

# Quantitative analysis of the relationship between higher-order risk attitudes and financial literacy

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## *I. Abstract*

*The following study is an attempt to identify a correlate of the higher-order attitudes prudence and temperance which could be used to manipulate these attitudes in the context of a confirmatory experiment. To this end, the correlational relationship between financial literacy and people's higher-order risk attitudes have been analyzed. Results from the linear regression analysis indicate that people who possess greater financial knowledge are also more likely to exhibit prudence. In addition to this, risk averters and risk lovers have been analyzed separately in order to determine the prevalence and correlates of mixed risk attitudes. Results indicate that mixed risk aversion is a lot more prevalent than mixed risk loving. Interestingly, a new type of risk lover was identified in the process. Implications for future research are discussed.*

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## 1. Introduction

Very little in life is certain and how people make decisions under uncertainty has long since been a focal point of economic research. The behavioral tendencies that people exhibit in risky situations are generally described as their attitude towards risk. The risk attitude that has by far received the most attention is risk aversion. A risk averter is someone who dislikes taking risks and is often willing to pay a premium in order to avoid or reduce uncertainty. Conversely, someone who is risk seeking is willing to tolerate much higher levels of risk at the potential prospect of a larger reward. Although the majority of the general population can be classified as risk averse (Kahneman, 2011), not everyone dislikes risk to the same extent as others. Extensive research has identified a number of individual determinants, including gender, age, cognitive ability, education, and several cross-cultural factors. Furthermore, measures of risk aversion have been used to predict occupational choice (King, 1974), pension savings (Rooij, Kool, & Prast, 2007), and whether or not someone is likely to buy insurance (Mossin, 1968).

Classifying people as being either risk averse or risk seeking, however, is not the only manner in which we can describe someone's attitude towards risk. Besides risk aversion, there are a number of so-called higher-order risk attitudes which go beyond a mere preference for avoiding risks. Instead, these attitudes are used to describe the kind of preparations people make when simply avoiding uncertainty altogether is no longer an option. Two of these higher-order attitudes are prudence and temperance. The economic interpretation of prudence was first suggested by Kimball (1990) and was meant to reflect a person's willingness to take precautionary measures in the face of uncertainty. In terms of behavior, a prudent individual will strive to take precautionary measures in times of greater uncertainty. The concept of temperance was also coined by Kimball (1992) and describes an individual's tendency to moderate his/her total exposure to risk. Behaviourally, a temperate individual will respond to an unavoidable risk by reducing his/her exposure to another risk even if the two risk factors are statistically dependent on one another. Although both prudence and temperance have been well-defined both conceptually and in terms of behavior, much less is known about how these attitudes correlate with demographic variables and how being prudent or temperate in turn affects other economic activities.

This lack of understanding is significant for a number reasons. First, both prudence and temperance deal with a qualitatively different type of risk than risk aversion does. Although the concept risk aversion provides us with a measure of how much someone dislikes risk and his/her tendency to avoid risk when possible, it does not tell us anything about the (optimal) behavioral response to uncertainty when total avoidance it is no longer a valid or reasonable option. When contrasting the concepts of prudence and

temperance with that of risk aversion it becomes useful to distinguish between two different types of risk, namely endogenous and exogenous risk. In a sense, risk aversion tells us something about human behavior in the presence of endogenous risks. When a risk is endogenous, this means that adjusting one's behavior can directly affect the probability of certain events happening. For example, getting behind the wheel while intoxicated greatly increases the probability of being involved in an accident and the type of beverage we choose to consume is clearly something over which we can exert direct control. In contrast, prudence and temperance are used to describe people's responses to exogenous risks, which are risks which remain unaffected by our actions. Examples of exogenous risks factors are the weather, labor income uncertainty, and economic shocks. This does not mean, however, that human beings are completely powerless in the face of exogenous risks. Even when it's not possible to directly affect the chances of something happening, we do often have the opportunity to prepare ourselves for the possibility of certain events occurring by preemptively adjusting our behavior. For example, even though bringing an umbrella outside won't change the probability of rain, it does at least guarantee you won't get wet. Prudence and temperance are used to describe two behavioral adjustments people make as the amount exogenous or background risk in their life increases. In the context of savings and investments decisions, wherein the concepts of prudence and temperance were first introduced, a prudent individual will increase his/her precautionary savings in response to an increase in background risk. Along these lines, a temperate individual will opt to take fewer risks when investing in times of greater economic uncertainty. It is important to stress the value of preemptively adjusting one's behavior in anticipation of exogenous risk factors because doing so allows us to regain some level of control over events which at first glance appear out of our hands. The second reason why the further investigation of prudence and temperance could be useful is that greater understanding of the demographic correlates of these attitudes can help identify the people who are most likely to be affected by certain interventions, and conversely, how effective an intervention can be. Lastly, additional benefits can be derived from the better understanding of the relationship between prudence and temperance on the one hand, and other economic activities outside the domain of savings and investments on the other. For example, White (2008) shows that prudent people tend to exhibit more patience when engaging in bargaining behavior. It remains unclear, however, to which extent (if any) this increased patience is the result of being more prudent. By fostering greater understanding of how prudence and temperance relate to other economic activities, measures of the risk attitudes could be used to predict individual behavior, similar to how we currently use measures of risk aversion.

One of the main obstacles to better understanding how prudence and temperance relate to other aspects of economic decision making is that, up till now, all research concerning these topics has been of a correlational nature. This makes it impossible to definitively establish the causal relationship between higher-order risk attitudes and other variables of interest (e.g. bargaining behavior). After all, being able to show that two variables are correlated with each other is only the first of three criteria for establishing the nature of the cause and effect relationship between the two. The other two criteria for determining cause and effect are *temporal precedence* and having ruled out any *third or missing variables*. Temporal precedence means showing that the hypothesized cause took place before the effect, so for example that someone became a more patient bargainer after he/she adopted a more prudent attitude. Unfortunately, correlational analysis does not lend itself to solving this chicken and egg dilemma, as all data is collected at one point in time. Failing to demonstrate temporal precedence introduces the potential problem of reverse causality. In other words, it remains unclear whether people become more patient when bargaining as the results of becoming more prudent, or vice versa, that people become more prudent as the result of becoming more patient when bargaining. The second unfulfilled criterion is eliminating the possibility of any missing variables. The missing variable problem relates to the possibility of a hidden (uncontrolled for) third variable that influences both the hypothesized cause and effect variables, thus creating the illusion of a causal relationship. Both the issue of temporal precedence and the missing variable problem could be resolved by conducting a confirmatory experiment. However, in order to conduct confirmatory studies, researchers would first need to be able to manipulate the degree of prudence and temperance an individual exhibits. Although a recent study has identified a number of correlates of prudence and temperance such as educational attainment and gender which are likely to influence these higher-order risk attitudes (Noussair, Trautmann, & van de Kuilen, 2014), the inherent problem is that these variables are either difficult or unethical to manipulate.

