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Article

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Article

The Moderating Effect of Financial Knowledge on Financial Risk Tolerance

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Abstract: The purpose of this paper is to describe a study that was designed to determine to what extent subjective and objective measures of financial knowledge moderate the relationship between an investor's financial risk tolerance and demographic factors thought to be important descriptors of an investor's willingness to take a financial risk. It was determined that those who identified as male, and those with more attained education and income, exhibited higher investment risk tolerance (IRT). Subjective financial knowledge (SFK) was positively associated with IRT. The relationship between gender and IRT was moderated by SFK, whereas the relationship between IRT and age was moderated by objective financial knowledge (OFK). A positive relationship between education and IRT was noted, but the relationship was moderated by OFK, whereas the association between IRT and household income was moderated by SFK. Findings from this study indicate that while SFK and OFK are positively correlated, they are not measuring the same underlying construct, and as such, each moderates IRT relationships differently.

Keywords: financial knowledge; subjective financial knowledge; objective financial knowledge; risk tolerance

JEL Classification: D90; D91; D14; D10



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1. Introduction

Over the past two decades, the interest in topics that are directly, or even tangentially, related to financial knowledge has garnered the increasing attention of researchers, educators, and policymakers from around the world and across fields of study (Rabbani et al. 2022). Robb and Sharpe (2009) were among the first to conceptualize what is meant by the term financial knowledge. They argued that financial knowledge is “an individual’s understanding of important concepts related to personal finance” (p. 29). The current body of literature suggests that financial knowledge is a construct that adds to a decision-maker’s degree of financial literacy, which, according to Warmath and Zimmerman (2019), is a concept that is a formative combination of financial knowledge, financial skill, and self-efficacy. When viewed this way, financial knowledge assumes a prominent place in many household economic models (Chujan et al. 2022; Jump\$Start Coalition 2017). Consider the life-cycle hypothesis. This theoretical model suggests that household financial decision-makers attempt to smooth consumption across their lifetime through borrowing and saving. Those whose income is most volatile are predicted to save more than others, whereas the optimality of spending versus saving is thought to change with one’s stock of human capital (Browning and Crossley 2001). Embedded in this theory is the notion that financial decision-makers are rational and able to make optimized decisions regarding when to save or consume resources. As noted by Lusardi and Mitchell (2014) and Nyakurukwa and Seetharam (2022), in order to optimize a

decision, individuals must possess the financial knowledge necessary to formulate saving, borrowing, and consumption plans and make somewhat complex calculations.

The notion of household financial risk tolerance is another construct that underlies many conventional economic models. Financial risk tolerance is defined as a household decision-maker's willingness to engage in a financial behavior in which the outcome is both uncertain and potentially negative (Rabbani and Nobre 2022). Financial risk tolerance, or its inverse financial risk aversion, is a necessary input into the formulation and implementation of saving and investment plans. Those with a greater degree of risk tolerance are more likely to obtain higher returns in exchange for more risk (Brayman et al. 2017; Nguyen et al. 2019; Reddy and Mahapatra 2017). The extant literature suggests that financial knowledge and financial risk tolerance are positively associated (Heo et al. 2022; Hermansson and Jonsson 2021).

As will be described later in this paper, the demographic profile of those who exhibit low, moderate, or high financial knowledge tends to be similar to the profile of those with low, moderate, and high financial risk tolerance (Grable 2000; Reddy and Mahapatra 2017). Older females with less education and income generally score lower on objective measures of financial knowledge. These same individuals often exhibit the lowest levels of risk tolerance. Alternatively, younger males with more education and income commonly score high on objective financial knowledge measures while concurrently reporting an elevated willingness to take financial risks. While the existing literature is robust in providing evidence of the existence of financial decision-maker knowledge and risk tolerance profiles, few studies have been conducted using interaction terms between financial knowledge and profiling characteristics when describing an investor's financial risk tolerance (Shusha 2017). The purpose of this study is to address this gap in the literature by documenting to what extent measures of financial knowledge moderate the relationship between an investor's financial risk tolerance and demographic factors thought to be important descriptors of an investor's willingness to take a financial risk.

2. Literature Review

A broad and growing body of research shows that several personal and household characteristics must exist prior to participation in financial markets that are characterized by uncertainty (e.g., the securities markets). First, a household must possess the resources to gain access to a market. This can occur through cash flow or the allocation of household assets. Second, a household's financial decision-maker(s) must have an awareness of and appreciation for the benefits associated with saving and investing. An understanding of the risks related to market participation must also be present. Third, a willingness to take a financial risk must exist. One characteristic that binds these three elements together is financial knowledge (Bayar et al. 2020; Bianchi 2018; Epaphra and Kiwia 2021; Van Rooij et al. 2011). While any person can be an investor, the evidence suggests that the likelihood of investing success increases in proportion to financial knowledge (Robb and Woodyard 2011)—and the ability to apply knowledge in daily practice—exhibited by a financial decision-maker (Lusardi and Mitchell 2014). Whereas the definition of financial knowledge is still being debated, how financial knowledge is assessed tends to be dictated by two approaches. The first is to measure financial knowledge quantitatively through a series of questions that evaluate a test taker's knowledge of economic concepts and financial terms. This is referred to as objective financial knowledge. The second measurement approach is sometimes called a self-assessment or a subjective evaluation. Subjective financial knowledge can be conceptualized as a self-assessed understanding of content knowledge (Tang and Baker 2016). Subjective knowledge is commonly measured using a single item or question (e.g., the knowledge assessment in the National Longitudinal Survey of Youth 1979 survey for the 2012, 2014, 2016, and 2018 cohorts relies on a single Likert-type question). Consider the work of Shim et al. (2009), Shim et al. (2010), and Serido et al. (2013). These researchers measured financial knowledge by asking survey respondents, "How would you rate your overall understanding of personal-finance and money management concepts and practices?" Responses were coded using a five-point scale ranging from 1

(very low) to 5 (very high). The validity of the question was supported in these studies. [Willows \(2019\)](#) reported that the correlation between objective and subjective measures of financial knowledge tends to be positive but relatively weak. Others have argued that objective measures reveal true financial knowledge, whereas subjective measures indicate financial confidence ([Amonhaemanon 2022](#)).

