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Human Attitude toward Risk: Simultaneous Testing of 'Allais Paradox' and Risk Aversion

Muhammad Mazhar Iqbal[1]

Abstract

In real life, human attitudes toward risk are mixed. However, economists have been using risk aversion as rational behavior in economic modeling ever since. The Expected Utility Hypothesis (EUH), which assumes risk-averse behavior but can also be used for risk-loving attitudes, comes into common use. Allais discovered a systematic violation of the EUH known as the 'Allais paradox', which initially discredited the EUH a great deal but was accepted, later on, as an exception to the EUH. A possible reason for ignoring the 'Allais paradox' could be that Allais himself and many studies which followed tested the EUH without reflecting risk aversion in particular. Therefore, this study tests the EUH and risk aversion simultaneously. The results are interesting. The greatest number of respondents verified the EUH based on risk aversion, but a majority of them showed a mixed attitude. This result, therefore, highlights the need for economic theorizing on the assumption of risk-loving and mixed attitudes as well.

Keywords: Choice under Uncertainty, Expected Utility Hypothesis, Risk Aversion, Allais Paradox, Certainty Effect

JEL Classification: D81

1. Introduction

In real life, human attitudes toward risk are mixed. On one hand, there are people who pay a certain amount of money to assume risk; they buy lottery tickets, they try their luck in casinos, they bet on horse races and other games, and they go to gambling dens. In every such activity, the expected return is usually less than the amount paid for it. Therefore, people who participate in games of chance are categorized as risk-loving. On the other hand, there are people who buy insurance to get rid of uncertainty regarding future outcomes. They pay insurance premiums, which are usually greater than the actuarial value of future loss. Such people are therefore categorized as risk-averse. There are yet some other people who may be called loss-averse

[1]Assistant Professor, School of Economics, Quaid-i-Azam University, Islamabad.
Email: mmiqbal@qau.edu.pk

because they hesitate to invest their money in a project in which there is any possibility of loss without caring much about its whole risk return profile.

Besides lotteries, games of chance, and insurance, people often confront uncertainly while apportioning their wealth into various categories of assets like bank accounts, bonds, stocks, real estate and business investment. Out of these options, bank accounts and bonds are less risky than stocks, real estate or business investment as returns on the former are fixed and their principal amount remains intact, whereas the returns on the latter are variable and their principal amount may also decline over time. Therefore, loss-averse and more risk-averse people prefer to deposit their money in banks and to hold bonds, whereas relatively less risk-averse people buy stocks and invest in real estate and business ventures.[2] On the same lines, people who prefer fixed-income jobs over comparable commission-based ones and self-employment with overall expected income being greater from the latter options can be classified as risk-averse individuals.

It is also interesting to note that an individual is neither exclusively risk-loving nor risk-averse in his/her practical life; rather he/she is both at the same time. In any society, one can easily find a person who, on one side, takes up a fixed-income job, but, on the other side, lives in an uninsured house, does not purchase any insurance policy and invests in stocks and real estate. One can also find, with the same ease, another person who, on one side, prefers self-employment over a fixed income job but, on the other side, gets his/her house and life insured and keeps his/her wealth in bank accounts and bonds. Moreover, Samuelson (1963) pointed out that one of his colleagues turned down an offer of coin toss to win Rs.200 on a head and to lose Rs.100 on a tail that shows an extremely risk-averse behavior. However, he expressed his willingness to accept 100 such bets if offered all together. This indicates that a person's degree of risk aversion also varies with the size of the bet.

Given such an intermingled and complicated state of human attitudes toward risk, it is really difficult to prove whether a typical individual is predominantly risk-loving or risk-averse. However, exposition of the 'St. Petersburg paradox' in the second half of eighteenth century and then its resolution through the Expected Utility Hypothesis (EUH) supported the risk-

[2] Since higher risk for the latter type of assets is compensated with higher return for them, therefore their holders are categorized as risk-averse rather than risk-loving. Technically a person is categorized as risk-loving if he/she invests in a venture for which expected return is less than the principal amount invested in it.

averse attitude so much that since then it has become the norm or rational behavior in economic modeling.[3] The 'St Petersburg paradox' refers to a betting game on the flipping of a coin. Participants in the game receive a payoff of \$1 if the coin shows head on the first flip, \$2 if it turns out head in the second flip too, and $\$2^i$ if it turns out head uninterruptedly till the i^{th} flip. The game ends as soon as the coin shows tail. It means that, on one extreme, the game may end after the first flip without the player winning any money and, on the other extreme, it may continue for a large number of flips, winning an infinite amount of money for the player. The expected payoff of this game is an infinite amount of money.[4] When potential players were asked to bid for getting the right to play this game, however, paradoxically none of them offered even a moderate amount of money, much less a large amount of money closer to the expected value of this game.

