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A test of traditional and psychometric relative risk tolerance measures on household financial risk taking

John E. Grable[a,*], Angela C. Lyons[b], Wookjae Heo[c]

[a] University of Georgia, Department of Financial Planning, Housing and Consumer Economics, Athens, GA, United States
[b] University of Illinois at Urbana-Champaign, Department of Agricultural and Consumer Economics, 440 Mumford Hall, 1301 W. Gregory Drive, Urbana, IL 61801, United States
[c] South Dakota State University, Department of Consumer Sciences, SWG 149, Box 2275A, Brookings, SD 57007, United States

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ABSTRACT

This article provides a comparative test of two ways in which individual relative risk tolerance is commonly measured in research and practice. Results suggest that the popular method of measuring gambles across lifetime income provides less insight into household investment behavior than the psychometric approach that is often used to derive a risk profile measure.

1. Introduction

Over the past half century, researchers have proposed numerous approaches to measure individual preference parameters in relation to financial risk taking. Two methodologies are most often utilized in practice. The first method derives estimates of risk aversion using lotteries or gambles across lifetime income (Barsky et al., 1997; Harrison et al., 2017). This approach is often described as a revealed preference methodology. An alternative approach involves measuring relative risk tolerance using psychometrically defined items that can be combined into a preference scale or index (Faff et al., 2009). Psychometric measurements are sometimes called propensity measures (Frey et al., 2017). The purpose of this study was to test these approaches to determine if one or both are empirically related to household financial risk taking.

A widely used revealed preference measure of risk aversion was proposed by Barsky et al. (1997). Barsky and his associates advocated the use of the series of questions shown in Table 1 to classify individuals into one of four categories of risk aversion (i.e., high, above-average, below-average, and low):

Those who answer ‘no’ to the first and third questions are classified as having high relative risk aversion. A person who answers ‘no’ to the first question and ‘yes’ to the third question is classified as having above-average relative risk aversion. Someone who answers ‘yes’ to the first question and ‘no’ to the second question is classified as having below-average relative risk aversion. Those who answer ‘yes’ to the first and third questions are considered to have low relative risk aversion. Barsky et al. (1997) argued that the four categories of risk aversion result from an expected utility function where U is the utility function and c is permanent

* Corresponding author.
E-mail addresses: grable@uga.edu (J.E. Grable), anglyons@illinois.edu (A.C. Lyons), wookjae.heo@sdstate.edu (W. Heo).

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Table 1
Revealed preference measure of risk aversion.

Question 1: Suppose that you are the only income earner in the family, and you have a good job guaranteed to give you your current (family) income every year for life. You are given the opportunity to take a new and equally good job, with a 50–50 chance it will double your (family) income and a 50–50 chance it will cut your (family) income by a third. Would you take the new job?
If the answer to this question is 'yes,' the respondent is then asked:
Question 2: Suppose the chances were 50–50 that it would double your (family) income, and 50–50 that it would cut it in half. Would you still take the new job?
If the answer to the first question is 'no,' the respondent is then asked:
Question 3: Suppose the chances were 50–50 that it would double your (family) income and 50–50 that it would cut it by 20 percent. Would you then take the new job?

consumption. Conceptually, "[an] expected utility maximizer will choose the 50–50 gamble of doubling lifetime income as opposed to having it fall by the faction $1 - \lambda$ if $\frac{1}{2}U(2c) + \frac{1}{2}U(\lambda c) > U(c)$" (Barsky et al., p. 540). In practice, the reciprocal of the risk aversion estimate is frequently used to account for an individual's risk preference in the context of developing portfolios using the Markowitz (1952) approach to portfolio selection (Chhabra, 2005; Mayo, 2017). The reciprocal is referred to as relative risk tolerance.

