ASSESSING THE RELEVANCE OF SHARPE SINGLE INDEX MODEL IN CONSTRUCTING AN OPTIMAL PORTFOLIO: A STUDY ON SELECTED SECURITIES

Abstract

Modern age has drastically increased the desires of people compared to their income. To fulfil these desires, they are more interested to invest in stock markets. In this study the focus is mainly on how to select the best securities to make an optimal portfolio. For this reason twenty best Auto and FMCG companies have been taken to prepare the Security analysis and construct a portfolio by using the Sharpe Single Index Model. With the help of this model a portfolio consisting of nine securities could be formed and finally the relevance of the Sharpe Index Model in portfolio construction could be found.

Keywords: Expected Return, Optimal Portfolio, Risk, Share Market, Sharpe Single Index Model.

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I. INTRODUCTION

In recent years, the Indian economy has expanded significantly setting an important precedent in the management of inflation. Currently inflation rate in India is in between four to six percent. Two aspects are responsible for it. First, it helps to minimise the cost of debt by encouraging businessmen to start their new business or increase the potential of their current businesses and second, it boosts the stock market and the industry by generating higher returns relative to other types of investments. Unlike the bank deposits, investment in share market bears some degree of risk as the return is dependent on several factors like economy, industry and company. Any change in these factors changes the return pattern which is, generally, referred as risk. Hence, a proper analysis of risk is required before making investment in the stock market. In 1952, Harry Markowitz laid the foundation for quantifying risk. His estimation was based on quadratic programming, which involved a large number of estimates of variance and covariance, but it did not become popular. There was an important shortcoming in the model that expressed the relationship between two or more securities but did not represent the market conditions. The model suggested by William Sharpe (1963) has overcome this shortcoming. Sharpe's approach emphasises on the principles of portfolio optimisation, which is an important aspect of portfolio selection.

This encourages the creation of optimal portfolio that produces highest returns at low risk. Sharpe's model is an extension of Markowitz's method of portfolio diversification. Sharpe streamlined the Markowitz method by reducing many of the complexities significantly. While providing his theory that, he also quoted; all securities in a market are dependent on the market or index return. That means when the market index increases, the stock price tend to increase and vice-versa. Thus, the single index model is based on the assumption that there exists a casual relationship between the market index and the security price. Apart from this, this model also assumes the casual relationship of the single market. Several literatures are available on this topic. These literatures can broadly be classified into two categories. The first category develops a portfolio using this model. The second category studies further by making performance evaluation of these portfolios using different ratios in general and Sharpe ratio in particular. The studies by Mishra(2011), Puri and Saxena(2012), Mandal(2013), Sarker (2013),Nalini (2014), Singh and Gautam(2014),Mahesh and Tulasinadh (2014), Shah (2015), Poornima and Remesh, (2015), Jayachitra (2010), Nandanand Srivastava (2017), Basha and Ramaratnam (2017) and Murthy (2018) are noteworthy in this regard. However, certain studies like Bilbao et. el. (2006), have made the extension of this model by including fuzzy logic concepts. But none of the authors has studied its relevance in their papers in the present day situation as over the years different sophisticated mathematical methods have been developed for creating an optimal portfolio. This paper is an attempt in this regard.

II. RESEARCH METHODOLOGY

The main aim of the study is to build an optimal portfolio out of the selected securities using the Sharpe Single Index Model. Later on, the model return or the return of the optimal portfolio is compared to the actual mean returns to test whether the model return is same as that of the actual mean returns. To test this hypothesis, one sample t-test has been used. The detail of the hypothesis is given below. The study has focused on two important sectors of the economy accounting to more than twenty percent of the GDP. A total of twenty companies

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from two sectors i.e. Fast Moving Consumer Goodsi. eFMCG and Automobile have been chosen on the basis of their turnover for the purpose of the study. Out of the twenty companies, ten companies belong to the FMCG sector and the remaining ten to the automobile sector. The monthly price data of these 20 companies along with Nifty have been collected for a period of 5 years (2014-15 to 2019-20) from the secondary sources like Yahoo finance website. Nifty, a benchmark index of National Stock Exchange has been taken as the market performance index for the purpose of the study. 364-Days Treasury bill yield of 6.3% as on 5/4/2019 has been taken as a risk free rate of return. This data has been collected from the RBI website. To evaluate the return of securities, Specific Return, Market Return, Systematic Risk, Variance of Market Return, and Variance of Residual Return have been calculated by using MS–Excel.

