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Full Length Research Paper

Behavioral approach to portfolio selection: The case of Tehran Stock Exchange as emerging market

Farshad Heybati[1], Freydoon Rahnamay Roodposhti[2] and Seyed Reza Moosavi[2]*

[1,2,2]Department of Business Management, Science and Research Branch, Islamic Azad University, (IAU) Tehran, Iran.

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Behavioral finance is the study of the influence of psychology on the behavior of financial practitioners and the subsequent effect on markets. In this paper, concepts of behavioral finance are surveyed and then the portfolio selection model in framework of behavioral finance theories is presented and compared with the Mean-Variance rational pattern. Historical data of TEDPIX for 10 years has been used and separated to 2 parts of test and evaluation groups. The optimum weight for risky asset proposed by standard mean-variance and behavioral model based on returns for the first 7 years (test data) in the 3 months periods. After that, returns of 84 optimum portfolios in a three year evaluation period are calculated. Mean test (CL=95%) shows that in Tehran Stock Exchange, the research hypothesis return of behavioral model is greater than return of standard mean-variance model, was rejected.

Key words: Behavioral finance, investment portfolio, mental accounting, asymmetric risk preference, loss aversion.

INTRODUCTION

In standard portfolio selection model, optimal values are determined regarding risk tolerance, investment limits, financial goals and mean-variance optimization pattern. But human being may not follow this process, because of behavioral biases. For instance, people encounter short-term changes and long-term trends, change their portfolio.

Several empirical studies about emotional biases have been done. Kahneman and Tversky (1992) showed that when encounter gain, investors are risk-averse, but encounter loss, are risk-seeking (Asymmetric Risk-taking Behavior). Also, lots of people have worse feeling toward loss compared with the same amount of gain. This phenomenon which is named risk-aversion is deeply related to psychology of people and taken into account as one of the fundamental concepts of prospect theory.

Most of financial theories are based on maximization of expected utility and risk-aversion whereas empirical studies about real world have criticized modern financial theories and rational behavior hypothesis in recent years. Psychologists' studies show individuals' behavior is different from what modern financial theories draw for rational human behaviors (Fernandez et al., 2009).

This paper surveys the hypothesis and frameworks of behavioral finance theories and then, represents a portfolio selection model based on behavioral finance assumptions.

Statement of problem

Portfolio selection has always been one of the subjects of financial theories. Before the 50th decade of 21st century, most of financial theories were in form of case study and nonsystematic. Harry Markowitz (1952) formulated the first portfolio theory, in title of "Modern Portfolio Theory" which was the first systematic financial theory. Modern portfolio theory evaluates return and risk of risky assets, using mean-variance pattern; and represents a normative pattern for portfolio selection. This theory assumes economic equilibrium, was the basis for other financial theories like capital assets pricing model (CAPM)developed by Sharp, Lintner and Mossine, and

*Corresponding author. E-mail: r-moosavi@iau-arak.ac.ir. Tel: (+98)122276163.

and efficient market hypothesis by Fama. Fallow up studies such as survey of behavior of stock price showed some anomalies in reality and efficient financial market hypothesis. So, researchers who are always looking for behaviors and reasons of financial markets events, attempted to explain behavior of decision makers in financial markets, using behavioral science. They explained the limits of rational financial theories such as limits of arbitrage and human cognitive limits. So, irregular behavior was known as an effective factor of economic behavior as well as other economic variables. Therefore, behavioral economics and behavioral finance attempt to explain economic variables in the framework of and normative theories, better and more accurate. The most important questions in this field are:

1. How do cognitive limits affect on economic behavior and investment decisions?
2. How the human behavioral biases could be modeled?

This paper attempts to explain irrational factors which affect investment decisions and portfolio selection in financial market of Iran and presents a behavioral model based on frameworks of behavioral finance. Finally, this model is evaluated and compared with rational portfolio selection models.