The paradox was resolved with the argument that it is not the amount of the payoff that people care about; rather it is the utility, which they derive from the payoff that concerns them. Furthermore, the utility of wealth, like the utility of any good or service, increases at a decreasing rate. In other words, in a bet or risky investment, the disutility of losing a dollar is always greater than the utility of winning a dollar. It clearly means that a utility maximizer is a risk averter who would never play a game for which expected payoff is equal to the price paid for it. He/she would be willing to play a game only if its expected payoff is sufficiently greater than its price. The difference between expected payoff and price represents his/her compensation for the assumption of risk. The novel idea of linking money with its utility was further developed to the present axiomatic form of the EUH by von Neumann and Morgenstern (1944). According to the EUH, every decision maker under uncertainty has a specific concave utility-of-wealth function in his/her mind. To evaluate competing investment opportunities or alternative games, a unique utility index in accordance with his/her utility function is assigned to each possible outcome and then the expected value of such utility indexes is worked out.

[3] See Machina (2008) for further details.

[4] Assuming a log utility function and an initial wealth of \$50,000 of a potential bidder of St Petersburg game and expressing its payoffs and probabilities as 2^{i-1} and $1/2^i$ respectively, Machina (1987) worked out \$9 as the offer price for this game.

Whichever investment opportunity or game has the highest expected utility is ranked at the top and so on.[5]

Risk aversion that explains the very logic of the EUH is reflected only implicitly from an increasing concave utility function, whereas an upward sloping straight line and an increasing convex utility function reflect risk-neutral and risk-loving attitudes, respectively. On the other hand, the mean-variance criterion reflects risk aversion explicitly as variance, one of its two parameters, is itself the most widely used measure of risk. This criterion, however, has two shortcomings. One is that it requires the comparison of two parameters, mean and variance, of competing projects. The other is that it is not helpful if both parameters of one project are greater than those of the other. For example, if project A has 2 possible payoffs, 0 and 10, with equal probability and project B has 2 possible outcomes, 0 and 30, with equal probability, then the mean-variance criterion is not helpful to rank these projects even though a common man who knows nothing about finance would prefer project B over project A. The EUH is free from these shortcomings. It is probably for these reasons that the EUH has always been preferred over the mean-variance criterion in the literature.

One of the earliest and most widely cited systematic violations of the EUH is 'Allais Paradox'.[6] The results of his experimental study showed that people consistently violate the EUH. However, interestingly, his results contradicted an increasing concave utility function as much as they contradicted an upward sloping line and an increasing convex utility function. In other words, 'Allais paradox' highlighted a notable violation of the EUH but it did not specifically contradict risk aversion. That is why many authors still try to defend the EUH and risk-averse attitudes as the norm. Their main argument is a 'certainty effect' that when a certain option is placed vis-à-vis a probable option, people are biased towards the certain option. Hence, the EUH does not work. However, if people have to choose from two probable options, then they rank them in accordance with the EUH. Since Allais included a certain option in the first option-pair of his experiment, he got paradoxical results. Many studies which retested 'Allais paradox' included similar questions. It seems that the main concern of previous studies had been verification or nullification of the EUH without bothering about its underlying

[5] Mathematically, possible payoffs of an investment project or a game are expressed as x_1, x_2, …, and x_n, and their respective probabilities as p_1, p_2, …, and p_n such that $\Sigma p_i = 1$and its expected utility as $EU = \Sigma\, U(x_i)\, p_i$ where $U(x_i)$ denotes the utility index of each payoff.

[6] See Allais (1953).

idea of risk aversion. On the other extreme is a study by Levy and Levy (2001) that tested only risk aversion without testing the EUH. Its results though showed evidence against risk aversion, yet it could not generate substantial reverberations in economic profession because the EUH was not challenged directly.

It is therefore desirable to test both the EUH and the mean-variance criterion simultaneously. That is the main objective of the present study. It is achieved by modifying competing options in Allais-like choice-sets in such a way that simultaneous testing of both the EUH and the mean-variance criterion becomes possible. Of course, implications of this study would be far-reaching; if its results verify both the EUH and the mean-variance criterion, then the EUH will continue to occupy a good space in microeconomic textbooks in spite of its systematic violations and its logical problems. On the other hand if its results verify the 'Allais paradox' and contradict the mean-variance criterion, then not only will the EUH become more doubtful but the very belief of risk aversion will also become debatable. Hence, the whole edifice of Economics will be shaken as already concluded by Levy and Levy on the basis of their results.

Following this introduction, this paper presents an appraisal of the 'Allais paradox' based on selected previous studies on the topic. Section three presents the distinguishing features of the experimental design of this study. Section four discusses the results of this study and compares them with those of previous studies. The last section is reserved for concluding remarks.

2. Appraisal of the 'Allais Paradox'

In his widely cited experiment, Allais asked selected subjects first to choose from a certain and a probable option, A and A^* respectively, and then from two probable options, B and B^*, as given below in Table 1.