The goal of the current investigation is to potentially identify a correlate of temperance and prudence that could easily be manipulated, namely financial literacy. Being more financially literate has been linked to overall better financial decision-making, whether it comes to planning, saving, or investing (Mitchell & Lusardi, 2015). Furthermore, an increase in financial literacy has been shown to influence people's tolerance for risk (Gustafsson & Omark, 2015). Similarly to prudence and temperance, risk tolerance plays a critical role in driving savings decisions (Than & Zeckhauser, 2011). It is therefore not unthinkable that financial literacy could relate to prudence and temperance as well. In order to investigate the relationship between higher-order risk attitudes and financial literacy, a quantitative analysis will be conducted on two datasets collected from the CentERdata LISS panel. The first contains experimental data on the higher-

order risk attitudes exhibit by the general population of the Netherlands. The second dataset was constructed as the result of a survey measuring the degree to which people are financially literate.

## 2. Theoretical framework

### 2.1 Decision making under uncertainty

The theory of expected utility has long since been the traditional model economists have used to describe how people make decisions under uncertainty. Consider the following scenario: suppose you arrive hungry at the train station. Your train leaves in a couple of minutes, but right around the corner is a small grocery store that sells sandwiches. If you go into the store and the line at register turns out to be long, you will miss your train and have to wait 30 minutes for the next one. You have two options: either go directly to the train or make a stop at the grocery store. How should you proceed?

When formalizing decision-making under uncertainty, it's useful to consider three separate entities (Singh & Bahi, 2015). Firstly *outcomes*, these are the all the possible end results of a decision. In the example, there are three possible outcomes: either you end up hungry and on time, you end up satiated and on time, or you end up satiated and late. Secondly, there are *states* – factors that are outside of the control the economic agent but that do influence the outcome of the decision. In the example, there are two states: either the line at the register is long or it isn't. And finally *acts*, these are the actions the agent can undertake. In the example, there are two acts: you either go into the store or you directly head for the train.

The expected utility framework provides a means for economic agents to rank their possible actions according to how desirable they are: the higher the expected utility, the better it is to take that course of action (Briggs, 2015). The expected utility of a certain act A is dependent on two factors. First, the probability of each outcome conditional on A. Second, the value of each outcome, quantified to represent utility. Given this information, the expected utility of act A is defined as:

$$EU(A) = \sum_{o \in O} P_A(o)U(o) \quad (1)$$

where  $O$  is the set of outcomes,  $P_A$  is the probability of  $o$  conditional on  $A$ , and  $U(o)$  is the utility of  $o$ .

### 2.2 Risk attitudes

Not everyone will respond in the same way when having to make a decision under uncertainty. This is because different people tend to have differing attitudes towards taking risks. Under the theory of

expected utility, people's risk attitudes are directly related to the curvature of their utility function (Wakker, 2010). The easiest to derive, and by far the most studied risk attitude is risk aversion. When a person is said to be risk averse, this implies that his/her utility function has a concave shape and shows diminishing marginal utility of wealth. With the help of these characteristics it can be shown that a risk-averse decision maker will always prefer the expected value of a lottery to the lottery itself, e.g. prefer receiving €25 for sure rather than a 50% chance to win €50. Let  $U(X)$  be the utility that a risk-averse decision maker derives from a monetary outcome  $X$ . Assuming diminishing marginal utility of wealth, it follows that  $U(2X) < 2*U(X)$ . Let  $EU_1$  be the expected utility of a sure payoff  $X$  and  $EU_2$  be the expected utility of a 50-50 lottery to win twice that amount ( $2X$ ). Implementation of equation (1) gives:

$$EU_1 = (100\%) * U(X) = U(X)$$

$$EU_2 = (50\%) * U(2X) + (50\%) * U(0) = 0.5 * U(2X)$$

Since  $U(2X) < 2*U(X)$ , it follows that  $EU_1 > EU_2$ . Thus proving that, under the theory of expected utility, a risk-averse decision maker will always prefer a sure thing over a gamble with the same expected value.

A person's degree of risk aversion can be measured as his/her willingness to pay a premium in order to avoid risk. Although the majority of the general population can be categorized as being risk averse, there is a large body of empirical evidence that suggests that individuals greatly differ in the amount of risk they are willing to tolerate. First of all, women tend to take fewer risks than men do in the vast majority of tasks (Figner & Weber, 2011). Additionally, there appears to be a correlation between risk aversion and age, with people becoming less tolerant of risk as they grow older. Height also seems to correlate with risk aversion, as taller individuals tend to take more risks, irrespective of gender (Dohmen et al., 2011). Furthermore, both educational attainment and cognitive ability have been shown to inversely relate to risk aversion (von Gaudecker et al., 2011). Lastly, there appear to be cross-cultural differences when it comes to risk preferences. Students in less developed countries appear to be significantly more tolerant of risk than their counterparts in richer countries (Vieider, Chmura, Martinsson, Thompson, & Sunday, 2015). Interestingly, this correlation seems to run in the opposite direction of the well-established positive relationship between risk tolerance and income.