LITERATURE REVIEW

Fernandez et al. (2009) classified behavioral biases into two groups: cognitive biases and emotional biases. These two groups cause irrational decision making. Cognitive biases such as “anchoring” and “availability” is caused by wrong reasoning and could be decreased by getting more information. Emotional biases such as “loss aversion” and “regret aversion” are caused by sudden emotions and insight and could not be corrected easily.

Shefrin (2005) showed that portfolio selection in framework of prospect theory is different from portfolio selection in framework of expected utility theory. The most important property of behavioral portfolio is that it involves some risk free securities and some risky securities and portfolio does not have enough diversification. In this framework, an optimal portfolio is one which covers the interests of decision maker instead of maximize the expected return. Therefore, interests and emotional biases are determinants in portfolio selection.

Kahneman and Tversky (1979, 1992) explained four new concepts in financial behavior of investors in prospect theory and in its newer model, cumulative prospect theory:

1. Investors evaluate assets based on gain and loss, not final value of investment (mental accounting).
2. Individuals are more averse to loss rather than gain (loss aversion).
3. Individuals are risk-seeker encounter loss and risk-averse dealing with gain (asymmetric risk preference).
4. Individuals assign higher weight to the events with less probability and lower weight to the events with more probability (probability weighting function).

Weber and Zuchel (2003) stated that investors, who have started morning with gain, avoid evening probable loss. In this way, they avoid probable risk and keep their gain. Shefrin and Statman (1985) presented disposition effect phenomenon, that individuals hold loser stocks for a long time and sell winner stocks soon. This behavior is named “fear of regret”. They showed that, individuals’ risk-aversion decreases after a period of loss and they become more risk-averse after a period of gain. This behavior is named asymmetric risk seeking.

Odean (1998) analyzed around 10,000 transactions of investors. His finding showed that, individuals are keen on gain from winner stocks. Weber and Kamerer (1998) showed that, individuals would like to sell winner stocks instead of loser stocks. Nevertheless, some researchers have observed a different behavior. Thaler and Johnsone (1990) and Barberis et al. (2001) presented a model which states that, individuals divulge less risk-aversion after a period of gain, and more risk-aversion after a loss. This phenomenon is known as “house-money effect”.

Odean (1999) stated that overconfidence is the reason of high volume of individuals’ transaction. According to his findings, overconfidence causes that individuals think that other investors’ decisions are affected from disposition effect and their decisions are more rational. This behavior is specially intensified in some fields that, individuals have knowledge. For instance investors prefer local stocks or stocks related to their country instead of foreign companies’ stocks because they feel they have more information about them, whereas it is possible that, this vision is incorrect. Another instant is that investors suppose that, successes due to chance are due to their skill. Individuals remember their successes but not their failure. This phenomenon is named “hot hand”.

Shiller (1998) studied the intellectual background and psychological, social and anthropological properties of individuals’ decisions. He introduced some behavioral biases such as anchoring, overconfidence and cultural roots of investors’ decisions.

Barberis and Thaler (2003) stated that, behavioral biases are the reason of deviation of decisions from rational decisions. Table 1 shows a brief behavioral phenomenon that contradict efficient market hypothesis.

Some of the most important theories in behavioral finance are listed in Table 2. Although several empirical studies about investors’ behavioral biases have been conducted, there are a few comprehensive studies about behavioral biases effect on assets selection in financial markets (Fernandez et al., 2009). Barberis et al. (2001) tried to explain stock price behavior in terms of risk-aversion concepts and mental accounting. Benartzi and

Table 1. Behavioral Phenomenon that Contradict Efficient Market Hypothesis.

Phenomenon Title	Researcher(s)	explanation
Risk-aversion	Friedman and Savage (1948)	-
Dependence to reference	Kahneman and Tversky (1979)	-
Regret-aversion	Shefrin and Statman (1985)	Holding the losers and selling the winners Over weighting to recent experiences
Overreaction	De Bondt and Thaler (1985)	Over pricing for winner and vice versa
Hot hand	Tversky and Gilovich (1989)	To attribute chancy successes to skills
Overconfidence	Odean (1999)	To buy local stocks
Scapegoat	Statman (1988)	-

Table 2. The Most Important Theories in Behavioral Finance.

