, Financial Risk-Taking

[1,*] Mr. Phatid Rongsirikul is currently doing a Ph.D. in Applied Statistics, Graduate School of Applied Statistics, National Institute of Development Administration (NIDA), Thailand, and also working as a full-time employee at a commercial bank. He obtains a master's degree in Finance - International Program (MIF), Thammasat Business School, Thammasat University, Thailand. Email: phatid.ron@stu.nida.ac.th, r.phatid@gmail.com

[2] Asst. Prof. Dr. Arnond Sakworawich is a full-time lecturer at Graduate School of Applied Statistics, National Institute of Development Administration (NIDA), Thailand. He obtains a Ph.D. in Psychometrics and Quantitative Psychology, Fordham University, USA.

1. INTRODUCTION

In the context of behavioral science, risk preference may refer to the attitudes of people toward risk. Roughly speaking, it implies the perception of people regarding the unpredictable outcome derived from the occurrence of a risky event that they must incur. In the decision-making process, it is often impossible to gather all the necessary information to conduct a full analysis before making a decision, in the limited time available. Therefore, there is always a level of uncertainty regarding the outcome, based on the decision-making process, which implies risk.

Risk preference is something embedded in an individual's mind and varies across people. One big question is how to reveal peoples' risk preferences. This study aims to investigate methods of gauging individuals' risk preferences, comparing their effectiveness in a given experimental setting. As suggested by prior studies, since financial investment incurs risk, it has been widely applied as a hypothetical situation in which people would have a chance to reveal their risk preferences. Therefore, the experiment has been designed so that each individual is required to make a decision on his/her hypothetical investment. The study is based on the linkage between what people know (i.e. financial knowledge) and how they invest, which surely reflects their risk-taking behavior. Moreover, the study investigates whether this linkage can be explained by risk preference.

The study attempts to suggest a tool for measuring the risk preference of people. This would benefit financial institutions and the financial investment business as a whole. The financial investment trend is now growing over time, while financial institutions (i.e. the sellers of the financial investment products) are facing up to the difficulty in suggesting the right investments to the right investors. Hence, without an appropriate tool, they may have a limited capability to reveal the true risk preference of the investors.

2. LITERATURE REVIEW

The term risk preference has long been used in order to describe how people feel about risks (i.e. like or dislike) which can elaborate what kind of people they are in terms of their perception of risks. Wen et al. (2014) defined risk preference as peoples' attitudes towards risks, which influence their decision-making when investing. Risk preference can be categorized into three types, namely risk-averse, risk-loving (or risk-taking), and risk-neutral preference. In economics, these can be explained by the expected utility theory. Given the theory, the utility function of risk-averse agents is represented by a concave function while that of risk-loving is represented by a convex function. Individuals with risk-averse preferences are prone to avoid taking risks and, as a result, value certain more than uncertain outcomes with all

other things being equal. Thus, in order to prompt these people to choose the risky choice, a positive amount of risk premium is required. On the contrary, for those with a risk-loving preference, uncertainty and the risky choice are preferred. A negative risk premium can be shown in this particular case. To understand more about risk preference, two related theories should be addressed, namely the Expected Utility theory and Prospect theory.

Expected Utility Theory vs. Prospect Theory

The idea of expected utility has come to play a role in economics since the early 18th century. The term was first initiated by Bernoulli (1738), who illustrated that the utility function (i.e. strictly concave-down function) would be used to correct the expected value, which could account for risk-averse behavior. This helps to explain the case where an individual does not decide on the choice with the highest value as suggested by the expected value criterion, but the choice with the highest utility. Von Neumann and Morgenstern (1947) developed four axioms of rational behavior to explain that when confronted with risky outcomes for different choices, individuals would prefer the choice that maximized their expected value of utility. The utility could also be expressed in a functional form known as the von Neumann-Morgenstern (VNM) utility function which is a fundamental idea in expected utility theory. As a result, individuals' risk attitudes can be different across people depending on their utility function.

Kahneman and Tversky (1979; 1986) pointed out that expected utility was a normative theory, meaning that it explained how individuals should behave rationally rather than how they actually do in reality, which is expressed as a positive theory[3]. As a result, prospect theory was presented as an alternative to the conventional expected utility theory. It also proved that regarding expected utility, some violations exist in reality. Instead of the expected utility function, the application of the prospect theory value function has been employed. Conceptually, they are analogous and represent the same function. However, the prospect's value function is based more on actual evidence from decision-making. Therefore, unlike expected utility theory, prospect theory can be viewed as a positive or descriptive theory which explains human behavior observed in a real-world setting. Empirical evidence was shown to demonstrate how people actually act or react in a given situation. In the event of gains, people are risk-averse while in the event of losses, they are risk-loving. The value function, as demonstrated by Kahneman and Tversky (1979), is concave for gains and convex for losses, and is also

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steeper for losses than gains. In other words, individuals were proved to be loss aversive. This provides a contradictory conclusion to the expected utility axioms.