Besides these individual determinants of risk aversion, there are also a number of contextual factors at play. This means that no individual has a singular preference for risk. Instead, people adjust their behavior in response to the characteristics of the specific decision they face. The *fourfold pattern*, developed by

Kahneman and Tversky, summarizes the interaction between two of these contextual factors: the probability of the outcome and the sign of the outcome (Kahneman, 2011). First of all, people tend to be more risk-averse when it comes to receiving gains with a large probability.<sup>1</sup> This is called the *certainty effect* and explains why people are willing to accept less than the expected value of a gamble in order to obtain a sure payoff. Secondly, people show an increased dislike for risk when they stand a low chance of losing. This explains why people are willing to pay much more for their insurance than it's expected value. Thirdly, when people stand a small chance of gaining something, they show an increased preference for risk. This is also called the *possibility effect* and helps explain why so many people buy lottery tickets. Finally and perhaps somewhat surprisingly, people tend to be more risk-seeking when they stand a high chance of losing, e.g. prefer a 95% chance to lose €10.000 to a sure loss of €9500. Clearly, the characteristics of a situation seem to affect people's tolerance to risk.

There is no denying that the concept of risk aversion has been instrumental in modeling people's decision making under uncertainty. However, the notion that most people prefer certainty over uncertainty is perhaps somewhat limited in its practical applicability, as most real-life situations involve some form of exogenous risk factors. A classic example is traveling. No matter the method of transportation there will always be a chance of something going wrong, whether is due to a human or technical error. Despite this, in 2013 alone, the Dutch population took over 18 million trips abroad, of which 93,9% involved transport by either car, plane, or train (Centraal Bureau voor de Statistiek, 2014). It is, therefore, important to go beyond the scope of risk aversion and attempt to model how people act when there is no option available that is completely safe.

Two higher-order risk attitudes that describe how people adjust their behavior in the presence of unavoidable risk are prudence and temperance. Within the framework of expected utility, prudence and temperance refer to properties of the third and fourth derivative of the utility function, respectively. Prudence is defined as the utility function having a positive third derivative, or alternatively that the marginal utility function is convex. The term prudence was first used by Kimball (1990) in order to connect the theory of precautionary savings with the concept of risk attitudes. According to Kimball, a prudent individual will choose to increase his/her savings in response to an increase in background risk. Temperance is known as the utility function having a negative fourth derivative. A temperate individual

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<sup>1</sup> All gains and losses discussed in relation to the fourfold pattern are assumed to be of a substantial size (€10.000+).



becomes more risk averse as the amount of background risk increases. This subsequently leads to the individual taking less risk when investing in times of greater uncertainty.

Since its inception, prudence has been linked to a number of economic activities other than precautionary saving. Within the context of auction bidding, prudent individuals tend to bid less aggressively as the value of the object that is auctioned off becomes riskier (Eso & White, 2004). Prudence also leads to a decrease in rent-seeking behavior for a risky rent as opposed to a riskless rent (Treich, 2010). With regards to taxes, Snow and Warren (2005) find that prudent individuals become more tax compliant as the uncertainty about the probability of being audited increases. Much less appears to be known about how temperance relates to economic activities other than investment decisions.

### *2.3 Behavioral approach*

Eeckhoudt and Schlesinger (2006) present an alternative way to model people's attitude towards risk. Instead of a mathematical model, they describe risk attitudes with the help of behavioral definitions. The model uses a lottery preference approach to assess people's decision making when faced with multiple possible losses. A decision maker is said to exhibit *risk apportionment* if he/she prefers to disaggregate harms instead of grouping them together. Besides its simplicity, an additional advantage of using such a behavioral approach is that it does not require additional assumptions about how probabilities enter decisions, contrary to the expected utility model. This allows the model to be applied in a broader array of settings.

Within the behavioral framework, risk attitudes are directly related to how individuals choose to apportion losses and/or risks when they are given the option to do so (Eeckhoudt & Schlesinger, 2013). Let  $W > 0$  be the initial level of wealth of an individual. It is assumed that the individual prefers having more money to having a lesser or equal amount. Furthermore, let  $k_1 > 0$  and  $k_2 > 0$  be positive constants that represent a sure loss of wealth. Consider the two lotteries depicted in Figure 1. All branches are assumed to be equally likely to occur (50%). Furthermore, it is assumed that  $W$  can never become negative as the result of a lottery. In lottery  $L_1$  the two losses are spread out over both possible outcomes. Although choosing this lottery guarantees that the individual will lose at least some money, it does limit the maximum possible loss. In lottery  $R_1$  both harms are aggregated together in the same state, essentially providing the individual with an all-or-nothing scenario. Another way of looking at it is that lottery  $L_1$  is a mean-preserving spread of lottery  $R_1$ . Under the behavioral approach, an individual is said to be risk-



Figure 1. Lottery pairs testing for risk aversion.



Figure 2. Lottery pairs testing for prudence.



Figure 3. Lottery pairs testing for temperance.

averse if he/she exhibits risk apportionment and thus prefers lottery  $L_1$  over lottery  $R_1$  for all values of  $W$ ,  $k_1$ , and  $k_2$  that satisfy the prior constraints.

In order to model prudence, let  $k > 0$  be a positive constant and let  $\tilde{e}$  be a zero-mean risk factor (e.g. a 50-50 chance of either winning or losing €10). Because  $\tilde{e}$  represents a form of uncertainty, a risk-averse individual will naturally dislike this random variable. Once again there's a situation where an individual is faced with two possible forms of loss, namely losing  $k$  and adding  $\tilde{e}$ , as illustrated in Figure 2. It is assumed that  $W - k + \tilde{e} > 0$  for all possible values of  $\tilde{e}$ . Lottery  $L_2$  guarantees that the individual will incur some form of loss, but never both at the same time. In lottery  $R_2$ , the individual stands a 50-50 chance of either receiving both harms or none at all. The behavioral model defines a decision maker as prudent if he/she strictly prefers lottery  $L_2$  over lottery  $R_2$ . Another way of looking at it is that a prudent person prefers to face the risk of  $\tilde{e}$  in the state where his/her wealth is highest. To allow for the modeling of temperance, one simply has to replace the sure loss  $k$  with another zero-mean risk factor. It is assumed that  $\tilde{e}_1$  and  $\tilde{e}_2$  are statistically independent of each other. The new lotteries are depicted in Figure 3. A temperate individual is someone who prefers lottery  $L_3$  over lottery  $R_3$ . Again this shows a preference for splitting up two harms when given the option to do so.

