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Rationality, irrationality, and "predictable irrationality": Does education, curriculum, or gender matter?

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Abstract

The behavioral finance literature suggests that ingrained biases block rational analysis by individual investors. In this study, we test for differences in a key investment bias across cohorts defined by college education, courses of study, and gender. We find that "predictable irrationality" because of a behavioral bias is a frequent and statistically significant response that is invariant with respect to college education or courses of study. Irrationality not linked to a behavioral bias varies with college education, courses of study, and gender. Men make more rational choices than women overall, but a college education eliminates the significance of the difference. © 2013 Academy of Financial Services. All rights reserved.

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1. Introduction

The financial service industry faces a challenge driven by an emphasis on individual responsibility for financial decisions on one hand, and a prevailing lack of both investment literacy and rationality of clients on the other hand. Research emphasizes the importance of education and financial literacy to the functioning of financial markets (Braunstein and Welch, 2002) but survey data reveal that most individuals do not have the basic knowledge

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and information to make good financial decisions (Chen and Volpe, 1998; Volpe, Chen and Liu, 2006). A number of studies address the roles that education and information play in improving individual financial decisions. Krajnak, Burns, and Natchek (2008) examine the importance of personal financial education in the workplace. They find that participants in financial education seminars change their savings goals and behaviors in a positive way. In a study of respondent answers to structured survey questions, Mandell and Klein (2007) find that motivational variables significantly increased the ability to explain differences in financial literacy.

Financial advisors play a key role in elevating the financial literacy of clients. Well organized information, matched with a client's motivation to learn, should lead to improved financial decisions—*if the client exhibits rationality*. In this study we examine rationality, irrationality, and "predictable irrationality" linked to a "mental accounting" bias. Using survey data of college students, we test for differences in rational, irrational, and predictably irrational choices across cohorts defined by the level of college education, course of study, and gender. The distinction between rational, irrational, and predictably irrational choice regarding sunk cost is developed using basic principles of economic rationality and behavioral finance.

2. Rationality, irrationality, and predictable irrationality

Theoretical finance presents a framework for how individuals "should" make financial decisions. The foundations of theoretical finance go back to neoclassical economics and subsequent extensions to finance by Nobel laureates, notably Tobin (1958), Markowitz (1952, 1959), and Sharpe (1964). Behavioral finance, founded by Nobel laureates Kahneman and Tversky, provides an alternative paradigm of how individuals make decisions (Kahneman and Tversky, 1972, 1973, 1979, 1984; Tversky and Kahneman, 1974, 1981, 1986; and Kahneman, Slovic, and Tversky, 1982).[1] Building on cognitive psychology, behavioral finance conceptualizes how individuals *actually* make decisions rather than how they *should* make decisions. Behavioral finance hypothesizes that humans resort to innate mental shortcuts when faced with complex decisions. These shortcuts are ingrained biases and heuristics leading to decisions that are predictable even though they systematically deviate from the choice implied by the marginal constructs of traditional rationality. In this way, behavioral finance suggests that individuals will make "predictably irrational" financial decisions. A succinct and readable summary of the key tenants of behavioral finance can be found in Nofsinger (2008) and Ariely (2008).

Although irrationality seems the obvious *single* alternative to rationality, irrationality actually takes two forms in behavioral finance—predictable and unpredictable. Choices that are unpredictably irrational lack any systematic logic for decision making. In other words, a decision is unequivocally irrational in that it is inconsistent with both the traditional marginal tenets of theoretical rationality and the "predictably" irrational outcomes hypothesized by behavioral finance. In contrast, predictable irrationality represents an outcome that is "wrong" in the strict sense of being an optimal decision, but it is nonetheless expected using the constructs of behavioral finance (e.g., mental accounting, reliance on heuristics).

3. Sunk cost and mental account biases

A key principle embodied in the "rational-person" assumption of theoretical finance and economics is the irrelevance of sunk costs in making optimal decisions. Optimal decisions require comparing only the forward-looking incremental benefits and incremental costs charged to the decision. The irrelevance of sunk costs is one of the most common principles taught in college economics, finance, and accounting courses.[2] However, behavioral finance takes a different view of how sunk costs may enter into data processing by humans. The concept of "mental accounting bias" is attributed to Richard Thaler (1985). Mental accounting is a tendency in individuals to code, categorize, and evaluate economic outcomes by grouping assets into a number of nonfungible mental accounts that in turn are charged against mental liabilities (see Arkes and Blumer, 1985; Lilm, 2006; and Nofsinger, 2008). When a cost first occurs, an account for the expense opens and that account is not closed until there is an offsetting benefit. A sunk cost incurred before new information or context for decision making is not segregated from future marginal costs. Subconsciously, individuals may prefer suboptimal decisions that close mental accounts to the alternative of making optimal decisions evoking cognitive dissonance over costs that are not recovered.

