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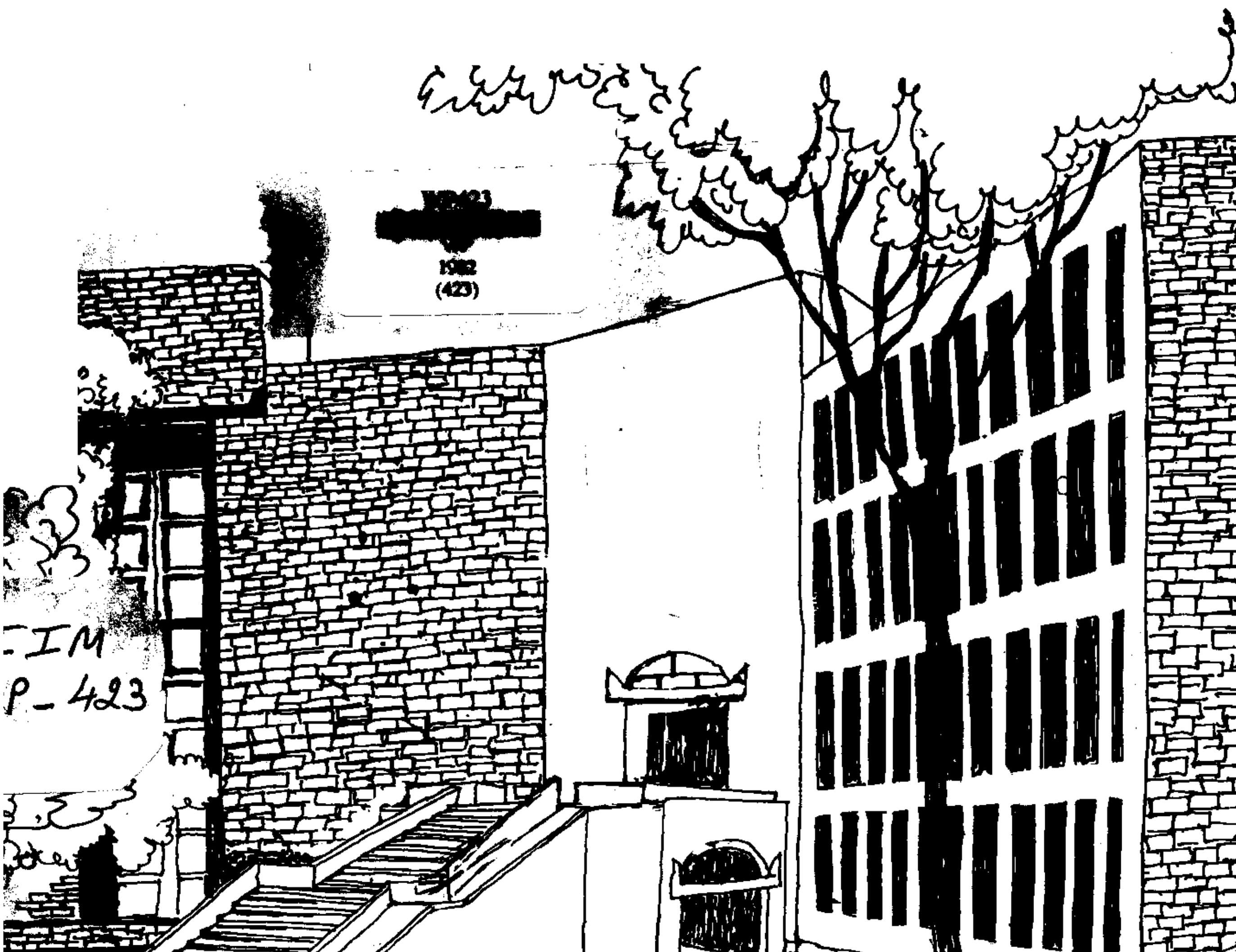

EXPERIMENT ON INDIVIDUAL INVESTMENT DECISION MAKING PROCESS

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Introduction

The pioneering work on individual investment decision making was done by Harry Markowitz(1959). He suggested a method of efficient allocation of funds to a set of risky assets using a mean-variance framework. Subsequently Sharpe(1964), Lintner(1965) and Mossin(1966) developed market equilibrium model for a set of risky assets and one riskless asset. Mossin showed that the results obtained by using mean-variance approach are identical to those obtained under the assumption that investors use quadratic utility function for deciding the composition of their portfolios. There is a lack of empirical evidence though on assumptions underlying this theory on investor behaviour.