The analysis of the portfolio is based on the following steps.

1. **Estimation of the Historical Return:** The historical returns of various companies as well as market indexes are calculated by using the following formula to find out the real returns.

$$\boldsymbol{R_i = \frac{P_t - P_{t-1}}{P_{t-1}}}$$

2. **Estimation of Expected Return:** The Expected Return is either profit or loss, an investor anticipates, on an investment. This is based on the premise that the market return influences security return. This is expressed through a linear equation which has been suggested by William Sharpe in the following manner.

$$\boldsymbol{R_i = \alpha_i + \beta_i R_m + e_i}$$

Where,
Ri = Return of the security i
α = Specific return of the security
β = Systematic risk of the security
Rm = Market performance index or market return

3. **Finding the Excess Return to Beta Ratio for each Security:** Excess return is the return over and above the risk free return and can be found out by deducting the risk free return from expected return and its ratio measures the units of additional return of a security per unit of systematic risk. This is a single number which signals the desirability of including a security in an optimal portfolio and it can be calculated as.

$$\boldsymbol{ERBRatio = \frac{R_i - R_f}{\beta_i}}$$

Where,
R_i = the expected return of stock *i,*
R_f = risk free rate of return,
β_i = systematic risk of stock *i*

4. **Calculation of Unsystematic Risk:** Unsystematic risk is the risk related to a specific company or the industry. It can be reduced through diversification. It can be calculated by using the following formula.

$$\sigma_{ei}^2 = \sigma_i^2 - \beta_i^2 \sigma_m^2$$

5. **Fixing the Cut-off Rate:** It is the point where an investor decides whether a particular security is worth purchasing. The securities, whose excess returns to Beta ratio are greater than the cut off rate, can be included in the optimal portfolio. The cut off rate can be calculated by using the following formula

$$C_i = \frac{\sigma_m^2 \sum_{i=1}^{N} \frac{(R_i - R_f)\beta_i}{\sigma_{ei}^2}}{1 + \sigma_m^2 \sum_{i=1}^{N} \frac{\beta_i^2}{\sigma_{ei}^2}}$$

Where,
σ^2_m = Variance of the market index
σ^2_{ei} = Variance of the residual return of individual security
R_i = Expected return of individual security
R_f= Risk-free return
β_i= Systematic risk of individual security
C_i = Cut-off Rate of Return

6. **Estimation of Relative Investment in each Security**: It is the risk premium over the cut-off rate of return. This can be calculated by using the following formula.

$$Z_i = \frac{\beta_i}{\sigma_{ei}^2}\left[\left(\frac{R_i - R_f}{\beta_i}\right) - C^*\right]$$

Where,
σ_ei^2= Unsystematic risk
βi = Beta value of individual security
Ri= Return of security i
Rf= Return of a risk free security
C* = Cut off point

7. **Estimation of Proportion of Investment (X_i):** Once the securities are selected, then the proportion of investment is to be made in each security can be known by using the formula below.

$$X_i = \frac{Z_i}{\sum_{i=1}^{N} Z_i}$$

Where,
X_i = proportion of investment
Z_i = relative investment
$\sum_{i=1}^{N} Z_i$ = Sum of relative investments

8. Hypothesis of the Study

H_0**:** There is no difference between the return of the optimal portfolio and actual returns of the selected securities.

H_1**:** There is a difference between the return of the optimal portfolio and actual returns of the selected securities.

This hypothesis is tested by using the single sample *t*-test.

III. ANALYSIS AND INTERPRETATION

First of all the returns of the company as well as the index i.e. Nifty, a proxy to the market, has been calculated by using the formula given in the step-1. Then both the returns have been regressed to find out the expected return by using the Sharpe Single Index Model as given in step-2 where return of the individual security is taken as dependent variable and return of the index or market is taken as independent variable. The result of the regression analysis as per Sharpe Single Index Model is given in table No. 1.

