Higher Order Risk Attitudes, Demographics, and Financial Decisions

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Abstract:

We study the prevalence of the higher order risk attitudes of *prudence* and *temperance*, in a large demographically representative sample, as well as in a sample of undergraduate students. Participants make pairwise choices between lotteries of the form proposed by Eeckhoudt and Schlesinger (2006). The choices in these lotteries isolate prudent from imprudent, and temperate from intemperate, behavior. We relate individuals' risk aversion, prudence, and temperance levels to demographics and financial decisions. We observe that the majority of individuals' decisions are consistent with risk aversion, prudence, and temperance, in both the student and the demographically representative samples. An individual's level of prudence is predictive of his wealth, saving and borrowing behavior outside of the experiment, while temperance predicts portfolio choices. Estimates of parametric specifications of risk and prudence parameters are compared to key thresholds of theoretical models.

1. Introduction

The analysis of the effect of risk attitudes on economic decisions has typically focused on the impact of risk aversion. Under expected utility, this amounts to an assessment of the impact of the second derivative of the utility function. However, many decisions also depend crucially on *higher order* risk attitudes. For example, changes in precautionary saving due to changes in the distribution of a future income stream are determined by individuals' *prudence* and *temperance* (Kimball 1990, 1992; Eeckhoudt and Schlesinger, 2008). Under expected utility, prudence is equivalent to a positive third derivative of the utility function (convex marginal utility), and temperance is equivalent to a negative fourth derivative (concavity of the second derivative). The degree of prudence and temperance that individuals exhibit has implications in a wide range of economic applications, including bargaining (White 2008), bidding in auctions (Eso and White 2004), rent seeking (Treich 2009), climate change (Gollier, 2010), tax compliance (Alm 1988; Snow and Warren 2005) and the valuation of medical treatments (Bleichrodt et al. 2003).[1]

Higher order risk attitudes have typically been analysed within the expected utility framework (Leland, 1968; Sandmo, 1970; Kimball 1990). Recently, however, Eeckhoudt and Schlesinger (2006) have proposed model-free definitions of prudence and temperance based on preferences over the apportionment of risks. They construct simple lottery choices in which the decisions taken distinguish between prudent and imprudent, and between temperate and intemperate, individuals. A prudent individual has a preference for adding an unavoidable zero-mean risk to a state in which income is high, rather than adding it to a state in which income is low. Temperate individuals have a preference for disaggregating two independent zero-mean risks across different states, rather than aggregating them in a single state. The classification of a choice as prudent or temperate does not depend on the risky choice model the individual uses (Bleichrodt and Eeckhoudt 2005). These lotteries are well-suited for use in

[1] Prudence and temperance influence the response of individuals to changes in risk. For a prudent individual, the expected marginal utility of wealth increases if future income becomes riskier. This means that he saves more in response to an increase in income risk. More generally, in these applications, prudence and temperance determine the optimal tradeoff between high risk options (future consumption, acquiring a good with an uncertain value, future uncertain wage offer) and low risk options (current consumption today, cash not paid in the auction, current wage offer).

experiments, both because of their simplicity, and because they can classify individuals as prudent and temperate regardless of whether or not they are expected utility maximizers.

The intuition of Eeckhoudt and Schlesinger's definitions of prudence and temperance is similar to the concept of risk aversion proposed by Rothschild and Stiglitz (1970). Under expected utility, an individual with a concave utility function ($u'' < 0$) prefers a certain outcome over a lottery with the same expected value. A preference for the certain outcome over the lottery, however, can be used to classify a decision maker as risk averse, irrespective of the decision model he uses. Analogously, the risk-apportionment decision of an expected utility maximizer with convex marginal utility ($u''' > 0$) always coincides with the prudent risk apportionment decision. Similarly, temperate risk apportionment decisions always coincide with those of an expected utility maximizer with a concave second derivative of the utility function ($u'''' < 0$). However, a risk apportionment decision that classifies an individual as prudent (resp. temperate) does not imply that the individual is an expected utility maximizer with $u''' > 0$ (resp. $u'''' < 0$). If expected utility is assumed a priori, the risk apportionment decisions do imply the aforementioned signs on the derivatives.

In this paper, we report the results of an experiment designed to measure the extent to which a demographically representative sample of the Dutch population exhibits risk aversion, prudence, and temperance. Each of the 3457 participants make lottery choices of the type introduced in Eeckhoudt and Schlesinger (2006). The data we have available about our participants allow us to consider how measures of prudence and temperance correlate with demographic variables, and with wealth and financial decisions outside of the experiment. We consider the correlation between risk aversion, prudence and temperance among individuals. We provide estimates of prudence and temperance parameters for the constant relative risk aversion and expo-power utility models, and test whether relative risk aversion is greater than one and relative prudence is greater than two, conditional on the expected utility hypothesis. These are critical thresholds in the comparative static results of a number of applications (see Gollier 2001; Eeckhoudt et al. 2010; Meyer and Meyer 2005; White 2008; Eeckhoudt and Schlesinger, 2008).

The use of experimental methods allows direct measurement of prudence and temperance. Empirical studies of precautionary saving have reported varying levels of prudence in the general population (Browning and Lusardi, 1996; Lusardi 1998; Carroll and Kimball, 2008). This evidence is indirect, however, because it is inferred from savings, consumption, and investment behaviour, and the level of prudence cannot be easily

distinguished from other variables. Selection biases may also arise in empirical studies if prudence is not elicited directly. For example, measurements of precautionary savings are biased downward if prudent individuals select into occupations with low income risk (Dynan 1993; Fuchs-Schuendeln and Schuendeln 2005). Furthermore, virtually all empirical studies assume a specific utility framework. Widely used utility functions such as the constant absolute (CARA) and the constant relative (CRRA) risk aversion families exhibit both prudence and temperance by definition. Consequently, estimates that are based on such parametric forms presuppose the prevalence of these attitudes. These utility functions also imply restrictions on the relationship between risk aversion and higher order risk attitudes.[2] As Carroll and Kimball (2008) argue, direct measurement of prudence and temperance are required to obtain accurate estimates of their incidence in the population.

Experimental methods, which can elicit such direct measures, have been applied to measure higher order risk attitudes with the undergraduate student populations typically employed in experimental research. Tarazona-Gomez (2003) measures prudence using a price list format in which certainty equivalents are elicited for various lotteries. She reports a modest incidence of prudence, with fewer than half of the students in her sample unambiguously categorized as being prudent. Among risk-averse subjects, however, the majority is prudent. Ebert and Wiesen (2009) study the relationship between prudence, skewness preference, and risk aversion. They find that a clear majority of their subjects are prudent, irrespective of their degree of risk aversion. Deck and Schlesinger (2010) measure both prudence and temperance. They present subjects with decision problems constructed from the decision-model-free definitions of Eeckhoudt and Schlesinger (2006), as we do here. Deck and Schlesinger (2010) find widespread prudence and modest intemperance, in their sample. Meier and Ruger (2010) find that a majority of individuals are prudent and temperate in both the gain and loss domains, and that risk aversion, prudence, and temperance are positively correlated. Ebert and Wiesen (2010), using a price list format to provide measures of prudence and temperance, find that a majority of their subjects are prudent and temperate.

The use of a demographically representative sample allows us to consider whether the results of these prior experimental studies generalize to broader populations. Furthermore, the availability of background data for our participants allows us to assess the relationship

[2] For example, for the CARA utility function the coefficient of absolute risk aversion equals that of absolute prudence and absolute temperance. For CRRA, the coefficient of relative risk aversion equals 1 minus that of relative prudence, which in turn, equals 1 minus that of relative temperance.

between prudence and temperance and other variables. In particular, we are able to associate decisions in the experiment with demographic variables and with wealth, saving, and investment decisions. However, to generate a more straightforward comparison with previous experimental studies, we also conduct our experiment with 109 university student subjects in a laboratory setting similar to those employed in the prior studies.