A mental accounting bias in the case of sunk costs has a number of detrimental consequences for individual investors. Shefrin and Statman (1985) use these behavioral biases to explain the observed tendency of individuals to hold on to losing investments too long. The mental account that opens when an individual purchases an asset creates a reluctance to close the account at a sales price below the purchase price. Of course, the rational investor would not be wedded to a historical price when evaluating an asset's performance going forward. A lack of adequate diversification is another common phenomenon that can be linked to mental accounting bias. The rational person treats all dollars of equal value and considers the correlations of assets that constitute an optimally diversified portfolio as a single account. In contrast, the mental accounting bias can cause investors to treat a dollar in one account differently from a dollar in another, leading to suboptimal diversification. Finally, in theoretical finance the risk-return tradeoff does not change with respect to different dollars of investment. However, empirical studies such as Thaler and Johnson (1990) find that individuals spend and invest money differently depending on how the money is acquired. For example, individuals may invest proceeds from a rich capital gain differently from savings out of ordinary income. To balance the mental account, a higher benefit is required from earned money than from a windfall. This "house money" effect suggests that the risk and return tradeoff varies for an individual depending on the mental account linked to the activity.

4. Survey questions and hypotheses

Our research design to identify predictable irrationality follows behavioral experiments described by Ariely (2008). Survey questions are structured first to reveal whether a sunk-cost bias exists. The question is then manipulated in a fashion that explores the phenomenon of mental accounting bias. Responses to these questions fall within one of three

categories; either rational or irrational based upon conventional marginal reasoning, or predictably irrational according to tenets of behavioral finance. While there are many different contexts for behavioral biases in the literature, we focus on sunk cost and mental accounting because they are psychological lapses that can undermine some of the most fundamental advice given to individual investors.

The first survey question appears in Fig. 1. The question poses a choice to attend a concert after a $100 ticket has been purchased (the sunk cost). The respondent is then told that the marginal benefit of attending the concert turns negative making the choice to stay home rational. Attending the concert is then irrational by any marginal calculation. However, if the mental accounting heuristic holds, a respondent still treats the fixed costs as relevant and opts to attend the concert. In this sense, the irrational outcome is also a predictably irrational choice. The matrix below summarizes the outcomes in the simple setting posed by our first question (Fig. 1).

Question #1. *You paid $100 for a ticket to a popular concert last week. On the day of the concert you are very tired and prefer to have a quiet evening at home. If you stay home you will not be able to get your money back. Which of the following would you do?*

Response:	A. Go to the concert.	B. Stay home and relax.
Behavior:	Irrational, but Predictably Irrational	Rational

Fig. 1. Possible responses to single sunk-cost question.

A subsequent survey question introduces a "zero-cost" dimension to the concert decision.[3] If a mental accounting bias prevails, the predictably irrational decision is to go to the concert in Question #1 but change to staying home when the ticket is free. Such a change in a decision because of a change from a positive to a zero price of a fixed cost is the dimension of predictable irrationality that this research design can detect. A rational choice in Question #1 (Fig. 1) to stay home (choice B) should not change in Question #2 (Fig. 2), because the sunk cost of the ticket before the decision is irrelevant. However, from a behavioral perspective, there is no mental account to close when the cost is zero. Considered in combination, the predictably irrational outcome is to attend the concert in Question #1 (choice A, Fig. 1) and to stay home in Question #2 (choice B, Fig. 2). Simple irrationality corresponds to either of the two other paired choices—not going to the concert in Question #1 and then going to the concert in Question #2 (BA), or going to the concert in both cases (AA). Based on conventional marginal analysis, the only rational decision pair is to stay home is both cases (BB). Figure 2 arrays and labels the paired responses that are rational, irrational, and predictably irrational. Measuring the paired responses across these four cells in Fig. 2 identifies the frequency of each behavior and allows statistical tests of proportions.

We stratify the sample to test whether rational choice in the presence of sunk cost is a learned response enhanced by a college education, exposure to economics, and depth in economics and business courses. Although innate rationality surely varies from person to person, a college education in general (and economics or business courses in particular) are designed to improve rational thought. By promoting critical thinking, a college education

may offset innate psychological biases and thus increase the degree of rationality a person brings to real world decisions. We also expect students with course work in economics and business to make rational choices because of a structured exposure to the key principles of rationality.

Question #2. *You won a ticket to a popular concert that cost $100. On the day of the concert you are very tired and would really prefer to have a quiet evening at home. Which of the following would you do?*

A. Go to the concert since you paid for the tickets and can't get your money back.

B. Stay home and relax.

Question #1 / Question #2	A. Go to the Concert ($100 ticket)	B. Stay at Home and Relax ($100 ticket)
A. Go to the Concert (Free ticket)	AA Irrational	BA Irrational
B. Stay at Home and Relax (Free ticket)	AB Predictably Irrational	BB Rational

Fig. 2. Possible responses to paired qeustions #1 and #2.

Gender represents another individual characteristic that may affect the degree of behavioral bias or rational choice. Barber and Odean (2001) find that among investors, men have higher portfolio turnover, take more risk, and achieve worse portfolio performance compared to women. Clinebell, Kahl, Schwartz, and Stevens (2010) find women exhibit lower behavioral rationality than men early in life but work experience and seasoning tends to level out this difference. To ascertain the impact of gender and education on choice we test for differences in rationality by gender overall, by gender given a college education, by gender given courses of study, and by gender given both a college education and courses of study.