A Majority of respondents chose option A from option-pair AA^* and option B^* from option-pair BB^*. It means that expected utilities of options A and A^* lead to following Inequality 1

$$U(1) \geq 0.01\,U(0) + 0.89\,U(1) + 0.1\,U(5)$$

or $$0.11\,U(1) \geq 0.01\,U(0) + 0.1\,U(5) \qquad \text{Inequality 1}$$

Similarly, the expected utilities of options B and B^* lead to following Inequality 2: -

$$0.89\ U(0) + 0.11\ U(1) \leq 0.9\ U(0) + 0.1\ U(5)$$

or $$0.11\ U(1) \leq 0.01\ U(0) + 0.1\ U(5) \qquad \text{Inequality 2}$$

Table 1: Original Questions in 'Allais Paradox'

A		**A***		**B**		**B***	
Payoff (million $)	**Prob.**	**Payoff (million $)**	**Prob.**	**Payoff (million $)**	**Prob.**	**Payoff (million $)**	**Prob.**
1	1.00	0	0.01	0	0.89	0	0.90
		1	0.89	1	0.11	5	0.10
		5	0.10				

Source: Allais (1953).

Since the expressions on both sides of inequalities 1 and 2 are same but the sign is reversed, therefore it shows a contradiction of the EUH. According to the EUH, they should have chosen either AB or A^*B^*. For choice-pattern AB^*, it can be argued that respondents showed risk-averse behavior by preferring option A with less payoff over option A^* with greater expected payoff only because the risk (variance) of the former was also less. Had they shown same attitude while choosing from option-pair BB^*, they should have chosen option B. To put it differently, respondents showed a risk-loving behavior by preferring option B^* with a smaller coefficient of variation (expected mean / variance) over option B only because the risk of option B^* was greater. Had they shown the same risk-loving attitude while choosing from option-pair AA^*, they should have chosen option A^*. Moreover, had respondents been risk neutral, they should have chosen A^*B^* because expected returns of these options are greater than those of their counter options AB. This means that the choice-pattern AB^* contradicted the EUH irrespective of the shape of the utility function. This is, respondents' behavior was neither risk-averse, nor risk-loving, nor even risk neutral consistently; rather it was mixed.

The results did not, however, contradict the 'mean-variance' criterion because it is not helpful to rank either option-pair as both the mean and variance of options A and B are less than those of option A^* and B^* respectively. To explain this paradox, it is argued that people attach significantly greater utility to a certain option while comparing it with a probable one whereas they show no such bias while comparing two probable

options. As option A is certain, that is why his experiment contradicted the EUH.

Later on, Kahneman and Tversky (1979) retested 'Allais paradox' from different angles. They included four choice-sets in their experimental survey as given below in Table 2.

Table 2: Retesting of Allais Paradox by Kahneman and Tversky

	A		A^*		B		B^*		Choice Pattern (%)			
	Payoff	**Prob.**	**Payoff**	**Prob.**	**Payoff**	**Prob.**	**Payoff**	**Prob.**	**AB**	**AB^***	**A^*B**	**A^*B^***
	2400	1.00	0	0.01	0	0.66	0	0.67	14	68	3	15
1			2400	0.66	2400	0.34	2500	0.33				
	(82%)		2500	0.33			(83%)					
	3000	1.00	0	0.20	0	0.75	0	0.80	28	52	7	13
2			4000	0.80	3000	0.25	4000	0.20				
	(80%)						(85%)					
	One week trip to UK	1.00	No trip	0.50	No trip	0.90	No trip	0.95	26	52	7	15
3			3 week trip to UK, France & Italy	0.50	One week trip to UK	0.10	3 week trip to UK, France & Italy	0.05				
	(78%)						(67%)					
	0	0.10	0	0.55	0	0.998	0	0.999	23	63	4	10
4	3000	0.90	6000	0.45	3000	0.002	6000	0.001				
	(86%)						(73%)					

Source: Kahneman and Tversky (1979).

The majority choice for each option-pair is given in percentage form in parenthesis below the payoff column, and the choice-pattern of respondents is given in the last four columns of the Table. Majority of respondents chose option A ranging from 78% to 86% from option-pair AA^* and option B^* ranging from 63% to 85% from option-pair BB^*. Majority choice-pattern was AB^* ranging from 52% to 68% in all choice-sets. These results confirmed 'Allais paradox'. In the first two choice-sets, respondents violated the EUH but not the 'mean-variance' criterion. In choice-set 3, the mean-variance criterion cannot be tested because payoffs are in kind, not in monetary terms. However, in choice-set 4, they violated not only the EUH but also the 'mean-

variance' criterion partially. They confirmed the 'mean-variance' criterion in option-pair AA^* but contradicted it in option-pair BB^* as expected payoffs of these options are equal but variance of option B^* is greater.