We find pervasive prudence in both the general population and the student sample, with the latter being even more prudent. A majority of decisions in both samples are temperate, but temperance is less widespread than prudence. Risk aversion, prudence, and temperance are positively correlated, and the most risk-seeking individuals are also imprudent and intemperate on average. Women are more risk averse and more temperate than men. Temperance is weaker when the risks involved are smaller. Students and more highly educated individuals are more prudent. Prudent decisions in the experiment are associated with greater wealth, a greater likelihood of having a savings account, and a lower likelihood of having credit card debt. Temperance is associated with less risky investment portfolios. Risk aversion exhibits no relationship with the financial status variables we have available.

While the elicitation method is model-free, we use our data to fit widely used utility functions and provide estimates for the coefficients of relative risk aversion, prudence and temperance, under the assumption of expected utility. Browning and Lusardi (1996, p.1808) emphasize the importance of such calibrations to restrict the precautionary saving model empirically, because of its many degrees of freedom. For a representative individual, we estimate a relative risk aversion coefficient between .89 and 1.43, and a relative prudence coefficient between 1.68 and 2.24, depending on the data and the specification of the utility function employed.

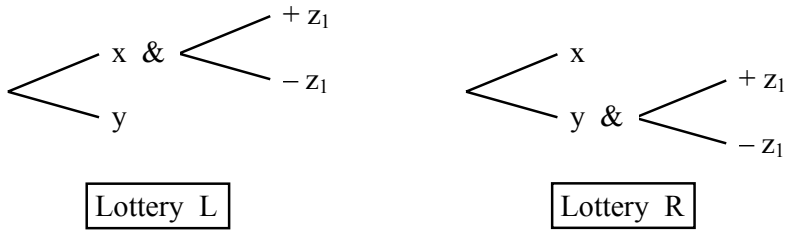
In the next section, we discuss the theoretical foundations of our elicitation method. Section 3 describes the experimental design, the subject pool and the background data we use. We then introduce the four treatment conditions that constitute our experiment. The treatments vary the strength of the financial incentives and the size of the risks. Two of our treatments have real incentives, while the other two have hypothetical incentives. Because most consumer surveys do not elicit incentivized choices (e.g., Barsky et al. 1997; Dohmen et al. 2010), the extent to which decisions involving hypothetical and real payoffs yield similar estimates is of interest. In section 4 we present the results regarding the prevalence of the risk attitudes, their correlation with each other, and the differences between treatments. Section 5 studies the relationship between our experimental measures and wealth/financial profiles

outside the experiment. Section 6 reports the results of the parametric utility estimation, and section 7 concludes.

2. Theoretical Background and Elicitation Method

Within the expected utility framework, prudence and temperance are properties of the third and fourth derivatives of the utility function, respectively. In particular, prudence is equivalent to a convex marginal utility function, and temperance is equivalent to a concave second derivative of the utility function. Let X be a risky lottery and x=E[X] be its expected value. Let u be a utility function, and let u^n denote its n-th derivative. Then the condition $E[u(X)]<u(x)$ implies concavity of u and risk aversion. The condition $E[u^1(X)]> u^1(x)$ is equivalent to convexity of u^1 and thus to prudence.[3] The condition $E[u^2(X)]< u^2(x)$ defines concavity of $u^2(x)$ and temperance. The two concepts of prudence and temperance can be defined locally or globally, and as weak versions which only require weak rather than strict inequalities.

Eeckhoudt and Schlesinger (2006) relate these higher order risk concepts to observable preferences in an analogous manner to Rothschild and Stiglitz (1970), who relate risk aversion to a distaste for mean preserving spreads. Eeckhoudt and Schlesinger (2006) define prudence and temperance in terms of principles of risk apportionment. Let x, y, k, z_1, and z_2 be positive monetary outcomes, and let y = x – k. We assume that realizations x and y, as well as $+z_1$ and $–z_1$, are equally likely, and that the chance outcomes are all independent within and between lotteries L and R.[4] The definition of prudence is illustrated in Figure 1.



[3] This condition is equivalent to the presence of demand for precautionary saving in the intertemporal consumption model (Kimball 1990, 1992).

[4] Under Eeckhoudt and Schlesinger's (2006) definition, the zero-mean risks are not restricted to be symmetric. Ebert and Wiesen (2009) show that asymmetry of the additional risks affects the higher order properties of the lotteries. In the current study we always use symmetric risks.

Figure 1: Observable Preference Definition of Prudence

In lottery L, a zero-mean risk, in which the individual can gain or lose z_1, occurs in the high wealth state. Lottery R is identical, except that the risk occurs in the low wealth state. An individual who is prudent prefers lottery L over lottery R, while one who is imprudent prefers R to L. Intuitively, given wealth level x, the decision maker has to confront two harms, a sure reduction in wealth by an amount k, and the addition of a zero-mean lottery risk of size z_1. A prudent decision maker has a strict preference for disaggregating these two harms. Accepting the risk in the state of high wealth x is preferred over accepting it in the state of low wealth y.

The condition for temperance is shown in Figure 2. As in the case of prudence, the decision maker has the choice between aggregating (lottery R) or disaggregating (lottery L) two harms, in this case two zero mean lotteries of sizes z_1 and z_2, both of which have equally likely positive and negative realizations. A temperate individual prefers lottery L, and an intemperate one prefers lottery R. A temperate decision maker thus has a preference for disaggregation of the two risks.[5]

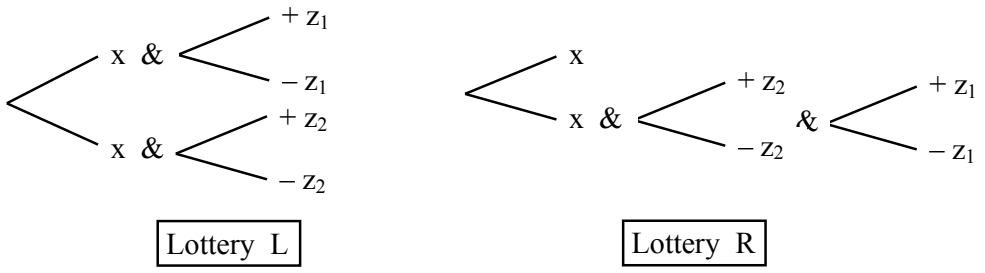


Figure 2: Observable Preference Definition of Temperance

We present our subjects with choices of the form described in Figures 1 and 2. To test two conditions regarding the strength of relative risk aversion and relative prudence under expected utility, we also include two additional choice problems. Eeckhoudt et al. (2010) provide conditions on lottery choices that, under expected utility, test whether the *coefficient of relative risk aversion*, $RR(x)= -xu^2(x)/u^1(x)$, is greater than one; and whether the *coefficient of relative prudence*, $RP(x)= -xu^3(x)/u^2(x)$, is greater than 2. Intuitively, in one of

[5] If a person is subject to the disposition effect, and is aware of it, it would make him more likely to make an intemperate decision. If the first lottery yields a relatively low outcome of y, the player would like to have a lottery available in order to possibly recoup his losses.

these tasks, the choice of the safer lottery is discouraged by a lower expected value. In the other task, the choice of the prudent lottery is discouraged by an increased variance. That is, to justify a choice of the safer and the more prudent lottery in these situations, the decision maker must have sufficiently strong risk aversion and prudence, respectively. Analogously to the relative coefficients defined above, we can define the *coefficient of relative temperance*, $RT(x)= -xu^4(x)/u^3(x)$ as well as absolute coefficients (Kimball 1990; 1992). The *coefficient of absolute risk aversion*, $AR(x) = -u^2(x)/u^1(x)$, the *coefficient of absolute prudence*, $AP(x) = -u^3(x)/u^2(x)$, and the *coefficient of absolute temperance*, $AT(x)= -u^4(x)/u^3(x)$. The actual choices subjects faced are described in the next section.

3. Experimental Design, Subject Pools and Background Data

3.1. Subject Pools and Background Data

In total, 3566 subjects participated in the experiment. 3457 subjects were members of the LISS panel, an internet panel managed by CentERdata, an organization affiliated with Tilburg University. The LISS panel consists of approximately 9000 individuals that complete a questionnaire over the internet each month. Respondents are reimbursed for the costs of completing the questionnaires four times a year. This payment infrastructure allowed us to provide incentivized monetary payments to participants.

