



## การตัดสินใจต่อเหตุการณ์ที่อาจต้องสูญเสีย ภายใต้ความเสี่ยงและความกำกวม

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### บทคัดย่อ

คนเรามักจะต้องเผชิญกับความไม่แน่นอนในชีวิต ซึ่งอาจจะทำให้เกิดการสูญเสีย เช่น การเจ็บป่วย อุบัติเหตุ และภัยพิบัติ ในสาขาวิชาศาสตร์แห่งการตัดสินใจ ความไม่แน่นอนเหล่านี้สามารถจำแนกได้ตามความรู้เกี่ยวกับความน่าจะเป็นของผลลัพธ์ที่อาจเป็นไปได้ทั้งหมด กรณีที่ผู้ที่จะทำการตัดสินใจทราบความน่าจะเป็นที่แท้จริงเรียกว่าความเสี่ยง ส่วนกรณีที่ผู้ไม่ทราบความน่าจะเป็นที่แท้จริงเรียกว่าความคลุมเครือ งานวิจัยนี้ศึกษาประเภทความไม่แน่นอน ระหว่างความเสี่ยงกับความคลุมเครือ และโครงสร้างของผลลัพธ์ ระหว่างความไม่แน่นอนเหตุการณ์เดียวกับความไม่แน่นอนที่เทียบเท่าหลายเหตุการณ์ที่ผลกระทบต่อการประเมินค่าของการสูญเสีย บทความนี้รายงานผลการทดลองกับคนทำงาน 81 คนในภาคธุรกิจและอุตสาหกรรม โดยใช้เงินจริง ผลการศึกษาพบว่าคนส่วนมากพอใจกับความเสี่ยงมากกว่าความคลุมเครือ และพอใจกับความไม่แน่นอนหลายเหตุการณ์มากกว่าความไม่แน่นอนเทียบเท่าเหตุการณ์เดียว ผลการศึกษาที่น่าสนใจมากคือความไม่สอดคล้องกันระหว่างทัศนคติเรื่องความเสี่ยงและพฤติกรรมการกระจายความเสี่ยง คนส่วนใหญ่พอใจกับความเสี่ยงท่ามกลางการสูญเสียที่อาจเกิดขึ้น และยังพอใจกับความไม่แน่นอนหลายเหตุการณ์มากกว่าความไม่แน่นอนเทียบเท่าเหตุการณ์เดียว ผลการค้นคว้านี้สามารถนำไปสู่ความเข้าใจที่ดีขึ้นและการปรับปรุงการตัดสินใจเรื่องงานและเรื่องส่วนตัวของบุคคล

**คำสำคัญ:** การกระจายความเสี่ยง ความคลุมเครือ ความไม่แน่นอน ความเสี่ยง การตัดสินใจ ความสูญเสีย



## **Diversification Behavior of Individuals over Potential Losses under Risk and Ambiguity**

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### **Abstract**

People constantly face uncertain prospects in life, many of which may result in losses such as illnesses, accidents, and disasters. In the field of Decision Sciences, these uncertainties can be further differentiated according to the decision-maker's knowledge of the probabilities for all possible outcomes. Prospects in which these probabilities are precisely known are called risky, while those in which the probabilities are imprecisely known are called ambiguous. This study explores how these different probability precisions of risk versus ambiguity, as well as outcome structures of a single prospect versus comparable multiple prospects, can affect people's evaluations of uncertain losses. The paper presents a series of experiments involving 81 Thai working adults in business and industrial sectors using real monetary losses as a condition. Results reveal that people are generally averse to ambiguity in comparison to risk. In addition, they prefer multiple prospects over a comparable single one in general. Most interestingly, there seems to be inconsistencies between individuals' risk attitudes and their diversification behaviors. In particular, the majority of the participants are risk-seeking with respect to potential losses, yet most preferred multiple prospects over a comparable single one. These findings can lead to better understanding and improvement of both professional and personal decisions by individuals.