Furthermore, they tested each option-pair in choice-sets 2 and 4 in Table 2 above against its mirror image having only negative payoffs as shown below in Table 3.

Table 3: Testing of 'Allais Paradox' with Positive and Negative Payoffs (Kahneman & Tversky)

	A		**A***		**B**		**B***		**Choice Pattern (%)**			
	Payoff	**Prob.**	**Payoff**	**Prob.**	**Payoff**	**Prob.**	**Payoff**	**Prob.**	**AB**	**AB***	**A*B**	**A*B***
5	3000	1.00	0	0.20	-3000	1.00	0	0.20	6	74	2	18
			4000	0.80			-4000	0.80				
	(80%)						(92%)					
6	0	0.75	0	0.80	0	0.75	0	0.80	20	15	38	27
	3000	0.25	4000	0.20	-3000	0.25	-4000	0.20				
			(65%)		(58%)							
7	0	0.10	0	0.55	0	0.10	0	0.55	7	79	1	13
	3000	0.90	6000	0.45	-3000	0.90	-6000	0.45				
	(86%)						(92%)					
8	0	0.998	0	0.999	0	0.998	0	0.999	19	8	51	22
	3000	0.002	6000	0.001	-3000	0.002	-6000	0.001				
			(73%)		(70%)							

Source: Kahneman and Tversky (1979).

In this case, a majority of respondents showed an interesting behavior. Whatever option they chose with positive payoffs, they chose exactly the opposite option with negative payoffs. From option-pairs with positive payoffs, AA^* in all these choice-sets, they contradicted the mean-variance criterion only in choice-set 8. However, from option-pairs with negative payoffs, BB^* in all these choice-sets, they contradicted the 'mean-variance' criterion in choice-sets 5 and 7. Therefore, the authors concluded that the certainty effect does not support the conviction of risk aversion. People are rather risk-loving in case of negative payoffs. Hence, in their view, a utility function is convex for negative payoffs and concave for positive payoffs.

While considering option-pairs with negative payoffs at serial number 5 and 6 in table 3 as one Allais-like choice-set and at serial number 7 and 8 as another one, a majority of respondents chose $A^{*}B$, which is totally opposite of their choice-pattern AB^{*} in the case of positive payoffs. Choice-pattern $A^{*}B$ also contradicted the EUH. On the basis of this evidence, the authors concluded, "In the positive domain, the certainty effect contributes to a risk averse preference for a sure gain over a larger gain that is merely probable. In the negative domain, the same effect leads to a risk seeking preference for a loss that is merely probable over a smaller loss that is certain."

Kahneman and Tversky also noted that academia believe in risk-averse attitude mainly due to the fact that a large number of people purchase insurance policies knowing that the premium, which they pay, is significantly greater than the expected actuarial value of loss. They, however, objected this idea with the argument that people often prefer insurance policies that offer limited coverage with low or zero deductibles over those policies that offer maximal coverage with slightly higher deductibles, which contradicts the idea of risk aversion. To put it differently, had people been truly risk averse, a majority of them would have preferred comprehensive insurance policies over minimal ones. To sum up, their study not only verified 'Allais paradox' in many different experiments but it also highlighted some violations of the fundamental mean-variance criterion.

In his survey article, Machina (1987) commented that the EUH had been the most useful theory for choice under uncertainty at least from its axiomatic presentation by von Neumann and Morgenstern (1944) until the finding of 'Allais paradox'. Although 'Allais paradox' initially damaged the EUH, it was later on accepted as an exception to the EUH that manifests, in plain words, certainty effect and, in technical language, either a fanning out of linear indifference lines or the non-linearity of indifference curves in a unitary probability triangle. However, other challenges to the EUH, like the response mode effect and the effect of framing, or the wording of questions on a respondent's choice have discredited the EUH further. That is why the author remarked that the EUH, having been a 'success story' roughly until 1970s, was then turned out a field in flux.

Conlisk (1989) retested Allais questions as such and got same results as Allais did. He also tested modified Allais questions and found evidence favoring the certainty effect against fanning out and non-linearity of indifference curves in a unitary probability triangle. However, in case of

actual payoffs of \$0, \$5 and \$ 25 in lieu of hypothetical ones of \$0, \$1 million and \$5 million with same probabilities as in original Allais questions, a majority of respondents chose options A^* and B^*. That is, a majority of respondents did not violate EUH, but showed a relatively less risk-averse behavior as both the mean and variance of the chosen options were greater than those of the rejected ones. The author, however, was not sure whether the switch over of respondents from more risk-averse to less risk-averse or risk-seeking attitudes was due to the replacement of hypothetical payoffs with real ones or due to the replacement of payoffs in millions to payoffs in numbers. In any case, his experiment with cash payoffs clearly demonstrated that both the certainty effect and risk aversion are not as profound as they appear from the original 'Allais paradox'.

