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Can portfolio risk be described with estimates of financial risk tolerance calibration?

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ABSTRACT

The purpose of the study was to analyze the degree to which categories of financial risk-tolerance miscalibration are associated with portfolio choices made by financial decision-makers. A differential prediction model was applied to investment risk tolerance data from 2017 to 2018 to assess the presence of miscalibration. Results from Tobit regressions showed that some survey respondents did engage in the miscalibration of their financial risk tolerance. Although results varied by sub-samples, those who systematically under-estimated their financial risk tolerance were observed to hold portfolios that were less risky than those who were able to match their self-assessed risk tolerance to their psychometrically reliable score. No clear pattern of portfolio choice for those who over-estimated their financial risk tolerance was noted. Being female and between the age of 55 to 64, having an income of $100,000 or more, and working with a financial advisor were found to be more consistent descriptors of portfolio risk compared to risk-tolerance miscalibration.

1. Introduction

The notion that over- or under-estimating one's financial risk tolerance is related to the level of portfolio risk held by a financial decision-maker requires further study. The relevant research has been framed in terms of overconfidence or the persistent over-evaluation of one's ability to make an appraisal (Dittrich et al., 2007). For example, Broihanne et al. (2014) showed that high-level finance professionals tend to be overconfident across domains (i.e., they overestimate their forecasting abilities). This over-confidence results in biased stock price forecasting, resulting in risk-taking choices that are more extreme than what would otherwise be the case. The opposite has also been observed, with decision-makers who exhibit under-confidence being less likely to hold assets that exhibit high price volatility and more likely to hold conservative portfolios (Grable et al., 2009). It is generally assumed as true that similar patterns of portfolio risk will be present when estimates of financial risk tolerance are examined in place of confidence. Although there is some evidence, as noted by Nosic and Weber (2010), showing that miscalibrations of risk-taking attitudes might be associated with risk-taking behavior, the actual direction of the association has not been widely reported in the literature.

This study analyzed the degree to which degrees of miscalibration in a decision-maker's willingness to take financial risk are associated with portfolio risk. Findings from this study provide evidence that those who under-estimate their financial risk tolerance tend to hold less risky portfolios. However, no support for the notion that those who over-estimate their financial tolerance take more portfolio risk than others was noted. The portfolio risk of those who over-estimated their risk tolerance was similar to those who

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exhibited accuracy when evaluating their willingness to take a financial risk.

2. Data and methods

A cross-sectional dataset (N = 60,378) was gathered from 2017 to 2018 using an open-access Internet survey hosted by the University of Missouri (http://pfp.missouri.edu/research_IRTA.html). The sample with complete survey responses was delimited to respondents older than 25 years of age, resulting in a sample of 12,416 respondents. In order to reduce the possibility of identifying very small effect sizes resulting from such a large sample (see Ellis, 2010 and Lanz, 2013), ten 10% random samples, each with 1241 respondents, were used for statistical analysis.

The dependent variable in the models was portfolio risk. Respondents were asked to indicate whether they currently own investable assets and in what proportion (see Table 2). Asset allocation data were then transformed into a portfolio risk score (PR) following a procedure proposed by Corter and Chen (2006), which incorporates a varying level of riskiness associated with different assets:

$$PR = \sum r_i p_i$$

where PR is the overall portfolio risk score for an investor, r_i is the risk weighting of the asset category, and p_i is the percentage of the investor's assets invested in that asset category. The PR variable ranged from zero to 0.2, with higher scores representing greater risk.

Risk-tolerance miscalibration was estimated using a differential prediction modeling technique (Linn, 1978) following a procedure described by Grable and Roszkowski (2007), Gilliam and Grable (2010), and Moreschi (2005). Specifically, respondents were asked to estimate their subjective financial risk tolerance using a single-item question (i.e., a subjective estimate of their financial risk tolerance). The subjective financial risk tolerance score was measured using the following question: "In general, how would your best friend describe you as a risk taker? (a) A real gambler (coded 4); (b) Willing to take risks after completing adequate research (coded 3); (c) Cautious (coded 2); or (d) A real risk avoider (coded 1)." Respondents were then asked to complete a risk-tolerance questionnaire that was thought to be a more psychometrically accurate indicator of their "true" or "valid" risk tolerance. Scale scores were measured using a 12-item summed propensity scale, which was similar to one developed by Grable and Lytton (1999). Scores ranged from a low of 12 to a high of 43, with higher scores representing a greater willingness to take a financial risk (Grable et al., 2019). Cronbach's alpha, across the 10 samples, averaged 0.70.