Relative risk tolerance scores offer insights into the way individuals make day-to-day risky choices. Those with high relative risk tolerance tend to drink alcohol, smoke, and be self-employed, among other behaviors (Barsky et al., 1997). Theoretically, those who exhibit higher relative risk tolerance should also engage in more risky investment behavior (Hoffmann et al., 2015; Huber and Kaiser, 2003). Certain demographic characteristics are thought to be associated with relative risk tolerance scores. For example, in the literature, males are reported to be more risk tolerant than females (Dwyer et al., 2002), as are younger individuals. While the traditional risk tolerance estimation procedure has been critiqued in the literature (e.g., Hanna et al., 2001; Hanna and Lindamood, 2004), the basic premise of using 50–50 gambles and lottery choice scenarios continues to be the primary way in which measures of relative risk aversion and relative risk tolerance are measured in national surveys and by some commercial risk profiling firms.

As already noted, the traditional approach to estimating utility is through income gambles and lottery choices (Hanna and Lindamood, 2004; Yao and Curl, 2011). A critique of the traditional approach is that measures of relative risk aversion using lottery and gambling choices fail to distinguish between what Dow and Werlang (1992) called quantifiable risks and unknown certainties. For example, gambling choices assume that tradeoffs are based on known probability risks. In reality, investors make portfolio decisions in an environment of uncertainty where probabilities are not known but rather subjectively developed (Klement and Miranda, 2012).

In response to the need to account for attitudes, beliefs, and individual characteristics that work to shape probability estimates at the household level, some researchers advocate for the use of psychometrically designed measures of relative risk tolerance when building portfolios. Grable and Lytton (1999) proposed a 13-item scale that can be used for this purpose,[1] although there are numerous similar scales in use by researchers and practitioners (e.g., Rom, 2000; Weber et al., 2002). The Grable and Lytton scale was designed to be multi-dimensional, incorporating items written to measure willingness to make investments, comfort and experience taking risks, and disposition to taking speculative risk. The measure has been used extensively in the literature, with scale scores being positively associated with risky asset holdings and other consumer choices that entail risk (see Kuzniak et al., 2015; Rabbani et al., 2017).

The purpose of this paper is to report findings from a test designed to determine the degree to which the Barsky et al. (1997) (henceforth, referred to as Barsky) and Grable and Lytton (1999) (henceforth, referred to as G&L) relative risk tolerance approaches are empirically related to household financial risk-taking behavior.

2. Data

Data for the analysis were collected from a sample surveyed using MTurk in 2017. To be included in the study, a respondent needed to exhibit some financial knowledge and hold investments. Specifically, a respondent first needed to be able to answer the following question correctly: "How is net worth defined?" Additionally, a respondent needed to be currently holding some portion of her or his investment assets outside of a traditional bank and/or credit union account.

Those respondents who qualified for the study (357 respondents out of a total sample of 987) were asked to answer the Barsky and G&L questions. Answers were then used to construct relative risk tolerance scores following the methodologies described by Barsky et al. (1997) and Grable and Lytton (1999), respectively. To measure financial risk-taking behavior, respondents were asked to report the percentage of their investment portfolio held in cash, where cash was defined as the total amount held in savings accounts, certificates of deposit, and money market mutual funds. Respondents were also asked to report the percentage of their investment portfolio held in equities, which included the total amount held in stocks, stock mutual funds, and direct business ownership and investment real estate, not including a respondent's personal residence. Based on the notion of revealed preferences,

[1] Examples of items asked in the scale include: (1) In general, how would your best friend describe you as a risk taker? a. A real gambler b. Willing to take risks after completing adequate research c. Cautious d. A real risk avoider. (2) You are on a TV game show and can choose one of the following. Which would you take? a. $1,000 in cash b. A 50% chance at winning $5,000 c. A 25% chance at winning $10,000 d. A 5% chance at winning $100,000. The scale can be found at: http://pfp.missouri.edu/research_IRTA.html.

those who held more of their portfolio in equities were thought to hold a higher degree of relative risk tolerance compared to others.

In addition, demographic data were collected on respondents' gender, age, education, income, marital, and employment status. Specifically, gender was measured dichotomously and equal to one if the respondent was male and zero if female. Age was measured in years. Education and income were measured as ordinal categorical variables, with education measured using four categories ranging from (1) some college education or less, (2) Associate's degree, (3) Bachelor's degree, and (4) graduate/professional degree. In the analyses, some college education or less was the reference group. Income included four categories ranging from (1) less than $40,000, (2) $40,001 to $80,000, (3) $80,001 to $100,000, and (4) more than $100,000. Those in the first category were used as the reference group. Marital and employment status were measured dichotomously with those who were married and those who were working full-time coded as one, otherwise zero.