**Keywords:** Diversification, Ambiguity, Uncertainty, Risk, Decision-making, Losses



## 1. Introduction

People make decisions every day, many of which may result in outcomes that are uncertain. In the field of Decision Sciences, these uncertain decisions can be classified into two categories: decisions under risk and decisions under ambiguity [1]. The former is when the decision-maker is fully informed of the probability for each possible outcome, while the latter is when he or she does not have exact information regarding these probabilities. Casino bets and state lotteries, which involve objective probabilities, are examples of decision-making under risk. Sporting gambles and investment decisions, in comparison, are examples of decision-making under ambiguity.

There has been extensive research work regarding human's decision-making processes both under risk and under ambiguity [2]-[5]. However, only a few studies has examined these decisions in the losses domain [6], [7]. In addition, most of the existing literature in this area has focused on decisions that involve a single uncertain event or prospect. This paper aims to close this gap by exploring scenarios where individual decision-makers face multiple risky and ambiguous losses. Such situations arise naturally in the real world. For example, an individual who wants to buy insurance may choose one umbrella coverage or multiple separate policies.

The primary goal of this paper is to explore the benefits that people perceive from diversification strategies under these different probability conditions. In particular, this study intends to determine whether individuals prefer a single risky/ambiguous loss over comparable multiple losses. The acquired knowledge will enable experts to understand and assist people to make better decisions in both their professional and personal lives.

## 2. Related Literature

### 2.1 Attitudes toward Risk and Ambiguity

People may have different attitudes toward risk. Individuals are defined as risk-averse, risk-neutral, or risk-seeking if their certainty equivalents or personal valuations for uncertain prospects are less than, equal to, or more-than the expected values of those prospects respectively [6], [8], [9]. The degree of risk-aversion can be also measured by the risk premium. This is the difference between the perceived value of a risky prospect and its expected value. Thus, a decision maker who is strongly averse to risk will also have a high premium. Attitudes toward risk depend on the decision domain as well as the likelihood of the event [10]. People are likely to be risk-averse when facing a high probability of winning, but risk-seeking when facing a low one. In contrast, people are risk-seeking when facing high probability of losing, but risk-averse when facing a low one. Furthermore, individuals' risk attitudes can be influenced by the stakes in the decision. The higher the stakes, the more risk-averse people become [8], [9].

Attitudes toward ambiguity also vary among individuals. A person who prefers an alternative with less immeasurable uncertainty is deemed ambiguity-averse, while one who prefers an equivalent one with more immeasurable uncertainty is regarded as ambiguity-seeking. According to many research findings [11] - [13], people are generally ambiguity-averse. However, others have found evidence of ambiguity-seeking, especially in situations with low chance of success [14], [15].

### 2.2 Decision-making in the Losses Domain

Many studies have found that people's decisions



differ in the gains and losses domains [10]. More precisely, prospect theory proposed that in general, an individual's utility function is concave for risky gains, but convex for risky losses. In addition, the change in utility is more affected by losses than by gains of the same magnitude. This phenomenon is called loss aversion. The behavior of people under ambiguity in the losses domain is not so clear, however. Most studies have found that people are less ambiguity-averse with respect to losses than gains [12], [16]-[18]. However, others claimed that the aversion is not significant [14].

### 2.3 Diversification Behavior of Individuals

Diversification is a method of risk reduction, which is almost costless [19]. The main idea is not to "put all your eggs in one basket". People tend to diversify when they face uncertainty in order to avoid maximum damage. In finance, benefits from diversification come from correlations among assets in the portfolio, especially when they are low or negative. The type of optimal portfolio depends on each investor's preference. Risk-averse investors tend to focus on the volatility, while risk-seeking investors pay more attention to the returns.

Things are more complicated when ambiguity is involved. One of the theories that is used to find the optimal portfolio involving ambiguity is Bayes' rules [20]. The method is to place a subjective mean against ambiguity and find the best allocation according to it. Maximin is an alternative theory, which reflects the ambiguity-averse nature of the decision-maker through pessimism. The theory suggests that decision-maker should choose the best option in its minimum state. Another theory is Minimax-regret. This theory suggests that the decision-maker chooses the least regret option,

which is quite different from Bayesian allocation [20].