5. Survey technique and data

The students participating in this study are entering first-year students and graduating seniors at a "highly competitive" private U.S. university with 3,000 undergraduates.[4] We conducted the survey by e-mail during the first two weeks of August to capture first-year students before they start college. Although the introduction to the survey was carefully worded to avoid description that might introduce bias, the students did know the names of the investigators and some of the senior respondents were likely to have been former students of one or both professors. Following a brief e-mail introduction, students accessed the survey through an Internet link. That e-mail contained a very brief summary of the project and a consent form as required by the University's Institutional Research Board. The first section of the survey requested information about gender and academic achievement (e.g., GPA, SAT scores). The remainder of the survey has 13 questions (see the Appendix for the complete survey), two of which frame the analysis of sunk cost. We use 13 questions to help

disguise the importance of the paired sunk cost questions (#3 and #9) for this study and to collect information on phenomena not reported in this paper. Students have complete confidentiality for all responses in the personal profile and questionnaire. There is no link between the e-mail used to contact respondents and the internet site through which students replied. A full disclosure of research intent and protection of confidentiality was required by the Institutional Research Board of the university.[5]

The sample design first defines two broad cohorts: (1) new nontransfer students who are entering the university; and (2) rising seniors expecting to fulfill graduation requirements by the following spring. Potential differences in these two cohorts likely stem from a blend of maturity, social seasoning, and critical thinking that should develop during a college education. The sample of seniors is further divided into three cohorts defined by varying degrees of economics or business education: (1) no exposure to economics; (2) a course in principles of microeconomics only; and (3) advanced course work in economics and business. The "advanced" cohort includes seniors with economics classes through intermediate microeconomic theory (i.e., typically major or minors) and seniors with a business major. For business majors, the minimum requirement includes two courses in economic principles, one course in finance, and two courses in accounting. All of these courses address the concept of fixed costs, the irrelevance of fixed costs in the decision process, and an emphasis on marginal optimization methods.

The registrar's office provided four separate e-mail lists, three defined by the senior cohort definitions noted above and one for entering first-year students. Among seniors, all students in each cohort were contacted to complete the survey. Because of the size of the freshman class (roughly 800), only 400 of the entering students are surveyed. The stratification of respondents is not transparent to the participants. If the topic of the survey comes up among any of the participants, the members of different cohorts would think they were part of one survey. The execution of this sample design allows us to explore differences in responses for cohorts based on gender, college experience, and the degree of economics and business education.

Table 1 presents an overview of the total sample and individual cohorts. The table reports sample sizes and SAT scores stratified by cohort and gender. Of the total sample of 443 respondents, 170 are first-year students as compared with a total of 273 across the three senior cohorts. Considering the size of the senior class, the response rate among the business/economics cohort is high compared to the two other senior cohorts. This outcome is perhaps unsurprising given that the investigators are much more likely to be known by the economics or business students who responded. Regarding gender, the shares of women and men respondents in the total sample are roughly equal; moreover, this proportion is consistent with the university community as a whole where there is only a slightly higher percentage of women. However, the gender proportions vary across cohorts. The share of women respondents is relatively high among first-year students and seniors with no exposure to business/economics (60%–72%), but the women proportion falls substantially once the criteria of varying degrees of economics or business are introduced. Indeed, note that the proportion of women with depth in economics or business education is roughly half that among seniors with no economic exposure. This result is consistent with the fact that the business school has significantly more men than women while some of the largest majors in

Table 1 Summary statistics for number of responses and SAT scores

	Total sample	Entering first-year*	Seniors no exposure†	Seniors econ 101 only‡	Seniors bus/econ depth§
Sample size	443	170	77	55	141
Women/men	237/206	102/68	56/21	27/28	52/89
Percent women	53.5%	60.0%	72.6%	49.1%	36.9%
SAT mean	1328	1311	1343	1340	1336
Women/men	1,318/1,339	1,298/1,330	1,335/1,370	1,318/1,361	1,343/1,332
SAT SD	107	112	106	112	97
Women/men	106/107	111/112	95/129	104/117	103/95

*Students just entering the university with no college courses.

†Senior students without an economics or business course.

‡Senior students with only principles of microeconomics and no business courses.

§Seniors with economics course work at least through intermediate microeconomic theory (i.e., typically major or minors) and seniors with a business major. For business majors, the minimum requirement includes two courses in economic principles, one course in finance, and two courses in accounting. All of these courses address the concept of fixed costs and the irrelevance of fixed costs in the decision process.

the arts and science program have substantially more women. Moreover, almost two-thirds of arts and sciences degrees are received by women.[6]

The mean SAT scores in Table 1 indicated similarities as well as differences across each group. Across the three senior cohorts, the mean SAT scores lie within a very small range of 1,336 to 1,343. These means compare to 1,311 for entering first-year students. The lower SAT score for entering students is probably due in part to the fact that this class has yet to experience attrition. Table 2 provides pairwise tests of statistical differences between mean

Table 2 Tests for Difference in SAT Sample Means

Comparison of SAT Scores by Cohorts*	t-value for Difference in SAT
SAT score differences: Men vs. women	
Men vs. women in total sample	1.26
Men vs. women entering students	1.85
Men vs. women seniors with no exposure	1.38
Men vs. women seniors with econ 101 only	1.45
Men vs. women seniors with business/econ depth	−0.64
SAT score differences: Entering students vs. seniors by cohort	
Entering students vs. seniors with no exposure	−2.11†
Entering students vs. seniors with econ 101 only	−1.67
Entering students vs. seniors with business/econ	−2.12†
SAT score differences: Seniors vs. seniors by cohort	
Seniors with no exposure vs. seniors with exposure	−0.15
Seniors with no exposure vs. seniors with business/econ depth	−0.45
Seniors with econ 101 only vs. seniors with business/econ depth	−0.21

*Two-sample difference-in-means t-statistic is $t = (x_1 - x_2)/s_{(m1 - m2)}$ where $(x_1 - x_2)$ is the difference in sample means and $s_{(m1 - m2)}$ is the standard deviation of the difference in the sample means. The *F*-test for each pair supported the assumption of equal variances.

