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Overconfidence and risky investment choices

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Abstract

Overconfident investors tend to overestimate their chances of relative success in competitive financial markets and undervalue risk; they are more likely to pursue risky rewards from financial markets. We intend to examine the effects of overconfidence on risk-taking behaviors among the active U.S. investors. We analyze a nationally representative survey among active investors in the U.S.: the National Financial Capability Survey (NFCS). We control for survey weights and endogeneity between dependent and independent variables. Control variables include investment depth, income, trading frequency, risk tolerance, and demographic information. We find that U.S. investors overconfident in their investment knowledge are more likely to purchase securities on margin, and invest in microcap stocks, derivatives and cryptocurrencies. We improve the previous literature by examining active investors in the U.S., studying investment choices riskier than stock market participation, using a continuous measure of overconfidence based on subjective and objective investment knowledge, and correcting for endogeneity. Taking more than optimal level of risk may reduce the welfare of investors. Investors and policy makers can collaborate to control overconfidence through financial education and counseling, which will improve the objective investment literacy and reduce the subjective literacy level, respectively.

1. Introduction

Many people are overly confident about their own abilities (Weinstein 1980; Taylor and Brown 1988). Overconfident investors tend to overestimate their chances of relative success in competitive financial markets where individual knowledge and skills in finance can improve investment returns, and are likely to pursue risky rewards from financial markets.

Studies about the effects of overconfidence on risk-taking behaviors in the U.S. have not been numerous other than stock market participation. This study contributes to the literature by examining riskier investment behaviors such as margin trading and cryptocurrencies and utilizing a direct measure of overconfidence instead of using a proxy such as I.Q. (Grinblatt, Keloharju and Linnainmaa 2011) and financial literacy (Van Rooij, Lusardi and Alessie 2011; Arrondel, Debbich and Savignac 2015; Thomas and Spataro 2018). We measure investor overconfidence as the subjective financial literacy not explained by an objective financial literacy measure. We also improve research methods by employing the weighted and two-stage least squares regressions to control for the dual sampling techniques applied in the survey and endogeneity.

We analyze the active investors from the 2018 National Financial Capability Survey (NFCS) with respect to risky investment choices. We find overconfident investors are more likely to engage in risky investments like microcap stocks, derivatives, cryptocurrencies and margin trading.

Next section reviews the previous literature and builds the research hypothesis. Our sample and variables are explained in section 3. Empirical results are reported in section 4, and section 5 will conclude our study.

2. Overconfident investors and risky investment

Participation in the stock market is considered a risky investment due to higher volatility than others like the bond markets, and the literature has examined the effects of financial literacy on stock market participation. Van Rooij, Lusardi and Alessie (2011) found from the *De Nederlandsche Bank (DNB) Household Survey* that the investors with low financial literacy are much less likely to invest in stocks. From a French household survey, stock market participation is also found positively related to basic financial literacy (Arrondel, Debbich and Savignac 2015). In addition, Thomas and Spataro (2018) found that financial literacy along with the level of human capital and social interaction has a positive effect on stock market participation among nine European countries.

Overconfidence, originated from self-deception, implies individual's over-optimism on own ability or belief on well-calibrated accuracy. Many people are overly confident about their own abilities (Weinstein 1980; Taylor and Brown 1988). Overconfidence is a personal trait that does not easily change over time, and persistently affects investors' risk-taking attitudes and behaviors in competitive financial markets (Morales-Camargo *et al.* 2015).

Investors' overconfidence is influential in making financial decisions. Camerer and Lovallo (1999) showed in experiments that people overconfident about own skills tend to overestimate their chances of relative success and are more likely to enter competitive markets and games when payoffs are based on own abilities. Investment in risky assets depends on

investors' skills and investment behaviors fit well with Camerer and Lovallo's (1999) framework of analysis. Overconfident investors believe they can pick investment choices that have higher expected return than other people do (DeBondt and Thaler 1995; Odean 1999; Daniel, Hirshleifer and Subrahmanyam 2001). Overconfidence is greater for challenging judgment tasks, and individuals tend to be more overconfident when feedback on their information or decisions is deferred or inconclusive (Hirshleifer 2001).