There is also empirical evidence of diversification behavior from existing literature. Many studies have found that people usually use the  $1/n$  Heuristic or naïve diversification with no regards of the differences of the portfolio [21], [22]. Moreover, the number of assets in people's portfolio also deviates from the theory. It is claimed that investors should hold a portfolio with around ten assets in it [23]. However, some studies found that most of them hold much less in their portfolio [24], [25]. With respect to ambiguity, it found that individuals tend to invest in domestic equity that they are more familiar with [26]. This phenomenon, known as home bias, is believed to be due to ambiguity aversion [27].

## 3. Methodology

### 3.1 Participants

The participants in this study are a random selection of 81 Thai working adults in business and industrial sectors in the Bangkok area, comprising 42 females and 39 males. Their ages range from 22 to 66 years ( $M = 42.4$ ) and their work experience varies between less than a year and 40 years ( $M = 16.1$ ).

### 3.2 Design

The experiments in this study are based on a  $2 \times 2$  factorial design. The first factor is Outcome Structure (Single or Diversified) and the second factor is Probability Precision (Risk: 50% or Ambiguity: 0-100%). This manipulation yields the following four types of prospects:

*Single Risk:*  $(-400, 0.5; 0, 0.5)$

*Single Ambiguity:*  $(-400, p; 0, 1 - p); p \in [0, 1]$



*Diversified Risk:*  $(-400, 0.25; -200, 0.5; 0, 0.25)$

*Diversified Ambiguity:*  $[-400, p_1; -200, p_2; 0, 1 - (p_1 + p_2)]$ ;  $p_1, p_2 \in [0, 1]$

### 3.3 Materials

The study consists of three parts with 11 questions in total.

Part 1 (Choice) and Part 2 (Pricing) were presented to the participants in random order, while Part 3 was the participants' expression of beliefs.

#### *Part 1: Pair-choices among the four prospects*

The following four questions, presented in random order, asks each participant to choose between the two prospects in each question.

Question 1: Single Risk versus Single Ambiguity

Question 2: Single Risk versus Diversified Risk

Question 3: Single Ambiguity versus Diversified Ambiguity

Question 4: Diversified Risk versus Diversified Ambiguity

#### *Part 2: Pricing of the four prospects*

In the second section of the experiment, participants stated their certainty equivalents for each of the four prospects: Single Risk, Single Ambiguity, Diversified Risk, and Diversified Ambiguity. The experimenter elicited these certainty equivalent values by asking three pair-wise choice questions in the following manner. Participants had to choose whether they were willing to accept the prospect, which could result in a loss (or not), or lose 100/200/300 baht as a certainty. For example, if a participant was willing to lose 100 and even 200 baht, but not 300 baht as a certainty instead of facing the prospect, his or her

certainty equivalent for that prospect would be equal to a certain loss of 250 baht.

#### *Part 3: Perception of probability and correlation in ambiguous prospects*

Participants expressed their beliefs regarding the probabilities and correlations in ambiguous prospects by answering the following three questions.

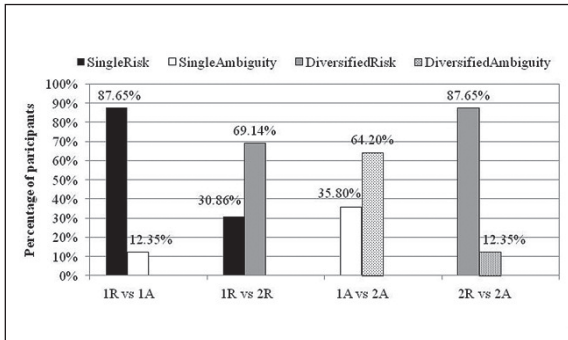
Question 1: The number of black and white balls in an unknown box. (The estimated probability of an ambiguous prospect.)

Question 2: The number of black and white balls in two unknown boxes. (The equality/inequality of probabilities in two ambiguous prospects.)

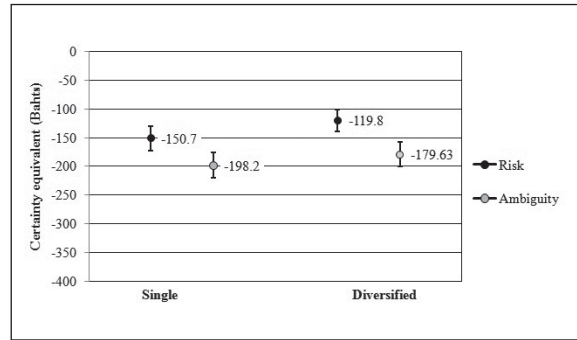
Question 3: The correct/incorrect result of the second draw given that the guess for the first draw was correct/incorrect. (The relation between two ambiguous prospects.)