Title	Researcher(s)
Prospect theory	Kahneman and Tversky (1979)
Cognitive dissonance theory	Festinger (1957)
Heuristics	Kahneman and Tversky (1974) Kahneman, Slovik and at al. (1982)
Forming effect	Kahneman and Tversky (1981)
Intellectual accounting	Kahneman and Tversky (1981), Thaler (1985 , 1999)
Reflection Effect	Kahneman and Tversky (1981)
Regret theory	Loomes and Sugden (1982), Bell (1982)
Regret-aversion theory	Statman (1988)
Disjunction Effect	Tversky and Shafir (1992)
Herding Behaviors	Shiller (2000)

Thaler (1995) explained individuals' risk-aversion behavior in framework of prospect theory and showed how myopic behavior affects portfolio selection. Magi (2005) used numerical calculations and explained the model of international portfolio selection based on behavioral preference. He also explained how investors prefer national stocks rather than foreign stocks, even though their performance is better.

Davies and Satchell (2004) showed the method of optimal assignment of stocks based on prospect theory concepts. Shefrin (2005) considered heterogeneous investors to survey behavioral biases effects on asset pricing.

Expected utility hypothesis as mental framework of modern financial theories, is extracted from the answer presented by Daniel Bernoulli (1954) to the paradox stated by Nicholas Bernoulli (1738) in title of "St. Petersburg Paradox". Two fundamental concepts which are extracted from this theory are:

1. Investors evaluate investment opportunities in terms of utility of outcomes.

2. Utility does not have a linear relationship with wealth but increase at a decreasing rate with increase in wealth (marginal utility).

The concept presented by Bernoulli, was expanded in form of expected utility hypothesis by Von Neumann and Oscar Morgenstern (1944). This theory presented a descriptive model for method of individuals' decision making under risky condition. According to this model, individuals' utility function is specified in terms of their preference on risky (probabilistic) condition. The hidden concept of this theory is that unlike Bernoulli's theory which states investors consider outcomes of decision, they consider objective probabilities of each decision.

Markowitz (1952) presented the concept of optimization based on maximum of utility and minimum of risk, in form of mean-variance efficient frontier. Efficient frontier involves all portfolios that are economically efficient in terms of expected return and risk trade off. He separated systematic and non-systematic risks and offered portfolio selection based on mean of returns and covariance of assets to decrease non-systematic risk.

Tobin's separation theorem (1958) explained the process of assignment of assets and method of selection between risky and risk free assets. He stated that, portfolio selection should be done between risky and risk free assets, and between different categories of assets as well.

Paul Samuelson (1965) mentioned efficient market hypothesis in his studies. He stated that, in the efficient market, where information is available for all participants, price change should be unpredictable. Fama (1970) briefed this concept and stated price reflects all available information and if there is no transaction cost, there would not be any outcomes due to transactions based on information. Roy (1973) and Locus (1978) tried to present a new version of efficient market hypothesis and believed return is not completely random.

Generally, financial theories have been presented based on two fundamental hypotheses:

1. Individuals behave rationally.
2. They use all available information for decision making.

But there are several instances of irrational behaviors and cognitive bias in real-world. So, some anomalies and empirical studies about market efficiency resulted in weakness of efficient market hypothesis and equilibrium. Experts are going to explain behaviors in market and in this condition, some researchers have used data driven methods and dynamic systems to discover the relationship between variables. On the other hand, some researchers like the well-known biologist, Kaufman (1988) and a computer scientist, Holland (1988) tried to explain and predict behaviors in market, using adoptive systems theory and finding the relationship between economic behaviors, growth and completeness of systems. The third path is behavioral finance development effort to discover the effect of cognitive and emotional errors on decision making. Behavioral finance theories states financial markets are not efficient because participants' decisions are affected from behavioral biases and framework of decision presence and it finally causes asset price deviate from intrinsic value.