For the Barsky measure, 44.07% of the sample was classified as having low risk tolerance, 34.62% had below-average risk tolerance, 12.15% had above-average risk tolerance, and 10.17% had high risk tolerance. Scores on the G&L risk measure can theoretically range from 13 to 47. Among respondents, mean and standard deviation scores on the scale were 25.03 and 5.24, respectively. With regards to cash and equity holdings, the mean percentage of cash holdings was 42.47% (SD = 33.00%), whereas the mean percentage of equity holdings was 29.36% (SD = 28.57%). Demographically, approximately 44.35% of respondents were male, with an average age of 62.34 years (SD = 19.43 years). Given the age of respondents, it was not surprising that respondents held a relatively high percentage of cash in their portfolios. More than 67.23% of respondents were married. The majority of respondents (65%) held at least a college degree. Fourteen percent of respondents had income less than $40,000, 36% had income between $40,001 and $80,000, 20% had income between $80,001 and $100,000, and 30% had income greater than $100,000. Slightly more than 30% of respondents were employed on a full-time basis. Given the demographic profile of the sample, employment status served as a proxy for retirement status.

3. Models

The Barsky and G&L relative risk tolerance measures were tested using four OLS regression models. Two models were estimated using the percentage of equities held in the i^{th} respondent's financial portfolio as the dependent variable. These models were specified such that:

$$\begin{aligned} &\%Equity_i = \alpha_0 + \alpha_1 G\&L_i + X_i'\alpha_2 + \varepsilon_i \\ &\%Equity_i = \beta_0 + \beta_1 Barsky_i + X_i'\beta_2 + \varepsilon_i, \quad where \quad i = \{1,...,I\}. \end{aligned} \tag{1}$$

Two additional models included the percentage of cash held in a respondent's financial portfolio as the dependent variable. These models were specified as follows:

$$\begin{aligned} &\%Cash_i = \alpha_0 + \alpha_1 G\&L_i + X_i'\alpha_2 + \varepsilon_i \\ &\%Cash_i = \beta_0 + \beta_1 Barsky_i + X_i'\beta_2 + \varepsilon_i, \quad where \quad i = \{1,...,I\}. \end{aligned} \tag{2}$$

In these models, $\%Equity_i$ and $\%Cash_i$ were the continuous independent variables that represented the percentage of equities and cash, respectively, held in the i^{th} respondent's financial portfolio using either the G&L or Barsky measure of relative risk tolerance. Thus, each model included the respective relative risk tolerance measure (*G&L* or *Barsky*), as well as the demographic controls (X_i) that were presented in the previous section. A quadratic term for age was also added to the models. The inclusion of the age^2 variable was based on recommendations by Faff et al. (2009) who argued that a curvilinear association may exist between measures of relative risk tolerance and age, with risk tolerance decreasing at an increasing rate as age increases. The error terms for each model, ε_i, were assumed to be distributed standard normally.

Recall that to be included in the sample a respondent had to be holding some type of investment asset (i.e., equity holdings). Given this requirement, all respondents had to have reported a positive amount of equity holdings, with no respondents reporting that they had zero investment assets. There were no restrictions on cash holdings. In fact, only 1.8% of the sample reported having no cash holdings. Still, it was determined that the estimates from Eq. (2) could be subject to potential selection bias because some observations were censored at zero. To account for this potential bias, an additional set of Tobit regressions was estimated for the cash ratio models using the standard maximum likelihood method. Tobit regressions could not be estimated for Eq. (1) since the equity ratios in these models were already conditional on holding a positive amount in equities.

4. Results

The regression results are presented in Tables 2 through 4. Each table includes the coefficients (B), standard errors, and standardized betas (β^S). The standardized betas compare the relative importance of each coefficient in the regression model and were calculated by subtracting the mean from the variable and dividing by its standard deviation.

The results illustrate the degree to which the Barsky and G&L measures for relative risk tolerance were empirically related to household financial risk-taking behavior as defined by each respondent's portfolio allocations. As shown in Table 2, the G&L measure

Table 2
OLS models showing relationship between relative risk tolerance scores and percentage of financial portfolio held in equities.