†Denotes statistical significance at the 0.05 level.

SAT scores for all 11 possible stratifications. These stratifications examine SAT differences by gender within each cohort as well as across cohorts. Regarding gender, the first panel of Table 2 indicates that there are no statistically significance differences in total SAT scores across cohorts.[7] The second and third panels of Table 2 examine combinations with respect to the four cohorts. As suggested above, entering first-year students have significantly lower SAT scores for two of the three pairwise comparisons—seniors with either no exposure or advanced exposure to economics and business. The SAT scores for seniors with some exposure to economics are higher but the difference is not statistically significant. However, even when the SAT means are statistically different at the 0.05 level, these differences are arguably not quantitatively important on two counts. First, a mean SAT of 1,311 is still high by national standards. Second, the mean SAT scores in the senior cohorts, though statistically different at a rather low level of significance, are only two percent higher (1,340 vs. 1,311).

6. Empirical results

We first test for differences in responses on the relevance of sunk costs using Question #1 (Fig. 1). Recall, this is the circumstance in which the student paid for the concert ticket ahead of time rather than receiving the ticket for free. Responses for the total sample and for all cohorts are converted to proportions that measure the fraction of respondents who chose the rational choice of staying home versus the irrational response of going to the concert. The test for the presence of irrationality, behaving as if sunk costs are relevant, takes two forms. First, if respondents correctly ignore sunk costs, the proportion of the sample making the irrational choice would not be significantly different from zero (Ho: $p = 0$). A second test examines the premise that the response proportions are a random variable. If respondents simply flipped a coin with no systematic logic for choice, the expected proportion for the irrational choice would be 0.5 (Ho: $p = 0.5$). An observed sample proportion of irrational responses that is statistically higher than 0.5 indicates that irrationality is predominant in a cohort. A proportion of irrational responses that is significantly lower than 0.5 supports rationality, as defined by conventional marginal analysis.

Results for statistical tests of proportions based on rationality and irrationality appear in Columns 5 and 6 of Table 3. First, even without statistical rigor, it is apparent from Column 5 that the proportion of respondents making the irrational response is high across all cohorts. Although the lowest proportion occurs for men with depth in in economics (0.551), the irrational response was still present for more than half of this cohort. The highest proportion of irrationality occurs for women with no exposure to economics or business (0.905). Women in general have high proportions of responses that treat sunk costs as relevant. The hypothesis that the proportion of irrational responses is zero is not accepted at a high level of significance (0.001). Test results for the random choice hypothesis ($p = 0.5$) appear in the Column 6. Using randomness as a baseline, the proportion of each cohort making the irrational choice ($p > 0.5$) is striking. The t-statistics are positive and significant for every cohort except men with economics or business depth. Generally, the results in Table 3 indicate that respondents behave as if a sunk cost is relevant.

The results in Table 4 are based on responses to the paired Questions #1 and #2 (Figs. 1

Table 3 Tests for predictable irrationality in the fixed cost decision (Question #1)

Cohort	Total responses	Frequency responding as if sunk cost is relevant	Proportion of sample responding as if sunk cost is relevant (p)	Test statistic* Ho: $p = 0$	Test statistic* Ho: $p = .5$
(1)	(2)	(3)	(4)	(5)	(6)
Total sample	443	351	.793	41.19‡	15.22‡
No exposure to economics	247	216	.874	35.00‡	17.73‡
Exposure to economics	196	135	.689	20.83‡	5.72‡
Depth in economics or business	141	90	.638	15.80‡	3.41‡
Men	206	144	.699	21.87‡	6.24‡
Women	237	207	.873	40.36‡	17.24‡
Men with exposure	117	71	.632	14.18‡	2.96†
Women with exposure	79	64	.810	18.35‡	7.03‡
Men with no exposure	89	73	.820	20.14‡	7.86‡
Women with no exposure	158	143	.905	38.80‡	17.38‡
Men with depth in economics or business	89	49	.551	10.45‡	0.97
Women with depth in economics or business	52	41	.788	13.90‡	5.08‡

*Student t-test statistic = $(p - 0)/[p(1-p)/n]^{.5}$

†Denotes statistical significance at the 0.01 level.