Rabin and Thaler (2001) criticized the EUH strongly on logical grounds. In their view, which is also in line with Arrow's (1971) formal limit result, all utility maximizers at any level of wealth are virtually risk-neutral for small stakes and are risk-averse only for large stakes. However, if small stakes are offered in isolation without highlighting their impact on overall wealth level, then many people show a risk-averse attitude which, in turn, implies an unbelievable risk-averse attitude for large stakes. To illustrate their argument, they supposed that an individual being a risk-averter rejected a 50:50 lose \$10 or gain \$11 gamble. It means that for this person $U(W) - U(W - 10) \geq U(W + 11) - U(W)$. In plain words, he/she valued, on the average, each of the next 11 dollars beyond his/her current wealth at no more than 10/11 of each of his/her current wealth's last 10 dollars. If the same rate of risk aversion continues as the EUH suggests, then by iteration the value of the 900^{th} dollar beyond his/her current wealth should be at most 2 percent of the value of her current wealth's last 10 dollars. This rate of decline in the value of money is simply not possible in real life.

The authors particularly criticized Samuelson (1963), a Nobel laureate in Economics, who had reported another major anomaly of the EUH that one of his colleagues refused to accept a 50:50 lose \$100 or gain \$200 bet when offered to play only once but he showed his willingness to accept 100 such bets if offered all together. Samuelson could not deduce the right implication of this anomaly which the authors did as stated above. Samuelson and many others speculated that his colleague violated the EUH by showing his willingness to accept 100 bets all together. On the contrary, the authors emphasize that his colleague violated the EUH by rejecting the bet when offered to play only once. In their view, had Samuelson offered his colleague

a coin flip bet that would either increase equity in his home by $200 or decrease it by $100, he would likely find this bet more attractive than the bet he was actually offered. They also objected to the EUH because, on one side, it suggests that the utility of winning $10 is less than twice as much as the utility of winning $5 but, on the other side, it suggests that utility of a 10 percent chance of winning $100 is twice as much as the utility of a 5 percent chance of winning $100. Furthermore, they argued that people do not display a consistent coefficient of relative risk aversion; therefore it was a waste of time to measure it.

Levy and Levy (2001) tested only risk aversion because, in their view, there is a lack of consensus on the shape of the utility function. They noted that although a majority of economists believe in risk aversion or the concavity of utility function for all levels of wealth, many renowned economists and psychologists support the convexity of utility function over specified levels of wealth. For example, Friedman and Savage (1948) argued that a typical utility function is concave up to roughly the current level of wealth of an individual and then it becomes convex for additional wealth. Markowitz (1952) claimed that a utility function has two concave and two convex segments. Kahneman and Teversky (1979) concluded that a utility function is convex for loss possibilities and concave for profit opportunities.

Levy and Levy asked their respondents to choose from two different option-pairs. However, only option-pair AA^* of their study as given below in table 4 was meant to test risk aversion.

Table 4: Testing of Risk Aversion (Levy and Levy)

A		**A***	
Payoffs	**Probability**	**Payoffs**	**Probability**
-500	1/4	0	1/2
500	1/4	2000	1/2
1000	1/4		
2000	1/4		
(56%)			

Source: Levy and Levy (2001).

The result was startling in that a majority of respondents (56%) showed risk-loving behavior as they chose option A, which has the same

expected value as option A^* but has greater variance than that of option A^*. Therefore, the authors concluded that many of our economic and finance models which are based on the fundamental assumption of risk aversion need to be re-examined.

It is clear from above discussion that the EUH had been ubiquitously used in economic modeling for a long period because it requires a single parameter, expected utility, and is applicable to evaluate even those competing projects for which the mean-variance criterion is of no help. Even after having found colossal evidence of 'Allais paradox' against the EUH, it is still surviving. One possible reason could be that previous researches mostly focused on the EUH without testing the risk aversion which is the very logic of the EUH. Later on, Levy and Levy (2001) went to the other extreme; they tested risk aversion without testing the EUH. Though their results clearly contradicted risk aversion, they could not challenge the EUH because they did not test it directly. Moreover, the option-pair they asked their respondents to choose from is not representative of reality, as explained in the next section. Therefore, the objective of this study is to perform an experiment regarding the human attitude toward risk through choice-sets which allow the testing of risk aversion and the retesting of 'Allais paradox' simultaneously.