When evaluating the association between financial knowledge and risk-taking behavior (e.g., participation in the securities markets) researchers have typically controlled for four financial decision-maker demographic characteristics: gender, age, education, and income ([Nyakurukwa and Seetharam 2022](#)). Self-identified males generally score higher on objective measures of financial knowledge. Males are also more likely to exhibit overconfidence and self-report higher levels of knowledge. Financial knowledge, both objective and subjective, are known to increase with age ([Robb and Woodyard 2011](#)). There may be an experience aspect at play in this relationship. Not surprisingly, formally attained education and financial knowledge tend to be positively associated ([Allgood and Walstad 2016](#); [Nyakurukwa and Seetharam 2022](#)). Finally, income and knowledge are generally reported to be positively associated ([Perry and Morris 2005](#)). It is important to note that none of these relationships are necessarily causal.

Gender, age, education, and income are also known to be associated with a financial decision-maker's willingness to take financial risks. Self-identified males, more so than similarly self-identified females, commonly report a greater willingness to take financial risks ([Ferreira and Dickason 2018](#)). In general, age is negatively associated with risk tolerance, however, this is not always the case. [Amonhaemanon \(2022\)](#) reported, for example, that older individuals are more likely to gamble and become addicted to risk-taking. In alignment with the financial knowledge literature, higher levels of attained education and income are known to be positively associated with a greater willingness to take financial risks ([Bayar et al. 2020](#); [Duasa and Yusof 2013](#); [Frijns et al. 2008](#); [Grable and Joo 2004](#); [Kannadhasan 2015](#); [Nosita et al. 2020](#); [Yong and Tan 2017](#)).

Conceptual Framework

This study of the moderation effect of financial knowledge was guided by the biopsychosocial model of risk-taking behavior described by [Irwin and Millstein \(1986\)](#). Irwin and Millstein showed that it is possible to estimate the probability that a person will engage in risk-taking behavior based on predisposing biopsychosocial and environmental factors as well as precipitating factors. Examples of predisposing biopsychosocial factors include age and gender. Education and income are examples of predisposing environmental factors. Knowledge represents a precipitating factor. Precipitating factors effectively alter the relationship between predisposing characteristics and vulnerability to risky situations. When viewed this way, financial knowledge—either subjectively or objectively measured—can be viewed as a moderating factor in the description of a person's willingness to take a financial risk. This fits with a theoretical model presented by [Delavande et al. \(2008\)](#) who treated financial knowledge as a form of human capital and the acquisition of knowledge as an investment. The Delavande et al. model assumes that investment in financial knowledge provides financial decision-makers a pathway to obtaining a higher expected rate of return on their assets. As conceptualized in their model, financial knowledge can be seen as fundamentally altering the way biopsychosocial and environmental characteristics relate to a person's risk tolerance.

3. Research Questions

The overarching question of interest in this study was to what extent do measures of financial knowledge moderate the relationship between an investor's financial risk tolerance and demographic factors thought to be important descriptors of an investor's willingness to take a financial risk? The following research questions were evaluated in this study:

RQ₁: What are the associations between subjective financial knowledge, objective financial knowledge, and an investor's financial risk tolerance?

- RQ₂: How stable are subjective financial knowledge, objective financial knowledge, and an investor's financial risk tolerance across time?
- RQ₃: To what degree do subjective financial knowledge, objective financial knowledge, and an investor's financial risk tolerance differ by gender, age, education, and household income?
- RQ₄: To what extent is gender related to an investor's financial risk tolerance, and is this relationship moderated by subjective financial knowledge and objective financial knowledge?
- RQ₅: To what extent is age related to an investor's financial risk tolerance, and is this relationship moderated by subjective financial knowledge and objective financial knowledge?
- RQ₆: To what extent is education related to an investor's financial risk tolerance, and is this relationship moderated by subjective financial knowledge and objective financial knowledge?
- RQ₇: To what extent is household income related to an investor's financial risk tolerance, and is this relationship moderated by subjective financial knowledge and objective financial knowledge?

4. Materials & Methods

4.1. Sample and Data

Data for this study were collected over the period January 2019 through July 2022 through an open access survey platform managed by the University of Missouri. The data file was delimited to include only responses from those who started and finished the entire survey with no missing data. The final dataset included cross-sectional responses from approximately 80,000 respondents. Data from a randomly selected sub-sample of approximately 10% of respondents (N = 8038) were used in the analyses.