	G&L model			Barsky model		
Variable	*B*	*Std. error*	β^S	*B*	*Std. error*	β^S
G&L Risk Score (#)	1.00***	0.29	0.18	-.–	-.–	-.–
Barsky Risk Score (#)	-.–	-.–	-.–	−0.16	1.51	−0.01
Age	1.75***	0.52	1.19	1.77***	0.53	1.20
Age^2	−0.01***	0.00	−1.08	−0.13**	0.00	−1.10
Gender (Male = 1)	−1.91	3.03	−0.03	0.97	2.96	0.02
Educ: Associate's Degree	3.71	5.41	0.04	3.61	5.50	0.04
Educ: Bachelor's Degree	14.48***	3.89	0.25	14.89***	3.92	0.25
Educ: Graduate/Prof Degree	14.84***	4.23	0.23	16.39***	4.22	0.26
Income: $40,001 - $80,000	−5.19	5.52	−0.84	−3.23	5.63	−0.05
Income: $80,001 - $100,000	−0.76	6.18	−0.01	1.04	6.27	0.02
Income: More than $100,000	0.58	5.93	0.01	1.82	6.02	0.03
Marital Status (Married = 1)	−10.98***	3.34	−0.18	−10.81***	3.38	−0.18
Employment Status (Full-time = 1)	−6.61*	3.67	−0.11	−5.44	3.68	−0.09
Constant	−46.71	17.23		−25.20	16.30	
Model	$F_{12,341} = 5.56$, $p < 0.001$ $R^2 = 0.16$			$F_{12,345} = 4.18$, $p < 0.001$ $R^2 = 0.13$		

*** $p < 0.01$,
** $p < 0.05$,
* $p < 0.10$.

Table 3
OLS models showing relationship between relative risk tolerance scores and percentage of financial portfolio held in cash.

	G&L model			Barsky model		
Variable	*B*	*Std. error*	β^S	*B*	*Std. error*	β^S
G&L Risk Score (#)	−2.34***	0.32	−0.37	-.–	-.–	-.–
Barsky Risk Score (#)	-.–	-.–	-.–	1.05	1.77	0.03
Age	−1.46**	0.58	−0.86	−1.43**	0.61	−0.84
Age^2	0.01**	0.01	0.82	0.01**	0.01	0.83
Gender (Male = 1)	−2.01	3.37	−0.03	−9.23**	3.47	−0.14
Educ: Associate's Degree	−5.00	6.03	−0.05	−5.99	6.43	−0.05
Educ: Bachelor's Degree	−14.43***	4.33	−0.20	−16.15***	4.58	−0.24
Educ: Graduate/Prof Degree	−13.46***	4.71	−0.18	−18.72***	4.94	−0.25
Income: $40,001 - $80,000	11.26*	6.15	0.16	7.60	6.59	0.11
Income: $80,001 - $100,000	6.49	6.88	0.08	1.38	7.34	0.02
Income: More than $100,000	3.07	6.61	0.05	−0.61	7.05	−0.01
Marital Status (Married = 1)	2.03	3.72	0.03	3.00	3.95	0.04
Employment Status (Full-time = 1)	1.76	4.09	0.03	1.43	4.30	0.02
Constant	145.11	19.20		90.94	19.08	
Model	$F_{12,345} = 8.10$, $p < 0.001$ $R^2 = 0.22$			$F_{12,345} = 3.34$, $p < 0.001$ $R^2 = 0.10$		

*** $p < 0.01$,
** $p < 0.05$,
* $p < 0.10$.

was positively associated with equity ownership as expected. The Barsky measure was not statistically associated with equity holdings.[2]

In terms of cash holdings, Table 3 shows that the G&L measure was significant at the $p < 0.001$ level. The coefficient sign was negative as expected. The Barsky measure, on the other hand, was not statistically associated with cash holdings.