3. Experiment Methodology

This study is different from previous ones in three respects; number of respondents, background of respondents and nature of questions. The number of respondents is 500, which is greater than that of any previous study quoted above. With regard to the background of respondents, in previous studies they were primarily students and teachers. Students and teachers, no doubt, have fresh textbook knowledge of decision-making under uncertainty, but they certainly lack practical experience in this field. Therefore, to have a fair representation from all walks of life in this study, ten categories of respondents were identified; automobile dealers, property dealers, factory managers, shopkeepers, street vendors, money changers, stock brokers, bank officers, graduate students and common people. Initially the plan was to select equal number of respondents from each category. However, it could not be followed strictly due to administrative problems. Despite these problems, respondents of this study had a more diverse background, and a majority of them did not have formal knowledge of the topic, but had some sort of practical experience of decision-making under uncertainty.

All the respondents were approached in commercial areas of the twin cities of Rawalpindi and Islamabad on a 'first contacted, first interviewed' basis, provided that a potential respondent contacted first was willing to answer the questionnaire. The cover page of questionnaire indicated its objective was to test human attitudes toward risk. It was printed in two languages, Urdu and English, and each respondent was allowed to chose the language of his/her choice. Team members assured him/her of the secrecy of the information and its use exclusively for academic purposes. Every respondent was requested to fill in the questionnaire on the spot.

Regarding the nature of questions, four choice-sets, each comprising of two option-pairs and each option-pair comprising of two options, were included as shown below in Table 5. In all questions of this study, it was ensured that the flaws and shortcomings of previous studies were not repeated. For example, to avoid certainty and even certainty-like effect, none of the options in this study included either a probability of one, or a probability of less than 0.1 or greater than 0.9. Also, each competing option in the first 2 choice-sets had both negative and positive payoffs whereas each competing option in the last 2 choice-sets had a zero payoff instead of negative payoffs. Such payoffs are closer to reality than all positive or all negative payoffs as used in many previous studies discussed above.

Payoffs in competing options in Levy and Levy (2001) are also objectionable because one option has negative and positive payoffs whereas the other has zero and positive payoffs as shown in Table 4 above. In our view, both options should have either positive and negative or zero and positive payoffs. The payoffs which they used might have induced loss-averse individuals to reject option A outright without carefully comparing its whole risk and return profile with that of option A^* because to such people losses hurt significantly more than gains give pleasure. They prefer to deposit their money in banks or to buy government bonds and refuse to invest their money in business and stocks even though expected return on the latter have been significantly greater than their risk[7]. Therefore, zero and positive payoffs have not been pitted against negative and positive payoffs in any option-pair of this study.

[7] See Benartzi and Thaler (1995) and Siegel and Thaler (1997) for loss aversion.

Table 5: Simultaneous Testing of 'Allais Paradox' and Risk Aversion

	A		**A***		**B**		**B***		**Choice Pattern (%)**			
	Payoff	**Prob.**	**Payoff**	**Prob.**	**Payoff**	**Prob.**	**Payoff**	**Prob.**	**AB**	**AB***	**A*B**	**A*B***
1	-10	0.167	-10	0.333	-10	0.333	-10	0.667	42	14	20	24
	20	0.667	20	0.333	20	0.667	50	0.333				
	50	0.167	50	0.333								
	(56%)				(62%)							
2	-10	0..167	-10	0.333	-10	0..167	-10	0.333	43	13	14	32
	0	0.500	0	0.500	20	0.333	50	0.167				
	20	0.333	50	0.167	100	0500	100	0.500				
	(56%)				(57%)							
3	0	0.1	0	0.2	0	0.4	0	0.6	31	20	24	25
	10	0. 7	10	0.4	10	0.6	15	0.4				
	15	0.2	15	0.4								
	(51%)				(55%)							
4	0	0.5	0	0.75	0	0.6	0	0.8	43	13	20	24
	5	0.5	10	0.25	5	0.4	10	0.2				
	(56%)				(63%)							

Source: Survey conducted by the author.

Furthermore, all choice-sets of this study are designed in such a way that they allow simultaneous testing of the EUH and risk aversion. To test the EUH, payoffs and their probabilities are set in such a way that the expected utilities of both options in each option-pair of a given choice-set give exactly the same expression on both sides of the inequality as illustrated above in context of 'Allais paradox.' So if the inequality sign that is to be determined on the basis of survey results comes out the same in both inequalities, then it verifies the EUH and if the inequality sign turns out opposite, it confirms 'Allais paradox.' To test risk aversion, payoffs and their probabilities are set in such a way that expected payoffs of both options in each option-pair turn out equal but their variances turn out different. Hence, if majority choice is for the option with lesser variance it confirms risk aversion, otherwise it violates it.