4.2. Variables

An investor's financial risk tolerance (measured as investment risk tolerance [IRT]) was assessed using the Grable and Lytton (1999) 13-item propensity scale. The scale is a widely used assessment tool among researchers to obtain a reliable and valid indicator of an investor's willingness to take a financial risk when the outcome of a decision is both uncertain and potentially negative (e.g., Amonhaemanon 2022; Beer and Wellman 2021; Chung and Au 2022; Kuzniak et al. 2015; Lucarelli et al. 2011; Rabbani et al. 2017; Thanki and Baser 2021; Uckun and Dal 2021). In this study, answers to the thirteen questions were summed, which resulted in scores ranging from 13 to 47. Higher scores represent increased levels of risk tolerance. In alignment with what has been reported in the literature, the average score fell between 27 and 28. Over a wide variety of studies, the scale has shown acceptable levels of validity and reliability (see Nunnally and Bernstein (1994) for standards of acceptability), with Cronbach's alpha scores ranging from 0.70 to over 0.80 (Heo et al. 2022; Kuzniak et al. 2015). In this study, Cronbach's alpha scores varied based on the age of a respondent. Cronbach's alpha for those under the age of 25 years was 0.69; reliability scores increased with each age category, with Cronbach's alpha estimated at 0.85 for those aged 75 and older.

Similar to Shim et al. (2009), Shim et al. (2010), and Serido et al. (2013), subjective financial knowledge (SFK) was measured with the following single-item question: "On a scale from one to five (where 1 is lowest and 5 is highest), how would you rate your overall understanding of personal finance and money management concepts and practices?" Most respondents indicated a moderate level of knowledge (i.e., a score of 3).

Objective financial knowledge (OFK) was measured using what is generally referred to as the "Big Three" financial literacy questions (Lusardi and Mitchell 2011). The questions were presented in this order (** represents the correct answer):

- (1) Suppose you had \$100 in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow?
 - (a) More than \$102 **
 - (b) Exactly \$102

- (c) Less than \$102
 - (d) Do not know
 - (e) Refuse to answer
- (2) Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?
- (a) More than today
 - (b) Exactly the same
 - (c) Less than today **
 - (d) Do not know
 - (e) Refuse to answer
- (3) Please tell me whether this statement is true or false. “Buying a single company’s stock usually provides a safer return than a stock mutual fund”.
- (a) True
 - (b) False **
 - (c) Do not know
 - (d) Refuse to answer

According to documents posted by the [Global Financial Literacy Excellence Center \(2022\)](#), these questions are used in more than twenty country-specific national surveys to assess financial knowledge. In this study, a knowledge index was estimated by adding together the correct answers. Those who refused to answer were excluded from the analyses. Scores ranged from 0 to 3. Respondents, on average, answered two of the three questions correctly. Similar to the analysis of IRT scores, Cronbach’s alpha varied according to the age of a respondent. Alpha for those under the age of 25 years was slightly less than 0.40; scores increased with each age category, reaching a high of 0.73 for those aged 75 and over.

The gender of survey respondents was assessed as female (coded 0) and male (coded 1). Approximately 41% of respondents identified as female. Age was measured as an ordinal variable with the following seven categories: (a) under 25, (b) 25 to 34, (c) 35 to 44, (d) 45 to 54, (e) 55 to 64, (f) 65 to 74, and (g) 75 and over. The majority of respondents were 34 years of age or older. Education was assessed using the following six ordered categories: (a) some high school or less, (b) high school graduate, (c) some college/trade/vocational training, (d) Associate degree, (e) Bachelor’s degree, and (f) graduate or professional degree. Most respondents indicated an attained education level between some college/grade/vocational training and an Associate degree. Household income was measured using the following five ordered classifications: (a) less than \$25,000, (b) \$25,000 to \$49,999, (c) \$50,000 to \$74,999, (d) \$75,000 to \$99,999, and (e) \$100,000 or greater. The majority of respondents reported household income between \$50,000 and \$74,999.

4.3. Data Analysis

Descriptive statistics, *t* tests, ANOVAs, and a series of regression analyses were used to evaluate the research questions. The purpose of the *t* and ANOVA tests was to ascertain mean SFK, OFK, and IRT score differences across time, gender, age, education, and income. Six regressions were estimated to determine the moderation effects of SFK and OFK on the relationship between IRT and gender, age, education, and income. The first model was used to evaluate the significance of gender, age, education, income, SFK, and OFK in describing IRT. The second through fifth models added interaction terms. The last model included all the terms. The first step in creating the interactions involved centering the SFK and OFK variables. These centered variables were then multiplied by gender, age, education, and income, respectively. The Hayes Model 1 moderation macro for SPSS was then used to interpret the significant interactions. Specifically, RQ₄ through RQ₇ were evaluated using a series of least squares regression models estimated with the following functions:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6) \dots \dots \quad (1)$$

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_1X_5, X_1X_6) \dots \dots \quad (2)$$

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_2X_5, X_2X_6) \dots \dots \quad (3)$$

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_3X_5, X_3X_6) \dots \dots \quad (4)$$

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_4X_5, X_4X_6) \dots \dots \quad (5)$$

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_1X_5, X_1X_6, X_2X_5, X_2X_6, X_3X_5, X_3X_6, X_4X_5, X_4X_6) \dots \dots \quad (6)$$

where:

Y = investment risk tolerance (IRT)

X_1 = gender

X_2 = age

X_3 = education

X_4 = household income

X_5 = subjective financial knowledge (SFK)

X_6 = objective financial knowledge (OFK)

The remainder of this paper describes the results of the statistical analyses. The paper concludes with a discussion of findings as they relate to the study's research questions.