Table 1: Expected Returns of Sample Companies

Sl. no	Company Name	Expected Return
1	Tata Motors Ltd.	-0.88571
2	Mahindra & Mahindra Ltd.	0.960254
3	Maruti Suzuki Ltd.	2.564605
4	Hero Motocorp Ltd.	0.712326
5	Bajaj Auto Ltd.	0.666393
6	Ashok Leyland Ltd.	3.209835
7	TVS motor Company Ltd.	3.690645
8	Eicher Motors Ltd.	2.699659
9	Force Motor Ltd.	3.438377
10	Hindustan Motors Ltd.	0.873088
11	Hindustan Unilever Ltd.	2.024526
12	Colgate Palmolive Ltd.	0.012287
13	ITC Ltd.	0.612653
14	Nestle India Ltd.	1.382203
15	Britannia Industries Ltd.	3.490606
16	Parle Agro Ltd.	0.31633
17	Marico Ltd.	2.201233
18	Procter & Gamble Ltd.	2.055715
19	Godrej Group Ltd.	1.984018
20	Dabur India Ltd.	1.696624

From table No. 1, it can be observed that TVS Motor gives the highest expected monthly return i.e. 3.69%among the sample companies in general and the automobile sector in particular followed by Force Motors and Ashok Leyland. In the FMCG segment, Britannia

Industries Ltd. gives the highest monthly expected return of 3.49% followed by Marico, Proctor & Gamble and Hindustan Unilever Ltd.

1. **Calculation of Beta Values:** Table No.2 represents the Beta values which were calculated by using the above regression model. Beta represents systematic risk which is inherent to the entire market and cannot be diversifiable. This also indicates the volatility of the security return with respect to market return. From the table it is found that Force Motor is having the highest Beta value of 1.74 followed by Tata Motors and Hindustan Motors. From this analysis, it is also found that the FMCG companies are less volatile compared to the companies in automobile segment.

Table 2: Beta Values of the Sample Companies

Sl. No	Company Name	Beta Values
1	Tata Motors Ltd.	1.5640
2	Mahindra & Mahindra Ltd.	1.0765
3	Maruti Suzuki Ltd.	1.2340
4	Hero Motocorp Ltd.	0.7995
5	Bajaj Auto Ltd.	0.7177
6	Ashok Leyland Ltd.	1.3872
7	TVS motor Company Ltd.	1.2947
8	Eicher Motors Ltd.	1.1492
9	Force Motor Ltd.	1.7452
10	Hindustan Motors Ltd.	1.4180
11	Hindustan Unilever Ltd.	0.7481
12	Colgate Palmolive India Ltd.	0.5485
13	ITC Ltd.	0.8363
14	Nestle India Ltd.	0.7935
15	Britannia Industries Ltd.	0.8230
16	Parle Agro Ltd.	1.1171
17	Marico Ltd.	0.6246
18	Procter & Gamble Ltd.	0.5465
19	Godrej Group Ltd.	1.0081
20	Dabur India Ltd.	0.8975

2. **Ranking of Companies based on Excess Return to Beta Ratio:** Excess returns and their relation to beta are seen in Table 3. As stated above, it signals the eligible securities to be included in the portfolio. All the calculations are made on the basis of the formula as explained in step 3 given in the research methodology section. The following table shows that Britannia Industries Ltd. have the highest excess return to Beta Ratio of 3.58% while Colgate Palmolive has the lowest of 0.01%. This ratio shows how a company's stock's prospective risk and reward are related to one another. Excess return to beta ratio is the basis of this ranking and the companies have been ranked in the order of the highest to the lowest accordingly. The following table reveals that the Britannia Industries Ltd. Have been ranked first and the Colgate Palmolive has been placed at the last.