Gordon et al (1972) conducted an experiment on a set of students to conjecture about the utility function used by investors. The students participated in an investment game where each student starting with certain initial endowment made a series of single period consumption and investment decisions. The data generated from the experiment was then examined to find out whether their investment decisions corresponded to some well known forms (quadratic, logarithmic and power) of utility functions. They inferred that the data did not support the hypothesis that investors follow any one of the above mentioned utility functions.

Cooley(1977) investigated through an experiment the determinants of the risk perception of investors. In his experiment each investor was required to rank a set of return distributions in order of preference. These distributions had different second, third and fourth moments; the first moment was the same for all distributions. Analysing the preference data thus generated, Cooley concluded that the third and the fourth moments in addition to the second influenced the risk perception of investors. Thus the assumption that risk is completely defined by the variance of return on an asset may not be entirely correct.

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The two experiments described above threw considerable light on actual behaviour of investors. The experiments conducted though suffered from certain limitations. In the experiment used by Gordon et al, the distributions of returns on risky assets were symmetric hence the impact of the third moment on the process of choice could not be investigated. The participants were given an initial wealth without any periodic income. Introduction of periodic income would have been more realistic. Similarly by assuming zero interest rates for both lending and borrowing they introduced an avoidable 'unreality' in the experiment. Cooley's experiment suffered from the fact that the investors were not required to choose a portfolio. This absence of explicit choice of portfolio may introduce some aberrations in the data generated.

The experiment described in this paper attempts to overcome the drawbacks described above. Through the experiment, the following issues were investigated:

a) Whether the investor behaviour conforms to standard utility functions when the lending and borrowing rates are different.

b) Whether the choice of risky asset for a portfolio is influenced by moments higher than the second moment.

<u>The experiment</u>

The experiment was administered to 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. Every period the participants had to decide on the following:

a) Outlay on consumption
b) Outlay on investment
c) Amount to be borrowed.

It is obvious that the sum of the outlays on consumption and investment would equal the sum of initial wealth, the periodic income and the borrowing in a period. Starvation and bankruptcy were taboos in the experiment, 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 level.

b) The participants could invest in at most one investment opportunity out of six opportunities (described in the next section) in each period. They could lend at a rate of 5% any excess funds after deciding the outlay on consumption and investment.

c) The participants were allowed to borrow at a rate of 10% upto a limit which was determined by the amount that could be repaid even if the outcome of the investment decision turned out to be adverse.

The participants were required to record their decisions for every period at two different places: (i) on a main sheet where they maintained a continuous record of their decisions and outcomes, and (ii) on a separate slip for each period which was collected from them before the announcement of the outcome of the investment opportunity (either favourable or adverse). The outcomes of these opportunities for each period were generated according to the probability distributions specifed for the opportunities. Based on the outcomes, they computed their final wealth, net of loan and interest payable on the loan. This together with the income for the next period became the starting resource for the next period. The data provided on the separate slips was used to verify the computations done on the main sheet.

The participants had to make a series of one period decisions with no idea about how long the experiment would continue. The experiment was conducted for fifteen periods.

The Opportunities

The data on the investment opportunities available to the participants is described in Table 1.

TABLE - 1

Investment Opportunities

S.No.	Outcomes			
	Return(r_1)	Probability(p_1)	Return(r_2)	Probability(p_2)
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

Investment opportunities one, three, and five have identical expected values. The variance associated with the fifth option is the lowest. Thus under mean-variance framework opportunity five dominates opportunities one and three. The sixth opportunity has an expected value which is less than sure return available from lending. The opportunity was included to find out as to when investors opt for unfair lottery. Thus the choice set under mean-variance framework reduced to opportunities two, four, and five. The actual choice will be decided by the risk preference characteristics of an individual.

The Choices

To gain insight into the process of choice the wealth levels were classified into six categories. The observed frequency of choice of the different investment opportunities for these categories are presented in Table 2.

TABLE – 2

Wealth Class and Frequency of Choice

Wealth Class	Opportunity						Total
	1	2	3	4	5	6	
$0 < w \leq 100$	4	19	57	26	10	12	128
$100 < w \leq 200$	1	13	23	6	5	2	50
$200 < w \leq 300$	0	8	14	1	1	0	24
$300 < w \leq 400$	2	2	1	1	0	0	6
$400 < w \leq 500$	1	3	0	1	1	0	6
$w > 500$	1	5	3	2	0	0	11
Total	9	50	98	37	17	14	225

Note: The wealth level has been specified in Rs.'000s.