These scores were then used in a multiple-step estimation procedure. The first step involved regressing subjective risk-tolerance estimations on scores from the psychometric financial risk-tolerance scale as follows:

$$predicted\ financial\ risk\ tolerance = b_0 + b_1 psychometric\ financial\ risk\ tolerance$$

Because of the ordinal coding of the subjective estimation, an ordered logistic regression model was used to predict each respondent's subjective risk category from scores on the psychometric risk tolerance scale. Table 1 shows that each of the regression models was statistically significant (the tests of the proportional odds assumptions were also significant at $\alpha = 0.01$). The predicted probabilities relating to the four subjective financial risk-tolerance levels from the ordered regression were then saved for all respondents. The predicted scores were assigned based on the highest predicted probabilities. For example, if the predicted probabilities for values of subjective risk tolerance levels 1, 2, 3, and 4 were 0.016, 0.244, 0.692, and 0.048, respectively, then the assigned score was 3.

The second step in the estimation procedure involved subtracting a respondent's predicted subjective risk-tolerance score from their subjective financial risk-tolerance score. The result was a measure of miscalibration for each respondent. A positive (+) value indicated over-estimation, whereas a negative (-) value indicated under-estimation. A score of zero indicated that a respondent's original estimation matched their predicted willingness to take financial risk. Respondents were then grouped into three classes: over-estimated, under-estimated, and calibrated.

A frequency distribution of calibration classes showed that about 64% of respondents were calibrated in estimating their risk tolerance (i.e., they had an estimation error of 0). Approximately 26% of respondents exhibited an under-estimation miscalibration, whereas approximately 10% of respondents exhibited an over-estimation miscalibration. Descriptive data across the 10 sub-samples are shown in Table 2.

Table 1
Regression analysis predicting subjective evaluation with propensity scores.

	B	Z-value	Likelihood Ratio Test of Proportionality of Odds
Sample 1	0.1888***	13.10	0.0163
Sample 2	0.1980***	13.98	0.1137
Sample 3	0.2011***	14.83	0.0210
Sample 4	0.1996***	13.42	0.1186
Sample 5	0.2034***	13.91	0.0129
Sample 6	0.1849***	12.36	0.0497
Sample 7	0.1714***	11.97	0.0785
Sample 8	0.1727***	13.19	0.0133
Sample 9	0.1967***	14.34	0.2143
Sample 10	0.1765***	13.17	0.1359

Table 2
Sample descriptive statistics.

