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Effects of Factors on the Market Price of the Shares Using Design of Experiment

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Abstract: When the cost of capital, dividends and the price of the share at the beginning is known, Modigliani and Miller's model can be used to estimate the price of the share at the end of the period. A design of experiment (Taguchi's orthogonal array) is used in order to investigate the impact of three parameters on the price of the share at the end of the period. The main aim of this research article is to find which parameter is more significant on the price of the share at the end of the period. Taguchi's methodology of design of the experiment is used for the experimental setup and to optimize the factors for the value of shares. In this study, the optimal combination of input factors is sought for the first time using the Taguchi method. To explore the effects of input factors, the Taguchi method L9 design of experiment (DOE), analysis of variance (ANOVA), regression analysis, and analysis of mean (ANOM) are used and the analysis is carried out using MINITAB 18 software. The ANOM is used to check the best optimal combination among the parameters where the value of the share is maximum, also it measures which parameter impacts more on the price of the share at the end of the period. ANOVA is used to measure the percentage contribution of each parameter on the price of the share.

Keywords: Modigliani and Miller's model, Taguchi Method, ANOM, ANOVA, Share price

1 Introduction

Almost all research begins with an experiment to try something new that the researcher is interested in. An experiment's primary goal is to draw conclusions about the population being studied. When conducting a statistical investigation, a researcher aims for reliable and useful findings. Creating an experimental setting that allows for a more accurate exploration of the hidden characteristics of a population is necessary to uncover the characteristics of a population that are hidden from view, such as the impact of several factors on a certain response variable.

The use of the DOE technique enables experiments to be conducted economically, from data collecting to the identification of the investigation's main goals and conclusion-making. Its goal is to collect data that statistical tools can analyse for the best/maximum output.

Sir Ronald Fisher introduced the DOE approach in his ground-breaking publications (the arrangement of field experiment, 1926 and the DOE, 1935 [1,2]. His significant contribution made it possible for the researchers to combine numerous components and an ANOVA [3]. The study examined agricultural productivity with the goal of examining multiple influences on it at once. He calculated the amount of light, fertiliser, water, and other resources required to produce exceptional agricultural output. Numerous studies have been conducted on the use and development of DOE since the notion was first proposed.

The Taguchi approach, developed by G. Taguchi in the 1940s, is one of the greatest techniques for minimising the number of orthogonal arrays (OA)-based trials because it gives the researcher significantly less variance for the experiment when the control input parameters are set to their ideal values [4]. To reduce the number of trials, Taguchi employed a partial factorial

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design; these trials were made up of OAs, which would provide the bare minimum of trials for a particular set of factors and levels [4]. The Taguchi method, developed by Taguchi in 1940, is a special arrangement of generic design guidelines for a factorial design approach that covers a wide range of applications. It aims to reduce the number of tests (i.e. to minimise the quantum of resources – material, manpower, equipment and time). Both the FFD and the Taguchi approach were utilised by Athreya and Venkatesh (2012) for the experimental setup, and it was discovered that both produced the same outcome [5]. DOE that employs the Taguchi technique can provide design optimization projects and meet the demands of problem-solving economically. The Taguchi technique is used for the first time in this study to quantify the impact of numerous input parameters such as cost of capital (K_c), dividends (d) and the price of the share at the beginning (P_o) on the price of the share at the end of the period (P_1).

The study discussed in the sections above examines the effects of various variables on the share at the end of the period(P_1). An appropriate statistical test is used at a 95 percent confidence level to determine the significance of the relationship between numerous causes and responses (i.e., the price of the share at the end of the period, or (P_1).The experimental data are analysed using the Taguchi OA design, analysis of mean (ANOM), regression analysis, and analysis of variance (ANOVA). ANOM is fairly straightforward and simple to comprehend [6]. It is utilised to accomplish one of the study's main goals, namely to choose the best combination levels that will result in the maximum share value at the end of the period (P_1). While ANOM may be sufficient for practical use, ANOVA is employed to gain insight into the variance components. It takes into consideration the variance from all input variables, including error terms and is used to calculate the percentage (percent) contribution of each input variable to the response variable's level-to-level correlation [3]. It aids in determining the variables that need to be more or less managed [7,8]. Finally, a confirmation test is conducted to determine whether the main factor model is adequate.