METHODOLOGY

This research is a kind of applied research, in terms of explanation of a mathematical portfolio selection model in framework of behavioral finance hypothesis. In addition, empirical test of this model and explanation of relationship between variables using Tehran stock exchange is considered.

In this paper, after explanation of hypothesis of behavioral finance theories, mathematical model of relationship between variables is presented in framework of a mathematical model. In the next step, empirical test of behavioral model is done and it is compared with classic model using ten year TEDPIX data in 2000 to 2009. For optimization, the Mathematical software and for statistical tests, SPSS is used. The hypothesis of research is that, portfolio selection model based on behavioral finance hypothesis is more efficient than rational model.

The model

This research evaluates a model of portfolio selection in framework of behavioral finance theories in Iran Capital Market. The goal is setting the optimal weights for risky asset. It is assumed that short-selling is impossible. Investors are going to select weight of risky assets so that, expected utility is maximized in framework of prospect theory.

Portfolio selection model is presented in two periods and in a market with two kinds of risky and risk free assets and investors' behavior is explained using Kahneman and Tversky's prospect theory. Therefore, investor's decision on weight of risky assets dependent to reference point and wealth changes can be explained. Weight of risky asset is θ and amount of return or loss in the first period is:

$$x = \Delta W = [(1-\theta)W_0(1+R_f) + \theta W_0(1+R_f)] - W_0$$
$$\therefore x = (1-\theta)R_f + \theta R$$
$$\therefore x = (1-\theta)R_f + \theta(\mu + \sigma n)$$

The process of selection in prospect theory is done in two stages of edition and evaluation, as mentioned in Kahneman and Tversky's model. In the edition stage, investor recognize and separate benefit and loss and modify the probability function of each outcome. Empirical studies show that individuals assign higher weights to the lower probabilities and vice versa. In this research, offered weighting function of Giorgi et al (2004) is used.

$$\pi(p) = \frac{p^{\gamma}}{(p^{\gamma} + (1-p)^{\gamma})^{1/\gamma}}$$

γ is coefficient of probability weight adjustment. In evaluation stage, investor attributes mental value to expected outcome. Giorgi et al (2004) and Fernandez et al (2009) explained hypothesis of portfolio selection based on Kahneman and Tversky's model. The value function is defined as:

$$v(x) = \begin{cases} \lambda^{+} - \lambda^{+} e^{-\alpha x}, if\ .x \geq 0 \\ \lambda^{-} e^{\alpha x} - \lambda^{-}, if\ .x \prec 0 \end{cases}$$

In this model, α is general risk-aversion coefficient. Because $\lambda^{-} > \lambda^{+} > 0$, the slope of value function is more in loss part and then λ shows risk-aversion. *x* shows wealth changes and is representative of investors' mental accounting concept. This value function is concave for points greater than reference point and convex for other points (asymmetric risk-aversion).

An investor defines weight of risky asset to maximize expected utility (V). Also his/her preferences are defined in framework of prospect theory and based on wealth changes. So, expected value is:

$$V = \int_{-\infty}^{+\infty} v(x) \frac{d}{dx} \pi(f(x)) dx$$

Where *v(x)* is expected value of event *x* and □ (f(x)) is cumulative weight of probability of event *x,* based on probability weighting function. An investor selects weight of risky asset in each stage of investment so that, expected value of investment is maximized.

$$\max V = \int_{-\infty}^{\infty} v(x) \frac{d}{dx} \pi(f(x)) dx$$

Table 3. Test period data.

Number of periods	Mean of return	Standard deviation
4	12.52	4.98
8	11.03	4.37
12	11.06	5.55
16	14.52	10.05
20	12.37	11
24	9.77	11.85
28	8.88	11.24

Table 4. Evaluation period data.