5. Results

Table 1 shows the mean and standard deviation for the variables of interest in this study. The table also presents the correlation coefficient estimates across these variables. The sample comprised relatively young males with average levels of risk tolerance, subjective financial knowledge, and objective financial knowledge. Given the sample size, it was not unexpected that each of the correlation estimates was statistically significant. Age and education were observed to have the highest association across the variables. This is not surprising given the age profile of respondents (i.e., young respondents are less likely to have attained a higher level of education). The other associations match what has generally been reported in the literature. Females were found to exhibit lower risk tolerance scores. Risk tolerance was, however, found to be positively associated with age, education, income, and knowledge. An interesting finding from the analysis is that while subjective and objective financial knowledge were positively associated, these two constructs were observed to be non-interchangeable. The effect size of the relationship was not particularly high. This means that these variables are measuring similar but not precisely the same concepts.

Table 1. Descriptive Sample Statistics (N = 8038).

	Mean	SD	Correlations						
			IRT	Gender	Age	Ed	Inc	SFK	OFK
IRT	27.97	4.85	1.00						
Gender	0.41	0.49	−0.21 **	1.00					
Age	1.80	1.21	0.11 **	−0.04 **	1.00				
Ed	3.28	1.83	0.17 ***	−0.06 **	0.56 **	1.00			
Inc	3.03	1.56	0.06 ***	−0.04 **	0.24 **	0.10 **	1.00		
SFK	3.16	0.93	0.26 ***	−0.19 **	0.19 **	0.18 **	0.17 **	1.00	
OFK	2.24	0.93	0.20 ***	−0.22 **	0.26 **	0.35 **	0.15 **	0.25 **	1.00

Note: ** $p < 0.01$; *** $p < 0.001$.

Table 2 shows the means, standard deviations, and standard errors for subjective financial knowledge (SFK), objective financial knowledge (OFK), and investment risk tolerance (IRT) over the years 2019, 2020, 2021, and 2022. ANOVA tests were used to determine if mean SFK, OFK, and IRT scores differed across the years of analysis. Significant differences were observed in IRT scores from 2019 and scores in 2021 and 2022, although the effect size of these differences was small. Mean plots are shown in the last column. Overall, the findings provide some evidence of the stability of SFK, OFK, and IRT. While IRT scores did increase

from 2019 to 2021/2022, the difference in mean scores fell within the historical average of the scale. Given these results (i.e., the relative stability of these constructs), evaluations of SFK, OFK, and IRT by gender, age, education, and income were undertaken with the assumption that the results would be reliable regardless of the year data were collected.

Table 3 shows the mean differences in SFK, OFK, and IRT scores by gender. Males exhibited higher SFK, OFK, and IRT scores. Based on estimates of Cohen's d and Glass's Delta, the effect size of the differences was determined to be large and meaningful. Males exhibited higher levels of risk tolerance. Males were also found to have subjectively and objectively higher levels of knowledge than females.

Table 4 shows the ANOVA test results where SFK, OFK, and IRT scores were compared across age categories. The models were statistically significant. The last column of Table 4 shows the mean plots. SFK and OFK scores increased in association with age. A modest inverted U-shaped relationship was noted between IRT scores and age, with scores increasing with age until age 65 when scores fell.

Table 5 displays the ANOVA results for SFK, OFK, and IRT mean score differences across education categories. The three models were statistically significant. In general, SFK and OFK scores increased in alignment with attained education, which was expected. Those with higher levels of education should, by definition, be more knowledgeable about household finance topics or at least be attuned to the need to gather information about important household financial topics. As shown in the last column of Table 5, IRT scores were also observed to increase in association with education.

Table 6 shows the ANOVA results for tests of differences in SFK, OFK, and IRT scores across household income categories. Each ANOVA test was statistically significant. A linear pattern between SFK scores and income was noted; however, the relationships between income and OFK and IRT scores were more nuanced. As indicated in the last column of the table, OFK and IRT scores started higher, dipped slightly, and then increased, resembling a weak U-shaped relationship. This implies that the associations between income and OFK and IRT, while positive and statistically significant, may be less pronounced than the associations between OFK, IRT, age, and education.

Table 7 presents the results from the regression analyses. The six models were estimated to determine if a moderation effect existed in the data that could be used to describe IRT scores (i.e., the outcome variable of interest in the model). The models were statistically significant, with the independent variables explaining approximately 12% to 13% of the variance in IRT scores.

As shown in Equation (1), gender, age, education, income, subjective financial knowledge (SFK), and objective financial knowledge (OFK) were significantly associated with IRT scores. In Equation (2), an interaction between gender and SFK was noted; however, OFK did not moderate the gender effect. In Equation (3), neither SFK nor OFK moderated the age relationship. A moderation effect between education and OFK, but not between education and SFK, was observed in Equation (4). SFK was found to moderate the income effect in Equation (5). The interaction between income and OFK was not significant.

When all of the variables and interaction terms were included in Equation (6), the significance of age and OFK was reduced. Four interactions were found to be statistically significant. The gender effect was moderated by SFK. This means that while females still exhibited lower overall IRT scores, the gap between males and females was reduced as SFK increased. The interaction between age and OFK was also significant. In this case, older respondents with more OFK exhibited lower IRT scores. OFK also moderated the education effect. This indicates that as attained education increased in alignment with OFK so did IRT scores. Finally, the interaction between income and SFK was significant. IRT scores were higher for those with more income and higher levels of SFK. An important takeaway from these analyses is that the moderative effect of financial knowledge varied based on the way the construct was measured. SFK appears to moderate the association between gender and IRT and income and IRT, whereas OFK appears to moderate the association between age and IRT and education and IRT.