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Table 3: Ranking of the companies based on Excess Return to Beta Ratio

Sl. No	Company Name	R_i	β_i	$\frac{R_i - R_f}{\beta_i}$	Rank
1	Tata Motors Ltd.	-0.88571	1.5640	-0.9126662	19
2	Mahindra & Mahindra Ltd.	0.960254	1.0765	0.38881003	13
3	Maruti Suzuki Ltd.	2.564605	1.2340	1.63930713	9
4	Hero Motocorp Ltd.	0.712326	0.7995	0.21341588	15
5	Bajaj Auto Ltd.	0.666393	0.7177	0.17373972	16
6	Ashok Leyland Ltd.	3.209835	1.3872	1.92339605	6
7	TVS motor Company Ltd.	3.690645	1.2947	2.4321812	4
8	Eicher Motors Ltd.	2.699659	1.1492	1.87779238	7
9	Force Motor Ltd.	3.438377	1.7452	1.65979658	8
10	Hindustan Motors Ltd.	0.873088	1.4180	0.23370099	14
11	Hindustan Unilever Ltd.	2.024526	0.7481	1.98212271	5
12	Colgate Palmolive India Ltd.	0.012287	0.5485	-0.9652015	20
13	ITC Ltd.	0.612653	0.8363	0.08484156	17
14	Nestle India Ltd.	1.382203	0.7935	1.05923503	12
15	Britannia Industries Ltd.	3.490606	0.8230	3.58311786	1
16	Parle Agro Ltd.	0.31633	1.1171	-0.2017456	18
17	Marico Ltd.	2.201233	0.6246	2.65695325	3
18	Procter & Gamble Ltd.	2.055715	0.5465	2.77038426	2
19	Godrej Group Ltd.	1.984018	1.0081	1.43072909	10
20	Dabur India Ltd.	1.696624	0.8975	1.2868234	11

3. **Calculation of Unsystematic Risk:** Table4 reveals that out of the 20 companies selected in this study, Force Motor has the highest unsystematic risk and Colgate Palmolive has the least of it. These unsystematic risks are evaluated by doing variance of the residual returns. These returns have already been ascertained while calculating the Alpha and Beta in Regression model. These Return to risk ratio values $(R_i\text{-}R_f/\sigma^2_{ei})\beta)$ and its cumulative (Cumulative of $(R_i\text{-}R_f/\sigma^2_{ei})\beta$ are very essential to calculate the Cut-off point.

Table 4: Sample Companies based on their Ranks and Unsystematic Risk

Sl. No	Company Name	σ^2_{ei}	$(R_i\text{-}R_f/\sigma^2_{ei})\beta$	Cumulative of $(R_i\text{-}R_f/\sigma^2_{ei})\beta$
1	Britannia Industries Ltd.	0.0027	898.8684074	898.8684074
2	Procter & Gamble Ltd.	0.0018	459.6672222	1358.53563
3	Marico Ltd.	0.0017	609.7198235	1968.255453
4	TVS motor Company Ltd.	0.0062	657.5614242	2625.816877
5	Hindustan Unilever Ltd.	0.0012	924.4022333	3550.219111
6	Ashok Leyland Ltd.	0.0071	521.2941296	4071.51324
7	Eicher Motors Ltd.	0.0037	670.2320757	4741.745316
8	Force Motor Ltd.	0.0202	250.2547683	4992.000084
9	Maruti Suzuki Ltd	0.0023	1085.329826	6077.32991
10	Godrej Group Ltd.	0.0023	632.1663609	6709.496271

11	Dabur India Ltd.	0.0016	647.8267188	7357.32299
12	Nestle India Ltd.	0.0020	333.468375	7690.791365
13	Mahindra & Mahindra Ltd.	0.0015	300.3435	7991.134865
14	Hindustan Motors Ltd.	0.0152	30.90680263	8022.041668
15	Hero Motocorp Ltd.	0.0019	71.78668421	8093.828352
16	Bajaj Auto Ltd.	0.0016	55.8908875	8149.719239
17	ITC Ltd.	0.0018	32.94092778	8182.660167
18	Parle Agro Ltd.	0.0029	-86.82563448	8095.834533
19	Tata Motors Ltd.	0.0040	-558.1134	7537.721133
20	Colgate Palmolive Ltd.	0.0008	-363.0384375	7174.682695

4. **Calculation of Cut-Off Points:** Table 5 represents the Cut-off points (C_i) of sample companies. This point has been calculated by using the formula given in step 5. It has been observed that the C_i value goes on increasing from 0.6588 to 0.8878 and after reaching at 1.54 it starts declining. Therefore, the value of **1.543** is considered as the *'cut-off value or point'*. For the optimal portfolio construction, therefore, securities that come after the cut-off point should be ignored.