Period duration	Mean of return	Standard deviation	Semi standard deviation
28-32	4.57	11.29	11.78
28-36	1.52	14.86	16.80
28-40	5.15	14.18	17.98

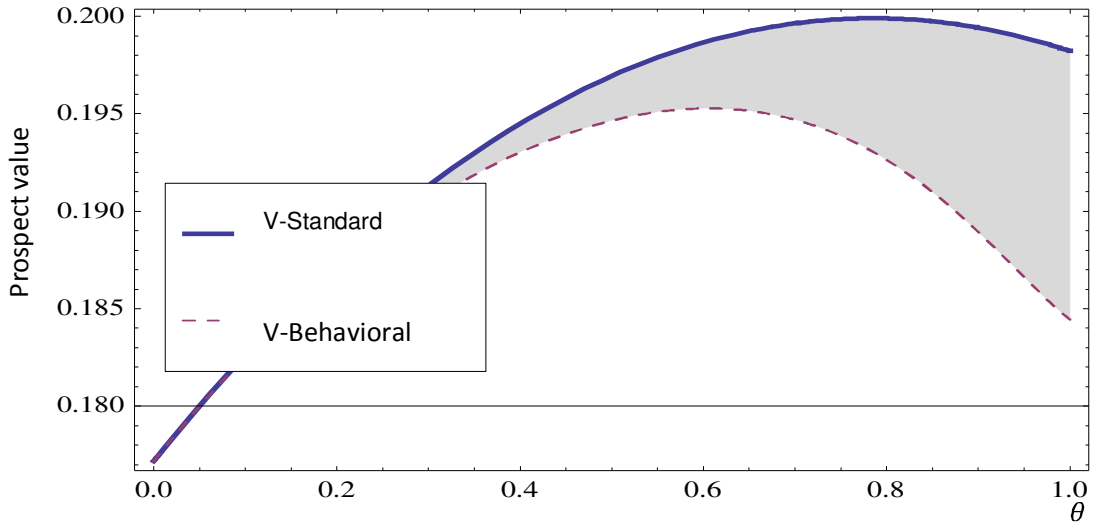

Figure 1. Value function of behavioral and standard portfolio models.

RESULTS AND ANALYSES

In this research, two periods of investment is considered to evaluate behavioral portfolio model. Therefore, data is separated to two parts. One part is used for optimal offered portfolio calculation and another part is used to evaluate the results.

Evaluation of behavior and standard portfolio model

Return and risk of risky portfolio is estimated using 28 three month periods data. Mean of long-term interest rate of bank deposits (15%) is used as risk free interest rate (Table 3). Also Table 4 shows the valuation data

Weight of risky asset in optimal portfolio is calculated using behavioral and standard models. If risk aversion coefficient (α) is 3, probability weighting coefficient (γ) is 0.9, $\lambda^+ = 1$ and $\lambda^- = 2.25$ (offered by Kahneman and Tversky), mean return and standard deviation of test period would be 8.88 and 11.24 respectively. Figure 1 shows the value function based on standard and behavioral models.

Calculation shows that according to behavioral model, weight of risky asset is 60.5% and according to standard model, it is 78.4%. Table 5 shows optimal weights of risky

Table 5. Optimal weights of risky portfolio based on standard and behavioral models.

Period	Standard model			Behavioral model		
	Weight of risky asset	Weight of risk free asset	value	Weight of risky asset	Weight of risk free asset	Value
1	0.874	0.126	0.307	0.597	0.403	0.305
2	0.720	0.280	0.277	0.545	0.455	0.277
3	0.758	0.243	0.275	0.337	0.663	0.273
4	0.763	0.237	0.325	0.491	0.509	0.324
5	0.816	0.184	0.280	0.354	0.646	0.272
6	0.674	0.327	0.220	0.400	0.600	0.214
7	0.455	0.545	0.209	0.343	0.657	0.207