Table 2. Descriptive Statistics for financial knowledge and investment risk tolerance. (N = 8038).

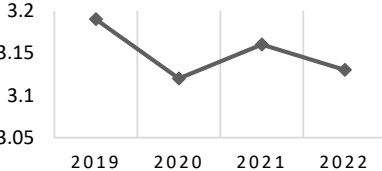
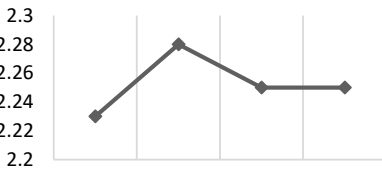
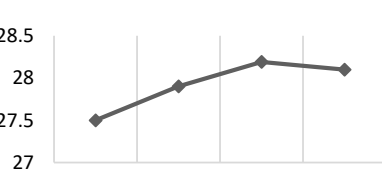
Year	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		ANOVA		Mean Plots	
				Lower Bound	Upper Bound	F	p		
SFK	2019	3.19	0.950	0.025	3.14	3.24	1.924	0.123	
	2020	3.12	0.948	0.019	3.08	3.15			
	2021	3.16	0.923	0.017	3.12	3.19			
	2022	3.13	0.909	0.023	3.09	3.18			
	Total	3.15	0.933	0.010	3.13	3.17			
OFK	2019	2.23	0.937	0.026	2.18	2.28	1.059	0.365	
	2020	2.28	0.907	0.018	2.25	2.32			
	2021	2.25	0.928	0.018	2.22	2.29			
	2022	2.25	0.928	0.024	2.21	2.30			
	Total	2.26	0.923	0.011	2.24	2.28			
IRT	2019	27.57	4.939	0.132	27.31	27.83	4.990	0.002	
	2020	27.91	4.978	0.098	27.72	28.10			
	2021	28.17	4.761	0.089	28.00	28.35			
	2022	28.05	4.794	0.122	27.81	28.29			
	Total	27.97	4.869	0.053	27.86	28.07			
* Post Hoc Analyses		The mean 2019 IRT score was statistically lower than IRT scores in 2021 and 2022. The effect size of significant differences was small.							

Table 3. Financial Knowledge and Investment Risk Tolerance Comparisons by Gender (N = 8038).

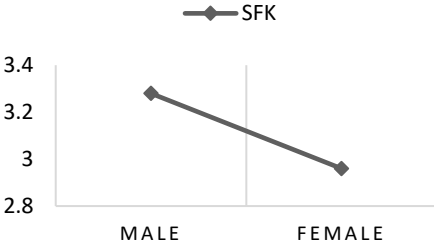
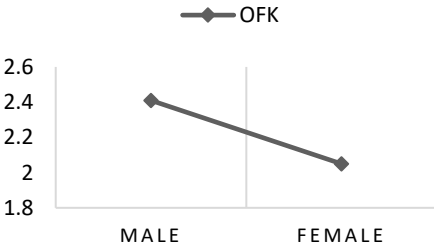
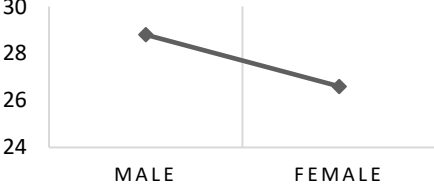
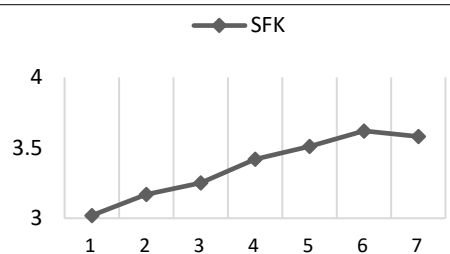
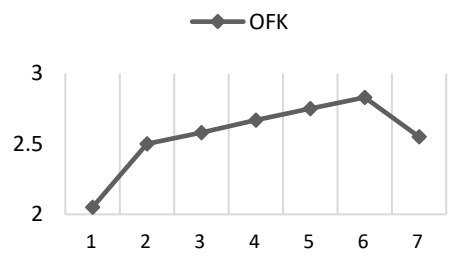
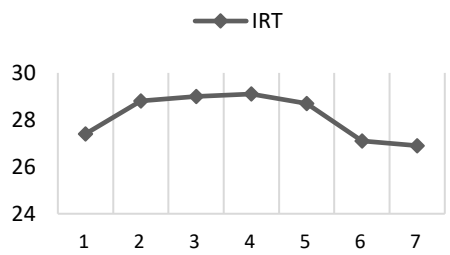
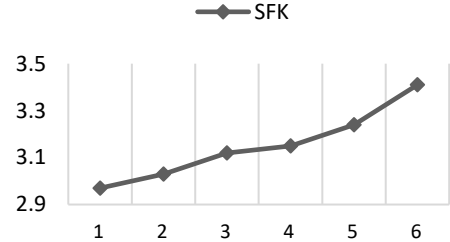
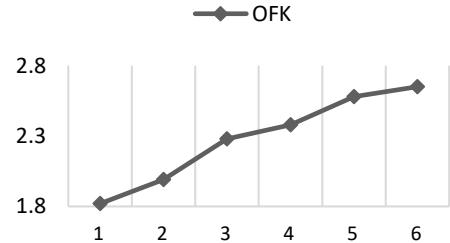
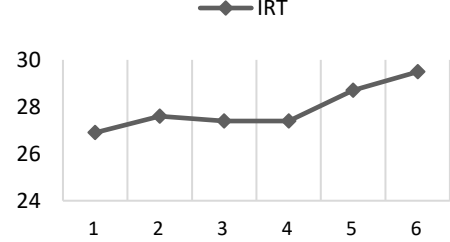
	Gender	Mean	Std. Deviation	Std. Error Mean	t	p	Mean Plots
SFK	Male	3.28	0.919	0.013	17.641	<0.001	
	Female	2.93	0.918	0.016			
OFK	Male	2.43	0.836	0.012	20.091	<0.001	
	Female	2.03	0.977	0.017			
IRT	Male	28.84	4.834	0.069	20.105	<0.001	
	Female	26.72	4.689	0.079			