Several studies examined the effects of overconfidence on stock market participation. Grinblatt, Keloharju and Linnainmaa (2011) showed individual's IQ (as a proxy for overconfidence) is related to stock market participation, controlling for wealth, income, age, and other demographic and occupational information. Xia, Wang and Li (2014) reported that overconfidence (measured by the difference between subject and object financial literacy measures) and stock market participation are positively related among Chinese consumers. Zhao and Zhang (2021) reported subjective investment knowledge level is positively related to the cryptocurrency investment.

Within the risk-return payoff framework, overconfident investors overestimate their chances of relative success and undervalue the risk of loss in competitive financial markets where investment returns are based on individual knowledge and skills in finance. At a fixed level of risk tolerance, overconfident investors are more likely to pursue risky rewards from financial markets. While Liao *et al.* (2017) reported that Chinese consumers with higher levels of objective financial literacy are more likely to hold at least one risky financial asset (i.e., stock, mutual fund, trust, foreign currency or other risky assets), studies on specific risky behaviors such as margin trading and investments in derivatives and cryptocurrency are rare especially among U.S. investors.

We examine highly risky investment choices: microcap stocks, commodity and futures, options, margin trading and cryptocurrency. Microcap stocks pose substantial risk due to liquidity and information asymmetry concerns. Derivative products carry much higher volatility than their underlying assets. Margin can magnify the investment losses while it can also increase returns.[1] In addition, there is the risk of margin call, which requires deposit of additional cash or securities. Inability to meet a margin call results in automatic sales of the securities. Cryptocurrency is also a highly risky investment. Baur, Hong and Lee (2018) reported that Bitcoin daily returns between July 2010 and 2015 exhibited the highest average and standard deviation among seventeen assets, including equity indices, bond indices, major foreign currencies and commodities. Bitcoin returns also had extremely high kurtosis, indicating a higher chance of tail events.

Investors' overconfidence in investment knowledge will lead to higher profit prediction and undervaluation of the risk when investment returns are based on their knowledge and skills (Camerer and Lovallo 1999; DeBondt and Thaler 1995; Odean 1998; Daniel, Hirshleifer and Subrahmanyam 2001). When other factors like risk tolerance and wealth level are equal, overconfident investors will be more likely to pursue risky rewards from financial markets. We predict that overconfidence in investment knowledge will be related to risky investment behaviors like margin trading and investments in microcap stocks, derivatives and cryptocurrencies.

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[1] Margin trading allows the investor to leverage the value of securities and increase the size of investment. Federal Reserve Board Regulation T allows investors to use margin to borrow up to 50% of the value of a securities purchase. The rate of return from a purchase on the full margin will be twice the return of the security minus margin interest, and the standard deviation of margin account will be twice that of a straight account.

H₁: Individuals' overconfidence in their financial knowledge is positively related to the propensity to choose risky investments like microcap stocks, derivatives, cryptocurrencies and margin trading, cet. par.

3. Research methods

To analyze the investment behaviors in risky assets, we use the National Financial Capability Survey (NFCS) database. First commissioned in 2009 by the FINRA Investor Education Foundation, the research objectives of the NFCS were to benchmark key indicators of financial capability and evaluate how these indicators vary with underlying demographic, behavioral, attitudinal and financial literacy characteristics. Each State-by-State Survey includes online surveys of more than 25,000 American adults, and observations are weighted to represent the Census distribution of the national population in terms of age, gender, ethnicity, education and nine Census Divisions. Follow-up Investor Survey was conducted to explore in-depth investment decisions. Our main database is the Investor Survey, which surveys people who have investments outside of their retirement accounts.

3.1. Overconfidence measure

Overconfidence has been measured as an individual's tendency to estimate own knowledge better than average (Busenitz and Barney 1997; Nikiforow 2010; Lambert, Bassiere and N'Goala 2012; Mihaylov, Yawson and Zurbruegg 2015). For example, Dorn and Huberman (2005) interpreted the investors who perceive themselves as more knowledgeable about financial securities than the average investor as overconfident (i.e., relative knowledge) because they assumed that those are unlikely to be better informed than the professional investors are. Graham, Harvey and Huang (2009) used the UBS/Gallop investor survey and measured overconfidence by an investor's forecast of his own portfolio return over the next 12 months minus his forecast of the stock market return over the next 12 months (mean difference was 2.30%).