Using the behavior model, Noussair et al. (2014) conducted an experiment in order to examine the prevalence of higher-order risk attitudes in both the general population and a student sample. Although it is well established that most people can be categorized as risk averse, much less is known about what portion of the population exhibit prudence and temperance. Furthermore, they set out to investigate how risk aversion, prudence, and temperance levels correlate with various demographic factors and financial decision making. Prudence appears to be very prevalent in both student and general population samples. Additionally, they found that prudent decisions are related to higher educational attainment and greater cognitive ability. Prudent people also seem to enjoy healthier financial prospects. Specifically, they have greater wealth, are more likely to have a savings account, and are less likely to have a credit card debt. There does not appear to be a correlation between prudence and gender. Temperance was found in a majority of both the student and population samples, although it was less prevalent than prudence. Across both samples, men made less temperate decisions than women. Consistent with previous studies, measures of temperance were negatively correlated with the amount of risk in people's investment portfolios. Interestingly enough, this relationship seems to be moderated by the degree of income uncertainty that individuals reported. The negative relationship between temperance and investment risk appears to strengthen as the amount of background risk increases. As expected, a majority of people was identified as being risk averse. Risk aversion appears to be positively related to both prudence and temperance, and those with the greatest distaste for risk seem to be on average also more imprudent and intemperate.

#### *2.4 Mixed risk attitudes*

An alternate way of interpreting the behavior exhibited by people who apportion risks was suggested by Eeckhoudt, Schlesinger, and Tsetlin (2009). They propose that risk averters have a preference for combining relatively good outcomes with relatively bad ones. Reconsider the lottery pairs  $L_1$  and  $R_1$  depicted in Figure 1. In essence, this lottery pairing present the choice between combining a negative outcome  $k_2$  with either a positive outcome ( $W$ ) or with a bad outcome ( $W - k_1$ ). Given this interpretation, it becomes clear how a preference combining good with bad outcomes should lead someone to prefer  $L_1$  to  $R_1$ , thereby expressing a risk-averse attitude. Now consider what happens when this philosophy is extrapolated to higher order risks. If risk averters do indeed prefer to combine good with bad outcomes, it follows that individuals who are risk averse should also exhibit prudence ( $u''' > 0$ ), as this combines a good outcome ( $W$ ) with a bad one ( $\tilde{e}$ ). Similarly, risk averters are also expected to exhibit temperance ( $u'''' < 0$ ). In this case, a temperate choice once again reflects a combination of a good ( $W$ ) and a bad

outcome ( $\tilde{e}_2$ ). Individuals who adhere to this alternating pattern of signs of successive derivatives of the utility function are said to be *mixed risk averse*.

More recent efforts have attempted to extend the idea of mixed risk attitudes to the domain of risk loving (Crainich, Eeckhoudt, & Trannoy, 2013; Deck & Schlesinger, 2014). If a preference for combining good with bad outcomes results in risk aversion, then conversely, a preference for grouping good with good and bad with bad outcomes should lead to risk loving. Looking back at Figure 1, it does indeed follow that a preference for grouping similar outcomes should lead someone to prefer lottery  $R_1$  over lottery  $L_1$ , as this combines the two bad outcomes  $k_1$  and  $k_2$ . Next, let us consider how risk lovers are going to respond when the sure loss of wealth  $k_2$  is replaced by the zero-mean risk factor  $\tilde{e}$ . It is important to remember that risk averters and risk lovers by definition disagree with each other on the evaluation of such a risk factor. Whereas risk averters see risk as something that is inherently bad, the reverse is true for risk lovers. Taking this into consideration, one would expect risk lovers to exhibit a preference for lottery  $L_2$ , as this combines the good outcome ( $W$ ) with a second good outcome ( $\tilde{e}$ ). Interestingly, this leads risk averters and risk lovers to express the same preference at the third order, albeit for different reasons. Finally, let us re-examine what happens when the last sure loss of wealth  $k$  is replaced by a second zero-mean risk factor  $\tilde{e}_2$ . If a decision maker prefers to combine good with good outcomes, he/she should state a preference for the intemperate lottery  $R_3$ . Individuals who exhibit this behavioral pattern of risk loving, prudence, and intemperance are said to be *mixed risk loving*. Mixed risk lovers agree with mixed risk averters on the sign of the odd derivatives of their utility function, but disagree on the sign of the even derivatives.

### 3. Methodology

#### 3.1 Research questions

The main research question of the current investigation is whether the degree to which people possess financial literacy is related to their higher-order attitudes towards risk. Due to the empirical finding that that increasing one's financial literacy subsequently leads to better saving and investment decisions (Mitchell & Lusardi, 2015), it is hypothesized that people who possess more financial knowledge will also exhibit higher levels of prudence and temperance. Another point of interest is the prevalence and correlates of the mixed risk aversion and mixed risk loving among the general population. Since the concept of mixed risk attitudes is arguably still in its infancy, no specific hypotheses regarding this subject have been constructed.

### *3.2 Participants*

All participants in the studies described below were recruited from the LISS (Longitudinal Internet Studies for the Social sciences) panel administered by CentERdata (Tilburg University, The Netherlands). This internet panel consist of 4500 households, comprising 7000 individuals. The panel was designed to create a pool of research participants that is truly representative of the Dutch population in terms of observable background characteristics. All members are recruited via address-based sampling. This prevents participants from possibly contaminating a study's sample through self-selection. Another advantage of the LISS panel is that it provides a welcome alternative to the usual pool of research participants, namely college students. While students are a cheap and accessible resource when it comes to recruiting participants, only using students tends to hurt the external validity of the study. Additionally, if a household has no computer and/or internet connection, participants are loaned the necessary equipment. In return for monetary compensation, each panel member completes a number of online questionnaires each month.

All participants in the higher-order risk attitudes study were randomly selected from the pool of LISS panelists aged 16 years and older. A total of 5788 questionnaires were sent out. Out of the 3457 (59,7%) people that responded to the survey, 32 (0,6%) did not complete it. This resulted in a total of 3425 (59,2%) complete responses. A total of 6,778 financial literacy surveys were sent out to LISS panel members aged 16 years or older, of these 1,918 (28,3%) were nonrespondents. Only 2 surveys were incomplete, leaving a total of 4,858 (71,7%) individuals who fully completed the questionnaire. By matching the unique identification codes of the participants of both surveys, a total of  $n = 2491$  panel members were identified who completed both the survey on financial literacy and participated in the experiment on higher-order risk attitudes.