‡Denotes statistical significance at the 0.001 level.

and 2, respectively) to test for predictable irrationality as a special form of irrationality. As explained in Fig. 2, a predictably irrational response corresponds with a choice to go to the concert when the ticket is purchased (sunk cost is positive) in conjunction with the decision to stay home when the ticket is free (sunk cost is zero). The paired-question outcome is a clearer test of the "mental account" hypothesis. Because the sunk cost is zero in Question #2, there is no need to open a mental account for the cost of the concert or to go to the concert to close the account. The null hypothesis is that the proportion of predictably irrational respondents is zero. All t-tests in Table 4 verify that the proportions are statistically greater than zero at a high level of significance. The decision to go to the concert changes for a significantly large proportion of the sample when we introduce the zero fixed-cost of the ticket, supporting the mental accounting expectation. Together, the findings in Table 3 and Table 4 suggest that respondents exhibit irrationality with respect to the relevance of sunk costs and that predictable irrationality based on a mental accounting bias is highly significant.

To this point we have only tested for simple irrationality and the *presence* of predictably irrational behavior in each of several cohorts. We now examine whether there are differences in predictably irrational behavior *between different* cohorts as defined by gender, college education, and the degree of economic or business education. Column 1 of Table 5 lists six paired subsamples (e.g., men − women for the total sample, men − women by cohort, and cross cohorts). As indicated in Column 3, this analysis tests for differences in the proportions of predictably irrational responses between each cohort pair. All of the test statistics in Column 4 support the null hypotheses—the proportion of predictably irrational choice in a

Table 4 Tests of significance in proportions of predictably irrational responses to the paired fixed cost question (Questions #1 and #2)

Cohort	Total responses	Frequency of predictably irrational responses	Proportion of predictably irrational responses (p)	Test of proportion Ho: Proportion = 0*
Total sample	443	122	.2754	12.96‡
No exposure to economics	247	64	.2591	9.29‡
Exposure to economics	196	58	.2959	13.64‡
Depth in economics or business	141	39	.2766	7.34‡
Men	206	56	.2718	8.767‡
Women	237	66	.2784	9.567‡
Men with exposure	117	32	.2735	6.64‡
Women with exposure	79	26	.3290	6.22‡
Men with no exposure	89	24	.2697	5.73‡
Women with no exposure	158	40	.2532	7.32‡
Men with depth in economics or business	89	22	.2472	5.41‡
Women with depth in economics or business	52	17	.3269	5.03‡

*Student t-test statistic = $(p_1 - 0)/[(p_1)(1\text{-}p_1)/n1]^{.5}$

†Denotes statistical significance at the 0.001 level.

setting of sunk cost is unrelated to cohort characteristics of gender and the degree of economic and business education. Considered together, the results in Tables 3–5 suggest that while predictable irrationality is pervasive, it is not systematic, at least not for the stratifications of gender and education defined here. This finding supports the notion that predictable irrationality is a broadly based and ingrained human phenomenon.

Table 6 expands the analysis to include all possible responses to the paired survey questions, not just the predictably irrational response. As developed in Fig. 2, three cate-

Table 5 Tests for differences between cohorts in predictably irrational sample proportions for paired fixed cost (Questions #1 and #2)

Cohort comparisons	Sample sizes (n_1 and n_2)		Proportion difference (p_1–p_2)	Test statistic of proportion difference Ho: (p_1–p_2) = 0*
	n_1	n_2	p_1–p_2	
Men − women (total sample)	206	237	.2718–0.2784	0.155
No exposures − at least some exposure	247	196	.2591–0.2959	0.849
No exposure − depth in economics or business	247	141	.2591–0.2766	0.373
Men no exposure − men depth in economics or business	89	89	.2697–0.2472	0.343
Women no exposure − women depth in economics or business	158	52	.2532–0.3269	1.001
Men depth of exposure − women depth of exposure	89	52	.2472–0.3269	1.004

*Student t-test statistic for difference-in-proportions = $(p_1 - p_2)/SE$ where $SE = [(p_1)(1\text{-}p_1)/n_1 + (p_2)(1\text{-}p_2)/n_2]^{.5}$

†None of the Student t-statistics are significant at a reasonable level of significance.

Table 6 Tests for difference in observed vs. random predicted responses to paired fixed cost (Questions #1 and #2)

Cohort	Total responses	Rational/ predicted	Irrational/ predicted	Pred. irrational/ predicted	χ^2*
Total sample	443	$88/147.67^{Low}$†	$233/147.67^{Hi}$	122/147.67	78.02‡
No economics or business	247	$29/82.3^{Low}$	$154/82.3^{Hi}$	64/82.3	101.05‡
Exposure to economics	196	59/65.3	79/65.3	58/65.3	1.63
Depth in economics or business	141	53/47	53/47	39/47	3.184
Men	206	60/68.67	$90/68.67^{Hi}$	56/68	10.17‡
Women	237	$28/79^{Low}$	$143/79^{Hi}$	66/79	86.93‡

*The χ^2 test-statistic is $\chi^2 = \Sigma$ [(Observed − Predicted)^2/Predicted]$_i$ as i goes from 1 to 3.

†Superscripts indicate proportions that are either higher (Hi) or lower (Low) than predicted in the vector of proportions that are significantly different based on the χ^2 test.