The LISS panel is a representative sample of the Dutch population, in terms of observable background characteristics of respondents. The random sample invited to participate in the current experiment was stratified to reflect the population. A large number of demographic variables are available for the LISS panel participants. In particular, we have extensive self-reported data on the financial situation of our participants. Because of the close relationship between prudence and temperance, and precautionary savings, wealth, and portfolio choice, we relate the financial data to the level of prudence and temperance that we measure.

In addition, we also conducted the experiment at the CentER laboratory, located at Tilburg University, with undergraduate student participants. A total of 109 student subjects participated in the experiment. For the student sample, we have the background variables of age, gender, program of study, and the results of a Cognitive Reflection Test (Frederick, 2005) that was included in the experimental session, available.

3.2. Experimental Design and Treatments

Subjects were presented with a total of 17 binary choices between lotteries. The 17 decisions were grouped in 4 parts, with part one consisting of five choices between a sure payoff and a risky lottery to evaluate a participant's degree of risk aversion. Part two consisted of five choices testing for prudence, of the form shown in Figure 1. Part three consisted of five choices testing for temperance, of the form shown in Figure 2. Part four was two choices testing for the two conditions on relative risk aversion and relative prudence under expected utility, described at the end of section two. Part one always came first and part four was always last. Parts two and three were counterbalanced.

A list of all choices is given in Table 1. For purposes of exposition, in table 1 and the rest of the paper, we use the following notation to describe the lotteries. Let [x_y] denote a lottery that yields outcome x or outcome y, with equal probability. Then, compound lottery L in Figure 1 can be written concisely as $[(x+[z_1\_-z_1])\_y]$. Similarly, compound lottery R in Figure 2 is written as $[x\_(x+[\ z_2\_-z_2]\ +[\ z_1\_-z_1])]$.

Subjects were presented with one choice at a time. The five choices measuring risk aversion were ordered such that the certain payoff increased monotonically (or decreased in counterbalanced conditions). The five choices for prudence and temperance varied in terms of (1) the initial endowment/wealth level x, (2) the reduced wealth level y (for prudence), and (3) the size of the risks z_1 and z_2. This variation allows us to study the effect of changes in endowment and risk magnitude. No lotteries were resolved before the end of the session. No indifference option was provided, i.e. subjects always have to choose one of the lotteries. The presentation of the lotteries with respect to the position on the left or the right sides of the screen was counterbalanced.

All risks involved in the experiment are equiprobable lotteries. All randomizations were conducted by the computer. For the interpretation of the compound lotteries in terms of prudence and temperance, it is crucial to emphasize the independence of the multiple risks. We therefore presented the lotteries to subjects graphically by means of three differently colored dice, as shown in Figure 3, with the understanding that each die represented a computerized equal chance draw. Figure 3 is an example of the display participants saw for the most complex decision type in the experiment, that for temperance.

Table 1: List of Choice Situations

	Left prospect	Right prospect
Riskav 1	20	[65_5]
Riskav 2	25	[65_5]
Riskav 3	30	[65_5]
Riskav 4	35	[65_5]
Riskav 5	40	[65_5]
Prud 1	[(90+[20_-20])_60]	[90_(60+[20_-20])]
Prud 2	[(90+[10_-10])_60]	[90_(60+[10_-10])]
Prud 3	[(90+[40_-40])_60]	[90_(60+[40_-40])]
Prud 4	[(135+[30_-30])_90]	[135_(90+[30_-30])]
Prud 5	[(65+[20_-20])_35]	[65_(35+[20_-20])]
Temp 1	[(90+[30_-30])_(90 +[30_-30])]	[90_(90+[30_-30] +[30_-30])]
Temp 2	[(90+[30_-30])_(90 +[10_-10])]	[90_(90+[30_-30] +[10_-10])]
Temp 3	[(90+[30_-30])_(90 +[50_-50])]	[90_(90+[30_-30] +[50_-50])]
Temp 4	[(30+[10_-10])_(30 +[10_-10])]	[30_(30+[10_-10] +[10_-10])]
Temp 5	[(70+[30_-30])_(70 +[30_-30])]	[70_(70+[30_-30] +[30_-30])]
Ra_EU1	[40_30]	[50_24]
Prud_EU2	[(50+[25_-25])_30]	[50_(30+[15_-15])]

Notes: [x_y] indicates an equal chance prospect to receive either x or y; choice of the left prospect indicates risk aversion, prudence, and temperance, respectively.

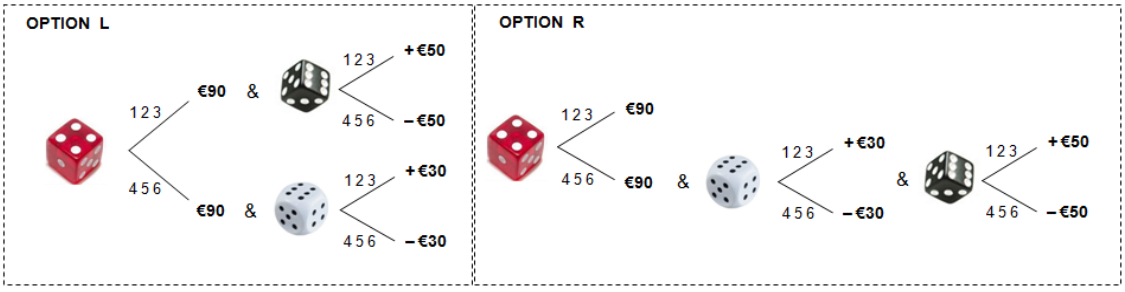


Figure 3: Graphical Presentation of Choice Situations

There are four different treatment conditions, as summarized in Table 2. Each subject participated in only one treatment. In the *Real* and *Real-lowvar* treatments, each individual has a 1 in 10 chance of being randomly selected to receive a real monetary payment. If an individual is selected, one of the 17 decisions is randomly chosen to count toward her earnings. The expected payoff, conditional on an individual being selected, is roughly €70,

and the actual payoff ranges from €10 to €150.[6] *Real-lowvar* is identical to the Real treatment, except that the risk z_1 is 1/10th as great in Real-lowvar. The background risk z_2 in the temperance decisions is identical in the two treatments. The Real-lowvar treatment is inspired by a remark of Eeckhoudt and Schlesinger (2006), who speculate that individuals might be more likely to aggregate risks than to disaggregate them, if one of the risks is very small. In all treatments, zero or negative earnings are impossible.

Table 2: Treatments

	N	Stakes	Risk z_1
Real	1054+109	1/10 chance of EV = €70	± 10 to ± 50
Hypo	1066	Hypothetical EV = €70	± 10 to ± 50
Hypo-highpay	995	Hypothetical EV = €10500	± 1500 to ± 7500
Real-lowvar	342	1/10 chance of EV = €70	± 1 to ± 5

We also include two hypothetical treatment conditions with different payoff scales. The hypothetical nature was made clear to participants at the beginning of the experiment. Treatment *Hypo* is identical to treatment Real, apart from the fact that no choices count toward participant earnings. This allows us to whether decisions are biased when they are hypothetical.

The *Hypo-highpay* treatment is identical to the Hypo treatment, except for the fact that payoffs are scaled up by a factor of 150. The factor is chosen so that baseline endowment in 6 out of 10 prudence and temperance decisions, viz. €90 in the other three treatments but €13,500 in Hypo-highpay, approximates the median annual net income of all panel members of €12,960. The framing in this treatment involves a range of payoffs that would have significant influence on individuals' wealth positions, comparable to a major financial shock such as temporary unemployment or uncovered medical expenses.

[6] Combining large payoffs and a random selection of participants for real payment is often done in large-scale studies with the general public (e.g., von Gaudecker et al. 2010). In the study of risk attitudes, the procedure leverages incentives, and avoids the potential problem of relatively linear utility for small payoffs (see Abdellaoui et al. (2010) and references therein). Abdellaoui et al. (2010) show that random selection leads to stronger incentives than a downscaled payoff scheme, where all subjects are paid with certainty. Starmer and Sugden (1991) provide evidence that selecting one decision for payment rather than all decisions does not affect preferences.