Actual and perceived financial knowledge could have different effects on financial behavior (Allgood and Walstad 2016; Bannier and Neubert 2016; Bannier and Schwarz 2018) and the discrepancy between those measures seems to be an attractive proxy for overconfidence (Dorn and Huberman 2005). An overconfidence measure that compares objective and subjective financial knowledge will be a good predictor of financial behaviors. Xia, Wang and Li (2014) used the 2012 Chinese Survey of Consumer Finance and defined overconfidence using above-average subjective measure (3-15 with a mean of 9.467) combined with below-average objective measure (0-6 with a mean of 3.093). Porto and Xiao (2016) used FINRA's 2012 National Financial Capability Study and similarly classified an investor as overconfident when his/her subjective measure of financial knowledge (1-7) is above average (5.17) and objective measure (0-5) is below its mean (2.99). Their classification yielded 11.6% of 2012 NFCS observations as overconfident.

NFCS has questions related to subjective and objective *investment* knowledge. Respondents were asked about self-assessed overall knowledge about investing, and this *SubInvLit* (1~7) variable takes value of the answer, one being very low and seven being very high. In addition, NFCS has ten questions to test one's investment knowledge: 1) stock ownership, 2) bond ownership, 3) bankruptcy risk, 4) risk versus return, 5) past versus future performance, 6) return levels of different asset classes, 7) index fund versus actively managed

funds, 8) tax exemption of municipal bonds, 9) margin trading returns, and 10) short selling. We take the number of correct answers to the above ten questions as objective investment literacy (*ObjInvLit*), which ranges from zero to ten.[2] As an overconfidence measure, we take the residuals from regressing *SubInvLit* on *ObjInvLit,* following Shin, Kim and Seay (2020).[3] The residual captures variations in subjective investment literacy not explained by objective investment literacy and is a better measure than an indicator variable since a person's overconfidence is a matter of degree rather than a dichotomous trait.[4]

3.2. Risky investment choices

We use five risky investment types from the NFCS. *Commodity* takes the value of one if respondent currently owns commodities or futures in non-retirement accounts and zero otherwise. *Option* and *Microcap* takes the value of one if respondent currently owns options, or microcap stocks or penny stocks, respectively, in non-retirement accounts and zero otherwise. *Crypto* takes the value of one if respondent has invested in cryptocurrencies either directly or through a fund that invests in cryptocurrencies, and zero otherwise. *Margin* takes the value of one if respondent has purchased securities on margin and zero otherwise. *RiskyChoices* is the summation of *Commodity*, *Option*, *Microcap*, *Crypto* and *Margin* variables, and takes the value of zero to five.

3.3 Other variables

Investment experience refers to individual's previous experience in investing in different financial products and assets (Nicolini, Cude and Chatterjee 2013). It affects investment decisions, especially new financial product adoption (Malmendier, Pouzo and Vanasco 2020), including cryptocurrencies (Xi, O'Brien and Irannezhad 2020; Zhao and Zhang 2021). Munnukka, Uusitalo and Koivisto (2017) reported that objective financial knowledge and width of investment portfolio (as a proxy for investment experience) affected investment intentions. To complement the previous studies, we analyze two aspects of investment experience: width and depth. Depth of investment experience (*InvDepth*) is proxied by the total value of all investments in non-retirement accounts. As the NFCS provides only categorical values, *InvDepth* takes the value of one if total value is less than $2000, two if $2000-5000, three if $5000-10000, four if $10000-25000, five if $25000-50000, six if $50000-100000, seven if $100000-250000, eight if $250000-500000, nine if $500000-1 million and ten if $1 million or more.

To control for investment characteristics, we use the following variables from the NFCS: *HalfStocks* takes the value of one if more than half of the respondent's non-retirement portfolio is invested in stocks or mutual funds that contain stocks, and zero otherwise. *TradingFreq* takes the value of one if respondent has bought or sold investments in non-retirement accounts 1 to 3 times in the past 12 months, two if 4 to 10 times, three if 11 times or more, and zero otherwise. *RiskTolerance* denotes the answer to the following question in a 10-point scale: When thinking of your financial investments, how willing are you to take risks? (1 not at all willing – 10 very

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[2] Zhao and Zhang (2021) investigated the effects of subjective and objective financial knowledge on the propensity of crypto investment from the 2018 NFCS but did not examine the data from the perspective of investor overconfidence.

