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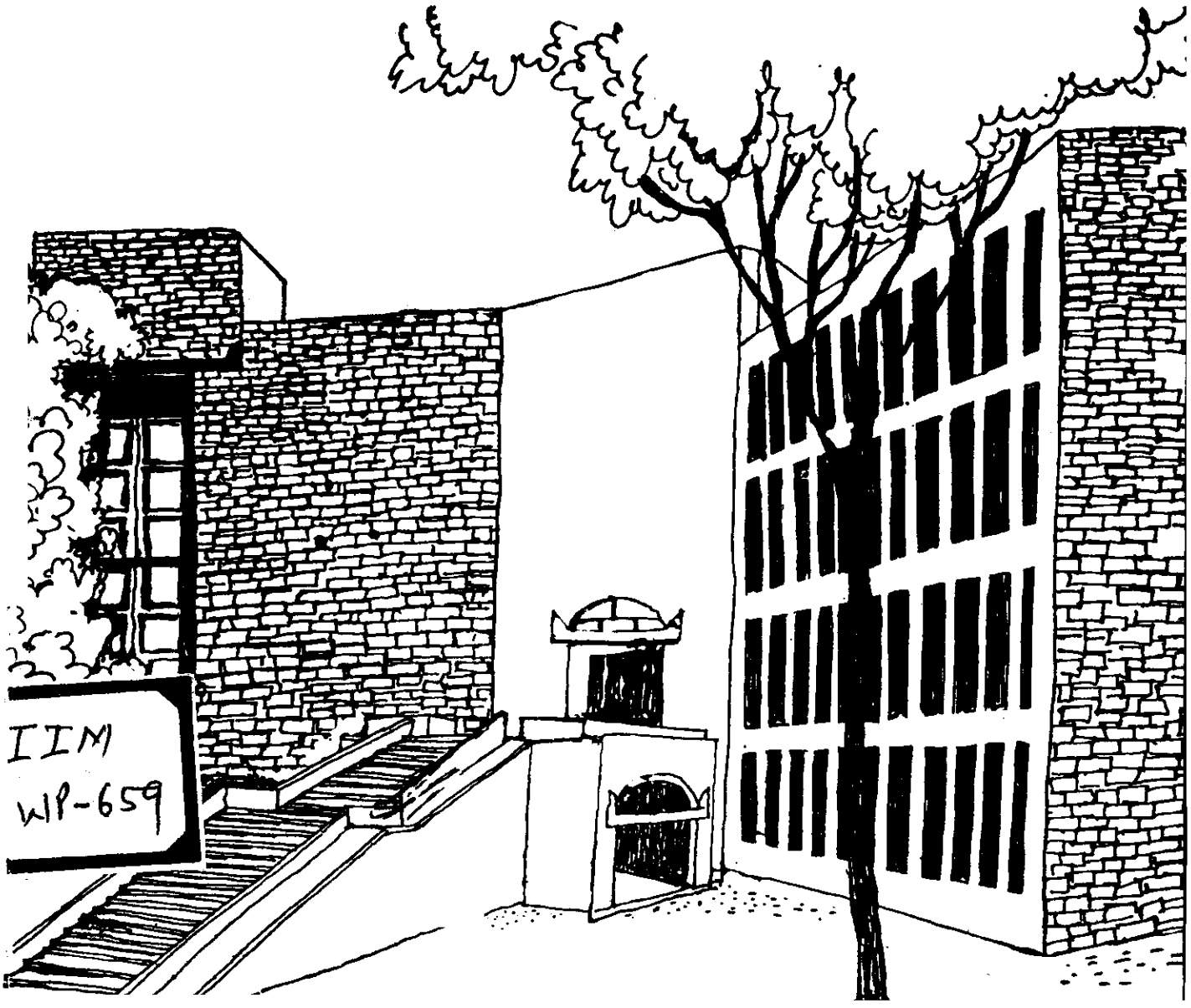