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
Portfolio Risk	0.1011	0.1006	0.0990	0.0961	0.1004	0.0984	0.0947	0.0977	0.1004	0.1052
Estimation Error										
Consistent	63.79%	65.48%	63.47%	63.47%	65.97%	63.06%	62.98%	62.50%	63.47%	64.31%
Overestimation	10.16%	10.40%	11.94%	10.40%	9.44%	11.21%	9.11%	11.74%	10.69%	10.07%
Underestimation	26.05%	24.11%	24.58%	26.13%	24.60%	25.73%	27.90%	25.76%	25.83%	25.63%
Sex										
Male	63.86%	65.56%	63.74%	64.46%	65.24%	63.44%	61.71%	64.39%	64.62%	64.53%
Female	36.14%	34.44%	36.26%	35.54%	34.76%	36.56%	38.29%	35.61%	35.38%	35.47%
Age										
25–34	45.40%	44.15%	45.28%	44.44%	44.87%	44.27%	46.48%	46.18%	42.94%	43.77%
35–44	24.96%	25.50%	24.65%	23.87%	23.20%	25.08%	24.33%	24.20%	25.54%	23.87%
45–54	15.02%	15.17%	14.44%	16.77%	14.39%	16.29%	14.71%	15.16%	15.24%	16.08%
55–64	9.05%	10.01%	10.49%	10.32%	12.05%	9.27%	9.78%	10.57%	10.02%	11.55%
65–74	4.28%	3.87%	4.38%	4.03%	4.45%	4.35%	3.80%	2.99%	5.43%	3.76%
75 and over	1.29%	1.29%	0.76%	0.56%	1.05%	0.73%	0.89%	0.90%	0.84%	0.97%
Marital status										
Never married	27.16%	25.04%	26.27%	26.17%	25.06%	26.21%	27.02%	28.74%	25.19%	25.59%
Living with significant other	10.99%	11.71%	9.87%	10.34%	10.59%	12.26%	10.84%	9.39%	10.23%	10.92%
Married	51.01%	55.01%	55.59%	53.88%	54.65%	51.61%	53.32%	53.10%	54.70%	54.03%
Separated or Divorced	8.25%	5.65%	6.05%	6.70%	7.68%	7.74%	6.80%	7.03%	7.03%	7.23%
Widowed	0.89%	1.37%	1.11%	1.05%	0.97%	1.05%	1.21%	1.04%	1.39%	0.90%
Shared living arrangements	1.70%	1.21%	1.11%	1.86%	1.05%	1.13%	0.81%	0.70%	1.46%	1.32%
Education										
Less than High School	0.73%	0.65%	0.90%	0.56%	0.49%	0.56%	0.81%	0.49%	0.97%	0.63%
High School	3.64%	3.07%	3.33%	3.71%	2.43%	4.44%	4.20%	3.27%	3.55%	3.97%
College	13.42%	15.91%	12.78%	15.40%	13.34%	13.56%	13.56%	14.53%	14.61%	12.87%
Associate Degree	8.25%	8.56%	9.38%	10.32%	10.11%	10.09%	8.80%	9.32%	9.67%	8.56%
Bachelor's Degree	34.84%	34.65%	34.93%	33.63%	34.44%	34.38%	34.62%	36.37%	33.47%	34.03%
Graduate Degree	39.13%	37.16%	38.68%	36.37%	39.21%	36.97%	38.01%	36.02%	37.72%	39.94%
Income										
Income <25k (ref)	9.70%	10.27%	9.05%	10.02%	10.06%	9.45%	10.11%	11.51%	9.08%	8.30%
Income 25k – 49K	16.98%	15.36%	16.85%	16.98%	16.22%	16.72%	17.07%	15.62%	17.81%	18.07%
Income 50k −74K	20.53%	20.45%	20.19%	20.37%	19.06%	19.39%	21.68%	19.39%	20.39%	17.86%
Income 75 K – 99k	15.12%	18.03%	14.48%	16.90%	14.44%	16.32%	12.94%	16.74%	14.46%	16.19%
$100,000 or greater	37.67%	35.89%	39.42%	35.73%	40.23%	38.13%	38.19%	36.75%	38.27%	39.57%
Financial Decision										
I or someone in my household	67.64%	67.21%	69.89%	67.64%	70.94%	70.54%	65.62%	68.87%	68.99%	70.77%
Rely on Professional	17.27%	17.81%	15.09%	15.50%	14.85%	13.96%	18.16%	14.52%	16.45%	16.14%
No Investment Asset	15.09%	14.98%	15.02%	16.87%	14.21%	15.50%	16.22%	16.61%	14.56%	13.08%

A Tobit censored regression analysis was then used to examine the relationship between financial-risk tolerance calibration status and portfolio risk (PR) controlling for the respondent demographic characteristics shown in Table 2 and each respondent's reliance on professional advice when making investment decisions. The calibrated class of respondents was used as the reference category. Tests for proportionality of odds were not significant for any of the samples. Multicollinearity tests showed that VIF scores for all samples were below 10.

3. Results

The results from the tests are nuanced (Table 3). In the majority of the samples, those who under-estimated their financial risk tolerance were found to hold portfolios with less risk compared to those whose risk-tolerance scores were calibrated. This finding aligns with much of the previous literature showing that under-confidence is associated with risk aversion. Counter to what is generally thought to be true, those who over-estimated their financial risk tolerance did not exhibit increased PR. In general, PR scores for those who over-estimated their financial risk tolerance matched PR scores from those with calibrated risk-tolerance scores. Forty percent of the time, over-estimation was found to be associated with lower levels of PR.