[3] R^2 of the regression is .0676.

[4] To compare with previous literature, we also classified a survey respondent as overconfident (*OC*=1) if his/her objective measure is below the mean, but the subjective measure is above its mean, and *OC* equals zero otherwise. The results using this measure of overconfidence are qualitatively the same.

willing). *CryptoRisky* is a measure of self-assessed riskiness of cryptocurrencies as an investment (1: not at all risky, 2: slightly risky, 3: moderately risky, 4: very risky and 5: extremely risky).

Respondents' other financial characteristics are also collected from the NFCS. *HomeOwn* takes the value of one if the respondent household currently own a home, or zero otherwise. *CreditRecord* denotes the self-reported credit record (1 very bad, 2 bad, 3 average, 4 good, 5 very good). *FinEduReq* takes the value of one if respondent was ever required to take financial education, or zero otherwise. *FinEduHours* takes the value of one if respondent received total financial education for 1 – 2 hours, two if 3 – 10 hours, and three if more than 10 hours.

To control for respondents' demographic information, we use the following NFCS variables. *Male* denotes respondent's gender as male, while *White* denotes the race of non-Hispanic White. *Married* takes the value of one if respondent is married, and zero otherwise. Age is also available as categorical variable, and six indicator variables are created: *Age1* (18~24), *Age2* (25~34), *Age3* (35~44), *Age4* (45~54), *Age5* (55~64) and *Age6* (65 or higher; reference age in regressions). Level of education is categorized into six indicators: *Educ1* (below high school; reference education in regressions), *Educ2* (high school diploma or GED), *Educ3* (some college), *Educ4* (associate degree), *Educ5* (bachelor's degree) and *Educ6* (post graduate degree).

Household's annal income, including wages, tips, investment income, public assistance and retirement plan income, is categorized in eight groups by NFCS, and we create the same number of corresponding indicator variables: *Income1* (less than $15,000; reference income in regressions), *Income2* ($15,000~$25,000), *Income3* ($25,000~$35,000), *Income4* ($35,000~$50,000), *Income5* ($50,000~$75,000), *Income6* ($75,000~$100,000), *Income7* ($100,000~$150,000) and *Income8* ($150,000 or more). Employment status is categorized into eight groups: *Employ1* (self-employed), *Employ2* (full-time for employer), *Employ3* (part-time for employer), *Employ4* (Homemaker), *Employ5* (full-time student), *Employ6* (permanently sick, disabled, or unable to work), *Employ7* (unemployed or temporarily laid off; reference status in regressions) and *Employ8* (Retired).

4. Results

Descriptive statistics are reported in Table I. More than 10 percent of active investors traded on margin (12.27%) or invested in cryptocurrencies (10.3%). Subjective investment literacy measure (*SubInvLit*) has a mean of 4.83 and the average correct answers out of ten questions as a measure of objective investment literacy (*ObjInvLit*) is slightly less than half of ten questions (4.93). *Overconfidence* measures are distributed around zero by construction and range from -4.13 to 2.88. Median total value of all investments in non-retirement accounts lies in the range of $100,000-$250,000. Fifty two percent of the investors invested more than half of their portfolio in equities.