THE DECISION PROCESS OF INDIVIDUALS UNDER CONDITIONS OF RISK: AN EXPERIMENTAL STUDY

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Abstract

Theoretical models in finance are many a time based on unrealistic assumptions about the behaviour of individuals. Empirical validation of the models is expected to vindicate the assumptions. However, in most situations, the approaches used for empirical validations suffer from serious limitations, either because of the nature of data used or because of the testing procedures used. Hence, the doubts about the underlying assumptions on individual behaviour remain unresolved. In this paper, an attempt has been made to study some common beliefs about behaviour of individuals in risky situations, through a controlled experiment. The results indicate that some oft-believed behavioural traits are indeed true, and the theories based on assumptions which are counter to these beliefs, need to be reconsidered .

THE DECISION PROCESS OF INDIVIDUALS UNDER CONDITIONS OF RISK : AN EXPERIMENTAL STUDY

INTRODUCTION

The normative theories explaining the choice of risky assets for investment are based on certain behavioural assumptions about individuals. The work of Markowitz (1959), Sharpe (1964), Lintner (1965), Mossin (1966) and others on portfolio theory assumes that the risk perception of individuals can be characterized by the variance of return on an asset. Their work led to the development of the capital asset pricing model based on the mean-variance framework. There have however been persistent doubts about this notion of risk perception. One way of testing this important assumption would be to investigate the empirical validity of the model itself - if the model is validated, the assumption on risk perception of individuals may also be accepted. There are however several pitfalls in testing the model directly. Roll (1977) has written an excellent critique of the attempts to empirically validate the model. Another method of testing the validity of the assumption would be through direct observations on the process of choice in risky situations through controlled experiments. This was the method adopted in this study to investigate the decision process of individuals in risky situations. Commonly held beliefs about behaviour of individuals in uncertain conditions were used for formulating the hypotheses. The implications of rejecting/accepting these hypotheses for theory of finance, other than portfolio theory have also been discussed in the paper.

THE HYPOTHESES

The mean-variance framework is possibly the most famous theoretical construct available for explaining the choice of risky assets by individuals. This assumes that individuals give the same weight to gains and losses. This assumption goes against the general belief that losses loom larger than gains. This belief has been used by Shefrin and Statman (1984) to explain why a cut in dividends would have a greater impact on market price of a scrip than an identical increase in dividends. Even Markowitz, when he proposed the mean-variance framework, had this notion at the back of his mind. He had suggested that use of semi-variance (variance below the mean) might be more appropriate for portfolio decisions. The above discussion implies that if losses indeed weighed more heavily than gains in the minds of investors, they would show a marked preference for positive skewness. To observe whether this preference was reflected in the decisions of the participants in the experiment, the following hypothesis was formulated :

Hypothesis 1 : There is no significant preference for skewness dominating opportunities among individuals.

In experiments involving risky situations, the outcomes are generated according to some specified probability distributions by using random numbers. The outcomes are thus independent from one trial to another. This notion of statistical independence is not believed by most individuals. Somehow, even those who are exposed to probability theory find it difficult to accept in practice that the chance of "heads" on the

sixth toss of a fair coin continues to be one-half (and not more) even if the first five tosses have resulted in "tails". This lack of belief in the independence of outcomes from one period to another would imply that the tendency to continue investing in a risky asset would be more pronounced if the outcome of the preceding trial was adverse rather than favourable. The hypothesis to test the above may be stated as follows :

Hypothesis 2 : The nature of outcome from investing in an opportunity has no impact on the chance of continuing investment in the same opportunity in the very next period .

Another way of examining the cautious behaviour of individuals would be by analysing the leverage they opt for while taking investment decisions. The Modigliani- Miller theory on cost of capital, proposed in 1958, is based on the assumption that equity holders expect a linear compensation in terms of expected return with increasing leverage. This assumption has been seriously questioned because it is strongly felt that the compensation required would increase at an increasing rate with leverage, especailly at higher values of leverage . If this is indeed true,in terms of individual behaviour,this would be reflected in the form of preference for low values of leverage as the experiment provides only a linear compensation. The statement of the resulting hypothesis would be :

Hypothesis 3 : There is no marked preference for low leverage among the individuals.