### 3.4 Procedure

The experimenter randomly approached people at several office locations in Bangkok and asked if they would be willing to participate in the study. She then conducted the study in one-on-one interview sessions, using the three-part questionnaire described earlier. Each session lasted an average of 20 minutes. Each participant was paid 500 bahts (approximately USD 17) upfront and informed that they could lose up to 400 bahts of that amount, depending on their answers and a random draw. At the end of the experiment, one of the 8 questions in Part 1 and Part 2 was randomly chosen to play for real losses. If the selected question is from Part 1, a ball is drawn from the box that the respondents have stated that they preferred. If the selected question is one from Part 2, the experimenter



**Figure 1** Pairwise choice preferences among the four types of prospects ( $N = 81$ ).



**Figure 2** Certainty equivalents for the four types of prospects.

first used the BDM method to determine whether they should pay the amount that is drawn, if it is less than the certainty equivalent that the participants had reported) or play out the prospect as in Part 1.

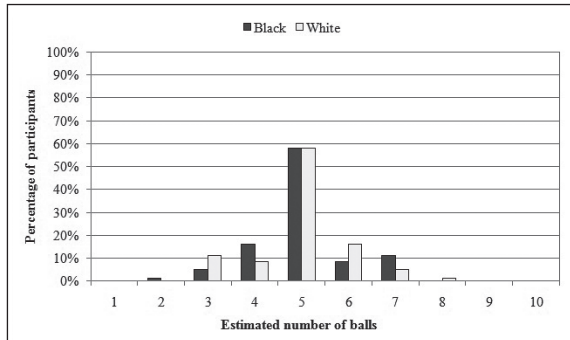
#### 4. Results and Analyses

Part 1 of the experiment contains pair-wise choices among the four prospects: Single Risk, Single Ambiguity, Diversified Risk, and Diversified Ambiguity. The result of the experiment is shown in Figure 1. Most of the participants (87.6%) preferred Single Risk over Single Ambiguity, which indicates that they are significantly ambiguity-averse in general,  $t(80) = -10.2, p < 0.001$ . In addition, 69.1% of the participants preferred Diversified Risk over Single Risk and 64.2% preferred Diversified Ambiguity over Single Ambiguity. These results imply that people strongly prefer to diversify under both risk ( $t(80) = 3.71, p < 0.001$ ) and ambiguity ( $t(80) = 2.65, p = .005$ ). Furthermore, 87.7% of the participants preferred Diversified Risk over Diversified Ambiguity. This suggests that people are strongly ambiguity-averse even when both prospects under consideration are

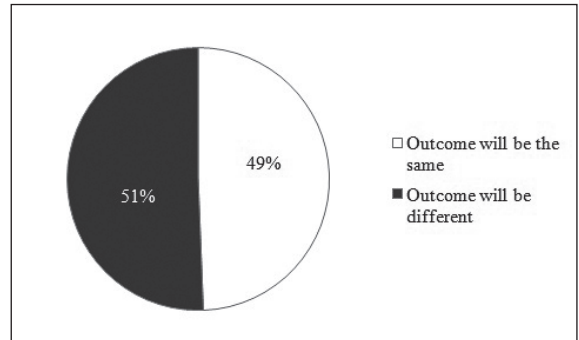
diversified,  $t(80) = -10.2, p < 0.001$ .

Part 2 of the experiment elicited certainty equivalents for each of the four prospects from a pricing task. Figure 2 shows certainty equivalents for the four types of prospects. Comparing each participant's certainty equivalent of the Single Risk prospect to its expected value of -200 baht found that 63% of the participants provided values that are less negative than -200 baht. This implies that they are risk-seeking. Next, a two-way ANOVA conducted on all the certainty equivalent data revealed a significant main effect of Outcome Structure, indicating that participants strongly preferred to diversify in general,  $F(1,80) = 13.4, p < 0.001$ . The main effect of Probability Precision is also significant, implying that participants are significantly ambiguity-averse on average,  $F(1,80) = 57.4, p < 0.001$ . However, the two-way interaction between Outcome Structure and Probability Precision is not significant,  $F(1,80) = 1.25, p = 0.267$ .