Also of importance were results showing that some financial decision-maker characteristics were more consistent in describing PR. Specifically, the portfolios of female respondents were less risky than portfolios held by males. Those between the age of 55 to 64 held portfolios with more PR. Likewise, the PR of those who reported income of $100,000 or more was higher than others. Finally, respondents who indicated working with a financial advisor held portfolios with more risk.

Table 3
Tobit regression analysis showing the association between risk-tolerance calibration status and PR scores.

Dependent Variable: Portfolio risk	Sample 1		Sample 2		Sample 3		Sample 4		Sample 5	
	B	t-value	B	t-value	B	t-value	B	t-value	B	t-value
(Constant)	0.0829***	3.06	−0.0122	−0.47	−0.0197	−0.62	−0.0073	−0.23	0.0089	0.21
Calibrated (ref)										
Overestimation	−0.0176***	−2.63	−0.0133	−1.89	−0.0110	−1.80	−0.0133	−1.87	−0.0106	−1.59
Underestimation	−0.0081*	−1.95	−0.0103 *	−2.28	−0.0093 *	−2.12	−0.0059	−1.27	−0.0020	−0.43
Male (Ref)										
Female	−0.0234***	−5.84	−0.0259 ***	−5.91	−0.0157 ***	−3.98	−0.0189 ***	−4.27	−0.0310 ***	−7.01
Age 25–34 (ref)										
Age 35–44	0.0126*	2.46	0.0019	0.37	0.0183 ***	3.71	0.0043	0.77	0.0086	1.54
Age 45- 54	0.0338***	5.93	0.0150 *	2.54	0.0208 ***	3.47	0.0150 *	2.56	0.0224 ***	3.80
Age 55- 64	0.0321***	5.34	0.0216 ***	3.33	0.0232 ***	3.84	0.0242 ***	3.92	0.0277 ***	4.38
Age 65- 74	0.0299***	3.86	0.0104	1.15	0.0259 ***	3.69	0.0167	1.93	0.0216 *	2.40
Age over 75	0.0362**	1.87	0.0152	0.93	0.0073	0.34	0.0518 **	2.58	0.0279	1.51
Not Married (ref)										
arried	−0.0033	−0.67	−0.0059	−1.10	−0.0027	−0.52	0.0006	0.10	0.0019	0.33
Separated/Divorced	−0.0082	−0.98	−0.0009	−0.09	−0.0013	−0.14	0.0065	0.70	0.0055	0.61
Widowed	−0.0201	−1.00	0.0138	1.01	0.0093	0.75	−0.0344	−1.47	−0.0249	−1.31
Living Together	0.0097	1.38	−0.0074	−0.95	−0.0009	−0.11	0.0052	0.68	0.0025	0.29
Shared Living	0.0091	0.62	−0.0187	−0.91	−0.0009	−0.05	−0.0042	−0.31	−0.0008	−0.04
Less than High School (Ref)										
High School	0.0218	0.76	0.0232	0.86	0.0164	0.50	0.0178	0.54	−0.0011	−0.03
College	0.0045	0.17	0.0101	0.39	−0.0194	−0.63	−0.0003	−0.01	−0.0283	−0.67
Associate Degree	−0.0198	−0.73	−0.0065	−0.25	−0.0149	−0.48	−0.0180	−0.58	−0.0260	−0.62
Bachelor's Degree	0.0135	0.51	0.0205	0.82	0.0074	0.24	0.0091	0.29	−0.0141	−0.34
Graduate Degree	0.0118	0.44	0.0160	0.63	0.0035	0.11	0.0049	0.16	−0.0092	−0.22
Income <25k (ref)										
Income 25k – 49K	0.0019	0.25	−0.0038	−0.45	0.0150	1.73	0.0008	0.09	0.0038	0.47
Income 50k −74K	0.0125	1.58	0.0108	1.41	0.0151	1.80	0.0045	0.52	0.0136	1.72
Income 75 K – 99k	0.0185**	2.34	0.0228 **	2.74	0.0166	1.87	0.0200 *	2.31	0.0219 **	2.68
$100,000 or greater	0.0297***	3.98	0.0357 ***	4.78	0.0384 ***	4.69	0.0355 ***	4.32	0.0410 ***	5.67
Professional Advice										
I or someone in my household (ref)										
Rely on Professional	0.0110*	2.34	0.0980 ***	12.76	0.1016 ***	14.16	0.0922 ***	12.89	0.0899 ***	11.62
No Investment Asset	−0.0987***	−13.89	0.1071 ***	12.50	0.1114 ***	13.90	0.0952 ***	11.49	0.0982 ***	11.29