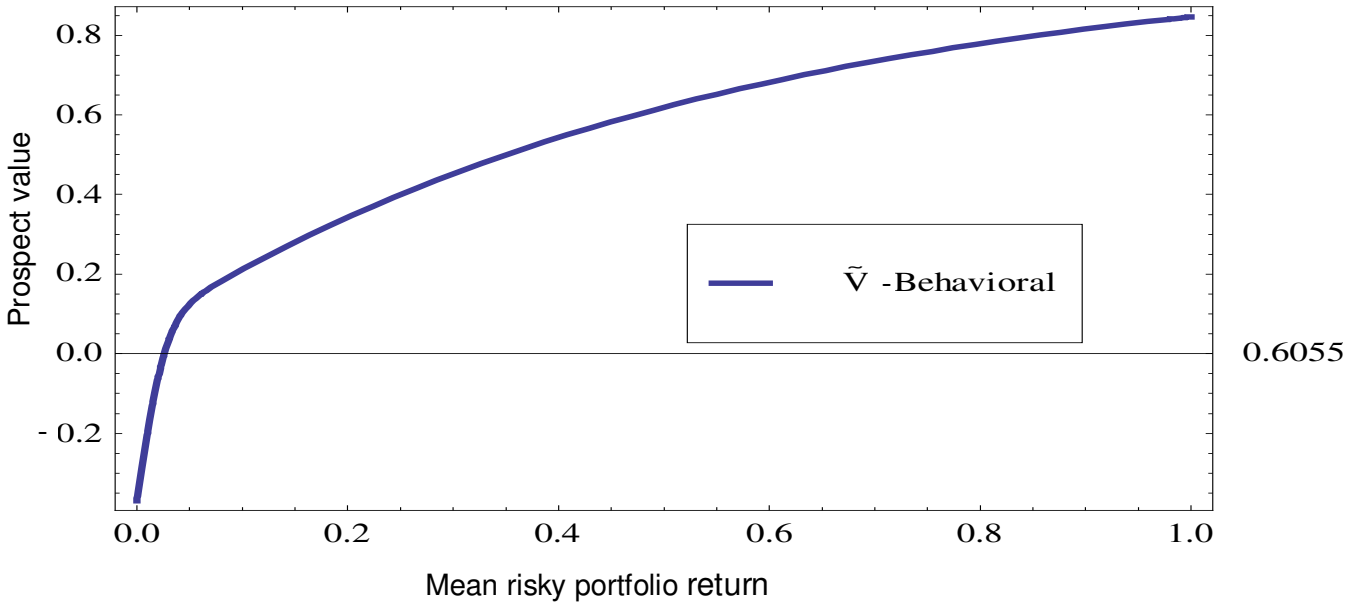

Figure 2. Expected value changes in terms of changes of expected mean return of risky portfolio.

portfolio based on standard and behavioral models and using 28 investment periods data (or 7 year test periods).

Figure 2 shows value in terms of mean return. So it is possible to survey the effect of mean return on expected value. Also figure 3 shows the effect of standard deviation (risk factor) on expected value.

Figure 4 shows the effect of both determinants (expected return and risk) on optimal weight of risky asset.

Now, to evaluate Standard and Behavioral portfolio models, return and risk of 7 optimal risky asset, calculated through first period based on 28 periods of test data, 12 optimall portfolio weights was calculated based on 3 year evaluation data. So, 84 portfolios based on behavioral model and 84 portfolios based on standard model have been evaluated. Figure 5 shows the optimal weight of risky portfolio in terms of return and risk changes in evaluation period.

Testing of hypotheses

In this section, using deductive statistics, it is surveyed that whether behavioral model is better than standard model or not.

Null-hypothesis (H_0): mean return of portfolios based on behavioral models is not greater than mean return of portfolios based on selected standard model.
Alternative-hypothesis (H_1): mean return of portfolios based on behavioral models is greater than mean return of portfolios based on selected standard model.

Equality of means test (confidence level is 95%) has been done to test equality of means of 84 offered portfolios based on behavioral and standard models.

According to Levene's test for equality of variances, sig.