‡Denotes χ^2 test-statistic significant at the 0.0001 level.

gorical responses emerge from the matrix pairing Questions #1 and #2—rational, irrational, and predictably irrational. We construct sample proportions for all cohorts where the proportion is the number of responses in a category divided by one-third of the total sample. A χ^2 test for differences in the vector of proportions by cohorts is constructed for each decision category. The null hypothesis is structured for random responses where one-third of the sample falls in each of the three decision categories. The χ^2 statistics reveal significant differences in the proportions of observed responses relative to the proportions predicted by the null hypothesis. The largest deviations (noted with the superscript Hi) and smallest deviations (noted with the superscript Low) relative to the predicted number of observations reveal the major contributors to the finding if the proportions are significantly different. In general, the proportions of irrational responses in Table 6 are higher and the proportions of rational responses are lower than randomness predicts. The observed predictably irrational responses are roughly equal to the predicted proportions. The χ^2 statistic is significant for all cohorts in Table 6 except for students with exposure to economics and business and students with depth in economics and business. These findings are interesting because they suggest that a college education alone does not seem to improve rationality but exposure to economics and depth in economics and business does. Even so, for all cohorts the number of rational responses to the paired survey questions is either less or about equal to what would be expected if responses were purely random.

Table 7 presents the results from the survey of paired questions in a more complex analysis of differences between selected cohorts and the rational, irrational, or predictably irrational responses. A traditional Pearson χ^2 statistic is performed to test for the significance of differences in the distribution of responses across the three decision categories (columns) for selected cohort comparisons (rows). The null hypothesis for the test procedures in Table 7 is that the propensity to exhibit rational, irrational, or predictably irrational behavior (columns) is not affected by differences represented by the selected cohorts (rows). The test first requires construction of a transition matrix that represents the number of respondents predicted to be in each column for a given cohort (row) based on random responses. For example, in Panel A we divide the total sample into men and women cohorts. From the total sample of 443 respondents, we have 206 men, or 46.5% of the total sample. There were 88

Table 7 Chi-square tests for differences in the vector of observed responses and predicted responses to paired fixed cost questions

Cohort and test	Total/% of total	Rational/ predicted	Irrational/ predicted	Pred. irrational/ predicted	χ^2*
Panel A. Total sample by gender	443	88	233	122	
Men	206/46.5	60/40.92^{Hi}†	90/108.3^{Low}	56/56.7	
Women	237/53.5	28/47.08^{Low}	143/124.7^{Hi}	66/65.3	22.5 (0.01)‡
Panel B. Total sample by college	443	88	233	122	
Entering students	170/38.4	22/33.7^{Low}	107/89^{Hi}	41/46.81	
Seniors	273/61.6	66/54.23^{Hi}	126/143.1^{Low}	81/75.19	13.4 (0.025)
Panel C. Total sample by exposure	443	88	233	122	
No econ or business	247/55.8	29/49.07^{Low}	154/129.92^{Hi}	64/68.03	
At least some econ or business	196/44.2	59/38.93^{Hi}	79/103.08^{Low}	58/53.97	29.2 (0.0001)
Panel D. Total sample by gender and college	443	88	233	122	
Entering men	68/15.3	13/13.51	35/35.76	20/18.73	
Senior men	138/31.2	47/27.41^{Hi}	55/72.58^{Low}	36/38	
Entering women	102/23.0	9/20.27^{Low}	72/53.66^{Hi}	21/28.1	
Senior women	135/30.5	19/26.81	71/70.99	45/37.17	22.8 (0.025)
Panel E. Total sample by gender and exposure	443	88	233	88	
No exposure – men	89/20.0	16/17.68	49/46.81	24/24.51	
At least some exposure – men	117/26.4	44/23.24^{Hi}	31/61.53^{Low}	32/32.22	
No exposure – women	158/35.7	13/31.39^{Low}	105/83.11^{Hi}	40/43.52	
At least some exposure – women	79/17.8	15/15.69	38/41.54	26/21.75	52.2 (0.0001)
Panel F. Exposure depth	196	59	79	58	
Econ principles only	55/28.1	10/16.56	26/22.17	19/16.27	
Econ or business depth	141/71.9	49/42.44	53/56.83	39/41.73	5.2
Panel G. Exposure depth and gender	196	59	79	58	
Econ principles only men	28/14.3	6/8.43	12/11.29	10/8.29	
Econ or business depth men	89/45.4	38/26.79	29/35.87	22/26.34	
Econ principles only women	27/13.8	4/8.13	14/10.89	9/7.99	
Econ or business depth women	52/26.5	11/15.65	24/20.96	17/15.39	12.9

*The χ^2 test statistic is $\chi^2 = \Sigma$ [(Observed − Predicted)^2/Predicted]$_i$ as i goes from 1 to 3.

†Superscripts indicate proportions that are either higher (Hi) or lower (Low) than predicted in the vector of proportions that are significantly different based on the χ^2 test.

‡Denotes χ^2 test statistic significant at the 0.0001 level.

rational responses to the paired questions for both men and women. We predict 40.92 rational responses by men, which is equal to 0.465 × 88, and 47.08 rational responses by women. All of the predicted responses in Table 7 are calculated in a similar fashion.

For each cell in each panel of Table 7 we report the observed/predicted data. The Pearson χ^2 statistics test the null hypothesis that observed and predicted responses are the same over the three response columns across cohorts in a given panel. If the χ^2 statistic is significant, the vector of differences in observed and predicted responses for the given cohort comparison is not zero. The highest deviations of observed from predicted responses for that cohort reveal which cells contributed most to this finding, noted with superscripts of Hi and Low.