Measurement of Risk Preference

Donkers et al. (2001) proposed an idea to estimate individuals' risk attitudes by using lotteries. The main objective was to identify whether or not and how an individual's attitude towards risk varied with observed characteristics. The study was based around eight questions on lotteries, for which five questions required the respondents to make a choice between two lotteries (i.e. first type), while the remaining three questions were probability equivalence questions (i.e. second type), meaning that the respondents were required to state the probability of winning a given prize that would have made them indifferent to entering such a lottery with a certain amount of money. Those two types of questions had a risky (i.e. high variance) and a safe (i.e. low or zero variance) option, which were used to discriminate between high and low degrees of individuals' risk aversion. The study found a significant relationship between the answer collected from questions on lotteries, and age, gender, income, and education level. The results revealed that high negative attitudes towards risk were found mostly in females and older people, while income and education level were positively related to the attitude towards risk for each individual.

In the study of Donkers et al. (2001), probability equivalent (PE) was used for respondents to state the chance of winning the prize which they were willing to accept given a certain cost for the lottery. Regarding expected utility theory, certainty equivalent (CE) is another measure of equivalence in decision-making between the risky choice and certainty. Conceptually, CE is the certain amount for which someone would feel indifferently between receiving the amount and taking the bet. Hershey and Schoemaker (1985) studied the two different methods in utility measurement (i.e. PE and CE) according to VNM utility functions. Based on four different experiments, the study found inconsistent results between using PE and CE. Possible explanations addressed in this research to account for these discrepancies included psychological biases and heuristics, as well as random errors which induced systematic biases in the utility function.

A contradictory result was found by Ruggeri and Coretti (2015) who studied two different techniques (i.e. PE and CE) in gambles involving life-years and quality of life. One objective of this study was to explore whether or not an inconsistency exists between PE and CE techniques. The data sample was collected via an interview process in an experimental setting. The results illustrated that there was no significant difference between the results of the elicitation technique used in this study, implying

that PE and CE could yield consistent conclusions regarding individuals' risk attitudes. Furthermore, they found that instead of the technique itself the results were sensitive to and caused by the different types of gamble.

Interrelationship Between Financial Knowledge, Risk Preference, and Financial Risk-taking Behavior

Awais et al. (2016) investigated the impact of financial literacy and investment experience on risk tolerance and investment decisions. They found that higher financial literacy and investment experience led to greater risk tolerance and made investors more likely to choose risky investment securities. The study concluded that an investor with high financial literacy and good experience would be able to deal with risky situations and handle them properly. This is consistent with Sabri and Afiqah (2016) who found that Millennials who had an advanced financial literacy tended to take risks in their investment decision-making.

Sadiq and Khan (2018) also examined the relationship between financial literacy, risk perception, and investment intention, among youth in Pakistan. The study found that financial literacy positively impacted individual intentions for short-term and long-term investment. This suggested that investors with high financial literacy would have more financial investment intentions. Aren and Zengin (2016) studied the influence of financial literacy and risk perception on choice of investment. They found that individuals' investment preferences were affected by risk perception and their level of financial literacy. The study illustrated a significant interrelationship between financial literacy and investment preference.

In terms of portfolio investment, Guiso and Jappelli (2008) studied the relationship between portfolio diversification and investors' characteristics, particularly the role of financial literacy. They found that a lack of portfolio diversification could be mainly explained by a lack of financial literacy. Furthermore, people with a low-education, as well as risk-averse investors, were prone to have less financial sophistication. Abreu and Mendes (2010) also found that the level of specific financial knowledge and general educational level had an impact on the number of different assets in investors' portfolios. This, in fact, could be shown as evidence of an increase in the diversification level of investment.

3. RESEARCH METHODOLOGY

As mentioned earlier, this study aims to investigate a measurement of risk preference – the Dollar Equivalence – through a connection between a person's financial knowledge, their risk preference, and financial risk-taking behavior. Therefore, these three variables should be drawn along with each factor and measurement in detail.

Variable and Measurement

Financial Knowledge

To test people's financial knowledge, a knowledge assessment was created. This assessment test was composed of nine questions involving different topics on both basic and intermediate financial knowledge i.e. type of financial products, characteristics of common stock, measurement of risk, understanding of risk vs. return, and portfolio risk and allocation. The test was intended to measure objective knowledge based on respondents' experiences or knowledge background.