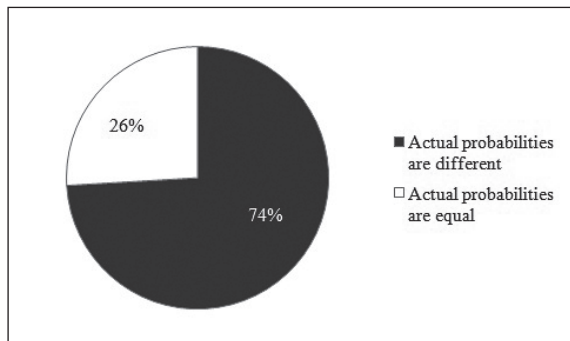
Part 3 of the experiment provided information regarding participants' perceptions with respect to the following issues: the estimated probability of an ambiguous prospect, the equality/inequality of



**Figure 3** Estimated probability of an ambiguous prospect.



**Figure 5** Participants' perceived correlation between two ambiguous prospects.



**Figure 4** Participants' perceptions of underlying probabilities in two ambiguous prospects.

estimated probabilities for two ambiguous prospects, and the correlation between the outcomes of two ambiguous prospects the results are shown in Figure 3, 4 and 5 respectively. First, the majority of the participants (58.0%) believed that there are equal number of black balls and white balls in the ambiguous box. This implies that perceived probability of an ambiguous prospect is not significantly different from 50% on average,  $t(80)=0.110, p=0.912$ . Second, 74.1% of the participants strongly believed that the color compositions of the balls in two ambiguous boxes are different. That is, they

perceived that the true probabilities for two ambiguous prospects are not equal,  $t(80) = -4.91, p < 0.001$ . Third, roughly half of the participants (49.4%) believed that draws from two ambiguous boxes will yield the same result. Thus, perceived correlation between outcomes of two ambiguous prospects are neither significantly positive nor significantly negative,  $t(80) = 0.110, p = 0.912$ .

## 5. Discussions and Implications

According to the results, people are generally risk-seeking with respect to potential losses. However, they are also ambiguity-averse on average. Results from both the choice task in Part 1 and pricing task in Part 2 are almost identical in terms of preference for risk and diversification. People prefer risky prospects over ambiguous ones for both single and diversified options. In addition, they prefer diversified prospects over single ones under both risk and ambiguity.

What is most striking from the findings is the apparent inconsistency between people's risk attitudes and their diversification behaviors. More specifically, although the majority of the participants are risk-





seeking, most preferred the diversified risky prospect over the single one in Part 1. Moreover, participants also valued the diversified risky prospect significantly higher than the single one on average in Part 2.

Another interesting finding is that people tend to diversify under ambiguity as well as under risk. Most prefer the diversified ambiguous prospect over the single one in the choice task even though they do not significantly value the former higher than the latter on average. Thus, this result implies that the benefit from diversification under ambiguity is less than that under risk.

There are certainly some limitations in this study. First, the incentive scheme of randomly choosing only one of the questions to play out for real money may affect participants differently depending on their risk attitudes. More specifically, this randomized mechanism may affect participants' responses and distort their true preferences and valuations. Second, it is possible that participants perceived prospects in this study to be potential gains rather than potential losses. This is because each was provided with an initial endowment of 500 bahts and could only lose a maximum of only 400 bahts. Furthermore, the magnitude of the incentive is relatively small and may affect the risk attitudes of participants and their behavior in the experiments.

The results that are found can be useful for both individuals and organizations that face situations involving potential losses with imprecisely known probabilities. In particular, from an individual perspective, the findings suggest that people should carefully evaluate their preferences and beliefs when making important personal or professional decisions. This is because their diversification behavior may not

be consistent with their risk and ambiguity attitudes, and thus may not be optimal. Additionally, firms offering products and services should also be aware that their customers may be reluctant to commit exclusively to one option when making investment or purchasing decisions. Thus, these firms should offer a selection of products and services with perhaps slightly different characteristics for the customers to choose from.

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