For Panel A the difference in responses from what would be predicted because of gender representation is statistically significant. This finding is not because of differences in predictable irrationality. Rather, men tend to be significantly more rational and less irrational than women on the fixed-cost mental-accounting questions. In Panel B of Table 7 the test

focuses on the role of a college education by comparing difference in responses of entering students and seniors. The significant χ^2 statistic indicates a difference in the vector of responses. Respondents with a college education exhibit higher than predicted rationality and lower irrationality than predicted relative to entering students. Entering students exhibit higher than predicted irrationality and lower than predicted rationality. It is also important to note that predictable irrationality is not affected by whether or not the respondent has a college education. This finding is robust across the various panels and is consistent with the behavioral finance literature that finds predictable irrationality to be ingrained and difficult to change (Clinebell, Kahl, Schwartz, and Stevens, 2008).

The results in Panel C indicate that students with exposure to economics or business provide more rational responses than predicted while students with no exposure to economics or business are more irrational than predicted. As with the findings for gender and a college education in prior panels, predictable irrationality is not altered by exposure to economics or business. In Panel D of Table 7 we test for the interaction of gender and a college education. This leads to 12 different cells of comparison between observed and predicted responses. The χ^2 statistic is significant, again suggesting that the differences between observed and predicted responses are not equal over the various cells. Senior men exhibit higher rationality and lower irrationality than predicted while entering women have a higher propensity for irrationality and lower propensity for rationality than predicted. The combined outcomes suggest that a college education improves rationality for men and women, with significant improvement in rationality between entering women and senior women. A college education brings the rational responses for women back to what would be predicted. Consistent with prior findings, there is no significant change in predictable irrationality because of a college education for either gender.

In Panel E we isolate our comparison to only senior respondents to consider the importance of exposure to economics by gender. Again, the χ^2 statistic is significant and students with exposure to economics or business have higher rationality for both men and women respondents with little change in predictable irrationality. The findings for exposure to economics mirror the findings in Panel D with respect to a college education. The last two panels of Table 7 test the influence that the depth of study in economics or business has on rationality for seniors and for the interaction of gender and depth of study. The χ^2 statistics in panels F and G are not statistically significant, revealing that depth of study does not significantly change rationality, irrationality, or predictable irrationality. This is true for both men and women. This lack of significance is interesting because it suggests that there is no improvement in rationality from depth of study beyond simple exposure to economics and a college education. A caveat to this conclusion is that the sample sizes are small when gender and depth of study are considered jointly.

7. Summary and conclusions

One of the most basic components of investor rationality is the principle that sunk costs are irrelevant in marginal decisions. Our results suggest that this assumed rationality is not common among young college adults. In the simple situation of having already paid for a

concert ticket, students opted to attend the concert. Even in the best case, almost half of graduating seniors with depth of study in economics or business fail to recognize the irrelevance of sunk cost in the context of a marginal decision. Among women entering college, more than 90% failed to ignore sunk cost. Overall, our statistical tests generally reject the rationality hypothesis except for men with depth in economics or business.

We find that respondents change their view of sunk costs when the cost goes to zero (i.e., the ticket is free). The predictably irrational response is consistent with the mental accounting hypothesis from behavioral finance. We find that predictable irrationality is invariant with respect to gender, college education, exposure to economics, or depth of study in economics or business. Although these factors fail to account for predictable irrationality, we do find important influences upon rationality. Respondents with a college education and exposure to economics or business have statistically significant improvement in rationality. This finding is robust for both men and women. However, depth in economics or business does not further improve rationality. We do find gender effects with respect to rationality in the sunk cost decision. Women appear to be less rational overall and are more prone to treat fixed costs as relevant, but the gender effect is attenuated by a college education and exposure to economics.

Among the cohorts of young adults surveyed for this study, the pervasiveness of predictable irrationality is quite striking. Moreover, predictable irrationality appears to be ingrained and unaffected by the mix of gender, college education, exposure to economics, and depth of study in economics or business. For clients with this behavioral bias it is difficult to use traditional financial investment theory. For example, if clients use mental accounting they will feel more comfortable with separate accounts for different investment goals and objectives. If a client's comfort level is a driving consideration in designing an investment plan, the advisor may need to use a goals and objectives approach with separate accounts for each goal. The alternative is to help educate the client with respect to rational marginal decisions. While unpredictably irrational clients may respond to this approach, our study suggests that undoing this bias with education is neither an easy nor certain endeavor. When dealing with clients with predictable irrationality biases, perhaps the most difficult problem for financial advisors is to arrest the client's temptation to hold on to losers too long. One strategy on this front is to set up criteria or set rules at the time of purchase that can be invoked at a later date without reference to the purchase price.

As college educators in general and financial educators in particular, we believe that rational thinking is an important outcome of a college education. It is comforting to find that rationality is improved by a college education and exposure to economic principles. This may be especially important for women students. Our findings suggest that all college students would improve rationality with respect to marginal decisions by having exposure to a basic economics or business course. Unfortunately, not all college students gain exposure to economics or business principles of rationality. General education requirements touted to produce well rounded graduates do not generally require course in economics or business. Oddly enough, our findings suggest that advisors may have more success with irrational clients compared with predictably irrational clients because education can prod the irrational investment client toward rationality more effectively than changing predictable irrationality.