The adage 'once bitten twice shy', captures a well accepted belief about human behaviour. If this is true, then an individual is likely to be far more cautious immediately after an adverse outcome than after a favourable outcome. This caution on the part of individuals would be reflected in a greater preference for positive skewness immediately after an adverse outcome, as they would like to 'play it safe'. This gave rise to the last hypothesis :

Hypothesis 4 : The preference for skewness is not dependent on whether an individual met with a success or a failure in the investment opportunity chosen in the immediately preceding period .

THE EXPERIMENT

To test the above hypotheses, data was generated through an experiment conducted on a set of fifteen post-graduate students in business management who had a fair exposure to portfolio theory. Each participant in the experiment was given an initial wealth and a constant periodic income received at the beginning of a period. A participant could augment his resources (subject to some conditions described later) through borrowing. In each period he had to decide on the following:

a. Outlay on consumption

b. Outlay on investment

c. Amount to be borrowed

It is obvious that in every period the sum of the outlays on consumption and investment would equal the sum of initial wealth, the periodic income and the borrowing . Starvation and bankruptcy were not allowed and hence the participants had to observe the following constraints on consumption and borrowing.

a. They had to maintain a minimum consumption level of Rs.1000/- in each period . Higher outlay on consumption would imply a better life-style. They were free to choose any life-style permitted by their wealth and income levels.

b. They could invest in at most one investment opportunity out of six alternatives (described in Table 1) available in each period . They could lend any excess funds at the rate of 5% .

c. They were allowed to borrow at the rate of 10% subject to a ceiling determined by the amount which could be repaid even if the outcome of the investment opportunity chosen turned out to be adverse.

The participants did not know in advance the number of periods for which the experiment was to be conducted . During the experiment they were required to maintain two distinct records : (i) a main record containing a continuous account of their decisions and outcomes, and (ii) a separate record of their decisions for each period which was collected from them before the announcement of the outcome of the investment opportunity for the period . The outcomes of these opportunities for each

period were generated according to the probability distributions specified . Based on the outcomes, they computed their final wealth , net of loan and interest payable on the loan. This together with the periodic income became the starting resource for the next period . The data provided on the separate record were used to verify the computations done on the main record . The experiment was conducted for fifteen periods.

TABLE 1 HERE

THE OBSERVED BEHAVIOUR

The four hypotheses formulated in the preceding section were tested using appropriate statistical testing procedures. The details of these tests and the inferences drawn from testing are described in this section .

Testing Hypothesis 1

Using portfolio dominance rules * the choices made by the individuals were classified into three categories: consistent with mean-variance framework, consistent with preference for positive skewness and consistent with neither . This categorical data for the fifteen participants in the experiment was used to test the following hypothesis :

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* A detailed discussion of the portfolio dominance rules and the resultant classification of the choices made is reported in Barua and Srinivasan (1987) .

H_0 : $\pi 1 \leq 1/3$

H_1 : $\pi 1 > 1/3$

Where $\pi 1$ is the proportion of choices consistent with preference for positive skewness .

The aggregate data revealed that 122 choices out of 225 were consistent with preference for skewness. Using the Binomial test, H_0 was rejected at a very low level of significance ($\alpha = .01$). Thus on an aggregate basis ,there was a distinct preference for skewness .

The Binomial probability of realizing the observed or a more extreme outcome under H_0 was computed separately for each individual . In eight out of fifteen cases , H_0 was rejected at $\alpha = 0.01$. In another case , H_0 was rejected at about $\alpha = 0.20$. There was thus a reasonable evidence at the individual level that the investors showed a preference for skewness .