All four conditions were conducted with members of the LISS panel. The sample sizes for the different treatments are shown in Table 2.[7] All of the undergraduate students in the laboratory were assigned to the Real treatment. The student participants faced exactly the same procedures and choices as the subjects in the LISS panel, including the 1 in 10 chance of having one of their decisions count toward earnings. In contrast to the panel, students also received a €5 participation fee. General instructions were given at the beginning of the experiment, and specific instructions for each part were given immediately before the part began. Participants from the LISS panel received the instructions on their screen. During the choice situations they could click on a link to go back to the respective instructions for each part. Students received the instructions on printed handouts. The laboratory sessions all took less than one half hour.

4. Prevalence of Prudence, Temperance, and Risk Aversion, and their Demographic Correlates

We first measure the incidence of prudence, temperance, and risk aversion in our sample, and then consider factors that correlate with these risk attitudes. We measure an individual's *risk aversion* as the number of safe choices out of the five decisions involving a sure payoff and a risky lottery (decisions 1 – 5 in Table 1). As another measure of risk aversion, we calculate the certainty equivalent (CE) of the risky lottery resulting from these five decisions.[8] We measure *prudence* as the number of prudent choices in the five choice situations of the form shown in Figure 1 (decisions 6 – 10 of Table 1). We measure *temperance* as the number of temperate choices in the five choice situations of the form illustrated in Figure 2 (decisions 11 – 15 of Table 1). Table A1 in Appendix A gives the percentages of trials in which each response was chosen, for each of the 17 questions.

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[7] Of the 3457 participants, a total of 31 people dropped out of the experiment at some point. Over all treatments, this reduces sample sizes by 3 for the risk aversion task, by 27 for the prudence task, by 23 for the temperance task, and by 31 for the EU-based task.

[8] The *certainty equivalent* is defined here as the midpoint between the largest certain amount for which the risky prospect was chosen and the smallest certain amount for which the safe option was chosen. While the number of safe choices made can be calculated for all subjects, the certainty equivalent can only be calculated for subjects who behaved monotonically with respect to the certain prospect, and switched only once between the certain and the risky prospect in the ordered risk aversion choices.

Table 3: Prevalence of Risk Aversion, Prudence and Temperance

	All	Students	Real	Hypo	Hypo-highpay	Real-lowvar
Risk aversion, i	3.38*	3.60	3.23	3.20	3.78°	*Included in Real*
CE(65_5), ii	24.93*	24.18	25.85	25.99	22.65°	*Included in Real*
Prudence, i	3.45*	4.45 [a]	3.39	3.43	3.47	3.34
Temperance, i	3.00*	3.12	3.02	2.96	3.12°	2.67[a]
RA_EU>1, iii	.50	.37[a]	.49	.48	.57°	*Included in Real*
Prud_EU>2, iii	.61*	.83[a]	.59	.62	.66	*Included in Real*

Note: Condition Real-lowvar identical to Real, except for prudence and temperance tasks. Real includes LISS panel participants only. Entries are i) the number of risk averse, prudent or temperate choices in five decisions, ii) the certainty equivalent in €, normalized by dividing by 150 for Hypo-highpay, and iii) the fraction of subjects choosing risk averse or prudent; *significantly different from random choice (i.e. 2.50 for risk aversion, prudence and temperance decisions (rows 1, 3, and 4), .50 in RA_EU and Prud_EU (rows 5 and 6) or risk neutrality with CE=€35.00 (row 2), at the 1% significance level, Wilcoxon test. [a] indicates Real-lowvar or the Student sample significantly different from Real treatment, Mann-Whitney test; °indicates Hypo-highpay significantly different from Hypo treatment, at 5% significance level, Mann-Whitney test; CE excludes subjects who violated monotonicity.

The prevalence of risk aversion, prudence, and temperance. Table 3 presents results for the whole sample, as well as separately for each treatment and for the student participants. In each treatment, a significant majority of decisions are consistent with risk aversion, prudence and temperance. The only exception is for temperance in the Real-lowvar treatment. Risk aversion is also indicated in the average certainty equivalent, which is significantly lower than the expected value of the prospect of €35 in all treatments. Prudence is more prevalent than temperance (Wilcoxon signed-rank test, $p<.01$).[9] Figure 3 provides more details about the distribution of choices. Strong risk aversion, prudence and temperance, with all five choices consistent with the attitude, is the modal outcome. Nevertheless, a considerable fraction of subjects choose intemperately in all five decisions. The next-to-last row of Table 3 indicates that the median relative risk aversion coefficient is exactly equal to 1 (50% chose the alternative consistent with a coefficient greater than one, and 50% did not). The last row of

[9] All tests in this paper are two-sided tests. There were some effects of counterbalancing the order and the presentation of the choices. Because counterbalancing always involved equally sized groups, we report population averages and include controls for counterbalancing in the regression analyses.

the table indicates that the coefficient of relative prudence is greater than two for a majority of individuals.

< sideways Figure 3 about here >

Columns 2 to 6 of Table 3 show the results for each treatment separately. We find treatment effects. Risk aversion is stronger in the Hypo-highpay treatment than in the Hypo treatment. This is indicated in the number of risk averse choices shown in row 1, the certainty equivalents given in row 2, and the responses to the task evaluating relative risk aversion in row 5. This is suggestive of increasing relative risk aversion. Prudence is stronger among the university students in the laboratory than among respondents in the LISS panel. Temperance is stronger in the Hypo-highpay than in the Hypo treatment. Temperance is less pervasive in the Real-lowvar than in the Real treatment, providing an affirmative answer to Eeckhoudt and Schlesinger's (2006) remark that decision makers might be more likely to aggregate small than large risks. There are no significant differences between the Real and the Hypo treatments for any of the measures. This suggests that hypothetical choices provide unbiased estimates of the average attitudes of a population for similar real stakes.

Correlation between risk aversion, prudence, and temperance. An important empirical question concerns the correlation of risk aversion with higher order attitudes (e.g., Browning and Lusardi 1996, section 5.3). If the most prudent agents are also the most risk averse, they would select into jobs with low income risk. This is the case, for example, for the German civil servants discussed by Fuchs-Schuendeln and Schuendeln (2005). Consequently, they do not have a strong need for precautionary saving compared to less prudent agents in riskier occupations. Such self-selection makes the empirical identification of precautionary motives difficult. While Fuchs-Schuendeln and Schuendeln (2005) used the German reunification natural experiment to identify such self-selection, we can study the relationship between risk aversion, prudence, and temperance directly.

Table 4: Rank Correlation Among Attitudes

	All Participants		Students		LISS Panel	
	Risk aversion	Prudence	Risk aversion	Prudence	Risk aversion	Prudence
Prudence	.251***		-.039		.256***	
Temperance	.320***	.362***	.367***	.180*	.319***	.366***

Note: Spearman rank correlation coefficients reported; */*** denotes significance at the 10%/1% level.

Table 4 shows that there is substantial positive correlation among the three measures in the LISS sample. The students exhibit similar patterns, except that they show no correlation between risk aversion and prudence. Table 5 provides more details. Each row contains the average number of prudent and temperate choices of individuals based on the number of safe choices they made in the risk elicitation tasks. On average, risk seeking subjects are both imprudent and intemperate, while risk averse subjects are both prudent and temperate. Both higher order attitudes increase monotonically with the level of risk aversion, though temperance is only significant for relatively strong levels of risk aversion. These results, indicating a strong correlation between risk attitudes, support the view that self-selection is an important factor to consider in empirical measurements of precautionary savings.