Notes

1 A list of the most important contributions to behavioral finance would include Thaler (1980), Shefrin and Statman (1985), and Tversky and Simonson (1993), Ariely, Loewenstein, and Prelec (2003), and Shampanier, Mazar, and Ariely (2007).
2 For example, see introductory college texts by Frank and Bernanke (2009), Parkin (2012), Gitman and Zutler (2012), and Garrison, Noreen, and Brewer (2011) for references to the irrelevance of sunk costs in the decision process.
3 "Subsequent" question does not mean "next" question. The survey explored other behavioral phenomenon and the appropriate defining questions in each case were mingled throughout the survey (i.e., the second context for considering sunk cost appeared several questions later in the survey).
4 *Baron's Profiles of American Colleges* (2011), p. 1527.
5 To conserve space, a complete set of documents required by our Institutional Research Board (IRB) can be found at: http://ssrn.com/abstract=2212872.
6 For graduates in 2012, women accounted for only a third of economics and business degrees. Women received 63% of the degrees awarded in the school of arts and sciences.
7 These tests use a .05 significance level. If a .10 standard is applied, the mean men SAT score is higher than for women for entering freshman only.

Appendix: full questionnaire

You will be answering questions where you must make a decision based on your preferences. There are no correct or incorrect responses; we are only interested in your choices and the varying preferences revealed by those choices. The questions do not ask that you disclose identifying or sensitive information. The purpose of the study is to compare how different respondents make decisions in the situations presented in the questionnaire.

The answers you will provide online are completely anonymous. The only record associated with your competed survey is the time at which it was submitted online. The collection and use of the data have been approved by the University's Institutional Review Board for the Protection of Human Participants. If you have any questions concerning your rights as a research participant, you may contact the Chair of the University's Institutional Review Board at (804) 484-1565 for information or assistance.

You must be 18 years old to participate in this study. Your participation is voluntary and you are free to withdraw your consent and discontinue participation at any time.

1. You are looking to buy a SONY 46" 1080p LCD HDTV today. You see one in a store for $1,500 while you are shopping. You call another store and find they have the same TV in stock for $1,493 but the other store is 15 min away. Which of the following choices would you make?
   A. Buy the SONY HDTV at the store where you are shopping for $1,500.
   B. Drive 15-min to buy the SONY HDTV at the other store for $1,493.

2. You want to subscribe to your favorite magazine. You have the following subscription choices. Which subscription would you choose?
   A. Internet-only subscription for $20.
   B. Print-only subscription $40 (includes mailing costs).
   C. Print-and-Internet subscription for $40 (includes mailing costs)
3. Last week you paid $100 for a ticket to a popular concert. On the day of the concert you are very tired and prefer to have a quiet evening at home. If you stay home you will not be able to get your money back. Which of the following would you do?
   A. Go to the concert.
   B. Stay home and relax.
4. A popular local theme park has a "full day" admission of $26, where a full day is from 9:00 a.m. to 10 p.m. A special admission of only $10 applies for admission after 4:00 p.m. Which of the two admissions would you take?
   A. Take the full day admission for $26.
   B. Take the special admission after 4:00 p.m. for $10.
5. The popular local theme park now offers a new program for a limited time only. You may enter for a special all day admission of only $14. If you enter the park after 4:00 p.m. admission is free.
   A. Take the special all day admission of $14.
   B. Take the free special admission after 4:00 p.m.
6. You broke your Microsoft wireless mouse 3000 and have been shopping to replace it. You see one while you are in a store for $25. You call another store and find they have the same mouse in stock for $18, but the store is 15 min away. Which of the following choices would you make?
   A. Buy the Microsoft wireless mouse at the store where you are for $25.
   B. Drive 15-min to buy the Microsoft wireless mouse for $18.
7. You won a ticket to a popular concert that cost $100. On the day of the concert you are very tired and would really prefer to have a quiet evening at home. Which of the following would you do?
   A. Go to the concert.
   B. Stay home and relax.
8. You see that the publisher of the popular periodical that you want has changed the subscription choices. Which of the following subscription choices would you take?
   A. Internet-only subscription for $20.
   B. Print-and-Internet subscription for $40 (includes mailing costs).
9. You are with friends at a casino. You see a game of chance that requires you to place $10 on either a red or a black square on a table. The game is set so there is a 50% chance that black will win and a 50% chance that red will win. If you win, you get your $10 back plus another $10. If you lose, you give up the $10 you placed on the table. Would you play this game?
   A. Yes
   B. No
10. Recall the game just presented in Question #9. In that game you could place $10 on either a red or a black square on a table, and there was a 50% chance that black will win

and a 50% chance that red will win. If you win, you get your $10 back plus another $10. Congratulations! You played the game in question #9 and won $10 more than you bet. In this case, would you play the game again?

A. Yes
B. No

11. OOPS! Assume you played the game in Question #9 but *instead* lost $10. You could win back the $10 you lost by playing the game again (double or nothing). Would you enter the game now?

A. Yes
B. No

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