Risk Preference

Risk preference is the attitude of people toward risk i.e. risk-loving vs. risk-averse. People may react or perform differently in any specific circumstance with an uncertain or unknown outcome. Their reaction can be caused by their experience, knowledge, or in this case their risk preference. In order to measure risk preference, the measurements were separated into three types of questions i.e. lottery choice questions, probability equivalence questions, and dollar equivalence questions.

A lottery choice question (LOTT) is a question involving selection between two different risk-embedded lotteries, as suggested by Donkers et al. (2001). This type of question aims to gauge the attitude of people toward risky vs. safe choices given a similar or slight difference in the expected outcome by using a lottery or game. There are five questions of this type which the participants were required to answer.

The PE questionnaire as suggested by Donkers et al. (2001) consists of five questions. In this type of question, participants were assumed to have a different amount of money as a reward for winning a game. They were asked to give that amount to purchase a lottery in which they could earn either a certain amount of another reward in case of winning or nothing in case of losing. The participants were asked to state the minimum probability of winning the lottery that would make them feel comfortable enough to buy the lottery. The reward for winning the lottery was held constant across all 5 questions; however, the amount of money that the participant must use to purchase the lottery would be increased from question 1 to 5.

The dollar equivalent (DE) questionnaire can be thought of as a tweaked version of the PE questions used in Donkers et al. (2001). The concept and computation of the DE questions were based on the certainty equivalence mentioned earlier in the literature review for CE and PE. However, this is not entirely and exactly the CE that is applied in this study. When talking about CE, following the expected utility theory, the utility function and the risk premium must be considered. Theoretically, the CE refers to the certain amount at which the individual feels indifferent between receiving this certainty and taking the bet, given his/her utility function. The DE, on the other hand, does not take into

account the utility function of the people. It could be said that the concept of DE is similar to CE, with a slight difference in detail as it is the maximum amount that people are willing to pay when taking the bet.

For DE, in comparison with PE, rather than asking about a required probability of winning the lottery, participants are asked to put in the maximum amount that they are willing to pay for the lottery, given a fixed amount of reward, and a pre-defined probability of winning. This type of question is the reverse logic of PE. In fact, for the sake of consistency, the numbers used in PE and DE questions reflect each other. Specifically, the probabilities used in DE questions are computed from the PE questions given a risk-neutral expected return.

Financial Risk-Taking Behavior

Financial risk-taking behavior is meant to elaborate on how people accept risk when they invest. To gauge this behavior, participants are asked to perform portfolio allocation such that they must select stock into their portfolio. There are 30 given stocks available for participants to choose[4]. However, each stock has different characteristics (i.e. embedded-risk, historical average return, financial backgrounds, and forecasted price movement[5]). All of this related information regarding each stock is provided to the participants who are able to view the information during the stock selection process. A fixed amount of initial money is given to each participant. Participants must fill in the amount to be allocated to each selected stock. They also have a choice not to invest all or some part of the provided budget. The remaining amount will be considered as a saving that generates a small return but at no risk.

To measure the financial risk-taking behavior, there are two major factors which are portfolio risk and information search behavior. Portfolio risk is used as an attempt to gauge the risk of the portfolio itself and can be measured by 1) the number of stocks in the portfolio, 2) portfolio standard deviation, 3) portfolio Beta, and 4) the percentage of money in the portfolio. The higher the value for the first three, the higher the degree of financial risk-taking for the given individual[6]. On the contrary, a high percentage of

[4] The stocks provided here are actual stock listed in Stock Exchange of Thailand (SET) market. Therefore, information involving the stocks is actual data (e.g. PE ratio, volatility, historical return, and Beta). However, in order to prevent bias against specific stock, their prices are standardized and their names are blinded and given as code (i.e. A01 to A30) instead.

[5] To simulate price path of the stocks and plot as a price prediction graph, the Geometric Brownian motion (GBM) method has been applied (Ermogenous, 2006).

[6] Given modern portfolio theory (MPT), investor is presumably risk-averse as he or she aims to maximize expected portfolio return for the lowest risk (Markowitz, 1952; Marling and Emanuelsson, 2012). The measurement of risk in this case could be standard deviation of return (SD) and Beta of the portfolio. Intuitively, increasing in number of selected stock should imply that investors are willing to add risk in their portfolio.

uninvested money from the given budget suggests a low degree of financial risk-taking. Information search behavior, on the other hand, focuses on the behavior of the participants regarding the stock selection process, which can be measured by 1) time used in stock selection[7], and 2) the number of clicks to open the stock price chart. A high value for each of these suggests that participants are more careful in their stock selection; hence, they are prone to have a low degree of financial risk-taking[8].