Table 5: Prudence & Temperance by Number of Risk Averse Choices

# risk averse choices	Prudence	Temperance
0 (n=317, risk seeking)	2.27** (imprudent)	1.73***(intemperate)
1 (n=228, risk neutral/risk seeking)	3.01***	2.34
2 (n=513, risk neutral/risk averse)	3.24***	2.59
3 (n=604, risk averse)	3.36***	2.81***
4 (n=468, risk averse)	3.55***	3.14***
5 (n=1409, risk averse)	3.87***	3.57***

Notes: **/*** denotes significance at the 5% /1% level, Wilcoxon test of the null hypotheses of random choice (prudence = temperance = 2.5)

Prudence, temperance, and the risk/endowment ratio. We next consider whether the likelihood of making a prudent or a temperate decision depends on the endowment to risk ratio of the decision. For each prospect, we calculate the ratio of the zero-mean risk z_1 that has to be allocated (e.g., ±€20, z_1=20) to the expected value of the prospect (e.g., €75 for a prospect [90_60], thus *Ratio*=26.7%). The ratio is then included in a random effects probit regression where the dependent variable is a choice in favor of the prudent or temperate alternative, and each individual decision is the unit of observation. We conduct separate regressions for prudence and for temperance, each using the five available choices per subject. For temperance, we also control for the size of the zero-mean background risk z_2 (e.g., €30 for the prospect [90_(90+[30_-30] +[10_-10])], with Ratio=10/90=11%), which does not affect

the ratio. In an additional specification we include controls for gender and age, and treatment dummies.[10]

Table 6: Effect of Risk-to-Endowment Ratios on Prudent and Temperate Choices

	Ia	Ib	IIa	IIb	IIc	IId
	Prudent choice	Prudent choice	Temperate choice	Temperate choice	Temperate choice	Temperate choice
Ratio (in %-points)	.052	.048	.162	.144		.160
	(2.06)**	(1.83)*	(5.34)***	(4.58)***		(5.27)***
Background risk						.063
						(1.17)
Female		.332		7.239	7.240	
		(.20)		(3.63)***	(3.63)***	
Age (10y)		-1.711		1.644	1.661	
		(.68)		(.54)	(.54)	
Age (10y) squared		-.028		-.100	-.101	
		(.11)		(.31)	(.32)	
Student		16.385		4.653	4.645	
		(11.76)***		(.80)	(.80)	
Real_lowvar		0.663		-6.562	-11.413	
		(.22)		(1.64)	(2.88)***	
Hypo		1.412		-1.789	-1.791	
		(.69)		(.69)	(.69)	
Hypo_highpay		2.367		3.891	3.881	
		(1.15)		(1.51)	(1.51)	
N (subjects)	3539	3539	3545	3545	3545	3545
N (obs)	17695	17695	17717	17717	17717	17717

Notes: Random effects (panel) probit regressions; Five observations per subject; Ratio= absolute size of risk that has to be allocated divided by the expected value of the prospect; background risk=absolute size of the zero-mean risk z_2 in temperance; marginal effects reported in percentage points; z-statistics in parenthesis; */**/*** denotes 10% / 5% / 1% significance level;

We find a strong effect of the risk-to-endowment ratio on temperance, with an approximately 0.16 percentage point (p.p) increase per percentage point increase in the ratio ($z>4.58$, $p<0.01$). To illustrate, consider an increase in the ratio by 22 percentage points e.g.

[10] The treatment condition Real_lowvar has very small ratios of between 1.33% and 5.33% for prudence and between 1.11% and 5.55% for temperance. For the other treatments, this variation lies between 13.33% and 53.33%, and 11.11% and 55.55%, respectively. Thus, when controlling for treatment, the coefficient on Real_lowvar reflects effects of the ratio as well.

by going from [90_(90+[30_-30] +[10_-10])] to [90_(90+[30_-30] +[30_-30])]. This increases the preference for the respective temperate alternative, [(90+[30_-30])_(90 +[10_-10])] and [(90+[30_-30])_(90 +[30_-30])], by 3.5 p.ps. This effect remains robust if we control for the size of the background risk (regression IId), or for treatments and background variables (regression IIb). The effect of the risk-to-endowment ratio is consistent with the relationship between the Real-lowvar treatment and temperance shown in Table 3. Indeed, comparison of regressions IIc and IIb shows that the effect of the Real-lowvar treatment disappears if the ratio is included.

For prudence, there is an approximately 0.05 p.p. increase per percentage point increase in the ratio ($z>1.83$, $p<0.067$). Here, increasing the risk-to-endowment ratio by 27 p.ps. with a change from [90_(60+[10_-10])] to [90_(60+[30_-30])], increases the preference for the respective prudent alternative, [(90+[10_-10])_60] and [(90+[30_-30])_60], by 1.35 p.ps. Overall, these relationships are consistent with decreasing absolute prudence and temperance, with significantly stronger effects for temperance. These findings are consistent with the evidence for decreasing absolute prudence found by Tarazona-Gomez (2003) and Guiso et al. (1992, 1996).

Demographics. We consider the influences of demographic characteristics on the indices for risk aversion, prudence and temperance. The demographic variables were selected on the basis of previous literature. We include all of the controls used in Fuchs-Schündeln and Schündeln's (2005) study of precautionary saving, as well as health status and a dummy for higher education (college). The latter two variables have strong influence on wealth accumulation, and are related to income uncertainty and risk preference (Guiso et al. 1996; Lusardi 1998, 2008; Viscusi and Evans 1990; Zeckhauser 1970). Although the dependent variables are in a discrete form and are censored at 0 and 5, we report OLS results here for ease of interpretation of the coefficients and because it requires fewer distributional assumptions. Table 7 shows the results. A random effects model, where each decision problem has a random effect, as well as ordered probit and tobit regressions yield qualitatively identical results.

We find that women are more risk averse than men, which is consistent with previous research (Eckel and Grossman, 2008; Croson and Gneezy, 2009). Older people are less risk averse, but become so at a decreasing rate as they age. The hypothetical treatment with scaled up payoffs elicits higher risk aversion, consistent with increasing relative risk aversion (Holt and Laury 2002). Students are more prudent than others, and higher education leads to more

prudence. No gender effect exists for prudence, but the age effects are jointly significant ($p<.01$ in regression IIa and $p<.05$ in regression IIb), suggesting a reduction in prudence with age. Females are more temperate. The Real-lowvar treatment leads to significant reductions in temperance. For all three attitude measures the explained variance is low, suggesting that idiosyncratic features are of greater importance than demographics (Malmedier and Nagel 2010).

< Table 7 about here >

We also conducted a regression analysis for the student sample separately (not reported in the table), including Frederick's (2005) cognitive reflection test (CRT) measuring cognitive ability, and whether a student was a Dutch national or a foreign student. Nationality had no influence on any of the attitudes. Higher scores on the CRT were associated with greater prudence ($t=2.40$, $p<0.05$), but had no effect on risk aversion or temperance. This finding supports the view that prudence is particularly pervasive among people with high ability and high education.

5. Implications for Savings and Portfolio Choice

In principle, higher order risk attitudes influence, through their effect on precautionary motives, how much people save and how they allocate their savings among different asset classes. Many studies have tried to evaluate the empirical importance of the precautionary saving motive by regressing a measure of income risk on wealth holdings or wealth changes (Browning and Lusardi 1996; Carroll and Kimball 2008). The lack of a reliable measure of income risk, and the potential self-selection into occupations with different income risk, however, complicate the identification of precautionary motives (Lusardi 1997). Consequently, the literature has given a wide range of estimates, many of them suggesting low levels of precautionary saving and thus low prudence. Our measurement of higher order risk attitudes and the availability of wealth and saving data allow us to approach this question with a different strategy. Instead of testing whether uncertainty leads to higher savings, implying prudence, we directly test whether our revealed preference measures of risk attitudes predict savings. If differences in income risk and other determinants of saving are sufficiently controlled for, the variation in the level of prudence and temperance would correlate with the

variation in savings.[11] Similarly, higher order risk attitudes would correlate with the share of risky assets that people hold (Gollier 2001; Guiso, Jappelli, and Terlizzese 2006). Under decreasing absolute risk aversion (i.e., strong prudence and temperance), people would reduce their exposure to risky assets in the presence of significant background risk.

In this section, we evaluate the predictive power of our experimental measures of higher order risk attitudes for saving and investment behavior outside the experiment. We conduct three different analyses. First, we consider the correlations between our measures and binary dependent variables that indicate whether or not individuals have savings, investments and debt. These variables are presumably measured with little error. Second, we relate our measures to indices of participants' wealth, which are similar to those typically used in studies of precautionary saving and wealth. While these continuous wealth measures have more variation across households, they naturally involve more measurement error than simple binary responses. Third, we correlate our measures to an index of the share of participants' portfolios that is allocated to risky investments.

5.1. Prudence/Temperance and the Presence of Savings, Investments, and Debt

We consider how risk attitudes relate to specific components of saving and wealth. We have data on whether or not each subject in the LISS panel has any (1) savings accounts or savings certificates, (2) risky investments, (3) real estate investment (4) long-term insurance,[12] (5) loans or revolving credit arrangements, and (6) an unpaid credit card balance. We conduct probit regressions with each of these variables on the risk measures, including two different sets of control variables. The first set, Controls A, consists of the exogenous variables of gender, age and treatment, as in the regressions of type (a) in Table 7. The second set, Controls B, includes several of demographic variables that may affect the propensity to save. These variables are listed in the (b) regressions of Table 7.