. Table 5: Cut-off point (C_i) of Sample Companies

Sl. No	Company Name	C_i
1	Britannia Industries Ltd.	0.658863689
2	Procter & Gamble Ltd.	0.887819127
3	Marico Ltd.	1.118530628
4	TVS motor Company Ltd.	1.293479008
5	Hindustan Unilever Ltd.	1.422124048
6	Ashok Leyland Ltd.	1.471213859
7	Eicher Motors Ltd.	1.517656218
8	Force Motor Ltd.	1.524197885
9	Maruti Suzuki Ltd.	**1.543553469 C***
10	Godrej Group Ltd.	1.532167568
11	Dabur India Ltd.	1.506867181
12	NestleIndia Ltd.	1.479752356
13	Mahindra & Mahindra Ltd.	1.338566832
14	Hindustan Motors Ltd.	1.314614039
15	Hero Motocorp Ltd.	1.257074211
16	Bajaj Auto Ltd.	1.205480363
17	ITC Ltd.	1.144570192
18	Parle Agro Ltd.	1.068132887
19	Tata Motors Ltd.	0.920249888
20	Colgate Palmolive India Ltd.	0.837477482

5. **Calculation of Proportion of Investment:** Table No.6presents the portion of money to be invested in each security. The cut-off point, here in table no. 5, suggests that an investor should choose to invest in all the nine companies. In order to find out suitable

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proportions of investments in all those companies, the formula is explained in the step no.7.

In a sample of twenty companies, nine were chosen for building the optimal portfolio using Single Index Model. The percentage or the amount of investment in each company's security has been calculated after the companies, in which the investment is to be made, have been identified. To know the proportion of investment, Xi is calculated by using the formula in step no.7 which shows the certain proportion of investment in each security. The figure shows that 30.96% of investment may be made in Britannia Industries Ltd. stock (This means much of the funds should be invested in the stocks of this company.), followed by 19.85% in Procter & Gamble, 19.63% in Marico Ltd, 8.26 % in TVS Motors, 12.12% in Hindustan Unilever Ltd, 3.06% in Ashok Leyland, 3.88% in Eicher Motors, 0.4% in Force Motor and 1.78% in Maruti Suzuki. The same has been displayed in the pie chart in figure 1. The proportions of investments are rounded off to the nearest percentage.

Table 6: Proportion of Investment Proposed

Sl. No.	Company Name	C_i	Z_i	X_i
1	Britannia Industries Ltd.	0.658863689	891.3538	0.309684436
2	Procter & Gamble Ltd.	0.887819127	571.5594	0.198577763
3	Marico Ltd.	1.118530628	565.2152	0.196373587
4	TVS motor Company Ltd	1.293479008	237.7795	0.082612094
5	Hindustan Unilever Ltd.	1.422124048	349.0908	0.121285174
6	Ashok Leyland Ltd.	1.471213859	88.34255	0.030692992
7	Eicher Motors Ltd.	1.517656218	111.8404	0.038856885
8	Force Motor Ltd.	1.524197885	11.71138	0.004068903
9	Maruti Suzuki Ltd.	**1.543553469 C***	51.37175	0.017848167
				$\Sigma X_i = 1$