Given all variables (i.e. financial knowledge, risk preference, and financial risk-taking behavior), Table 1 provides a summary of all the variables and their associated measurements along with the scale used for each variable.

Experimental Design

An online testing platform was applied in which the questionnaires were divided into three parts. Participants would be provided both a URL and QR code to access the online testing page. They were required to fill in their basic information on the registration page (e.g. gender, occupation, educational background, and monthly income) before entering the test. Once the participants completed all the required information on the registration page, they were entered into the testing and questionnaire sections which contained the measurement questions for each variable. A risk warning statement (RWS) was applied in this study, in order to investigate whether or not people act differently in the case of the presence of an RWS. The

Table 1 Variables and Measurements Summary

Variable	**Measure**	**Score/ Value Range**
Financial knowledge	FIN	0 to 9
Risk preference	LOTT	0 to 5
	PE	0% to 100%
	DE	≥ 0
Financial risk-taking behavior	NumStock	0 to 30
	SD	≥ 0%
	BETA	≥ 0
	CASH	0 - 100%
	SPEED	≥ 0
	CLICK	≥ 0

[7] In the model, this measure is captured by SPEED which is a one divided by time used.

[8] Referring to Moorthy et al. (1997), they found a positive relationship between risk aversion and amount of search for both directed search and random search.

RWS is basically a phrase of investment disclaimer which can be found when people make their financial investment e.g. investing in a mutual fund. Therefore, after filling in the information on the registration page, the participants were randomly assigned by the program into two different groups i.e. a group being subject to the RWS, or the group not being subject to RWS (control group). In accordance with Mercer et al. (2010) who suggested that rephrasing the SEC's standard content of disclaimer could help investors to capture the exact meaning of the warning, the RWS used in this study is a strong version of disclaimer which has been modified from the standard phrase.

The data collected were analyzed in two ways. Firstly, a reliability test of the measurements was performed. This can illustrate if the measurement is reliable or not. Due to the different types and scales of measurement used for each of the three measurements (LOTT, PE, and DE), different methods of reliability tests were applied. For the LOTT, as the answer to each question is binary (i.e. either 0 or 1), the KR-20 technique[9] was used to test its reliability. For PE and DE, since the score can be varied, Hoyt's reliability test[10] was applied. Secondly, a correlation analysis was performed to analyze and compare across the three measures. Dependent and independent tests for the correlation analysis were done in order to further scrutinize if a statistically significant difference existed within or between each group of the sample.

4. RESULTS & DISCUSSION

Participant Profile

Observations were randomly selected in this study. The experiment was conducted in Thailand among Thai people. The participants could easily access the testing platform online by using their own electronic devices such as mobile phone, tablet, laptop, or PC. Provided an internet connection was present, the participants could join the online testing via web browser by entering the URL or simply scanning the QR code. The URL and QR code were distributed by various online channels, with a total of 446 participants joining and providing answers for the questionnaire. Based on the RWS group randomization, 220 participants were subject to RWS, while the remainder (226) were placed in the control group with no RWS. The participant profile is illustrated in Table 2.

[9] KR-20 is a Kuder-Richardson 20 which can be seen as a special case of Cronbach's Alpha where the result of the test is binary.

[10] Hoyt's reliability test usually refers to the Hoyt (1941) – so-called Hoyt's analysis of variance or Hoyt's ANOVA method. The method is widely adapted to compute the reliability coefficient for the data which its scale is not an interval scale such that the Cronbach's Alpha cannot be applied.

Table 2 Participant Profile

Profile	Detail	Number	Percent
Gender	Male	190	43%
	Female	256	57%
Occupation	Government officer	50	11%
	State-owned enterprise officer	19	4%
	Corporate Employee	109	24%
	Self-employed	25	6%
	Merchant	4	1%
	College Student	205	46%
	Freelance	11	2%
	Retiree	4	1%
	Other	19	4%
Level of Education	Undergraduate	61	14%
	Vocational/ High Vocational Certificate	7	2%
	Bachelor's degree	276	62%
	Master's degree or higher	102	23%
Income per Month	None	117	26%
	Less than or equal to THB 15,000	91	20%
	THB 15,001 - 30,000	119	27%
	THB 30,001 - 45,000	53	12%
	THB 45,001 - 60,000	23	5%
	THB 60,001 - 75,000	14	3%
	More than THB 75,000	29	7%

Table 3 Reliability Test Results

Measures	RWS Group	Reliability	Method
FIN	No	0.552	KR-20
FIN	Yes	0.654	KR-20
PE	No	0.904	Hoyt's
PE	Yes	0.906	Hoyt's
DE	No	0.828	Hoyt's
DE	Yes	0.812	Hoyt's
LOTT	No	0.384	KR-20
LOTT	Yes	0.563	KR-20