Table I. Descriptive Statistics: 2018 NFCS

Variable	N	Mean	Std Dev	Min	Med	Max
Commodity	2003	0.0849	0.2787	0	0	1
Option	2003	0.0868	0.2816	0	0	1
Microcap	2003	0.1079	0.3102	0	0	1
Margin	2003	0.1227	0.3281	0	0	1
Crypto	2003	0.0859	0.2802	0	0	1
RiskyChoices	2003	0.4882	1.0377	0	0	5
SubInvLit	1989	4.8313	1.3461	1	5	7
ObjInvLit	2003	4.9292	2.4112	0	5	10
Overconfidence	1989	0	1.3009	-4.1276	0.1605	2.8806
InvDepth	1895	6.2812	2.4729	1	7	10
HalfStocks	2003	0.5211	0.4996	0	1	1
TradeFreq	1873	1.1681	1.0658	0	1	3
RiskTolerance	1991	6.1314	2.2768	1	6	10
CryptoRisky	1530	4.2139	0.9269	1	4	5
HomeOwn	2003	0.8385	0.3680	0	1	1
CreditRecord	1986	4.5616	0.8742	1	5	5
FinEduReq	2003	0.1634	0.3697	0	0	1
FinEduHours	2003	0.5943	1.1326	0	0	3
Male	2003	0.6020	0.4895	0	1	1
White	2003	0.7486	0.4338	0	1	1
Married	2003	0.6261	0.4838	0	1	1
#Dependents	2003	0.4752	0.9215	0	0	4
InstVar	1983	6.9312	2.0424	1	7	10
Weight	2003	1.3426	0.6882	0.3004	1.2669	4.5614

Correlations among the variables are reported in Table II. Risky investment choices are highly correlated pairwise ($\rho > .47$), and each of them is positively correlated with *Overconfidence*. Zhao and Zhang (2021) also showed that investors who invested more than half of non-retirement portfolio in equity, and those who owned commodities, futures or options are more likely to invest in cryptocurrencies.

We test whether investors with high overconfidence level are more likely to make risky investment choices, and the results are presented in Table III. 10.65 percent of overconfident investors invested in commodity and futures, while 4.23 percent of the others did. The difference of 6.42% is statistically significant. We see similar patterns for *Option*, *Microcap*, *Margin* and *Crypto* variables. Especially, 15.83 percent among overconfident investors traded on margin compared to only 4.01 percent among the others.[5]

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[5] When we divide the sample with 10%, 30% and 40% top and bottom observations, the results are qualitatively the same and stronger across most asset classes.