2 Modigliani- Miller Theory on Dividend Policy

Franco Modigliani and Merton Miller put up the Modigliani-Miller theory in 1961. They were the first to propose that, when an investor thinks about returns on investment, dividends and capital gains are similar. The only factor that affects a company's valuation is its earnings, which are a direct result of its investment strategy and long-term prospects. According to this hypothesis, an investor won't want any further information regarding the company's dividend history once he is aware of the investing philosophy. Thus, the company's investment policy, not the dividend policy, governs the investment decision [9].

One of the main proponents of the idea of "dividend irrelevance" is the Modigliani-Miller theory. This idea holds that investors give little weight to a firm's dividend history, hence dividends have no bearing on how much a company is worth. The "dividend relevance" idea, which holds that dividends play a significant role in a company's valuation, stands in stark contrast to MM's theory on dividend policy.

MM theory on dividend policy is based on the assumption of the same discount rate/rate of return applicable to all the stocks.

$$P_1 = P_0*(1\text{-}K_c)\text{-}D_1$$

3 Literature Review

Taguchi method provides the relationship between the input and the output variables. It is used to create new products as well as to enhance existing ones or processes. To choose the most effective treatment plan, the DOE compares the results with the use of the appropriate statistical techniques. On the OAs, the Taguchi method is based. In 1946, C. R. Rao developed the idea of an orthogonal array as an experimental design [10]. OAs have gained widespread use in industrial experimentation because they can determine the best combination of the elements on a limited number of factor combinations.

The US industry later embraced Taguchi's approach after it had been adopted with great success in the Indian and Japanese industries. The Taguchi approach has the benefit of allowing researchers and engineers to analyse which component has a greater impact on the response variable with limited statistical expertise and resources [11]. Engineers must utilise statistical analysis, teamwork, planning, communication, and engineering while using the Taguchi technique in the workplace [12]. Unlike FFD, which requires that every potential combination be studied, Taguchi's goal is to obtain powerful processes or products under diverse elements at different levels with a limited number of tests [13]

The Taguchi method was also applied to biotechnology [14,15], engineering [16], health care [17], improving forecasting rate [18] and so forth and it is used in various fields such as the following.

Dar and Qadir (2019) looked into how the value of the debt, the firm's worth, the interest rate, and volatility over a specific time affected the likelihood of default and the distance to default. To determine which element has a greater impact on the likelihood of default and the distance to default, the Taguchi L27, analysis of mean, and ANOVA were all applied. It was discovered that asset volatility had a greater effect on both the probability of default and the distance to default [19].

Wang and Huang (2007) used the Taguchi method to calibrate the controllable parameters of a forecasting model. It was found that the Taguchi method with S/N ratio provides the ranking for the controllable parameters and it allows decision-makers to achieve the goal [20].

Sun et al. (2018) investigated the impacts of flow discharge, slope and freeze-thaw on the soil detaching capacity. The Taguchi method was applied for the experimental setup to determine the result by using ANOVA and signal-to-noise (S/N) ratio. It was found that factors (slope and flow discharge) have more significance on the soil detaching capacity [20].

Cabrars Rios et al. (2002) designed a new technique to finalise the design of cell manufacturing. The regression model and the Taguchi method were used for designing a new method. It was found that the Taguchi method is a single and viable way to generate a cell design with a high margin of profit and low volatility to noise variables [22].