Reliability Test

Before evaluating the test results, a reliability test of the measurements was performed. Thus, the measures of financial knowledge (FIN), and risk preference i.e. lottery choices (LOTT), probability equivalence (PE), and dollar equivalence (DE), for which it is possible to compute a

reliability value were tested. However, due to the different types of variables being used, as illustrated in Table 1, different methods were applied to compute the reliability values. The reliability test for FIN and LOTT was KR-20, while Hoyt's reliability was applied for PE and DE. The results of the reliability test are illustrated in Table 3. Please note that the common rule of thumb for the acceptable value of the reliability should be around 0.6 to 0.7, with a value of 0.8 or higher indicating good reliability.

Correlation Analysis

To analyze the effectiveness of the measurement, the correlation values between each measure were computed and provided in a correlation matrix displaying both groups, No RWS and RWS, as shown in Table 4, and Table 5). From the results of the control group (i.e. No RWS), it can be seen that for the interrelationship between financial knowledge and risk preference, the highest value belongs to financial knowledge and lottery choice, that is $r_{FIN,LOTT}$ = 0.2267, while $r_{FIN,PE}$ = 0.1371, and $r_{FIN,DE}$ = 0.0794. The positive value for $r_{FIN,LOTT}$ indicates that people with high financial knowledge tend to have a low degree of risk aversion i.e. they are prone to be risk-loving rather than risk-averse. Likewise, for the correlation between FIN and LOTT, the positive value of $r_{FIN,DE}$ illustrates that people who have higher financial knowledge tend to be more risk-loving. These results are consistent with those of Awais et al. (2016), which suggests a higher risk tolerance for people who have high financial literacy and investment experience. On the contrary, the $r_{FIN,PE}$ also shows a positive value, suggesting that people with high financial knowledge tend to be more risk aversive.

In the control group, a high correlation exists between financial knowledge and measures of financial risk-taking behavior i.e. SD, BETA, and SPEED. In this case, $r_{FIN,SD}$ = 0.2087, $r_{FIN,BETA}$ = 0.2741, and $r_{FIN,SPEED}$ = -0.2112. The SD and BETA measure the risk level of the portfolio which results from the stock selection of the participants. The positive value of these two correlations implies that people with higher financial knowledge tend to select risker stock or put more weight on the risky stock in their portfolio compared with those who have lower financial knowledge. This is also in line with the prior suggestion that people with higher financial knowledge tend to be less risk-averse (i.e. more risk-loving). In addition, this is consistent with the work of Awais et al. (2016); Sabri and Afiqah (2016); and Aren and Zengin (2016), which suggested that people with high or advanced financial literacy tend to choose risky assets and take greater risks in their investment decisions. Furthermore, to support this idea, it can be observed from Table 4 that the $r_{FIN,CASH}$ = -0.1825. This suggests that people with higher financial knowledge tend to put less weight on cash in their portfolios. In other

Table 4 Correlation Matrix (Group: No RWS)

	FIN	PE	DE	LOTT	NumStock	SD	BETA	CLICK	SPEED	CASH
FIN	1									
PE	0.1371	1								
DE	0.0794	0.0889	1							
LOTT	0.2267	0.0062	0.0819	1						
NumStock	-0.0183	-0.0177	0.0742	-0.0075	1					
SD	0.2087	0.0973	0.2509	-0.0037	0.1414	1				
BETA	0.2741	0.1197	0.2685	0.0145	0.3729	0.8774	1			
CLICK	0.1115	0.0875	0.0553	-0.0335	0.0136	0.0834	0.1049	1		
SPEED	-0.2112	-0.0004	0.0326	0.1073	-0.3133	-0.3498	-0.4362	-0.2241	1	
CASH	-0.1825	-0.1082	-0.1724	0.0090	-0.3635	-0.7617	-0.9014	-0.1427	0.4681	1

Table 5 Correlation Matrix (Group: With RWS)

	FIN	PE	DE	LOTT	NumStock	SD	BETA	CLICK	SPEED	CASH
FIN	1									
PE	0.1071	1								
DE	0.2412	0.0546	1							
LOTT	0.0802	0.0406	0.0553	1						
NumStock	-0.0415	0.1024	0.0789	-0.0552	1					
SD	0.3282	0.0413	0.1586	0.1215	0.1654	1				
BETA	0.3329	0.0557	0.1733	0.1183	0.3387	0.9218	1			
CLICK	0.1591	0.0341	0.2039	0.1322	0.0450	0.1010	0.1474	1		
SPEED	-0.2545	-0.0851	-0.1720	0.0048	-0.3299	-0.3521	-0.4218	-0.2652	1	
CASH	-0.3036	-0.0816	-0.1777	-0.0942	-0.3312	-0.7817	-0.9002	-0.1588	0.4576	1

words, they are prone to put more weight in stock which is a riskier asset class. The negative value of the correlation between FIN and SPEED implies that the people who have higher financial knowledge tend to use more time in the stock selection process (i.e. lower speed). It might be the case that the more people know, the more they search. Thus, they would need to spend more time carefully selecting the stock to put into their portfolio. As explained in Sadiq and Khan (2018), investors with high financial literacy would have more financial investment intentions.