In these choice-sets, choice-pattern AB is in accordance with a concave utility function or risk-averse attitude, choice-pattern A^*B^* is in accordance with a convex utility function or risk-loving attitude and choice-patterns A^*B and AB^* show the mixed attitude, risk-averse as well as risk-loving. According to the EUH, for a risk-averse individual the following inequalities 3 and 4 must be true for option-pairs AA^* and BB^* respectively; for a risk-loving individual the sign '>' in inequalities 3 and 4 must be replaced with the '<' sign; and for the mixed attitude, the sign in inequalities 3 and 4 must be opposite. For illustration, the expected utilities of options A and A^* in choice-set 1 lead to following Inequality 3: -

0.167 U(-10) + 0.667 U(20) + 0.167 U(50) > 0.333 U(-10) + 0.333 U(20) + 0.333 U(50) or0.333 U(20) > 0.167 U(-10) + 0. 167 U(50) Inequality 3

Similarly, the expected utilities of options B and B^* in choice-set 1 lead to the following Inequality 4: -

0.333 U(-10) + 0.667 U(20) > 0.667 U(-10) + 0.333 U(50)

or 0.667 U(20) > 0.333 U(-10) + 0.333 U(50)

dividing both sides of this inequality by 2, we get

0.333 U(20) > 0.167 U(-10) + 0. 167 U(50) Inequality 4

The same pattern emerges for the expected utilities of competing options in other choice-sets.

4. Results and Discussion

The results of this study are quite interesting. Looking at majority choice for each option-pair that is given in percentage form in parentheses below the outcomes in Table 5, it is clear that a majority of respondents ranging from 51% to 56% preferred option A over option A^* and a majority ranging from 55% to 63% preferred option B over option B^* in all choice-sets. Since in each option-pair both options have an equal expected payoff but options AB have smaller variances than those of options A^*B^* respectively, it is concluded that a majority of respondents are risk averse. Although the majority is less than two-thirds in all cases and is closer to break-even point in some cases, the majority choice, at least in terms of percentage figures, supports the long-held paradigm that individuals are predominantly risk-averse.

However, a risk-averse attitude is not confirmed from the choice-pattern of respondents that emerges from their combined choice for both option-pairs in each choice-set as given in the last 4 columns of Table 5. Though the highest percentage of respondents, ranging from 31% to 43%, showed risk-averse behavior consistently in both options of each choice-set, this percentage significantly falls short of the 50% threshold. In other words, the majority choice-pattern apparently verified risk aversion but statistically it did not establish that risk aversion was the predominant behavior of individuals. Moreover, the next highest percentage of respondents, ranging from 24% to 32%, showed risk-loving behavior consistently as they chose both risky options A^*B^* in each choice-set. In economic modeling, where a risk-loving attitude is usually disregarded as irrational or against the norm, this result further weakens the long-held belief that people are consistently risk-averse.

The percentage of respondents who showed the mixed attitude by choosing the riskier option from one option-pair and the less risky option from the other option-pair in each choice-set is also conspicuous. It is highest (20 + 24 = 44) in choice-set 3 and it is not insignificant (less than 27%) in any other choice-set. Logically, the mixed choice-pattern may be used to support both risk aversion and risk-loving attitudes equally. However, theoretically it should be counted_against risk aversion. The reason is that the standard of risk aversion as the norm implies that the majority of people should show a risk-averse attitude not only for each option-pair but also for both option-pairs in each choice-set. If this is accepted, then the percentage of risk-lovers and people showing mixed behavior significantly exceeds that of risk averters. Hence, the conclusion derived on the basis of majority choice above that a majority of people ranging from 51% to 63% are risk-averse is totally reversed if judged on the basis of the majority choice-pattern. The majority choice-pattern ranging from 57% to 69% did not support risk-averse behavior consistently.

In previous studies, two choice-patterns, AB and A^*B^*, were in line with the EUH and the other two choice-patterns, A^*B and AB^*, were against the EUH or in line with 'Allais paradox.' However, in this study, only choice-pattern AB confirms the EUH and all other choice-patterns contradict it. Therefore, choice-pattern AB, with the highest percentage of respondents ranging from 31% to 43%, fails to verify the EUH because the aggregate percentage of respondents ranging from 57% to 69% chose choice-patterns which contradict the EUH. Hence, this result is in line with that of Levy and

Levy that a majority of people are not risk-averse and it also explains the remarks of Rabin and Thaler that people do not display a consistent behavior toward risk.

5. Concluding Remarks

In real life, human attitudes toward risk are mixed. Some people are fond of gambling, lotteries and casinos while others hate these activates and pay money to get insured against uncertainty of future; some people prefer investing in stocks, property and business while others like to deposit their money in banks and buy bonds; some people line up for salaried jobs while some others look for commission-based jobs and self-employment. Even a single person may show opposite behavior at different times and venues. Ignoring such a diversity of human attitude, economists have, however, long accepted that a risk-averse attitude is the norm or rational attitude for decision-making under uncertainty.