### *3.3 Procedures*

#### *3.3.1 Higher-order risk attitudes*

All data regarding higher-order risk attitudes was collected in December 2009. The experiment consisted of a total of 17 trials (Noussair et al., 2014). Each trial the participant was presented with a choice between two lotteries (L and R), as depicted in Figure 4. All lotteries had equiprobable outcomes. Furthermore, there was no indifference option, thus subjects were forced to make a decision each trial. The 17 trials were divided into four parts. Part one was made up of five choices between a sure payoff and a risky



Figure 4. Graphical representation of a prudence trial during the higher-order attitudes experiment. Adapted with permission from Vis, C., & Streefkerk, M. (2010) *Codebook Measuring Higher Order Risk attitudes*, CentERdata: LISS Panel.

lottery in order to measure the participant's aversion to risk. Part two consisted of five trials testing for prudence. Part three consisted of five trials testing for temperance. Part four was two trials to test the two conditions on relative risk aversion and relative prudence under expected utility. Part one and part four were always presented first and last, respectively. Parts two and three were counterbalanced. The 17 trials were presented to the subjects one at a time. In half of the surveys, the trials measuring risk aversion were ordered in such a way that the size of the sure payoff increased with each successive trial. The other half of the surveys were counterbalanced so that the size of the sure payoff decreased with each successive trial. The five trials testing for prudence and temperance differed in terms of (1) the initial level of wealth  $W$ , (2) the reduced level of wealth  $W - k$ , and (3) the size of the background risks  $\tilde{e}_1$  and  $\tilde{e}_2$ .

Each subject was assigned to one of four possible treatment conditions: two "Real Conditions" and two "Hypothetical Conditions". Under the real conditions, the amounts were either low (*RealLow*) or normal (*RealNorm*). Via the instructions, participants were told that they could win actual money. At the end of the survey participants were informed whether or not they had won any prizes. Each participant had a 10% chance of being randomly selected to receive a prize. If a subject was selected, one of his/her 17 choices made was chosen at random and played out to determine the payout. The expected payoff of any given subject in the *RealNorm* treatment, if selected, was approximately €70. The *RealLow* condition was identical to the *RealNorm* condition, with the exception of the background risk  $\tilde{e}_1$  which was 10 times smaller in the *RealLow* treatment. The background risk  $\tilde{e}_2$  in the temperance trials was equal across both treatments.

Under the hypothetical conditions, the amounts were either normal (*HypoNorm*) or high (*HypoHigh*). Via the instructions, subjects were explicitly informed of the hypothetical nature of the experiment. All amounts in the *HypoNorm* treatment were identical to those in the *RealNorm* treatment. The *HypoHigh* treatment was identical to the *HypoNorm* treatment, except that all amounts were multiplied by a factor

of 150. This was done so that the baseline endowment  $x$  in this treatment would reflect the median annual net income of the participants (€13,500). The distribution of respondents across the four experimental conditions was determined beforehand. Both hypothetical treatment groups and the *RealNorm* treatment group were assigned 30% of the participants each, the remaining 10% were assigned to the *RealLow* condition.

An individual's risk aversion was measured as the number of safe choices that were made, out of the five trials involving a sure payoff and a gamble. Prudence was measured as the number of prudent choices made (0-5) when given the option to allocate an unavoidable risk to states with varying levels of wealth. Temperance was measured as the number of times (0-5) a participant chose to split up two risks rather than assigning them to the same state.

### 3.3.2 Financial literacy

All financial literacy surveys were sent out during August 2011. First, participants of the survey were asked to score their own understanding of financial matters on a scale from 1 to 7. Next, they were asked 4 multiple-choice questions designed to ascertain their understanding of financial matters. The questions concerned the following 4 topics: savings and interest rate, inflation, investment risk, and the relationship between interest rate and bond prices. Depending on the question, participants were given 2-4 possible answers to choose from. Besides that they were given two additional neutral options, namely: '*I don't know*' and '*I would rather not say*'. To conclude the survey, participants were asked to rate the questionnaire on various scales (e.g. difficulty, enjoyment).

No guidelines for assigning financial literacy scores were provided by the authors of the survey. It should be noted that the following scoring system was constructed by the present author. Whenever a participant gave a correct answer, he/she was rewarded with one point. A possible point of contention is whether or not one should differentiate between participants who answer a question incorrectly and those who opt for a neutral response. One could argue that when it comes to financial decision making, it is worse to be misinformed or to take a guess than to admit that you don't possess the necessary knowledge to solve a particular problem. This is because people who are aware of their lack of knowledge should be more likely to seek out (professional) help when faced with a difficult financial decision. To reflect this argument, one point was deducted from the total score whenever a participant gave a wrong answer. Additionally, participants were not punished for admitting they lacked certain knowledge and

were given a score of zero whenever they gave a neutral answer. This scoring system resulted in a set of possible scores ranging from -4 to +4.

### *3.4 Data Analysis Plan*

To determine whether or not financial literacy levels are able to predict an individual's attitude towards risk, three linear regressions will be conducted. Linear regression is used to assess the relationship between an interval/ratio predictor variable and an interval/ratio criterion variable. In this case, financial literacy is the predictor variable and the criterion variables are risk aversion, prudence, and temperance. The following regression equation will be used as the basis for each analysis:  $y = b_1 * x + c$ , where  $y$  = estimated risk aversion, prudence, or temperance,  $c$  = constant,  $b$  = regression coefficient and  $x$  = financial literacy. In addition to financial literacy, a total number of four control variables will be added to each regression in an attempt to reduce the effect of any spurious relationships, namely: gender, age, education, and self-assessment score.

In order to investigate the predictors of mixed risk attitudes, four additional linear regressions will be conducted. The first two regressions will enter prudence and temperance as their respective dependent variables, but instead of evaluating all participants, only those who exhibit strict risk aversion will be considered. These are the participants who opted for the sure payoff in all five of the risk aversion trials. In each regression, the predictor and control variables will be identical to the ones mentioned above. This process will then be repeated but for the risk lovers of the sample. These are the participants who strictly preferred the gamble over the sure payout in all five of the risk aversion trials.