Dependent Variable: Portfolio risk	Sample 6		Sample 7		Sample 8		Sample 9		Sample 10	
	B	t-value	B	t-value	B	t-value	B	t-value	B	t-value
(Constant)	0.0292	0.68	−0.0386	−1.31	0.0566 **	2.90	−0.0198	−1.02	0.0242	1.00
Calibrated (ref)										
Overestimation	−0.0236 ***	−3.25	−0.0124	−1.73	−0.0169 **	−2.81	−0.0136 *	−1.96	−0.0051	−0.79
Underestimation	−0.0096 *	−2.02	−0.0031	−0.66	−0.0146 ***	−3.54	−0.0107 *	−2.53	−0.0055	−1.45
Male (Ref)										
Female	−0.0209 ***	−4.83	−0.0169 ***	−3.99	−0.0197 ***	−5.11	−0.0191 ***	−4.83	−0.0212 ***	−5.71
Age 25–34 (ref)										
Age 35–44	0.0179 ***	3.22	0.0238 ***	4.44	0.0105 *	2.20	0.0139 **	2.70	0.0108 *	2.29
Age 45- 54	0.0294 ***	4.57	0.0195 **	3.16	0.0244 ***	4.13	0.0188 **	3.26	0.0277 ***	5.24
Age 55- 64	0.0298 ***	4.43	0.0385 ***	6.32	0.0380 ***	6.45	0.0198 **	3.01	0.0382 ***	7.78
Age 65- 74	0.0210	2.30	0.0502 ***	5.47	0.0342 ***	3.75	0.0109	1.61	0.0266 ***	3.38
Age over 75	0.0512 ***	3.83	0.0248	1.75	−0.0083	−0.41	0.0003	0.01	0.0059	0.25

(*continued on next page*)

Table 3 (*continued*)

Not Married (ref)														
Married	0.0080		1.48	−0.0063		−1.17	−0.0058		−1.22	0.0105	*	1.97	−0.0067		−1.43
Separated/Divorced	0.0125		1.43	−0.0127		−1.36	−0.0050		−0.68	0.0180	*	2.29	−0.0039		−0.53
Widowed	0.0043		0.26	−0.0094		−0.58	−0.0093		−0.86	0.0031		0.18	−0.0295		−1.42
Living Together	0.0067		0.89	−0.0093		−1.19	0.0001		0.01	0.0013		0.18	0.0049		0.72
Shared Living	0.0511	**	2.94	−0.0203		−0.79	0.0177		0.76	−0.0098		−0.50	0.0072		0.52
Less than High School (Ref)														
High School	−0.0243		−0.56	0.0500		1.64	−0.0431	*	−2.00	0.0270		1.32	−0.0174		−0.71
College	−0.0278		−0.65	0.0116		0.40	−0.0488	**	−2.62	−0.0130		−0.69	−0.0194		−0.84
Associate Degree	−0.0361		−0.85	0.0007		0.03	−0.0642	**	−3.38	−0.0094		−0.50	−0.0299		−1.29
Bachelor's Degree	−0.0273		−0.65	0.0361		1.25	−0.0399	*	−2.21	0.0069		0.38	−0.0145		−0.64
Graduate Degree	−0.0226		−0.54	0.0318		1.10	−0.0366	*	−2.03	0.0049		0.27	−0.0153		−0.68
Income <25k (ref)														
Income 25k – 49K	−0.0055		−0.61	0.0020		0.22	−0.0180	*	−2.30	0.0034		0.40	0.0003		0.04
Income 50k −74K	−0.0036		−0.41	0.0097		1.13	−0.0042		−0.56	0.0156		1.89	0.0097		1.21
Income 75 K – 99k	0.0060		0.69	0.0087		0.94	0.0082		1.09	0.0225	**	2.60	0.0115		1.42
$100,000 or greater	0.0232	**	2.82	0.0230	**	2.83	0.0167	*	2.23	0.0368	***	4.61	0.0246	***	3.23
Professional Advice														
I or someone in my household (ref)														
Rely on Professional	0.0863	***	11.47	0.0986	***	13.52	0.0921	***	14.14	0.0976	***	13.79	0.0922	***	13.32
No Investment Asset	0.0915	***	10.80	0.1087	***	13.87	0.0981	***	13.39	0.1091	***	13.91	0.0969	***	12.89