As one may observe in Table 4, the dollar equivalence (i.e. the DE) is the only measure amongst the three measures of risk preference which illustrates a relatively higher correlation between risk preference and financial risk-taking behavior (i.e. $r_{DE,SD} = 0.2509$ and $r_{DE,BETA} = 0.2685$), while the PE shows $r_{PE,SD} = 0.0973$, and $r_{PE,BETA} = 0.1197$, and the LOTT shows $r_{LOTT,SD} = -0.0037$ and $r_{LOTT,BETA} = 0.0145$. Thus, DE seems to outperform the other two measurements regarding risk preference. DE also shows a negative correlation with CASH of -0.1724 which points to the same direction with financial knowledge. This implies that people with a higher degree of being risk-averse tend to put more money in cash savings rather than stock investment. In addition, the size of the correlation with CASH is higher than for the other two measures of risk preference (i.e. LOTT and PE) which may substantiate the greater effectiveness of DE over LOTT and PE.

In the case of the presence of RWS, it is interesting that a higher correlation value was found between FIN and DE at 0.2412, and a lower correlation value between FIN and LOTT at 0.0802. This is actually a significant shift from the control group (i.e. absence of RWS). Furthermore, FIN still interacts strongly with SD, BETA, and SPEED as in the control group. However, a significant improvement exists in the correlation between FIN and CASH (i.e. $r_{FIN,CASH} = -0.3036$) when compared with the control group which has the value $r_{FIN,CASH} = -0.1825$. This could perhaps be due to the fact that with the presence of RWS, people would be more cautious about their investment selection. Thus, in such circumstances, the correlation between financial knowledge and the portion of cash in the portfolio is observed more obviously. Comparatively, this implies that people are more sensitive toward cash saving in the case where RWS is presented.

As in the case of no RWS, DE is still the only measure amongst the three that can illustrate a comparatively high correlation with financial risk-taking behavior. A lower correlation exists between DE and SD, and between DE and BETA, compared with the investigation in the control group. However, the values are still higher than other measures (i.e. PE, and LOTT). In addition, a significant increase is seen in the correlation between DE and CLICK. With the absence of RWS, less of a relationship is seen between risk

preference and information search behavior. Nevertheless, with the presence of RWS, the correlation between DE and CLICK, and also between DE and SPEED, can be observed considerably. It could be interpreted that in the presence of RWS, people may be more cautious about their investment selection. As a result, those who are more risk-loving tend to spend more time searching for more information before making a decision compared with the case where RWS is not presented. This can be observed through the $r_{DE,SPEED}$ = -0.1720. Moreover, further supporting the increase in information search behavior, there is a prominent positive correlation between DE and CLICK ($r_{DE,CLICK}$ = 0.2039) implying that in the case of the presence of RWS, people do more searching, especially those who are more risk loving. In comparison with PE, and LOTT, DE can, therefore, more effectively capture the shift in the search behavior of the people, which is caused by the presence of an RWS.

According to the correlation analysis, compared with LOTT and PE, DE seems to be a superior measure for illustrating the relationship between risk preference and financial risk-taking behavior in cases of both presence and absence of RWS. For the relationship between financial knowledge and risk preference, in the case of the absence of RWS, the LOTT shows a better measure to illustrate the relationship. However, in the case of the presence of RWS, DE can clearly be seen to overcome LOTT.

Independent test and Dependent Test of Correlations

Since there are two groups of participants in this study (i.e. the group of people being subject to RWS and those not subject to RWS), it is appropriate to perform a statistical test to see if a significant difference exists between the correlations of the two groups. Therefore, an independent test of the correlations was applied, in order to investigate the correlations between risk preference and financial risk-taking behavior. In this case, each measure of risk preference (i.e. PE, DE, and LOTT) was compared in this analysis. The correlations (i.e. r) were mapped using Fisher's Z Transformation[11] (i.e. Z) and statistically tested. Accordingly, the hypothesis was set, such that $H_0 : \rho^{AR}=\rho^{PR}$ where ρ^{AR} represents the correlations from the group of participants not being subject to RWS (i.e. absence of RWS) and ρ^{PR} represents the correlations from the group of participants being subject to RWS (i.e. presence of RWS). The test results are illustrated in Table 6.