Table 4. Financial Knowledge and Investment Risk Tolerance Comparisons Across Age Categories (N = 8038).

Age Category	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max	ANOVA		Mean Plots	
				Lower Bound	Upper Bound			F	p		
SFK	1	3.02	0.875	0.012	2.99	3.04	1	5	37.180	<0.001	
	2	3.17	0.983	0.024	3.13	3.22	1	5			
	3	3.25	0.950	0.032	3.19	3.32	1	5			
	4	3.42	1.074	0.049	3.32	3.51	1	5			
	5	3.51	0.993	0.060	3.39	3.63	1	5			
	6	3.62	1.000	0.097	3.43	3.82	1	5			
	7	3.58	1.057	0.190	3.19	3.97	1	5			
OFK	1	2.04	0.998	0.014	2.01	2.0632	0	3	128.151	<0.001	
	2	2.50	0.769	0.019	2.47	2.54	0	3			
	3	2.59	0.704	0.024	2.54	2.63	0	3			
	4	2.67	0.636	0.029	2.61	2.72	0	3			
	5	2.73	0.628	0.038	2.65	2.80	0	3			
	6	2.75	0.566	0.055	2.65	2.86	0	3			
	7	2.89	0.320	0.062	2.76	3.02	2	3			
IRT	1	27.34	4.854	0.068	27.21	27.48	13	47	33.842	<0.001	
	2	28.96	4.692	0.115	28.73	29.18	15	43			
	3	28.85	4.648	0.154	28.55	29.16	14	45			
	4	28.75	5.169	0.235	28.29	29.21	13	47			
	5	27.80	4.840	0.294	27.22	28.38	16	42			
	6	26.94	4.730	0.457	26.04	27.85	17	40			
	7	27.84	5.404	0.971	25.86	29.82	13	36			

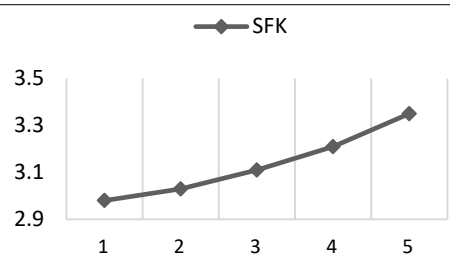
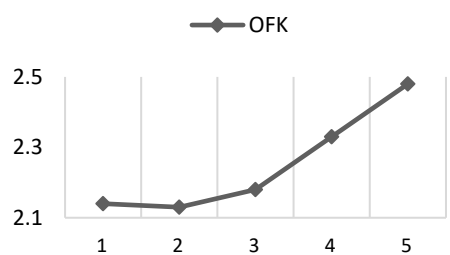
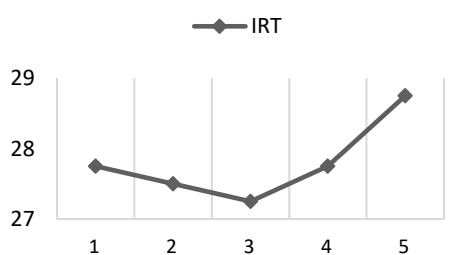
Notes: 1 = Under age 25; 2 = 25 to 34; 3 = 35 to 44; 4 = 45 to 54; 5 = 55 to 64; 6 = 65 to 74; 7 = 75 and over. The effect size of the differences was low for SFK and IRT but medium for differences in OFK (e.g., eta-squared = 0.085). The \cap -shaped relationship between IRT scores and age was significant with those over the age of 65 years exhibiting scores that matched respondents aged 25 years or younger.

Table 5. Financial Knowledge and Investment Risk Tolerance Comparisons Across Education Categories (N = 8038).

Educ. Category		Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max	ANOVA		Mean Plots
					Lower Bound	Upper Bound			F	p	
SFK	1	2.97	0.850	0.018	2.93	3.00	1	5	47.974	<0.001	
	2	3.01	0.875	0.024	2.96	3.06	1	5			
	3	3.04	0.894	0.025	2.99	3.09	1	5			
	4	3.17	0.912	0.036	3.10	3.25	1	5			
	5	3.22	0.997	0.023	3.17	3.26	1	5			
	6	3.41	1.01	0.028	3.36	3.47	1	5			
OFK	1	1.83	1.03	0.023	1.79	1.88	0	3	234.776	<0.001	
	2	2.01	0.982	0.027	1.96	2.06	0	3			
	3	2.26	0.886	0.025	2.21	2.31	0	3			
	4	2.31	0.861	0.035	2.24	2.37	0	3			
	5	2.58	0.733	0.017	2.54	2.61	0	3			
	6	2.72	0.606	0.017	2.68	2.75	0	3			
IRT	1	27.06	4.841	0.105	26.86	27.27	13	47	67.893	<0.001	
	2	27.29	4.887	0.133	27.03	27.56	13	44			
	3	27.20	4.845	0.134	26.94	27.46	13	46			
	4	27.50	4.993	0.199	27.11	27.90	13	42			
	5	28.90	4.633	0.108	28.69	29.11	15	46			
	6	29.49	4.615	0.130	29.23	29.74	13	47			