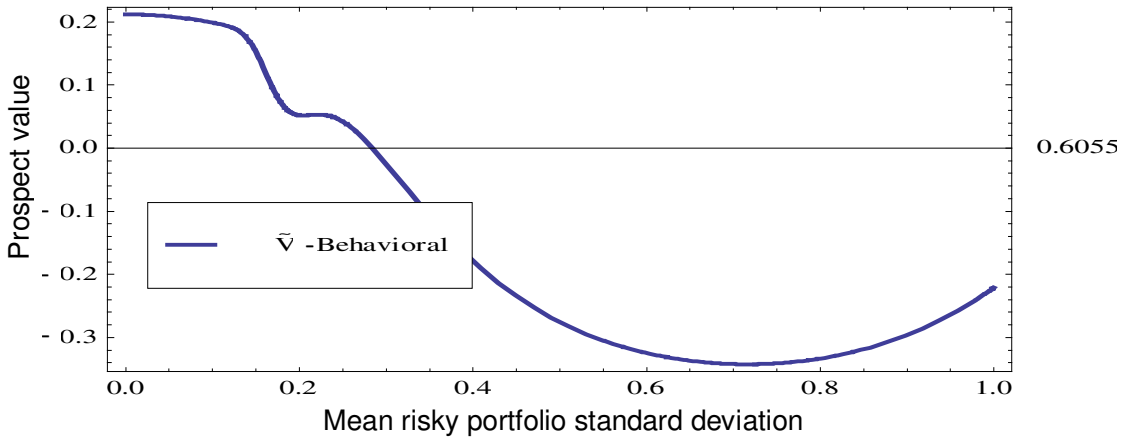

Figure 3. Expected value changes in terms of changes of standard deviation of risky portfolio.

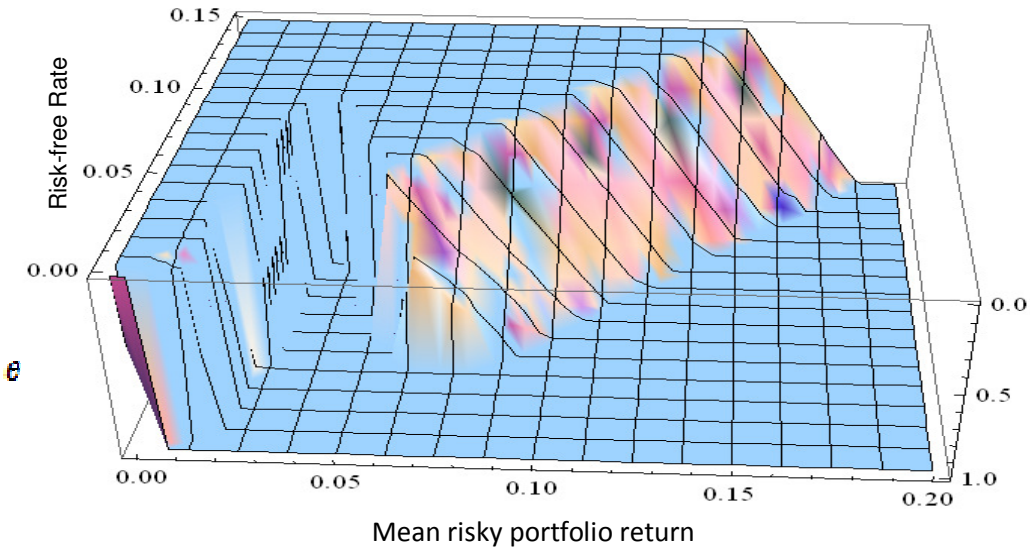

Figure 4. Expected value changes in terms of changes of and standard deviation of expected return of risky portfolio.

is 0.003 and less than 0.05 (error level). So, it is deducted that, the variances of two populations are not equal. Therefore, equality of means has been tested in the next step.

Results show that, sig. is 0.773 and greater than 0.05. Therefore, H_0 is not rejected. The lower bound (-0.47726) and upper bound (0.64059) have different signs and it shows that, there is no significant difference between mean returns obtained from behavioral and standard models, in 95% confidence level.