According to the testing results, it can be shown that, for DE, a

[11] The Fisher Z Transformation technique was applied in order to transform the sampling distribution of Pearson's correlation coefficient (i.e. r) into a normally distribution. The formula is given as follows: $z=0.5\times\ln\left(\frac{1+r}{1-r}\right)$. The Z transformation values of the correlations are illustrated in Table 7 and Table 8.

Table 6 Results of Independent Test of Correlations

Financial Risk-taking Behavior	PE		DE		LOTT	
	Z score	P-value	Z score	P-value	Z score	P-value
NumStock	-1.263	0.103	-0.049	0.480	0.501	0.308
SD	0.591	0.277	1.012	0.156	-1.319	0.094*
BETA	0.677	0.249	1.051	0.147	-1.094	0.137
CLICK	0.562	0.287	-1.588	0.056*	-1.746	0.040**
SPEED	0.890	0.187	2.164	0.015**	1.079	0.140
CASH	-0.281	0.389	0.057	0.477	1.085	0.139

Remark: ** = significant at 0.05, * = significant at 0.1

significant difference was found between the two groups of participants when paired with CLICK or SPEED. A significant difference was also found between the two groups of participants regarding the correlation between LOTT and SD, and between LOTT and CLICK. However, there was no significant difference found for the correlation pairs of PE, with any of the measures of financial risk-taking behavior. It is interesting that the significant differences of the correlations are found in the measure of information search behavior. With the presence of RWS, it could be the case that people might be more cautious about their decision making, leading to an observable increase in the correlations between risk preference and search behavior. People take more time (i.e. represented by SPEED) doing more information searching (i.e. represented by CLICK) when a warning exists.

Keep in mind that the independent test intends to test whether a significant difference exists between the correlations drawn from the different sample groups (i.e. in this case, the group of participants being subject to RWS, and those not subject to RWS). Hence, with the dependent test of correlations, a further statistical test can be carried out to see if a significant difference exists amongst the correlations, between the three measures of risk preference (i.e. PE, DE, and LOTT) and the measures of financial risk-taking behavior, given the same group of participants. Following the calculation formula and steps suggested by Meng, Rosenthal, and Rubin (1992), and Sakworawich (2003), the Chi-square (χ^2) results of the test and the Fisher Z transformation are illustrated in Table 7 and Table 8 for the case of absence of RWS and presence of RWS respectively. The null hypothesis is set such that for each measure of financial risk-taking behavior, there is no difference in the correlation across its pair of risk preferences. For instance, H_0: $\rho_{SD,PE}=\rho_{SD,DE}=\rho_{SD,LOTT}$ are used when performing the test on the correlation between SD and each measure of risk preference.

Table 7 Fisher Z Transformation and the Dependent Test Results (Group: No RWS)

Fisher Z transformation	NumStock	SD	BETA	CLICK	SPEED	CASH
PE	-0.018	0.098	0.120	0.088	0.000	-0.109
DE	0.074	0.256	0.275	0.055	0.033	-0.174
LOTT	-0.007	-0.004	0.014	-0.034	0.108	0.009
Chi-square	1.235	8.242**	8.225**	1.911	1.487	4.151

Remark: ** = significant at 0.05

Table 8 Fisher Z Transformation and the Dependent Test Results (Group: With RWS)

Fisher Z transformation	NumStock	SD	BETA	CLICK	SPEED	CASH
PE	0.103	0.041	0.056	0.034	-0.085	-0.082
DE	0.079	0.160	0.175	0.207	-0.174	-0.180
LOTT	-0.055	0.122	0.119	0.133	0.005	-0.095
Chi-square	3.515	1.771	1.716	3.606	3.845	1.361

According to the results, provided that the critical χ^2 for the 1%, 5%, and 10% significance levels are 9.21, 5.99, and 4.61 respectively, a significant difference exists for SD and BETA in the group of participants not being subject to RWS. In this case, it can be clearly seen that the DE has a relatively high correlation with SD and BETA, when compared to PE and LOTT. Although the correlations between DE and CLICK and between DE and SPEED comparatively increase in the case that the RWS has been presented to participants, the difference is not sufficient to be statistically significant according to these test results. As mentioned earlier, given the presence of RWS, the correlations between DE and SD and between DE and BETA drop, but no significant difference was found in the dependent test. One possible explanation could be that, given the presence of RWS, people would try to reduce the risk in their portfolio by either choosing the less risky stock or putting more weight on cash saving, provided that their risk preferences held constant. This behavior is evidenced by the decrease of the average portfolio's SD and BETA in the case of the presence of RWS, when compared to the case of the absence of RWS. The average values are reported at 9.50% for the portfolio's SD and 0.43 for the portfolio's BETA in the case of the absence of RWS. These values are lower in the case of the presence of RWS, at 7.96% for the SD, and 0.37 for the BETA. Moreover, the average portion of cash saving increases from 50.93% in the case of the absence of RWS to 56.88% in the case of the presence of RWS.