## **4. Results**

### *4.1 Exclusions<sup>2</sup>*

A total of 56 people were excluded from the dataset because they took longer than one and a half hour to complete a survey. Another 14 exclusions were made due to missing data points and/or incomplete surveys. This resulted in a total of 2421 valid data points across all variables.

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<sup>2</sup> All exclusions mentioned here were made by the present author, not by the original authors of the surveys.



## *4.2. Financial Literacy and Higher-Order Risk Attitudes*

### *4.2.1 Descriptive Analysis*

The mean age of the sample is 49.84 years, comparing this with the population data provided by the Central Bureau of Statistics ( $M = 39.41$ ), suggests that the current sample is relatively old (Centraal Bureau voor de Statistiek, 2009). The gender ratio of the sample reflects that of the general Dutch population, as the sample contains slightly more women (52%) than men. The average number of risk averse ( $M = 3.41$ ), prudent ( $M = 3.42$ ), and temperate ( $M = 3.01$ ) answers indicate that all three risk attitudes are fairly common among the general population. Moreover, across all three parts of the risk attitude experiment, the modal result was that people made five choices consistent with either risk aversion, prudence, or temperance. The average score of the financial literacy test was 1.67 and on average participants rated their own financial capabilities a 4.85 out of a possible seven. The vast majority of people did at least manage to attain a positive score, with only 6.1% of people scoring less than 0 points. The average number of neutral answers given was 1.05.

An overview of the correlational analysis is given in Table 1. The first thing of note is that there appears to be a positive correlation between all three risk attitudes. This could suggest a causal relationship between people's attitude towards avoidable and unavoidable risk, whereby an individual's attitude towards one type of risk directly influences his/her attitude towards other types of risk. Another possibility is that all three risk attitudes are the expression of a common underlying variable. Unfortunately, none of the measures considered for this analysis is significantly correlated with all three attitudes. Although people tend to become less risk-averse and prudent as they grow older, there appears to be no relationship between age and temperance. Risk aversion is the only attitude significantly correlated with gender. Women tend to be more risk-averse than men, which is consistent with the findings in the literature. No gender differences were found with regards to prudence and temperance. Education appears to significantly correlate with people's degree of prudence, as those higher educated show an increased tendency to assign unavoidable risks to the state where their wealth was highest. The decision to split up or aggregate two unavoidable risks does not seem to be affected by an individual's level of educational attainment.

Most people do appear to have some level of insight into their own financial literacy, as there is a positive correlation between self-assessment scores and actual test scores. Men and people who are better

TABLE 1  
Pearson Correlation matrix

	1	2	3	4	5	6	7	8	9
1 Age	-								
2 Gender	-.053**	-							
3 Education	-.103**	-.105**	-						
4 Risk Aversion	-.040*	.119**	-.006	-					
5 Prudence	-.079**	-.004	.068**	.250**	-				
6 Temperance	.018	.031	-.011	.313**	.349**	-			
7 Self-assessment	.031	-.142**	.121**	-.041*	.029	-.017	-		
8 Financial literacy	-.002	-.167**	.286**	-.030	.064**	.008	.151**	-	
9 Neutral responses	-.107**	.250**	-.261**	.027	-.033	.018	-.243**	-.338**	-

Notes: \*\* indicate significance at the 5%, 1% level.

educated are more likely to rate their own financial capabilities higher. Furthermore, this increased confidence does not appear to be unfounded, as these groups do actually score higher on their financial literacy test. If a higher self-assessment would have been indicative of overconfidence rather than actual knowledge, this surely would have resulted in lower rather than higher test scores. Because overconfident people overestimate their ability, it is assumed that they are more likely to forego the neutral response options. This denies them the opportunity to get 0 points whenever they don't possess the necessary knowledge to answer a question, whether or not they are themselves aware of that lack of knowledge. Consequently, their actions become behaviorally inseparable from guessing, which has a negative expected value using the current scoring system. There appears to be a negative correlation between risk aversion and self-assessment. However, this does not seem to translate itself into actual lower test scores, suggesting that the risk averters of the sample slightly underrate their financial literacy. Out of the three risk attitudes, prudence was the only one significantly correlated with financial literacy. The results suggest that a higher degree of financial literacy is associated with a higher degree of prudence.

The total number of neutral answers given was significantly correlated with four other variables, namely gender, age, education, and self-assessment scores. The first thing of note is that women were more likely than men to opt for a neutral answer. This could be related to the finding that the women in the sample were also less educated and less confident in their financial capabilities than their male counterparts. Because choosing a neutral option is the honest thing to do whenever one can't answer a question, it makes sense that those less knowledgeable should opt for more neutral answers. Another influencing factor could be the fact that the female subjects scored higher on the measure of risk aversion, which could in turn have affected their willingness to guess an answer. Contrary to women, both more highly educated subjects and those who rated their financial capabilities higher were less likely to give a neutral

response. What's interesting is that both these measure were also positively correlated with financial literacy. This suggests that better education and greater confidence in one's financial capabilities does not lead to more guessing, but rather that these measures are related to a higher degree of financial literacy. Age ,however, did not follow this pattern. Despite giving fewer neutral answers, older subjects in the sample did not score significantly higher on their financial capabilities test. This could be indicative of an increased prevalence of guessing and/or misinformation among older participants.

#### *4.2.2 Regression Analysis*

Three separate regression were carried out with risk aversion, prudence, and temperance as dependent factors and financial literacy as the independent factor. The results of each regression analysis are summarized in Table 2. The first thing of note is that gender appears to be the only variable that is significantly related to an individual's aversion to risk. The results indicate that the women of the sample are on average more risk averse than their male counterparts. When comparing the results of the regression with those of the correlational analysis two things stand out. First, age does no longer appear to be related to people's degree of risk aversion when controlling for gender. One possible explanation could be that the men in the sample are older than the women, which would in turn create an illusory negative relationship between age and risk aversion. An independent t-test was conducted to compare the age of men and women in the sample. The results of the analysis do indeed confirm this suspicion, as it turns out that the men ( $M = 50.77$ ,  $SD = 16.75$ ) in the sample are on average slightly older than the women ( $M = 49.00$ ,  $SD = 16.73$ ;  $t(2419) = 2.594$ ,  $p = .010$ ). The second thing that stands out is that the negative relationship between self-assessment scores and risk aversion seems to dissipate as additional control factors are considered in the regression. Again the most likely explanation would be that women rated themselves less financially capable than the men did, thereby making it seem like a low self-assessment is related to a lower degree of risk aversion. An independent t-test was conducted to compare the self-assessment scores of men and women. Results show that women ( $M = 5.03$ ,  $SD = 1.20$ ) indeed rated themselves less financially capable than men did ( $M = 4.67$ ,  $SD = 1.29$ ;  $t(2419) = 7.052$ ,  $p < .000$ ). Neither financial literacy nor education seem to relate to an individual's aversion to risk.