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[11] While this effect immediately follows for prudence, effects for temperance relate to more specific changes in risk (Eeckhoudt and Schesinger 2008) and would there be harder to detect. Because we cannot control for self-selection, our estimates form lower bounds of the effects of prudence and temperance.

[12] In the Netherlands, many households have insurance contracts that in the event of the death of the policy holder, pay off a mortgage he holds and provide a payment to his heirs, and also have the feature that they pay off a different sum if the policyholder is living when he reaches retirement age. Our variable "long-term insurance" indicates the value of such policies, which roughly correspond to life insurance, mortgage insurance, and 401K/IRA retirement savings accounts in the United States.

Table 8 shows the estimates for savings and credit card debt, using different specifications. The models are estimated for the entire sample of participants, and for the subsamples consisting of those who indicated that they made their household's financial decisions, and those who report relatively high income uncertainty.[13] We find that prudence increases the likelihood that a participant has a savings account or certificate, and it reduces the likelihood that he has unpaid balances on a credit card. The former effect is very robust, while the latter effect is reduced if we include the large set of controls or restrict the sample to those people who report high income uncertainty. Females are less likely, and home owners, high income, and highly educated subjects are more likely, to have savings accounts (not shown in the table). Older and higher income subjects are more likely, and home owners are less likely, to have a negative credit card balance.[14]

< sideways Table 8 about here >

Temperance reduces the likelihood of risky investments, as shown in the left portion of Table 9, in regressions 1–4. This effect is reduced for self-reported household financial decision makers, but particularly strong for people facing high income uncertainty. Females are less likely, and older subjects, home owners, and highly educated subjects are more likely, to have risky investments. There is no robust effect of any risk attitude measure for life insurance, real estate and loans. Perhaps surprisingly, risk aversion does not predict any of the financial variables for which we have data.

< sideways Table 9 about here >

5.2. Prudence/Temperance and Precautionary Wealth

[13] The LISS panel includes a question regarding the change in the financial situation of the participant over the last 12 months, ranging from "much worse" through "no change" to "much better." The high income uncertainty sample excludes subjects who indicate no change.

[14] As indicated earlier, risk aversion, prudence, and temperance are correlated. This raises the possibility of multicollinearity in the regressions reported in tables 8 and 9. In all of the regressions reported, however, both the variance inflation factors (VIFs) and the condition numbers are well below conservative thresholds of 5 for VIF and 15 for condition number. This indicates that multicollinearity is not a serious problem in our regression analyses.

We construct the following measure of wealth from quantitative information on assets and liabilities:

$$\textit{wealth} = \textit{savings balance} + \textit{long term insurance balance} + \textit{risky investments} + \textit{real estate investments} - \textit{mortgage liabilities} - \textit{other loans.} \quad (1)$$

We also consider a second wealth measure, which excludes long-term insurance, real estate, and mortgages. Thus, we exclude housing related assets and liabilities, and focus on the most liquid components of wealth. We run OLS regressions of log wealth on our set of risk attitudes, including the two sets of control variables. Table 10 shows the results.

< sideways Table 10 about here >

The table contains the coefficients of our three risk attitude measures on log wealth. Risk aversion and temperance do not affect wealth in our sample, while prudence is associated with greater wealth. The effect of prudence varies between an 11% and a 25% increase in wealth per prudent choice in the experiment, depending on the specification. The effect is robust with respect to the wealth measure used, and also appears with similar force if we restrict the sample to those who report to be the main financial decision maker of a household or to those who face high income uncertainty. For both wealth measures, inclusion of the full set of controls reduces the effect of prudence. The effect for financial decision makers is less pronounced than for the whole sample, and becomes insignificant if we include the full set of controls. The largest effects obtain for those participants who report significant income uncertainty.

Overall, the results show clear evidence that prudence is correlated with greater wealth. The regressions also reveal relationships between demographics and wealth (not shown in the table). Females and married people have lower wealth, and higher income, more highly educated and home owning subjects hold more wealth. The effect of higher education also explains the reduction of significance if we include Controls B; education is strongly correlated with prudence as shown in Table 7. The three measures of risk aversion are significantly correlated. Including each measure separately, the effects of risk aversion and temperance remain insignificant. The effect of prudence is reinforced, becoming both economically larger and statistically more significant in all specifications.

5.3. Prudence/Temperance and Portfolio Choice

To construct a measure of the share of a participant's portfolio that is composed of risky assets, we divide his total holdings of risky assets by the sum of his total holdings of risky assets plus his savings. These are are presumably the most liquid and flexible components of portfolio wealth, and also relatively unlikely to be affected by factors unrelated to the riskiness of the holding.[15] Because 83% of the participants hold no risky assets, there are many zero values for the risky portfolio share. Thus in regressions 5 – 8 in Table 9, in which risky portfolio share is the dependent variable and we use a Tobit regression specification.

The regressions show that temperance is related to lower exposure to risky assets. This is consistent with the finding reported in subsection 5.2, that temperance reduces the likelihood that people hold investments. The effect on portfolio shares becomes stronger, if the complete set of controls is included, or if we restrict the sample to the self-reported household financial decision makers. The strongest reduction in risky portfolio share per temperate choice is obtained for people who report high income uncertainty. Females hold less risky portfolios, and older, more highly educated and home owning subjects hold more risky portfolios.

6. Parametric Analysis

Most microeconomic level empirical studies of saving and portfolio decisions rely on a parametric expected utility framework. In this section we provide estimates of the coefficients of risk aversion, prudence and temperance for the widely used constant relative risk aversion and expo-power utility functions, under the assumption of expected utility. The CRRA family has sometimes been criticized because the empirical evidence suggests that relative risk aversion increases with wealth (Abdellaoui et al. 2007; Holt and Laury 2002). Our results support this view (see also Table 7 Ia and Ib, effect of the Hypo-highpay treatment). The *expo-power* family has been proposed as an alternative specification that combines the desirable features of decreasing absolute and increasing relative risk aversion. We estimate the two parameter specification employed by Holt and Laury (2002).

All 17 decisions that the subjects made are used to fit a maximum likelihood model of the CRRA and the expo-power utility functions. We estimate the models for the Real, Real-lowvar and Hypo treatments together, and separately for the Hypo-highpay treatment, which had greater nominal payoffs. For the CRRA utility function, $u(x) = x^{1-\rho}(1-\rho)^{-1}$, the

[15] For instance, life insurance is usually necessary to obtain a mortgage,

coefficients of risk aversion, prudence and temperance are given by ρ, $\rho + 1$, and $\rho + 2$, respectively. For the expo-power utility function, $u(x) = \frac{1 - \exp\left(-\alpha x^{1-r}\right)}{\alpha}$, the coefficient of relative risk aversion equals $RR(x) = r + \alpha(1 - r)\, x^{1-r}$. The expressions for the relative prudence and temperance coefficients are more complex, and we give closed forms, as well as the details of the estimation method and statistical tests, in the online appendix. For expo-power utility, all three coefficients depend on wealth. We evaluate the coefficients at the expected payoff over all choices, as given in Table 2. Thus, for the Real, Real-lowvar, and Hypo treatments, x is set equal to €70, and for the Hypo-highpay treatment x is set equal to €10,500. Note that the expo-power function reduces to CARA for $r = 0$, and to CRRA for $\alpha = 0$. If both parameters are positive, the utility function exhibits decreasing absolute and increasing relative risk aversion (IRRA). The estimation results are given in Table 10.

Table 10: Parametric Estimates of Relative Risk Aversion, Relative Prudence and Relative Temperance under Expected Utility

	CRRA		Expo-power	
Payoff size	Normal	High	Normal (α = .097; r = .483)	High (α = .089; r= .652)
Risk aversion	0.89	0.94	0.93	1.43
Prudence	1.89	1.94	1.68	2.24
Temperance	2.89	2.94	2.58	3.13

Note: Estimates for expo-power utility evaluated at x=€70 for the normal size payoff treatments, and x=€10500 for the hypothetical high payoff treatment.