Table II. Pearson Correlation Coefficients: 2018 NFCS

	Opt	Micr	Mar	Cryp	RC	O.C.	Sub	Obj	I.D.	H.S.	T.F.	R.T.	C.R.	H.O.	C.R.	FEd	Hrs	M	Wh	Mar	#Dep
Commod	0.42	0.37	0.32	0.38	0.69	0.19	0.15	-0.14	0.02	0.04	0.18	0.18	-0.26	-0.03	-0.16	0.12	0.06	0.09	-0.13	-0.03	0.15
Option	1.00	0.35	0.35	0.38	0.71	0.22	0.21	-0.02	0.04	0.09	0.24	0.14	-0.18	-0.08	-0.10	0.16	0.11	0.07	-0.13	0.00	0.10
Micro	0.35	1.00	0.31	0.37	0.68	0.13	0.10	-0.12	-0.09	0.07	0.17	0.11	-0.23	-0.13	-0.20	0.10	-0.02	0.06	-0.13	-0.06	0.07
Margin	0.35	0.31	1.00	0.44	0.70	0.30	0.21	-0.32	-0.03	0.02	0.22	0.22	-0.32	-0.04	-0.15	0.24	0.04	0.01	-0.21	0.02	0.16
Crypto	0.38	0.37	0.44	1.00	0.73	0.25	0.20	-0.17	-0.12	0.07	0.18	0.19	-0.34	-0.09	-0.22	0.23	0.08	0.06	-0.15	-0.01	0.19
RiskyCh	0.71	0.68	0.70	0.73	1.00	0.31	0.27	-0.12	-0.04	0.13	0.31	0.24	-0.35	-0.10	-0.22	0.23	0.09	0.12	-0.20	-0.03	0.19
OverCon	0.22	0.13	0.30	0.25	0.31	1.00	0.97	0.00	0.09	0.10	0.25	0.29	-0.12	0.01	-0.06	0.13	0.12	0.15	-0.11	0.01	0.12
SubIL	0.21	0.10	0.21	0.20	0.27	0.97	1.00	0.26	0.14	0.16	0.32	0.30	-0.03	0.03	-0.01	0.12	0.14	0.21	-0.09	0.01	0.09
ObjIL	-0.02	-0.12	-0.32	-0.17	-0.12	0.00	0.26	1.00	0.21	0.26	0.30	0.08	0.31	0.10	0.17	-0.01	0.12	0.22	0.08	0.01	-0.09
InvDepth	0.04	-0.09	-0.03	-0.12	-0.04	0.09	0.14	0.21	1.00	0.06	0.15	0.00	0.16	0.28	0.33	-0.08	-0.01	0.02	0.12	0.17	-0.07
HalfStock	0.09	0.07	0.02	0.07	0.13	0.10	0.16	0.26	0.06	1.00	0.29	0.16	0.07	-0.03	0.02	0.03	0.08	0.14	0.01	0.00	0.03
TradeFrq	0.24	0.17	0.22	0.18	0.31	0.25	0.32	0.30	0.15	0.29	1.00	0.26	-0.03	-0.06	0.00	0.08	0.10	0.19	-0.13	-0.02	0.12
RiskTolr	0.14	0.11	0.22	0.19	0.24	0.29	0.30	0.08	0.00	0.16	0.26	1.00	-0.08	-0.04	-0.08	0.17	0.14	0.22	-0.14	0.00	0.16
CryptRisky	-0.18	-0.23	-0.32	-0.34	-0.35	-0.12	-0.03	0.31	0.16	0.07	-0.03	-0.08	1.00	0.13	0.19	-0.10	0.01	0.04	0.12	0.06	-0.15
HomeOwn	-0.08	-0.13	-0.04	-0.09	-0.10	0.01	0.03	0.10	0.28	-0.03	-0.06	-0.04	0.13	1.00	0.34	0.00	-0.02	-0.08	0.15	0.32	0.02
CrdRecord	-0.10	-0.20	-0.15	-0.22	-0.22	-0.06	-0.01	0.17	0.33	0.02	0.00	-0.08	0.19	0.34	1.00	-0.15	-0.04	-0.02	0.20	0.18	-0.23
FinEduRq	0.16	0.10	0.24	0.23	0.23	0.13	0.12	-0.01	-0.08	0.03	0.08	0.17	-0.10	0.00	-0.15	1.00	0.55	0.07	-0.06	-0.05	0.15
FinEduHs	0.11	-0.02	0.04	0.08	0.09	0.12	0.14	0.12	-0.01	0.08	0.10	0.14	0.01	-0.02	-0.04	0.55	1.00	0.10	-0.06	0.00	0.09
Male	0.07	0.06	0.01	0.06	0.12	0.15	0.21	0.22	0.02	0.14	0.19	0.22	0.04	-0.08	-0.02	0.07	0.10	1.00	0.01	-0.03	0.02
White	-0.13	-0.13	-0.21	-0.15	-0.20	-0.11	-0.09	0.08	0.12	0.01	-0.13	-0.14	0.12	0.15	0.20	-0.06	-0.06	0.01	1.00	0.10	-0.22
Married	0.00	-0.06	0.02	-0.01	-0.03	0.01	0.01	0.01	0.17	0.00	-0.02	0.00	0.06	0.32	0.18	-0.05	0.00	-0.03	0.10	1.00	0.15
#Dep	0.10	0.07	0.16	0.19	0.19	0.12	0.09	-0.09	-0.07	0.03	0.12	0.16	-0.15	0.02	-0.23	0.15	0.09	0.02	-0.22	0.15	1.00
IV	0.14	0.12	0.14	0.16	0.21	0.71	0.75	0.24	0.11	0.17	0.29	0.30	-0.03	0.01	0.01	0.11	0.13	0.20	-0.06	0.02	0.03

Table III. Tests of Mean Difference on Investments in Risky Asset: 2018 NFCS

This table reports the results from the tests of mean differences in *Commodity*, *Option*, *Microcap*, *Margin*, *Crypto*, and *RiskyChoices* variables between low and high overconfidence subgroups, using the data from the 2018 National Financial Capability Survey. OC is classified as high (low) if the actual value of subjective investment literacy is greater (smaller) than its predicted value. *RiskyChoices* denotes the number of risky investment choices, and other variables take the value of one if the respondent has such an asset, and zero otherwise. Equality of variances rejected for all variables. *, ** and *** represent the statistical significance at 10%, 5% and 1% levels, respectively.