Contrary to risk aversion, an individual's prudence level does appear to be significantly related to financial literacy, as those who are more financially literate also tend to be more prudent. This could suggest that it's possible to change people's behavior in response to unavoidable risk by increasing their knowledge of financial matters. Alternatively, it's possible that prudent people are more likely to make a conscious effort to increase their financial literacy. Lastly, the positive correlation between financial literacy and

TABLE 2  
Risk attitudes

Dependent	Risk aversion	Prudence	Temperance
Independent	<i>B (SE B)</i>	<i>B (SE B)</i>	<i>B (SE B)</i>
(Constant)	3.582 (.214)	3.407 (.230)	2.865 (.236)
Financial literacy	-.019 (.026)	.059 (.028)**	.027 (.028)
Gender	.387 (.070)***	.033 (.076)	.106 (.078)
Age	-.003 (.002)	-.008 (.002)***	.002 (.002)
Education	.007 (.024)	.062 (.026)**	-.007 (.026)
Self-assessment	-.035 (.028)	.025 (.030)	-.018 (.031)
R <sup>2</sup>	.016	.012	.002
F	6.588***	5.026***	.838

Notes: \*/\*\*/\*\* indicate significance at the 10%, 5%, 1% level. B, unstandardized regression coefficient; SE, unstandardized standard error.

prudence could be the sign of a mere indirect relationship. Additional experimental research is required in order to confirm any of these suspicions. In addition to financial literacy, two other variables seem to independently relate to prudence levels. First, age seems to be negatively related to prudence, suggesting that older people are less likely to make prudent choices. Unfortunately, because of the cross-sectional nature of the data, it's not possible to distinguish the correlation between aging and prudence from possible cohort effects. It thus remains unclear whether the older people in the sample are more prudent because this somehow relates to the process of aging or because they grew up in a time where financial knowledge was perhaps less accessible. Secondly, there is a positive relationship between education and prudence, suggesting that those who are higher educated tend to be more prudent. Similarly to financial literacy, this could mean that education attainment leads to people becoming more prudent. The results of the regression mirror those of the correlation analysis. This suggests that financial literacy, age, and education all have some independent explanatory power when it comes to prudence.

As was the case with prudence, no significant relationship was found between gender and temperance. The pattern that arises when considering how the three risk attitudes relate to gender suggests that men and women behave differently when there's an option to avoid risk. When no safe option is available, however, the gender differences seem to disappear. Similar to risk aversion, it does not appear that temperance is something that can be taught, as temperance levels were unrelated to both financial literacy and education. This could suggest that individuals have distinct mental mechanics for deciding to allocate an unavoidable risk to either a high or low state of wealth and for deciding whether or not to aggregate two separate unavoidable risks.

TABLE 3  
*Regression Risk Lovers and Risk Averters*

Dependent	Prudence		Temperance	
	Risk Lovers	Risk Averters	Risk Lovers	Risk Averters
Independent	<i>B (SE B)</i>	<i>B (SE B)</i>	<i>B (SE B)</i>	<i>B (SE B)</i>
(Constant)	3.023 (.900)	3.471 (.322)	2.691 (.805)	2.970 (.340)
Financial literacy	.139 (.112)	.021 (.040)	.116 (.100)	-.010 (.042)
Gender	-.385 (.302)	-.076 (.114)	-.097 (.270)	.041 (.120)
Age	-.023 (.010)**	.004 (.003)	-.002 (.009)	.012 (.003)***
Education	.103 (.101)	.001 (.038)	.084 (.090)	-.038 (.041)
Self-assessment	.031 (.120)	.034 (.044)	-.247 (.107)**	.019 (.047)
R <sup>2</sup>	.069	.004	.038	.014
F	3.080**	.726	1.631	2.834**

Notes: \*/\*\*/\*\* indicate significance at the 10%, 5%, 1% level. B, unstandardized regression coefficient; SE, unstandardized standard error.

#### 4.3. Mixed Risk Attitudes

The first thing to note when comparing the prevalence of mixed risk attitudes in the sample is that mixed risk aversion seems to be a lot more prevalent among risk averters than mixed risk loving is among risk lovers. Nearly 41% of all risk averters consistently follow the pattern predicted by mixed risk aversion, making five prudent and five temperate choices. Comparatively, only 9% of risk lovers can be classified as mixed risk loving, making five prudent and five intemperate choices. A far greater portion of risk lovers (32%) seems to never apportion any risks at all, making five imprudent and five intemperate choices. Interestingly, a third type of risk lover seems to emerge from the data, as 8% of risk lovers exhibit strict prudence in combination with strict temperance. These people seem to completely reverse their stance on risk apportionment when a certain degree of risk becomes unavoidable. No reference to this combination of risk attitudes has been found in the literature.

The results of the separate regressions for risk lovers and risk averters are shown in Table 3. When comparing these results with those of the previous section, a number of things stand out. First of all, both financial literacy and education no longer appear to be related to the degree to which people exhibit prudence. Secondly, age continues to show a negative relationship with prudence, but only for risk lovers. This means that older risk averters are less likely to adhere to the pattern of mixed risk loving. Age also seems to have some predictive power when it comes to the number of temperate choices risk averters make, as older risk averters tend to be more temperate. Furthermore, the degree to which risk averters demonstrate prudent behavior appears to be completely unrelated to any of the variables considered. Finally, temperance appears to be less prevalent among risk lovers who highly rate their financial capabilities.