The estimates for the CRRA model indicate significant risk aversion for both payoff magnitudes with coefficients of .89 and .94. The estimates are in the range typically observed in direct measurements from lottery choices (Guiso and Paiella 2008, Harrison et al. 2007). The coefficient for the Hypo-highpay treatment is significantly larger than for the other treatments, suggesting increasing relative risk aversion. The estimation of the expo-power function results in significantly positive parameters α and r, and thus also indicates increasing relative risk aversion.[16] Relative risk aversion is greater than one for this functional form for the high payoff condition, but smaller than one for the other three treatments. Note that for

[16] Holt and Laury (2002) also report DARA and IRRA (α=.029; r=.269), while Harrison et al. (2007) do not reject the CRRA model with α not significantly different from zero.

expo-power utility the difference between the coefficients of relative risk aversion and prudence (and temperance) is less than one (than two).

In section 4 we reported that the direct test of RR(x)>1 and RP(x)>2 proposed by Eeckhoudt et al. (2010) lends support only to the latter condition. The data in Table 10 illustrate the sensitivity of the estimated coefficients to whether a representative or a median individual is considered, and to the estimation methodology and assumptions. Both utility functions considered here cannot accommodate the pattern of moderate risk aversion and relatively strong prudence. To model risk aversion and higher order attitudes more flexibly under expected utility and accounting for the observed pattern, a different utility function might be more appropriate. Alternatively, we may allow for deviations from expected utility. Deck and Schlesinger (2010, section 5) and Bleichrodt and Eeckhoudt (2005) discuss non-expected utility models that allow for more complex patterns of higher order risk attitudes.

7. Conclusion

In this paper, we have measured prudence and temperance directly in a demographically representative sample of the Dutch population and in a sample of undergraduate students. The methodology we employ is model-free, in the sense that it requires no auxiliary assumptions about decision making under uncertainty.

Prudence is widespread and positively correlated with financial well-being, education, and cognitive ability. The decisions taken on our prudence tasks predict financial status. The more prudent an individual, the greater is his wealth, the more likely he is to have a savings account, and the less likely he is to have credit card debt on average. Prudence is correlated with education, and university students make more prudent choices than the overall population. This is consistent with previous studies of student populations that have found that a majority are prudent (Ebert and Wiesen, 2009, 2010; Maier and Ruger, 2010; Deck and Schlesinger, 2010). Furthermore, within the sample of students, those that perform better on a test of cognitive ability make more prudent choices. Prudence is not correlated with gender or age. Under expected utility, the typical individual's coefficient of relative prudence appears to be roughly 2 for the stakes of our experiment, though the estimation is sensitive to the methodology employed.

A majority of decisions are temperate, but temperance appears to be less pervasive than prudence. Temperance and prudence are positively correlated. Women are significantly more temperate then men are, and temperance is moderated when the risk involved is relatively

small. The share of an individual's portfolio that is composed of risky investments is negatively correlated with his temperance. The relationships are strongest for people reporting high income uncertainty, suggesting that background risk is an important influence on financial decisions (Eeckhoudt et al. 1996; Guiso and Paiella 2008).

We also find that the majority of individuals are risk averse, which is consistent with previous studies (see for example Holt and Laury, 2002, or Harrison et al. 2007). Risk aversion is positively correlated with prudence and temperance; the more risk averse an individual the more prudent and temperate she is likely to be. Risk aversion does not predict wealth or saving behavior. Women are more risk averse than men. Individuals exhibit increasing relative but decreasing absolute risk aversion. The coefficient of relative risk aversion for a representative individual for the stakes we study is close to one.

We also make two observations concerning methodology. The first is that hypothetical elicitation yields very similar results to real payoff elicitation. It appears simple hypothetical questions to elicit prudence and temperance in policy surveys is therefore a valid option to obtain unbiased estimates of average behavior under real monetary incentives. The second is that estimates of risk aversion and prudence coefficients depend considerably on the estimation methodology employed. For relative risk aversion, the estimates are in a close range for all methodologies. The median coefficient is exactly 1 for a binary decision which sorts individuals based on that threshold. When we impose the functional forms the estimate of the representative individual shows a moderately less risk aversion. For prudence, however, the estimates are more sensitive. While our binary choice to distinguish individuals with relative prudence of greater than two from those less than two implies a median estimate greater than 2, imposition of functional forms on the utility function give mixed results, but with estimates close to 2.

The current study shows that the methodology to measure higher order risk attitudes introduced by Eeckhoudt and Schlesinger (2006) can readily be implemented in surveys with general populations. It yields direct measurements of preferences that have a good external validity in the context of financial decision making. While measurements of risk aversion have successfully been included in survey instruments (Barsky et al. 1997; Guiso and Paiella 2008), prudence and temperance have not been. Our results suggest that information about these attitudes can significantly improve predictions, especially if combined with the more sophisticated measures of income uncertainty available in some surveys (Fuchs-Schündeln and Schündeln 2005; Guiso et al. 1996). Explicitly accounting for heterogeneity in higher

order risk attitudes may then help to solve some of the puzzles in the literature, such as the low saving rates for lower income classes (Hubbard et al. 1995), or the low consumption of highly educated young people with strong future income prospects (Browning and Lusardi 1996).

Appendix

A Choice percentages for each decision problem

Table A1: Raw Choice Proportions

	Left prospect	Right prospect	% left prospect chosen[a]	
			LISS	Lab
Riskav 1	20	[65_5]	49.6	42.2
Riskav 2	25	[65_5]	58.1***	53.2
Riskav 3	30	[65_5]	69.2***	79.8***
Riskav 4	35	[65_5]	78.2***	91.7***
Riskav 5	40	[65_5]	82.7***	92.7***
Prud 1	[(90+[20_-20])_60]	[90_(60+[20_-20])]	69.5***	89.0***
Prud 2	[(90+[10_-10])_60]	[90_(60+[10_-10])]	67.1***	88.1***
Prud 3	[(90+[40_-40])_60]	[90_(60+[40_-40])]	68.6***	91.7***
Prud 4	[(135+[30_-30])_90]	[135_(90+[30_-30])]	67.9***	87.2***
Prud 5	[(65+[20_-20])_35]	[65_(35+[20_-20])]	69.0***	89.0***
Temp 1	[(90+[30_-30])_(90 +[30_-30])]	[90_(90+[30_-30] +[30_-30])]	59.3***	53.2
Temp 2	[(90+[30_-30])_(90 +[10_-10])]	[90_(90+[30_-30] +[10_-10])]	58.5***	56.0
Temp 3	[(90+[30_-30])_(90 +[50_-50])]	[90_(90+[30_-30] +[50_-50])]	61.8***	69.7***
Temp 4	[(30+[10_-10])_(30 +[10_-10])]	[30_(30+[10_-10] +[10_-10])]	59.0***	65.1***
Temp 5	[(70+[30_-30])_(70 +[30_-30])]	[70_(70+[30_-30] +[30_-30])]	60.9***	67.9***
Ra_EU1	[40_30]	[50_24]	50.9	36.7***
Prud_EU2	[(50+[25_-25])_30]	[50_(30+[15_-15])]	61.0***	82.6***

Notes: [x_y] indicates an equal chance prospect to receive either x or y; a: choice of left prospect indicates risk aversion, prudence, and temperance, respectively; *** indicates significant difference at 1% level from random choice between left and right option, binomial test, two sided

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Sideways and large Tables/Figures