It is apparent that opportunity 6, an unfair lottery, is chosen when the wealth level is low. This is consistent with the general belief that at lower wealth levels an individual may show a preference for risk by investing in a highly skewed unfair gamble in an attempt to jump to higher wealth levels.

As mentioned earlier, from among opportunities 1,3, and 5 only the fifth opportunity should be chosen if the investors use a mean-variance framework. The observed behaviour in fact shows that not only are all the three opportunities chosen but there is also a marked preference for opportunity three instead of five. This warrants a search for alternate criteria for the process of choice. A closer look into the parameters of return distributions could be rewarding.

TABLE - 3

The Parameters of Distributions

Opportunity	Mean	Variance Below Mean	Variance Above Mean	Variance Total	Skewness
1	1.15	0.0612	0.612	0.1225	0.0000
2	1.20	0.0490	0.0150	0.0640	-0.0068
3	1.15	0.0271	0.0812	0.1083	0.0412
4	1.25	0.0705	0.0140	0.0845	-0.0439
5	1.15	0.0380	0.0127	0.0507	-0.0132

It can be observed that though opportunity three has a high variance compared to five, substantial variability is located above the mean. It is reasonable to believe that variability above the mean is in fact preferred. This essentially implies that the semi-variance below the mean alone may be traded off with expected return. But had this been the only criterion for choice, option one would never have been preferred over five. If skewness is also one of the factors considered by the participants then the simultaneous choice of options one and five can be explained. However, option three dominates both one and five on these criteria. Hence combination of variance below mean and skewness too cannot explain the observed behaviour completely. A possible explanation for the observed choice pattern may lie in a criterion based on total variance and skewness. Only under such a criterion no single opportunity would dominate the rest.

The above observations make one suspect that the quadratic form of utility function which is consistent with a mean-variance framework may not be able to explain the choice pattern. The following sections explore the empirical validity of alternate utility functions.

The Hypotheses

It is assumed that investors attempt to maximize the expected utility of wealth. The form of the utility function that governs their choice would determine the composition of their portfolios. The relationships between the optimal amount invested in risky asset and wealth for quadratic, logarithmic, and power functions have been derived in the Appendix. The empirical validity can be examined through regression estimate of the following kind of specification:

$$\frac{G}{Q} = b_0 + b_1 W + e$$

where G is amount invested in risky asset

W is the wealth available for investment

Q is a constant which differs across utility functions, and across interest rates in case of quadratic utility function.

If the investor behaviour is governed by quadratic utility function, the hypotheses would be,

$$b_0 < 0$$

and $b_1 = -1.05$ for lending portfolio

$= -1.10$ for borrowing portfolio,

that is, the estimated value for the whole set will be between the two values specified above.

The null hypotheses in case of both logarithmic and power functions would be,

$$b_0 = 0$$

and $b_1 = 1$

The Results

The estimated values of the regression coefficients for different utility functions are presented in Table 4.

TABLE – 4

Regression Results

S.No.	Utility Function	b_0	b_1	R^2
1	Quadratic	-121,83 (209.93)	20.12 (0.68)	0.83
2	Logarithmic	90.73 (31.18)	0.95 (0.10)	0.34
3	Power			
	δ = 0.10	130.07 (45.73)	1.17 (0.15)	0.27
	δ = 0.50	-214.28 (80.08)	1.47 (0.26)	0.16
	δ = 0.90	-38.58 (11.78)	-0.58 (0.04)	0.57

Note: (i) The figures in parantheses are standard errors of estimates

(ii) The estimates are based on one hundred and seventy-three observations. All observations which had no investment in risk-less asset or where the risky asset chosen was opportunity six were omitted.

The coefficients of determination for the quadratic form of utility function is fairly high but the estimated values of the coefficients donot support the null hypotheses. Hence the quadratic form of utility function cannot be accepted. The power function for high values of delta (.5 and .9) is unacceptable because the hypothesis on the second coefficient (b_1=1) is rejected.