Risky Asset	OC	Nobs	Mean	Difference	t stat	*p*-value
Commodity	Low	923	4.23%	6.42%***	5.59	<.0001
	High	1080	10.65%			
Option	Low	923	4.88%	5.40%***	4.64	<.0001
	High	1080	10.28%			
Microcap	Low	923	6.83%	5.86%***	4.47	<.0001
	High	1080	12.69%			
Margin	Low	923	4.01%	11.82%***	9.20	<.0001
	High	1080	15.83%			
Crypto	Low	923	3.90%	7.30%***	6.34	<.0001
	High	1080	11.20%			
RiskyChoices	Low	923	0.2384	.3681***	9.01	<.0001
	High	1080	0.6065			

The next natural step is to examine if overconfident investors are more likely to choose these risky investment choices after controlling for other variables using Logit regressions.[6] We suspect reverse causality exists because individuals who chose risky investments may exhibit high level of subjective investment literacy (*SubInvLit*) relative to objective measure (*ObjInvLit*); hence higher *Overconfidence* measure. However, the standard method of using instrumental variables (IV) to solve endogeneity cannot be applied when the dependent variable is a binary variable because of the non-linearity between regressor and the error term.

Instead, we analyze *RiskyChoices*, ranging from 0 to 5, by applying a two-stage least squares regression with instrumental variable. Age, sex, education and income have been found related to overconfidence in the literature and are potential instrument variables (IVs) for the overconfidence (Deaux and Farris 1977; Prince 1993; Lundeberg, Fox and Punccohar 1994; Barber and Odean 2001; Dorn and Huberman 2005; Bhandari and Deaves 2006; Mittal and Vyas 2009; Graham, Harvey and Huang 2009). The above-mentioned IV candidates, however, are already the control variables in our regressions and cannot be used as IVs. Instead, we select the following instrumental variable: *IV*: How comfortable are you when it comes to making investment decisions? (1: not at all comfortable ~ 10: extremely comfortable; Code=G1).

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[6] In the simple logit regressions, overconfidence is positively related to the likelihood of making the risky investment choices although the estimators may be biased and/or inconsistent because of endogeneity.

The validity of the IV is tested. The first stage F-statistic is above the critical value, suggesting the instrument has significant explanatory power for the *Overconfidence*. Using this IV, we perform the Hausman tests for potential endogeneity in *Overconfidence*. The *p*-value for the residuals from the first stage regression is less than 1%, which indicates *Overconfidence* is correlated with the error term in the structural form. This implies *Overconfidence* was endogenous and the ordinary regression results will be biased.

Table IV reports the results of the second stage regression using the predicted values of *Overconfidence,* which is significantly positively related to the number of risky investment choices. Its impact is economically significant too as one unit increase in *Overconfidence* measure leads to .17 more risky investment choice. We do not reject H_1 and conclude that investor overconfidence in their investment knowledge is related to risky investment choices.

Investors' depth of investment experience, investment more than half in stocks, trading frequency are related to risky investments, but self-assessed riskiness of cryptocurrencies is negatively related, similar to Zhao and Zhang's study (2021). Self-reported credit record is also negatively related to the risky investment choices, but previous studies did not examine this variable. Age and income are negatively related to such risky investment choices, while married people tend to choose more risky investments These demographic variables show different results from Zhao and Zhang (2021) because they performed a logistic regression of intention to invest in cryptocurrencies but we examined the number of risky asset choices including cryptocurrencies while trying to avoid the endogeneity problem with instrumental variables.

5. Conclusions and Discussions

Overconfident investors tend to overestimate their chances of relative success where investment returns are based on individual knowledge and skills in finance; hence, they undervalue risk and pursue risky rewards from financial markets. Our analysis of the respondents who invested outside retirement accounts from the 2018 National Financial Capability Survey (NFCS) shows that the U.S. investors overly confident about their investment knowledge are more likely to pursue highly risky investment behaviors: purchasing securities on margin and investing in microcap stocks, derivative products and cryptocurrencies.