Table7

Table 7: Demographic Correlates of Prudence and Temperance

	Ia	Ib	IIa	IIb	IIIa	IIIb
	Risk aversion		Prudence		Temperance	
Female	.402	.383	-.004	.007	.219	.233
	(7.30)***	(5.65)***	(.07)	(.10)	(3.55)***	(3.01)***
Age (10y)	- .199	-.209	-.069	-.083	.036	-.173
	(2.42)**	(1.62)	(.76)	(.58)	(.40)	(1.17)
Age (10y) squared	.017	.016	-.001	.001	-.002	.019
	(1.99)**	(1.28)	(.12)	(.08)	(.18)	(1.29)
Married	-	.062	-	.073	-	.144
		(.65)		(.72)		(1.34)
Divorced	-	-.234	-	-.149	-	.047
		(1.55)		(.93)		(.29)
# children	-	.023	-	.011	-	.051
		(.70)		(.31)		(1.33)
Log gross income	-	-.022	-	-.025	-	.020
		(1.44)		(1.49)		(1.09)
Home ownership	-	.056	-	.054	-	-.036
		(.67)		(.63)		(.40)
Health status (1= worst, 5 =best)	-	-.072	-	.068	-	.008
		(1.61)		(1.45)		(.16)
High education	-	.035	-	.190	-	-.138
		(.47)		(2.30)**		(1.57)
Civil Servant	-	.100	-	.071	-	.057
		(1.28)		(.57)		(.41)
Self-employed	-	-.185	-	-.100	-	-.005
		(1.05)		(.55)		(.03)
Student	.189	-	.849	-	.145	-
	(1.35)		(6.86)***		(.82)	
Real_lowvar	-.066	-.064	-.049	-.062	-.363	-.297
	(.64)	(.52)	(.44)	(.46)	(3.17)***	(2.16)**
Hypo	-.046	-.037	.037	.063	-.068	-.063

	(.63)	(.44)	(.48)	(.70)	(.86)	(.67)
Hypo_highpay	.526	.527	.074	.073	.095	.106
	(7.28)***	(6.29)***	(.93)	(.80)	(1.18)	(1.10)
N	3563	2427	3539	2413	3543	2416
R^2	4.52	5.82	1.79	1.82	0.96	1.10

Notes: OLS regressions; t-statistics in parenthesis; */**/*** denotes significance at the 10% / 5% / 1% level.

Figure 3

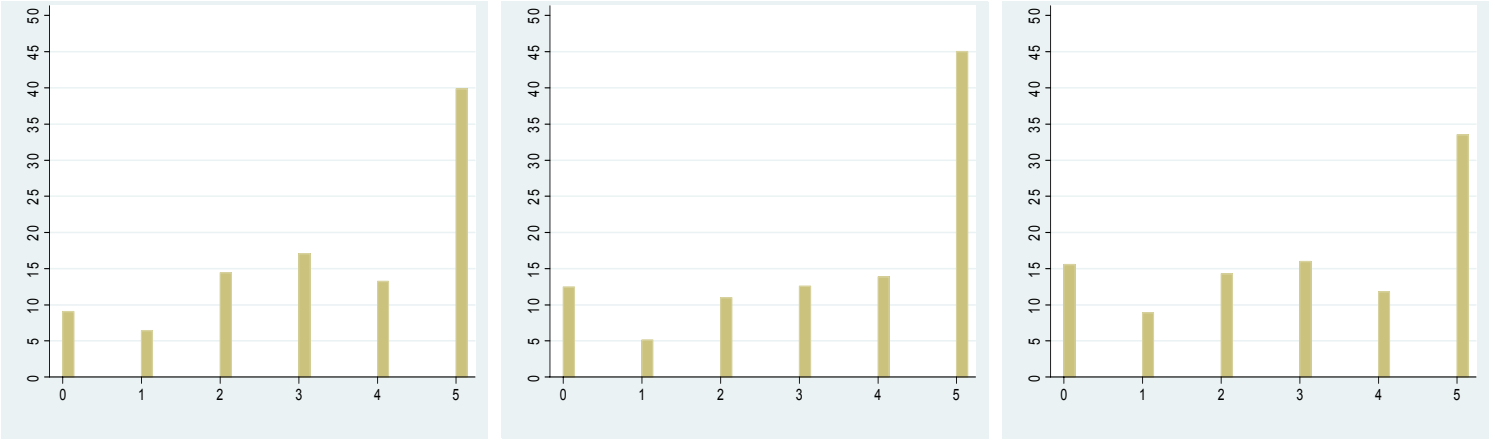

Figure 3: Distribution of Risk Aversion, Prudence, and Temperance (all data; percentages)

Table 8

Table 8: Savings, credit card debt, and (higher order) risk attitudes

	Presence of savings accounts				Presence of credit card debt			
	All	All	Main financial decision maker	High income uncertainty	All	All	Main financial decision maker	High income uncertainty
	1	2	3	4	5	6	7	8
Risk aversion	.304 (.58)	.111 (.21)	-.066 (.11)	.398 (.61)	-.179 (.73)	.025 (.12)	-.527 (1.34)	-.144 (.41)
Prudence	1.679 (3.55)***	1.291 (2.58)***	1.371 (2.65)***	1.911 (3.18)***	-.478 (2.20)**	-.362 (1.87)*	-.818 (2.38)**	-.367 (1.17)
Temperance	-0.548 (1.13)	-.526 (1.06)	.033 (.06)	-1.052 (1.71)*	.159 (.68)	.076 (.38)	.269 (.72)	.271 (.81)
Controls A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls B	No	Yes	No	No	No	Yes	No	No
N	2366	2158	1269	1462	2360	2153	1265	1457
Pseudo R^2	2.09	5.02	1.69	2.29	5.62	10.05	5.25	4.49

Notes: probit regressions; marginal effects reported in percentage points; z-values based on robust s.e. in parenthesis; */**/*** indicate significance at 10%, 5% and 1% level. Self-reported main financial decision maker in household; High income uncertainty excludes participants who indicated that there was no change in their financial situation over the last year.

Table 9

Table 9: Investment, portfolio choice, and (higher order) risk attitudes

	Presence of risky investments (probit)				Portfolio share of risky investments (tobit)			
	All	All	Main financial decision maker	High income uncertainty	All	All	Main financial decision maker	High income uncertainty
	1	2	3	4	5	6	7	8
Risk aversion	.223 (.45)	.214 (.42)	.234 (.30)	.639 (1.08)	-.011 (.51)	-.006 (.28)	-.003 (.15)	.031 (1.13)
Prudence	.245 (.51)	.155 (.31)	.599 (.80)	.463 (.79)	.0003 (.01)	-.007 (.36)*	-.029 (1.39)	.009 (.33)
Temperance	-1.123 (2.41)**	-.902 (1.88)*	-1.042 (1.42)	-1.742 (3.11)***	-.032 (1.76)*	-.038 (2.05)**	-.044 (2.20)**	-.061 (2.55)**
Controls A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls B	No	Yes	No	No	No	Yes	No	No
N	2366	2158	1269	1462	1144	1078	673	709
Pseudo R^2	5.39	10.47	4.35	7.17	8.15	11.42	8.26	11.60

Notes: probit regressions for presence of risky investments, marginal effects reported in percentage points; z-values based on robust s.e. in parenthesis; tobit regressions for portfolio share of risky investments, coefficients reported; */**/*** indicate significance at 10%, 5% and 1% level. Self-reported main financial decision maker in household; High income uncertainty excludes participants who indicated that there was no change in their financial situation over the last year.

Table 10

Table 10: Wealth and (higher order) risk attitudes

	Log wealth				Log wealth (liquid)			
	All	All	Main financial decision maker	High income uncertainty	All	All	Main financial decision maker	High income uncertainty
	1	2	3	4	5	6	7	8
Risk aversion	.083 (1.19)	0631 (.21)	.106 (1.09)	.109 (1.26)	.057 (.84)	.033 (.46)	.106 (1.13)	.085 (1.01)
Prudence	.198 (3.01)***	.118 (1.69)*	.176 (1.87)*	.25 (3.10)***	.184 (2.94)***	.117 (1.76)*	.167 (1.86) *	.241 (3.06)***
Temperance	-.037 (.59)	-.014 (.21)	.075 (.83)	-.123 (1.55)	-.055 (.91)	-.035 (.56)	.006 (.07)	-.141 (1.85)*
Controls A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls B	No	Yes	No	No	No	Yes	No	No
N	2043	1854	1049	1247	2126	1929	1105	1296
R^2	3.35	9.39	5.71	4.13	3.31	8.82	5.93	4.00

Notes: OLS regressions; t-values based on robust s.e. in parenthesis; */**/*** indicate significance at 10%, 5% and 1% level. Self-reported main financial decision maker in household; High income uncertainty excludes participants who indicated that there was no change in their financial situation (in either direction) over the last year; parameters are growth rates