Recall that the cash models were re-estimated as a robustness check since some data points were censored. Table 4 shows the results from the tests. The results were essentially the same as those presented in Table 3, which is not surprising given that only 1.8% of the observations were censored. The G&L measure was significant ($F_{1,345} = 54.91$, $p < 0.001$) and negatively associated with cash holdings. The Barsky measure was insignificant and not associated with cash holdings ($F_{1,345} = 0.29$, $p > 0.10$).

[2] Note that income was found to be insignificant. Due to the small sample size, age and education were likely picking up some of the income effects. Although not shown in this study, additional specifications were estimated as a robustness check for all models. A significant income effect was noted when the education variables were excluded. Given the age and life-cycle stage of the respondents, this is perhaps not surprising since education was likely more important than income in describing equity and cash holdings for this older, retired population.

Table 4
Tobit models showing relationship between relative risk tolerance scores and percentage of financial portfolio held in cash.

	G&L model			Barsky model		
Variable	*B*	*Std. error*	β^S	*B*	*Std. error*	β^S
G&L Risk Score (#)	−2.37***	0.32	−0.01	-.–	-.–	-.–
Barsky Risk Score (#)	-.–	-.–	-.–	0.90	1.77	0.00
Age	−1.40**	0.57	−0.03	−1.28**	0.62	−0.02
Age^2	0.01**	0.00	0.03	0.01**	0.01	0.02
Gender (Male = 1)	−1.59	3.36	−0.00	−8.65**	3.48	−0.00
Educ: Associate's Degree	−5.09	6.01	−0.01	−6.02	6.46	−0.00
Educ: Bachelor's Degree	−14.05***	4.32	−0.02	−15.53**	4.64	−0.01
Educ: Graduate/Prof Degree	−13.25***	4.69	−0.02	−18.68***	5.00	−0.01
Income: $40,001 - $80,000	−2.67	6.58	−0.00	1.65	7.05	0.00
Income: $80,001 - $100,000	8.56*	4.45	0.01	9.35*	4.78	0.00
Income: More than $100,000	3.69	4.24	0.00	2.36	4.57	0.00
Marital Status (Married = 1)	1.96	3.71	0.00	2.94	3.98	0.00
Employment Status (Full-time = 1)	1.34	4.08	0.00	1.21	4.39	0.00
Constant	146.72***	18.95		85.97***	18.67	
Model	$\chi^2 = 86.53$, $p < 0.001$			$\chi^2 = 36.02$, $p < 0.001$		
	Pseudo $R^2 = 0.03$			Pseudo $R^2 = 0.01$		

*** $p < 0.01$,
** $p < 0.05$,
* $p < 0.10$.

With regards to the other control variables, the results were generally consistent with the findings from previous literature on household portfolio allocations and risk tolerance, with the exception that household income was not significant at the $p < 0.05$ level. This result was likely due to the age of the sample, where the majority of respondents were near retirement or already retired. Age was positively associated with holding equities and negatively associated with holding cash. The quadratic relationship for age in relation to equities was negative, suggesting an inverted U-shaped downward relationship. On the other hand, a U-shaped upward age association with cash was noted. Holding a Bachelor's or graduate/professional degree, compared to some college or less education, was positively associated with equity ownership and negatively related to holding cash. Being married was only significant in relation to equity ownership, with married respondents holding smaller equity portfolio positions.

5. Conclusion

Although evidence has been published regarding the positive association between income gambles and lottery choices and diverse indicators of risk taking, findings from this study suggest that a measure of relative risk tolerance based on psychometric concepts may provide more insight into the financial risk-taking behaviors of individuals at the household level, particularly among those nearing or in retirement. The Barsky measure was not statistically associated with equity or cash ownership among those in the sample. On the other hand, the G&L measure, which was employed as an indicator of the psychometric approach often used to estimate relative risk tolerance, was found to be positively related to holding equities and negatively associated with holding cash. It is possible that psychometric tools are able to capture elements that comprise risk preference more precisely than traditional income gamble and lottery choice scenarios. This conclusion should be considered in the context of the exploratory sample used in this study. While the sample was representative of the type of individual who may be working with an investment professional, the demographic profile of respondents is not generalizable across age or income categories. Future studies should test the models with larger samples that include a wider age range and more heterogeneous set of respondents.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.frl.2019.03.012.

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