Testing Hypothesis 2

The data on how many times each participant continued choosing the same opportunity after a favourable or an adverse outcome was compiled for all the individuals to test the hypothysis which may be specified as follows :

H_0 : $\pi 2f = \pi 2s = \pi 2$

H_1 : $\pi 2f > \pi 2s$

Where $\pi 2f$ is the probability of choosing the same option after an adverse outcome (a failure)

$\pi 2s$ is the probability of choosing the same option after a favourable outcome (a success)

The contingency table for the aggregate data turned out to be:

	After Success	After Failure	
Continued	42	70	112
Changed	64	34	98
	106	104	

The computed value of χ^2 was 16.18 and H_0 was rejected for the aggregate data at $\alpha = 0.001$. The outcome in any period had a significant impact on the decision to continue investing in the same opportunity in the next period. The chance of continuing with the same opportunity was higher after an adverse outcome.

Each individual has a certain propensity to continue investing in the same opportunity. Given this basic tendency, does the individual show significantly different propensities, depending or the nature of outcome ? To answer this question, a different method of testing, designed from first principles, was used. The method is described below:

Let , p_f : the proportion of cases where participants continued to invest in the same opportunity after a failure

p_s : the proportion of cases where participants continued to invest in the same opportunity after a success

p : the proportion of cases where participants continued to invest in the same opportunity

n_f : the total number of failures

n_s : the total number of successes

The proportion p is the most likelihood estimate of $\pi 2$. Under H_0 therefore, p_f would follow a Binomial distribution with parameters n_f and p_s, and p_s would follow a Binomial distribution with parameters n_s and p_s. These two distributions were used to generate the empirical distributions for $(p_f - p_s)$ for each individual. Under H_0, $(p_f - p_s)$ should be zero. The probability of realizing the observed difference or a higher value was computed for each individual. The rejection of H_0 at various levels of α are summarized below:

Significance level, α	No. of cases where H_0 was rejected
0.01	4
0.05	6
0.10	7
0.15	9
0.25	10

Since in ten out of fifteen cases, H_0 was rejected, the results provided a strong evidence that the chance of continuing investing in the same opportunity was higher after an adverse outcome.

Testing Hypothesis 3

To test this hypothesis, the scale of play for every period was computed for all the individuals. The scale of play is the ratio between the amount of money invested in risky asset and the amount of money available for investment after deducting the

outlay on consumption. Since the limit on the borrowing was decided by the opportunity chosen for investment, so as to eliminate the possibility of bankruptcy, a slight modification in computations was necessary to capture an individual's willingness to borrow. The scale of play chosen by an individual was expressed as a proportion of the maximum scale of play permissible for the opportunity chosen * . This proportion represented the extent of utilization of the borrowing capacity . The average utilization of the borrowing capacity by each individual and the distribution of utilization of the capacity are presented in Exhibit 1 . It is quite apparent from the exhibit that most individuals showed a very low utilization of the borrowing capacity . On an aggregate basis, in nearly three-fourths of the cases, the utilization was below 0.50 . There was thus a marked preference for low scale of play or leverage, compared to what was permissible in the situation. The null hypothesis was thus rejected.

Testing Hypothesis 4

The data on the number of times participants' choice was according to skewness criterion after a success or a failure was compiled to test the hypothesis which may be specified as follows:

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* As mentioned while describing the experiment, the maximum amount that could be borrowed was such that it could be repaid with interest even if the outcome of the investment turned out to be adverse.

H_0 : $\pi 4f = \pi 4s = \pi 4$

H_1 : $\pi 4f > \pi 4s$

Where $\pi 4f$ is the probability of choice based on skewness preference after an adverse outcome (failure)

$\pi 4s$ is the probability of choice based on skewness preference after a favourable outcome (success)

The contingency table for the aggregate data turned out to be :

	After Success	After Failure	
Skewness Criterion	44	74	118
Other Criteria	62	30	92
	106	104	

The computed value of χ^2 was 20.75 and H_0 was rejected for aggregate data even at $\alpha = .001$. There was thus a significant impact of outcome of an investment opportunity on the criterion for choice for the very next period. The preference for skewness was significantly higher after an adverse outcome than after a favourable outcome.