Notes: 1 = Some high school or less; 2 = High school graduate; 3 = Some college/trade/vocational training; 4 = Associate degree; 5 = Bachelor's degree; 6 = Graduate or professional degree. The effect size differences were low for SFK and IRT but large for differences in OFK (e.g., eta-squared = 0.124). This means that while respondents reported increasing levels of knowledge across education categories, the trend was most pronounced from the lowest to the highest education categories. In other words, differences in objective financial knowledge were quite large across the education categories.

Table 6. Financial Knowledge and Investment Risk Tolerance Comparisons Across Income Categories (N = 8038).

Income Category	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max	ANOVA		Mean Plots	
				Lower Bound	Upper Bound			F	p		
SFK	1	2.96	0.915	0.020	2.92	3.00	1	5	46.703	<0.001	
	2	3.01	0.887	0.023	2.97	3.06	1	5			
	3	3.12	0.924	0.024	3.07	3.17	1	5			
	4	3.19	0.916	0.028	3.13	3.24	1	5			
	5	3.31	0.962	0.020	3.27	3.35	1	5			
OFK	1	2.12	0.966	0.021	2.08	2.16	0	3	57.355	<0.001	
	2	2.10	0.980	0.026	2.05	2.15	0	3			
	3	2.22	0.970	0.026	2.16	2.26	0	3			
	4	2.32	0.903	0.028	2.26	2.37	0	3			
	5	2.48	0.814	0.017	2.45	2.51	0	3			
IRT	1	27.78	5.010	0.109	27.56	27.99	13	47	17.297	<0.001	
	2	27.37	4.740	0.123	27.13	27.61	13	43			
	3	27.64	4.780	0.125	27.40	27.89	13	44			
	4	27.79	4.830	0.150	27.49	28.08	13	47			
	5	28.57	4.832	0.099	28.38	28.77	13	47			

Notes: 1 = Less than \$25,000; 2 = \$25,000 to \$49,999; 3 = \$50,000 to \$74,999; 4 = \$75,000 to \$99,999; 5 = \$100,000 or greater. The effect size differences were low for SFK, OFK, and IRT. This was interpreted to mean that while the relationships were statistically significant, the actual linear associations were modest.

Table 7. Regression Results Showing the Moderation Effect of Subjective and Objective Financial Knowledge through Age, Education, and Income on Investment Risk Tolerance (N = 8038).

	Equation (1)	Equation (2)	Equation (3)	Equation (4)	Equation (5)	Equation (6)
(Constant)	23.256	22.934	23.063	24.130	23.996	24.022
Gender (1 = Female)	−1.583 ***	−1.601 ***	−1.584 ***	−1.570 ***	−1.573 ***	−1.574 ***
Age	−0.145 **	−0.144 **	−0.121 *	−0.160 **	−0.156 **	−0.094
Education	0.343 ***	0.337 ***	0.340 ***	0.338 ***	0.342 ***	0.317 ***
Income	0.088 **	0.082 *	0.090 **	0.083 *	0.090 **	0.084 *
SFK	1.048 ***	1.222 ***	1.024 ***	0.907 ***	0.805 ***	0.900 ***
OFK	0.395 ***	0.307 ***	0.506 ***	0.204	0.406 ***	0.239
Gender × SFK		−0.410 ***				−0.401 ***
Gender × OFK		0.188				0.194
Age × SFK			0.015			−0.048
Age × OFK			−0.076			−0.190 **
Education × SFK				0.038		0.048
Education × OFK				0.074 *		0.126 **
Income × SFK					0.080 *	0.079 *
Income × OFK					−0.003	0.005
Model	F = 197.121 ***	F = 149.759 ***	F = 148.021 ***	F = 148.894 ***	F = 148.548 ***	F = 87.226 ***
R ²	0.128	0.129	0.128	0.128	0.128	0.131

Notes: * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$.

6. Discussion

Seven research questions were posed at the outset of this study as a guide to examining the association between financial knowledge and financial risk tolerance. The first question asked about the degree to which subjective financial knowledge (SFK), objective financial knowledge (OFK), and an investor's financial risk tolerance are associated. It was determined that these three constructs are positively correlated. However, the degree of association among the variables, while statistically significant, was not large enough to suggest that one of the constructs (particularly SFK and OFK) can be used as a proxy for the other constructs.

The second question asked about how stable SFK, OFK, and an investor's financial risk tolerance (measured as investment risk tolerance [IRT]) were over the period 2019 through 2022. No statistically significant differences in SFK or OFK scores were noted, which indicates a high degree of knowledge assessment stability. IRT scores, on the other hand, were found to vary across the periods of analysis, ranging from a low of 27.57 in 2019 to a high of 28.17 in 2021. It is important to note that while a significant difference was observed, the practical implications of score variations were not meaningful. When rounded, the mean IRT score, regardless of period, was unchanged (i.e., a score of 28.00).