The logarithmic, which is a special case of power function (δ=0) and the form of power function with δ=.10 appear interesting. In both cases the hypothesis on b_1 is acceptable. The hypothesis on b_0 though is rejected in both cases. This suggests that the adjusted logarithmic and power functions of the following kind could explain the investment behaviour of the participants.

$$U(W) = l_n(W+K) \quad \text{adjusted logarithmic}$$

$$U(W) = (W+K)^{.10} \quad \text{adjusted power}$$

where U is the utility
W is the wealth level
K is a constant

If these adjusted forms are used then the hypotheses would be as follows:

$$b_o \neq 0$$
$$b_1 = 1$$

These hypotheses are acceptable from the estimated values of b_o and b_1 for the adjusted forms of utility functions mentioned above.

In Summary

The inquiry into the investment behaviour of individuals through experimental data provided a good insight. The importance of combination of variance and skewness in determining the risk perception of individuals was suggested by the analysis of data generated. The influence of skewness on the decision process implies that investors may be interested in minimizing maximum loss.

The behaviour of the participants is well explained by the adjusted logarithmic and adjusted power functions with low values of the coefficient of power. The rejection of quadratic utility function was consistant with the evidence that higher moments also played a role in the decision making process of individuals.

Though validation of the results through repeated experiments is equirec before drawing broad generalisations. The results were quite ignificant. The fundamental assumptions about the objective of and riterion used by investor has to be looked into more carefully in leveloping alternate theories.

APPENDIX

List of Variables

- W : the initial wealth available for investment
- G : the amount invested in risky asset
- r : the fixed rate of return
- R_j : the rate of return on j^{th} risky asset
- Y : the final wealth
- U : the utility function
- E : the expectation operator

Quadratic Utility Function

$$Y = rW + G(R_j - r)$$

$$U(Y) = Y + \frac{\alpha}{2} Y^2$$

$$E(U) = \sum_{j=1}^{2} p_j \left[U\left(rW + G(R_j - r)\right)\right]$$

Maximizing E(U) with respect to G,

$$E'(U) = (\bar{R}-r) + \alpha rW(\bar{R}-r) + \alpha G \left[p_1 (R_1 - r)^2 + p_2 (R_2 - r\right.$$

Hence the optimal value of G,

$$G^* = -\frac{1}{\alpha V}(\bar{R}.r) - \frac{(\bar{R}-r)}{V} rW$$

where $V = E(R_j - r)^2$

Putting $Q = \frac{\bar{R}-r}{V}$ in the above expression,

$$\frac{G^*}{Q} = -\frac{1}{\alpha} - rW$$

Logarithmic Utility Function

$$Y = rW + G(R_j - r)$$
$$U(Y) = \ln Y$$

$$E(U) = \sum_{j=1}^{2} p_j \ln \left[rW + G(R_j - r) \right]$$

Maximizing E(U) with respect to G,

$$E'(U) = p_1 \frac{(R_1 - r)}{rW + G(R_1 - r)} + p_2 \frac{(R_2 - r)}{rW + G(R_2 - r)} = 0$$

Hence the optimal value of G,

$$G^* = \frac{(r - \bar{R})r \quad W}{(R_1 - r)(R_2 - r)}$$

Putting $Q = \dfrac{(r - \bar{R})r}{(R_1 - r)(R_2 - r)}$ in the above expression,

$$\frac{G^*}{Q} = W$$

Power Utility Function

$$Y = rW + G(R_j - r)$$
$$U(Y) = Y^{\delta}$$

where $0 < \delta < 1$

$$E(U) = \sum_{j=1}^{2} p_j W_j^{\delta}$$

Maximizing E(U) with respect to G,

$$E'(U) = p_1 \frac{(R_1 - r)}{\left[r(W-G) + GR_1\right]^{1-\delta}} + p_2 \frac{(R_2 - r)}{\left[r(W-G) + GR_2\right]^{1-\delta}} = 0$$

or $$\frac{r(W-G) + GR_2}{r(W-G) + GR_1} = \left[-p_2(R_2-r)/p_1(R_1-r)\right]^{1/(1-\delta)}$$

putting $-p_2(R_2-r)/p_1(R_1-r)^{1/(1-\delta)} = C,$

$$G^* = \frac{r(C-1)}{(R_2-r)-C(R_1-r)} W$$

utting $Q = \dfrac{r(C-1)}{(R_2-r)-C(R_1-r)}$,

$$\frac{G^*}{Q} = W$$

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