There are two main criteria based on risk aversion, mean-variance and the EUH, to evaluate competing investment projects or games of chance. The merits of the mean-variance criterion are that it reflects risk explicitly and does not require decision-makers to think of any utility function. Its demerits are that it requires two parameters, mean and variance, for each of the projects or games under consideration and it is not applicable if both the mean and variance of one project or game are greater than those of the other. On the contrary, the merits of the mean-variance criterion are the demerits of the EUH and the demerits of the former are the merits of the latter. In any event, the EUH has been used more extensively in economic theorizing than the mean-variance criterion.

The EUH continued to be the dominant theory even after the discovery of 'Allais paradox' which, based upon an experimental survey, pointed out a systematic violation of the EUH. Many studies reexamined this paradox and found similar results. One possible reason for 'Allais paradox' not having deleterious effect on the EUH as expected initially seems to be that Allais himself as well as most of the subsequent researchers on the topic concentrated on the EUH and neglected risk aversion. That is, they included questions in experimental surveys which were useful to verify or nullify the EUH but were not helpful in testing risk aversion. On the other extreme, a few studies tested only risk aversion without testing the EUH. This study, therefore, took up the task of testing both the EUH and risk aversion simultaneously. For this purpose, questions were framed carefully. Two

option-pairs were included in each Allais-like choice-set. However, unlike previous studies, the expected payoffs of both options in each option-pair were set to be equal, and their variances were set to be different which facilitated the testing of risk aversion and the EUH simultaneously. Respondents were selected from diverse backgrounds. Most of the respondents had some sort of practical experience of decision-making under uncertainty.

While compiling the results, the majority choice in each option-pair was used to test risk aversion and the majority choice-pattern for both option-pairs in each choice-set was used to test 'Allais paradox.' The results of this study are quite revealing. A simple majority of respondents, not a resounding one, showed risk-averse behavior in each of the total eight option-pairs included in this study. This result verifies the fundamental idea of risk aversion. Their choice-pattern in two option-pairs of each choice-set apparently verifies the EUH because the highest percentage chose options A and B which reflects a consistently risk-averse behavior. However, the next highest percentage of respondents chose options A^* and B^* in each choice-set which reflects a consistently risk-loving behavior. Also, a significant percentage of respondents showed a risk-averse attitude in one option-pair and a risk-loving attitude in the other. Since risk-loving and mixed attitudes contradict risk-averse behavior, their percentages may be summed up. Consequently the aggregated percentage exceeds the percentage of risk-averse respondents. Hence, the above conclusion drawn on the basis of the majority choice for each option-pair and on the basis of the choice-pattern of the highest percentage of respondents for both option-pairs of each choice-set is reversed. That is, a majority of respondents did not show risk-averse behavior consistently.

An important implication of this research is that due to evidence against risk aversion in this study and in previous studies, it should not be treated as the only norm or exclusive behavior of decision-makers under uncertainty; it can be used at best as a good working assumption for choice under uncertainty, as perfect competition is assumed in commodity markets. Economists should rather attempt to develop decision-making criteria which takes into account mixed and risk-loving behaviors as well as they did with monopolistic competition and other imperfections in commodity markets.

References

Allais, M. (1953). Le Comportement de l'Homme Rationnel devant le Risque, Critique des Postulats et Axioms de l'Ecole Americaine. *Econometrica,* 21: 503-546.

Arrow, K. (1971). *Essays in the Theory of Risk Bearing.* Amsterdam, the Netherlands: North-Holland.

Benartzi, S., & Thaler, R. H. (1995). Myopic Loss Aversion and the Equity Premium Puzzle. *Quarterly Journal of Economics,* 110: 75-92.

Conlisk, J. (1989). Three Variants on the Allais Example. *American Economic Review,* 79 (3): 392-407.

Friedman, M., & Savage, L. (1948). The Utility Analysis of Choices Involving Risk. *Journal of Political Economy,* 56: 279-304.

Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica,* 47: 263-291.

Levy, M., & Levy, H. (2001). Testing for Risk Aversion: A Stochastic Dominance Approach. *Economics Letters*, 71: 233-240.

Machina, M. J. (2008). Expected Utility Hypothesis. *The New Palgrave Dictionary of Economics,* New York, NY: MacMillan.

Machina, M. J. (1987). Choice under Uncertainty: Problems Solved and Unsolved. *Economic Perspectives,* 11: 121-154.

Markowitz, H. (1952). The Utility of Wealth. *Journal of Political Economy,* 60: 151-156.

Rabin, M., & Thaler, R. H. (2001). Anomalies: Risk Aversion. *Journal of Economic Perspective,* 15: 219-232.

Samuelson, P. (1963). Risk and Uncertainty: A Fallacy of Large Numbers. *Scientia,* 98: 108-113.

Siegael, J. J., & Thaler, R. H. (1997). Anomalies: The Equity Premium Puzzle. *Journal of Economic Perspective,* 11: 191-200.

Von Neumann, J., & Morgenstern, O. (1944). *Theories of Games and Economic Behavior*. Princeton, NJ: Princeton University Press.