The third question asked about the degree to which SFK, OFK, and IRT differed by gender, age, education, and household income. It was determined that self-identified males scored higher in SFK, OFK, and IRT. SFK and OFK scores increased with age, whereas a small inverted U-shaped relationship between age and IRT scores was noted (i.e., IRT scores increased with age until 65 years, at which time scores fell). SFK, OFK, and IRT scores increased in alignment with educational status. Finally, a positive association between SFK and income was noted. A weak U-shaped relationship between income and OFK and income and IRT was observed, although the relationship's strength was not practically meaningful.

The final four research questions were related to moderation effects in the multivariate models. Question four asked about the extent to which the relationship between IRT and gender is moderated by SFK and OFK. An interaction with SFK, but not with OFK, was observed. This was interpreted to mean that the gap in IRT scores between males and females was reduced as SFK increased.

The fifth research question asked to what extent the relationship between age and IRT is moderated by SFK and OFK. The interaction between age and OFK was statistically significant, meaning that older respondents with more OFK exhibited lower IRT scores.

The sixth question asked about the extent to which the association between education and IRT is moderated by SFK and OFK. A moderation effect was noted with OFK but not SFK. This was interpreted to mean that as attained education increased in alignment with OFK so did IRT scores.

The final question asked about the extent to which the relationship between household income and IRT is moderated by SFK and OFK. An interaction effect with SFK was noted; however, the interaction effect with OFK was not significant. This means that IRT scores were elevated for those with more income and higher levels of SFK.

Two important insights emerged from the analyses. First, the relationship between IRT and financial knowledge can be accurately evaluated more with SFK than OFK. The statistical association between IRT and SFK remained positive and statistically significant in the bivariate and multivariate models evaluated in this study. When controlling for all variables in the final regression, OFK was not statistically significant. Second, the moderative effect of financial knowledge appears to vary based on the way financial knowledge is conceptualized and measured. SFK moderates the association between gender and IRT and income and IRT, whereas OFK moderates the association between age and IRT and education and IRT.

7. Conclusions

The purpose of this study was to determine to what extent measures of financial knowledge moderate the relationship between an investor's financial risk tolerance and demographic

factors thought to be important descriptors of an investor's willingness to take a financial risk. This study was guided by the [Irwin and Millstein \(1986\)](#) biopsychosocial model of risk-taking behavior. In their model, Irwin and Millstein noted that predisposing biopsychosocial and environmental factors, as well as precipitating factors, can be combined to describe a person's tendency to engage in risky behaviors. Specifically, Irwin and Millstein maintained that decision-maker characteristics, like age and gender, represent predisposing biopsychosocial factors and that education and income denote predisposing environmental factors. An important precipitating factor in their model is a person's level of knowledge. As conceptualized in this study, it was thought that financial knowledge, as a precipitating factor, would moderate the relationship between gender, age, education, and income and IRT. This assumption was based on a model presented by [Delavande et al. \(2008\)](#) who argued that financial knowledge can be viewed as a form of human capital that helps financial decision-makers obtain better household financial outcomes by fundamentally altering the associations between decision-maker characteristics and choice behaviors. The results from this study provide evidence that the propositions presented by Delavande et al. and Irwin and Millstein align with observations from a large and diverse sample.

Those who identified as male in the survey, and those with more attained education and income, exhibited higher IRT scores. SFK was also found to be positively associated with IRT. The relationship between gender and IRT was moderated by SFK, whereas the relationship between IRT and age (which was not significant by itself) was moderated by OFK. The positive relationship between education and IRT was moderated by OFK, whereas the association between IRT and household income was moderated by SFK. These findings add support to reports in the literature that SFK and OFK, while positively related, are not measuring the same underlying construct. Some have argued that SFK is a proxy for financial confidence ([Amonhaemanon 2022](#)). This might explain the moderation effects between SFK and gender and SFK and income. Confidence, rather than factual knowledge, may be altering the relationship between gender and IRT and income and IRT. If OFK represents factual comprehension rather than conviction, it is this understanding that alters the effect of age and education on IRT. This makes intuitive sense. Those with higher levels of attained education and those who are older, by way of experience, are more likely to be acquainted with personal finance, investing, and household financial management concepts and tasks.

This insight has research and practice management implications. When constructing a survey, or when assessing the risk tolerance of someone who is going to be participating in the securities markets, it is important to concurrently assess IRT, SFK, and OFK. While the relationships among these variables should be positive, the moderation effects will likely be different. An investor who exhibits high SFK and OFK scores can be viewed as confident and aware, which should enhance their willingness to take a financial risk. The opposite is also true. If IRT predictions resulting from a study seem odd or if a financial decision-maker displays behavior that conflicts with their IRT assessment, this may be the result of misaligned SFK (i.e., confidence) and OFK (i.e., comprehension) scores. When this occurs, it behooves the researcher or practitioner to explore the misalignment in scores through additional assessments.

As noted at the outset of this paper, the assessment of financial knowledge plays a significant role in many household economic models. The results from this study add to the existing body of literature on financial knowledge by showing that SFK and OFK differ in what is being measured. Results also suggest that SFK and OFK can moderate the relationships between gender, age, education, and income and IRT in diverse ways. While the findings from this study are noteworthy, it is important to evaluate the results in relation to certain study limitations. For example, while the sample was large and diverse in terms of age, income, and educational attainment, the sample was not nationally representative. It is possible that had a nationally representative sample been used the results might have changed. Additionally, the way data were collected means that only those with internet access and knowledge about the assessment platform were present in the data. This means that some potential study participants may have been unintentionally

excluded from the study. Even in the face of these limitations, the findings reported here do add to the financial knowledge and risk tolerance literature by showing that these two constructs are associated in a meaningful way.

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