CONCLUSION

This research explained behavioral finance concepts and compared the model of portfolio selection based on behavioral finance concepts and standard model. In this paper, the most important financial concepts are mental accounting, risk-aversion and asymmetric risk preference. Other studies in other countries show that mathematical model of portfolio selection based on behavioral finance concepts leads to different results versus Markowitz' model. In this research, behavioral portfolio model was evaluated using 10 year data of TEDPIX. Although, point estimation of return of offered portfolio and optimal weight of risky portfolio are different in two models (it is the same as results of empirical studies in other countries), equality of means test for 84 behavioral and standard portfolios does not reject null-hypothesis (H_0). In point estimation, behavioral portfolio model suggests 60.5% as weight of risky asset in optimal portfolio, whereas Markowitz model suggests 74.4%. One

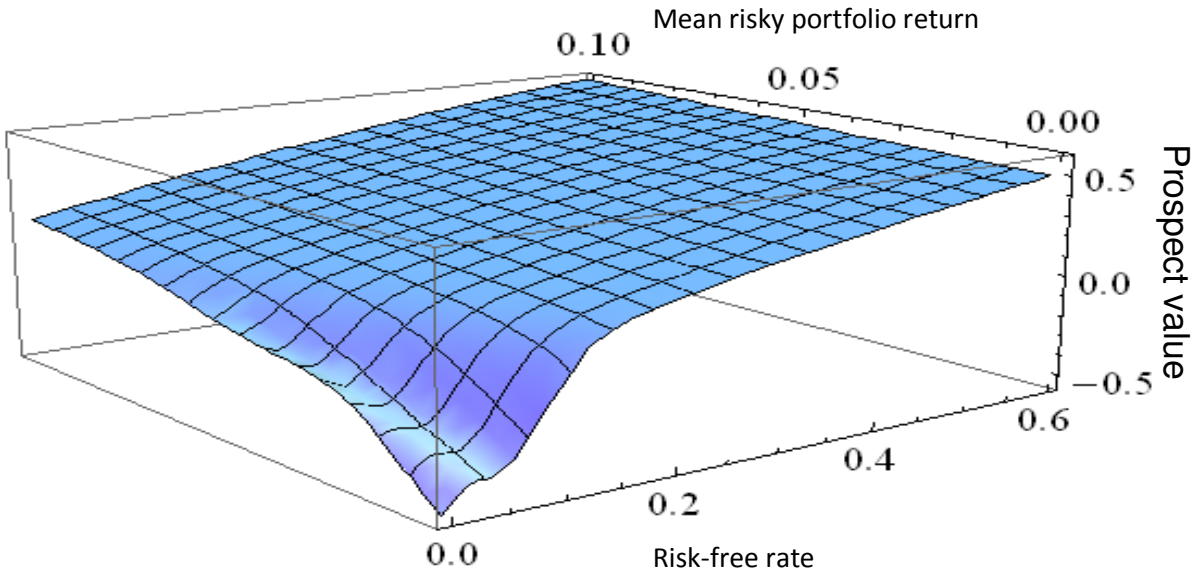

Figure 5. Optimal weights of risky portfolio in terms of changes of expected return and standard deviation.

of the reasons of difference between point estimation and result of statistical test in Tehran Stock Exchange can be due to data. TEDPIX is modified after evolution of capital market, especially entrance of new companies and it leads to instability and incomparability of index value. Finally, it is proposed to use more stable indices (such as industry index) and other method of risk evaluation such as semi standard deviation instead of standard deviation.

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APPENDIX

Group statistics.

SB	N	Mean	Std. deviation	Std. error mean
1	84	4.2081	2.20937	0.24106
2	84	4.1264	1.35284	0.14761

Independent samples test.

Variable	Levene's test for equality of variances		t-test for equality of means		t-test for equality of means			t-test for equality of means 95% Confidence interval of the difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	Lower	Upper
Equal variances assumed	8.951	0.003	0.289	166	0.773	0.08167	0.28266	-0.47641	0.63975
Equal variances not assumed			0.289	137.569	0.773	0.08167	0.28266	-0.47726	0.64059