Our results add value to the previous literature about stock market participation. Grinblatt, *et al*. (2011) used individual's IQ as a proxy for overconfidence, which is different from our direct measure using the objective investment knowledge score and subjective perception of investment knowledge. While Xia, Wang and Li (2014) used the sample based on the general consumers in China, our samples come from the recent comprehensive survey conducted by the FINRA, and effectively represent the active U.S. investors. We also control for endogeneity problems between asset choice and overconfidence, using proper instrument.

Taking more than optimal level of risk may reduce the welfare of investors. Investors and policy makers can collaborate to control overconfidence through financial education and counseling. Financial education will improve the objective investment literacy while counseling reduces the subjective literacy level compared to investors' actual investment knowledge.

Overconfidence levels and dynamics, however, may be different across countries, and our results should be generalized among global investors with caution since Nicolini, Cude and Chatterjee (2013) showed that objective financial literacy levels are significantly different among Canada, Italy, the U.K. and the U.S.

Table IV. Number of Risky Assets: 2018 NFCS

RiskyChoices denotes the number of risky investment choices. SE means standard error. *, ** and ***
represent the statistical significance at 10%, 5% and 1% levels, respectively.

Variable	1st stage regression Dep=*Overconfidence* Estimate	SE		2nd stage regression Dep= *RiskyChoices* Estimate	SE
Intercept	-2.5922 ***	.4592		1.4788 ***	.4873
Overconfidence			*Overconfidence^*	.1690 ***	.0339
InvDepth	.0474 ***	.0111		.0462 ***	.0121
HalfStocks	-.0374	.0491		.1228 **	.0526
TradeFreq	.0065	.0237		.1956 ***	.0255
RiskTolerance	.0255 **	.0114		.0069	.0124
CryptoRisky	-.0818 ***	.0263		-.2341 ***	.0285
HomeOwn	.1658 **	.0729		.0900	.0784
Credit Record	-.0559 *	.0312		-.1940 ***	.0335
FinEduReq	.0399	.0754		.2708 ***	.0810
FinEduHours	-.0016	.0240		-.0285	.0257
Male	.0387	.0509		.0884	.0548
White	-.1603 ***	.0550		-.0954	.0595
Married	-.0389	.0555		.1971 ***	.0595
#Dependents	.0982 ***	.0300		.0127	.0322
Age1	.0636	.1439		1.0636 ***	.1543
Age2	.1383	.1095		.7748 ***	.1175
Age3	.0860	.1028		.3202 ***	.1101
Age4	.0080	.0924		.1313	.0991
Age5	.0181	.0698		.0418	.0749
Income2	-.2660	.2011		-.4142 *	.2159
Income3	-.1003	.2012		-.4954 **	.2160
Income4	-.2099	.1954		-.6782 **	.2097
Income5	-.3409 *	.1928		-.5242 **	.2071
Income6	-.3307 *	.1969		-.5416 **	.2115
Income7	-.3761 *	.1968		-.6212 ***	.2117
Income8	-.3356	.2057		-.7118 ***	.2211
Educ2	.5433	.3582		.3092	.3856
Educ4	.5096	.3577		.0273	.3848
Educ5	.6089 *	.3610		-.0218	.3888
Educ6	.4823	.3563		.0281	.3833
Educ7	.4020	.3574		-.0016	.3843
Employ1	-.3507 *	.1891		.4663 **	.2039
Employ2	-.3899 **	.1798		.4281 **	.1940
Employ3	-.5601 ***	.1953		.3849 *	.2119
Employ4	-.3636	.2275		.0087	.2449
Employ5	-.1910	.2519		-.0154	.2707
Employ6	-.9876 ***	.3092		.1267	.3347
Employ8	-.4419 **	.1835		.3609 *	.1984
IV	.4152 ***	.0131			
Nobs	1,379			1,378	
F value	4.01			21.97	
p-value	<.0001			<.0001	
R²	.5315			.3839	
Adj. R²	.5182			.3664	

The relationship between overconfidence and risk-taking behavior may also be affected by the financial market conditions. Our sample year of 2018 coincides with the bull market in the U.S. and investors may have been more confident about the economy and invested more in risky assets. Since market conditions and experience may affect investors' psychology, they may behave differently during the bear markets. Assuming the financial literacy questions remain or are reinforced in the NFCS, a future study to examine differential risk-taking behaviors between bull and bear markets will be interesting.

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