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$. b-values are unstandardized.

4. Discussion

This study adds to the literature on risk-tolerance calibration as it relates to financial risk-taking. While much of the literature shows that decision-makers who are overconfident hold riskier portfolios and make riskier decisions, findings from this study indicate that miscalibration of financial risk tolerance does not always result in the same biased behavior. In this study, those who under-estimated their tolerance for risk held less risky portfolios. The PR for those who over-estimated their financial tolerance generally matched that of those who exhibited a calibrated level of risk tolerance. Some evidence was found that a tendency to over-estimate one's financial risk tolerance may actually be related to taking less PR. One explanation for this particular finding is that the sample, while large, may not have been representative of those who make investment choices. The sample included relatively few respondents who over-estimated their financial risk tolerance. Another explanation is that the findings are indicative of the better-than-average effect.[1] Similar to drivers who believe they are better than others when driving a car (when in fact they are not), it is possible that decision-makers who over-estimate their financial risk tolerance fail to extend their appraisal into actual behavior. Those classified as calibrated may be in a better position to match their tolerance for risk with an appropriate level of PR.

Two other insights emerged from this study. The first is that rather than rely on a subjectively-derived estimate of financial risk tolerance, portfolio choices should be informed by more psychometrically robust measures of financial risk tolerance. Second, certain financial decision-maker characteristics appear to provide unique insights into portfolio choices. Whereas no clear pattern of portfolio choice for those who over-estimated their financial risk tolerance was noted, it was determined that being female and between the age of 55 to 64, having an income of $100,000 or more, and working with a financial advisor were consistent descriptors of PR. This means that rather than relying solely on estimates of subjective financial risk tolerance to explain PR, certain financial decision-maker characteristics can be used to supplement evaluations with the goal of better understanding the portfolio choices of financial decision-makers.

5. Conclusion

This study analyzed the degree to which categories of miscalibration in a decision-maker's willingness to take financial risk are associated with portfolio risk. Decision-makers in this study who systematically under-estimated their financial risk tolerance held portfolios that were less risky than those who were able to match their self-assessed risk tolerance to their true score. The PR of those who over-estimated their financial tolerance generally matched the PR of those whose risk-tolerance estimates were calibrated. Future research is needed to replicate this study with a different sample over different time periods.

CRediT authorship contribution statement

Abed G. Rabbani: Conceptualization, Methodology, Data curation, Validation, Formal analysis, Investigation, Writing – original draft. **John E. Grable:** Methodology, Validation, Writing – review & editing.

Declaration of Competing Interest

Abed Rabbani declares that there is no conflict of interest to disclose in reference to this paper. John Grable declares that there is no conflict of interest to disclose in reference to this paper.

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[1] The better-than-average effect is the tendency of some decision-makers to believe they are better than others in specific ways when they are not. In one study, for example, 93% of American drivers reported themselves to be more skillful than the median American driver (Svenson, 1981). This represents a miscalibration in driving skills, given that it is not mathematically possible for the majority of drivers to be better than either the average or median. Miscalibrations like this have been linked with numerous biased day-to-day choice outcomes, including insurance choice decisions and portfolio choice outcomes (Sutton, 1987; van de Venter & Michayluk, 2008). When viewed this way, it can be seen that those who over-estimate their willingness to take a financial risk may not really be different, in practice, from others.

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