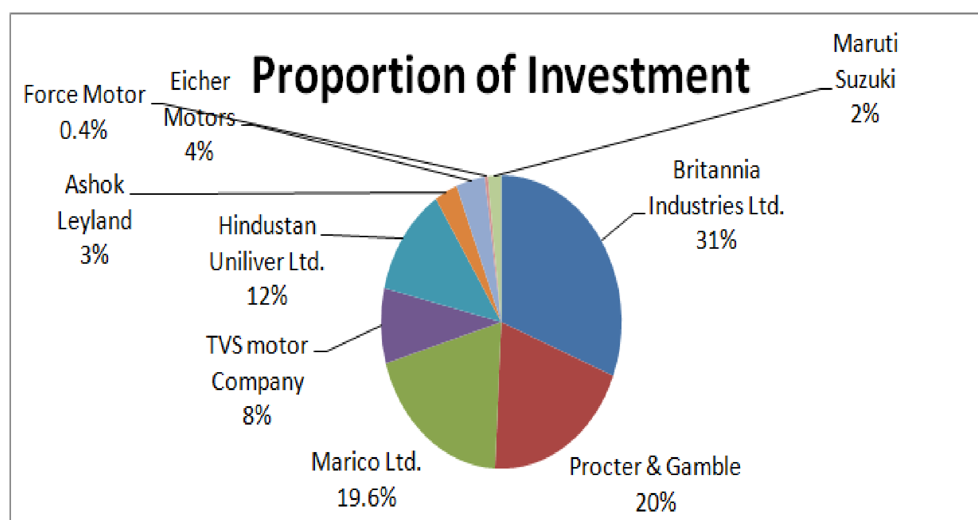

Figure 1: Proportion of Investment

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6. **Calculation of Return on Portfolio:** Table No.6presents the proportion of investment, monthly return of individual security and the returns on portfolio. The highest return on portfolio is from Britannia Industries Ltd. i.e. 0.3096% and the lowest from Force Motor i.e. 0.004%. The total return from the optimal portfolio is 2.735%.These returns that have been calculated above, are on a monthly basis. If, these are converted to yearly returns then it comes to 32.82% approximately. On the visual observation of the individual returns from the stocks in the above portfolio, the returns from Britannia, TVS Motor, Ashok Leyland and Force Motor are higher than the portfolio returns. Thus, based on the above estimate, investors and fund managers can decide which securities are to be including in their portfolio in order to reap the greatest benefits from diversification.

Table 7: Return on Portfolio

Sl. No.	Company Name	X_i	Return	Return on Portfolio
1	Britannia Industries Ltd	0.309684436	3.4906	1.080984492
2	Procter & Gamble Ltd.	0.198577763	2.0557	0.408216307
3	Marico Ltd.	0.196373587	2.2012	0.43225754
4	TVS motor Company Ltd.	0.082612094	3.6906	0.304888194
5	Hindustan Unilever Ltd.	0.121285174	2.0245	0.245541835
6	Ashok Leyland Ltd.	0.030692992	3.2098	0.098518366
7	Eicher Motors Ltd.	0.038856885	2.6996	0.104898047
8	Force Motor Ltd.	0.004068903	3.4383	0.013990109
9	Maruti Suzuki Ltd.	0.017848167	2.5646	0.045773409
	Total Proportions	$\Sigma X_i = 1$	Total Return on Portfolio	2.735068299

7. **Testing of the Hypothesis**

Table 8: Results of One-Sample *t*- Test

Test Value = 2.735								
Variable	No. of Obs.	Mean	Std. Deviation	*t*	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Return	9	2.8194	.653978	.387	8	.709	-.418259	.587125

Table 8, labelled as results of one-sample t-test, gives the descriptive statistics and the results of the *t*-test analysis. From the descriptive statistics, it can be seen that the mean return is 2.8139 %. The lower standard deviation value indicates the precision of the mean returns. The test result gives the *t*- statistic of 0.387 with 8 degrees of freedom and the corresponding two tailed *p* value is 0.709. At a significance level of 5%, the obtained *p* value is greater than 0.05. Therefore, the null hypothesis is accepted. This means that the sample return or actual return is not significantly different from the anticipated return.

IV. FINDINGS AND CONCLUSION

Analysing securities is a very hard task to accomplish. Even the large financial institutions and consultants are also bewildered while observing the securities movement and constructing an optimum portfolio for investments. This paper is an attempt to analyse the selected securities and to identify the best securities for construction of an optimal portfolio by using the Sharpe Single Index Model. For this purpose, companies of two sectors namely; Automobile and FMCG were selected. After a careful examination of companies from the above mentioned two sectors, nine companies were finalised to construct an optimal portfolio. From the estimation it is found that the constructed optimal portfolio generates 2.7% monthly return which comes to 32.82% annually. From the hypothesis testing it has revealed its relevance in portfolio management. Numerous techniques for building effective portfolios have been developed in recent years. However, this study still continues to be relevant today. Investors can use this model for building their own portfolio. This model is a very simple model and requires very less number of input estimates. But it is fact that the return from a share depends on several factors. Hence, the result cannot be accepted in its absolute form. This can be taken as an indicative, if the investors plan to invest in such type of portfolios. The present study is based on small samples. Therefore, a study with a large sample size can be carried out for accessing the greater degree of precision of this model.

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