The testing procedure at the individual level was identical to the procedure used for the second hypothesis. The probability of realizing the observed or a higher difference in proportions was computed separately for each individual. One participant did not use skewness criterion in any period, while another participant used skewness criterion in every period. The rejection of H_0 at various levels of α are summarized below :

Significance level , α	No. of cases where H_0 was rejected
0.01	1
0.05	4
0.15	8

Since in 8 out of 13 valid cases, H_0 was rejected, there was a strong evidence of a marked preference for skewness after an adverse outcome .

CONCLUSIONS

The analyses of data revealed the following features of the individual decision process under risky situations: a) individuals tried to minimize the maximum loss that might result from their choice, b) the choices were strongly influenced by the outcome of the immediately preceding decision, and c) at higher risk levels, a mere linear compensation in terms of expected return for every unit of additional risk, was inadequate. These observations clearly demonstrated that the single period, two-parameter model might be inadequate to explain the choice of portfolio by individuals. Any alternate model should be multi-period and must recognise the importance of skewness and the fact that individuals tend to be affected by outcomes of their decisions, implicitly revising the probabilities associated with the outcomes. Some lessons are also available for theory of corporate finance. Given the apparent inadequancy of linear compensation for risk, theories on cost of capital based on linear relationship between risk and return need to be reconsidered . The observed behaviour also lent support to the recent behavioural arguments advanced to expalin the preference for cash dividends.

TABLE 1

Investment Opportunities

Opportunity	Outcomes			
No.	Return r1	Probability p1	Return r2	Probability p2
1	1.50	0.50	0.80	0.50
2	1.35	0.67	0.90	0.33
3	1.72	0.25	0.96	0.75
4	1.38	0.83	0.60	0.17
5	1.28	0.75	0.76	0.25
6	90.00	0.01	0.00	0.99

EXHIBIT 1

Utilization of Borrowing Capacity

Data	Aggregate Data			
Utilization of Borrowing Capacity	Borrowing Capacity	Frequency	Relative Frequency	Cumulativ Relative Frequency
0.480	0 to <= .1	24	0.107	0.107
0.368	.1 to <= .2	77	0.342	0.449
0.290	.2 to <= .3	27	0.120	0.569
0.551	.3 to <= .4	22	0.098	0.667
0.190	.4 to <= .5	18	0.080	0.747
0.148	.5 to <= .6	13	0.058	0.805
0.527	.6 to <= .7	10	0.044	0.849
0.196	.7 to <= .8	5	0.022	0.871
0.474	.8 to <= .9	14	0.062	0.933
0.505	.9 to<= 1.0	15	0.067	1.000
0.125		225		
0.687				
0.160				
0.390				
0.207				

REFERENCES

1. Barua, S.K. and Srinivasan, G. "Investigation of Decision Criteria for Investment in Risky Assets", Forthcoming Omega , May 1987 .

2. Lintner, J. "Security Prices, Risk and Maximal Gains from Diversification", The Journal of Finance, Dec.1965, pp 587-616

3. Markowitz,H.M. "Portfolio Selection : Efficient Diversification of Investment", Cowles Foundation Monograph, No.16, New York, 1959

4. Miller, M.H.and Modigliani, F. "The Cost of Capital, Corporate Finance and The Theory of Investment", American Economic Review, June 1958

5. Mossin, J. "Equilibrium in Capital Asset Market", Econometrica, October 1966, pp 768-783

6. Roll, R. "A Critique of the Asset Pricing Theory's Tests", Journal of Financial Economics, March 1977, 4, pp 129-76

7. Sharpe, W. "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk", Journal of Finance, Sept.1964, 19, pp 425-42

8. Shefrin, H.M. and Statman, M. "Explaining Investor Preference for Cash Dividends", Journal of Financial Economics,13(2),June 1984