## 7. Conclusion

The main goal of the current study was to potentially identify a correlate of prudence and temperance that could be used to manipulate these higher-order attitudes towards risk in the context of a confirmatory experiment. To this end, the predictive power of financial literacy with regards to prudence and temperance was investigated. It was hypothesized that people who are more financially literate should also exhibit higher levels of prudence and temperance. This hypothesis was partly confirmed, as it turns out that financial literacy is positively related to the degree that people exhibit prudence. This result is in line with the finding in the literature that people who are more financially literate tend to make better saving decisions. Contrary to expectations, no connection between financial literacy and temperance was found.

In addition to financial literacy, each regression also considered the effects of gender, age, education, and self-assessment score. Prior studies have concluded that women are on average more risk-averse than men and the results of the current investigation echo these findings. No gender differences were found with respect to any of the higher-order risk attitudes. This could suggest that, while men and women disagree on how to evaluate avoidable risks, this disagreement fades in the presence of unavoidable risk factors. When considering the sample as a whole, older people are less likely to exhibit prudence than their younger counterparts. Age also appears to have some predictive power when considering risk averters and risk lovers separately. Whereas older risk lovers are less prudent, older risk averters are more temperate. This could suggest that risk lovers become even less cautious as they grow older, while risk averters become more cautious. It should be noted, however, that since the data considered for analysis was of a cross-sectional nature, it is impossible to distinguish the effects of aging from any possible cohort effects. A longitudinal study would have to be performed in order to fully differentiate between these two possibilities. Educational attainment appears to be positively related to prudence levels. If it turns out to be true that prudent decision-making can be learned, educational programs or other inventions could be developed with the aim of improving financial decision making through an increase in prudent behavior. Interestingly, the relationship between education and prudence seems to dissipate when isolating risk lovers and risk averters from the rest of the sample. This could suggest that prudence is less malleable in individuals who have a very strong attitude towards risk, be it positive or negative. Future research should attempt to further investigate this finding, as it could have significant consequences for considering which people are most likely to change their higher-order attitude towards risk in response to an intervention. Alternatively, educational attainment could have functioned as a proxy for cognitive ability, which is

something future research should address. Self-assessment scores appear to be predictive of temperance among risk lovers, as risk lovers who display a high confidence in their own financial capabilities are less likely to exhibit temperance. It is hard to imagine what makes splitting up two unavoidable risk factors such an unattractive proposition to risk lovers who highly rate their financial capabilities. Subsequent research could perhaps conduct exit interviews with risk loving participants in order to gain a better insight into their decision-making process.

An additional point of interest was the prevalence and correlates of mixed risk attitudes. Mixed risk aversion appears to be a lot more common than mixed risk loving, even when taking the low prevalence of risk loving itself into account. A risk averter was more than five times more likely to exhibit mixed risk aversion than a risk lover was to exhibit mixed risk loving. A far more common pattern among risk lovers was to exhibit imprudence in combination with intemperance. Interestingly, a third type of risk lover emerged from the data, as a significant subset of risk lovers were identified as being both prudent and temperate. It seems that these risk lovers prefer to combine good with good outcomes as long as there is a singular risk factor present. When multiple risk factors have to be taken into consideration, however, these people appear to change their preferences. Either this means that they change their stance on what they consider good or bad outcomes or they reconsider how they like to combine the two types of outcomes. Future research should consider exploring these two possibilities.

Although the regressions that were conducted attempted to reduce the effects of any spurious relationships by controlling for variables such as age and education, an inherent problem of using regression analysis is that it's practically impossible to control for all potential influencing factors. A next logical step towards possibly determining a causal relationship between financial literacy and prudence is to design a within-subject design experiment. Researchers would need to recruit two demographically matched groups of participants, preferably drawn from a pool representative of the general population in order to preserve generalizability. The LISS panel could possibly provide such a group of research participants. To start of the experiment, both groups would need to complete a number of tests in order to measure their base levels of financial literacy as well as their current higher-order attitudes towards risk. It would be recommendable to make use of the behavioral model of Eeckhoudt and Schlesinger (2006), in order to preserve comparability to the current dataset. Next, one group would go through a financial education program for the sake of increasing their financial literacy. As prudence has been shown to most reliably relate to saving behavior, it would make sense to develop an educational program that focuses on this aspect of financial decision making. The second group would receive no such intervention,

effectively creating a treatment and a control group. As people need both time and sleep to fully process information and consolidate their memories, the retesting of the groups' financial literacy and higher order risk attitudes should take place at least a couple of days after the last financial lesson. A second retest a couple of months after the intervention could determine whether or not the financial education program resulted in any long-lasting changes in people's financial literacy and their higher-order attitudes towards risk.

One benefit of using a within-subject design is that it automatically addresses the possibility of a hidden third variable. Say for example that general intelligence directly influences both people's understanding of financial matters as well as their higher order risk attitudes. It's reasonable to assume that any such third variable would remain constant between the pre- and the post-tests. Therefore any change in higher order risk attitudes would be attributable to the financial education program, rather than a change in intelligence or any other missing variable. There is, of course, the possibility of interaction effects occurring between a hidden variable and (1) the transference of financial education into financial literacy and (2) the transference of financial literacy into better financial decision making. It would therefore still be recommendable to collect as much data on relevant background variables as possible. The second advantage of conducting an experiment instead of doing correlational research is that it allows researchers to circumvent the potential issue of reverse causality. This is because the focus of experiment would be the change in financial literacy and higher order risk attitudes, rather than the base levels themselves. Within the context of the proposed experiment, it doesn't matter how these base levels came to be. The only point of interest is whether an increase in financial literacy subsequently leads to a change in a person's higher-order attitude towards risk. If this turns out to be the case, it would present a strong argument that at least part of people's higher order risk attitudes is determined by their financial literacy. The question remains, however, whether or not this effect of financial literacy on the formation of higher-order risk attitudes would be large enough to justify the development of financial education programs. One potential caveat of using a within-subject experimental design is the manifestation of the so-called testing effect. The testing effect refers to the finding that the act of performing a test can improve the long-term retention of information. For the suggested experiment this could mean that that the simple act of measuring an individual's financial literacy could have an impact on the variable itself. Although the use of a control group would allow someone to detect the occurrence of the testing effect, there is no way to stop it from happening. Any increase in the financial literacy, as well as any subsequent changes in higher order risk attitudes, should therefore be interpreted in relation to any changes within the control group.



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