5. CONCLUSION AND RECOMMENDATIONS

In the control situation where no risk warning is posted, the linkage between financial knowledge, risk preference, and financial risk-taking behavior, as the measures of risk preference, DE does a better job of drawing the connection between risk preference and financial risk-taking behavior. Among the six measures of financial risk-taking behavior, SD and BETA have a clearer correlation with DE. The SD and BETA directly gauge the financial investment portfolio risk when people do the stock selection. Therefore, this provides crucial information about people's risk preference and their financial risk-taking behavior. The positive correlation between these variables indicates that the less risk aversive people are, the more risk they take into their portfolio. Although in the case of the absence of RWS the LOTT shows the highest correlation value compared with other measures of risk preference. This result is not consistent, as in the case of the presence of RWS the correlation significantly drops.

In the case where a risk warning is posted, financial knowledge seems to have a stronger interaction with DE compared with LOTT. This is evidenced by the higher correlation between FIN and DE, and lower correlation between FIN and LOTT. A positive correlation still points us to the same conclusion regarding the relationship between financial knowledge and risk preference. Due to the fact that the presentation of a risk warning statement puts pressure on people regarding their behavior, a higher correlation can be observed between risk preference and information search behavior. The correlation between DE and CLICK and between DE and SPEED, which are measures of information search behavior, can be proved to significantly increase in the case of the presence of RWS. The same pattern is also seen for the correlation between LOTT and CLICK. A significant increase in the positive correlation between risk preference and CLICK suggests that the less risk aversive (i.e. the more risk-loving) people are, the more information they search for given that they have been warned about the risk. Furthermore, a significant increase in the negative correlation between risk preference and SPEED implies that the less risk aversive (i.e. the more risk-loving) people are, the more time they spend on stock selection in the case of the presentation of a risk warning. In summary, when people are warned about the risk, they become more cautious and more careful about their decision making. The measure that seems to be more effective in capturing this behavior is DE.

In comparison between the three measures of risk preference (i.e. PE, DE, LOTT), DE and LOTT seem to be easier to comprehend in most people's point of view. Basically, the questions are simple and straightforward compared with those for PE, which ask people to write down the probability. Thus, it is quite

reasonable to see either DE or LOTT as a measure that can capture the relationship between the variables more efficiently. However, the DE seems to be a more effective measure compared with LOTT due to the fact that it can illustrate a clearer relationship between risk preference and financial risk-taking behavior in cases of both absence and presence of a risk warning statement.

The contributions of this study can be shown in two ways. Firstly, given that DE can work well as a measure of risk preference, in the financial investment industry, regulators or financial institutions may further adapt this tool to build on their testing, in order to gauge the risk preference of their customers. The concept of the suitability test for investors has been long applied to financial business. However, the effectiveness of this test is still in doubt as to whether or not it can properly gauge the risk tolerance of investors. If an alternative method exists that can be used to assess the risk preference more effectively, it could help investors to identify investment products that match their risk preference and prevent excessive risk-taking behavior. Secondly, it can be observed from this study, that financial knowledge is directly correlated with financial risk-taking behavior. People who have a higher level of financial knowledge tend to choose riskier stock for their portfolio to receive a better portfolio return. They also appear to be more careful about their investments, as demonstrated by the greater time spent on the stock selection process. In the case of the presence of a risk warning statement (i.e. investment disclaimer), they also show a better reaction by shifting their portfolio toward riskless assets (e.g. cash). All of these behaviors are what one would expect of a rational investor. Therefore, in order to achieve this, financial knowledge plays a key role.

Finally, it is worth addressing the limitation of this study. Given the online nature of the data collection, the test was based on randomization, meaning that it was distributed to multiple groups of people via online and social distribution channels, without any special criteria. However, according to the results, there was quite a large portion of participants who were college students. It could be the case that younger-age participants, who have a greater capability to fluently deal with the online platform, could more easily answer the test. Another possible explanation is that the parts of the test which involved theoretical questions (i.e. knowledge of finance and economics theory) could be more familiar to the eyes of college students, such that they were able to work through all the questions and complete the questionnaire in full. Since the test may take some time to go through and complete part-by-part, it could also be viewed as time-consuming for the non-college student participants – especially those who have a regular job. Thus, this point should be well noted and considered when looking at the results of this study.

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