Parinam et al. (2019) utilized the Taguchi L9 design method to draft parameters optimization for high-transmission optical filters. The Taguchi L9 method combined with a genetic algorithm to generate the optimal values of design parameters. The three parameters: material refractive index, thickness and the number of levels were studied. It was found that the thickness of the material has a major impact on the response variable [23].

Ghosh and Mondal (2019) optimized the process parameters for higher percentage elimination of fluoride from aqueous saluting by AI-IEBA in a system. The parameters that impact the response are adsorbent dose, initial concentration, pH, temperature and contact time. It was found that contact time has a significant impact on the response variable. With the increase in contact time, the percentage of removal gradually increases. The Taguchi method and S/N ratio were used for the experimental setup and data analysis respectively [24].

Mazumdar and Hoa (1995) investigated the impact of laser power, tap speed and consolidation pressure on body strength. To find which factors impact more on the interplay bond strength more, the Taguchi method was used for the minimum trials and the ANOVA was used to analyze the data. It was investigated that laser power has a significant impact on the interplay bond strength. The percentage contribution of the consolidation process, laser power, and tap speed on interplay strength bond was 2.72 percent 79.08 percent, and 17.05 percent respectively [25]. Other references of same work [26,27,28,29]. Taguchi's methodology of design of the experiment is used for the experimental setup and to optimize the factors for value of shares. In this study, the optimal combination of input factors is sought for the first time using the Taguchi method.

4 Methodology

The Taguchi method depends on the followings steps (shown in Figure 1):

I. Select the control input parameters, the response variable and levels: A researcher's initial goal is to identify the problem, select the parameters, and determine the precise number of levels.

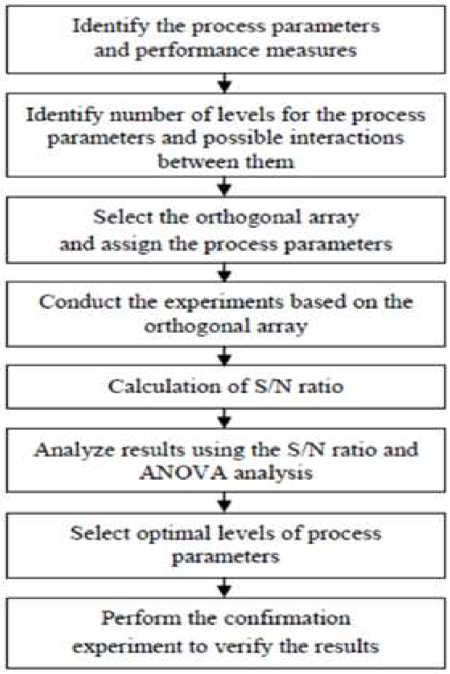

Fig. 1: Steps in Taguchi method

II. Choose an orthogonal Array: Based on the input parameters and their levels, as illustrated in Figure 2, the orthogonal array table is chosen.

III. Assignment of the parameters: Choosing the appropriate orthogonal arrays and interactions for the right vertical columns is one of the key tasks of the Taguchi approach. Using triangular tables and linear graphs, Taguchi simplifies the factor assignment process.

IV. Conduct the experiment: The investigations are conducted in accordance with the level combination after the orthogonal array table has been chosen. Every analysis must be focused, which is essential. For running the experiment, the connecting segments and dummy variable segments will not be taken into consideration (sometimes researchers consider both dummies as well as interaction). For each assessment, the exhibition parameter under inquiry is noted down to guide the affectability examination.

V. Analysis: After conducting the experiment, it is necessary to analyse the output values. Different statistical tools can be used for analysis such as ANOVA, S/N ratio, ANOM, regression etc.

VI. Confirmation: Finally, we have to check whether our optimal combination of parameters at different levels is accurate or not.

Number of Levels	Maximum Number of Factors														
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2	L4	L4	L8	L8	L8	L8	L12	L12	L12	L12	L16	L16	L16	L16	L32
3	L9	L9	L9	L18	L18	L18	L18	L27	L27	L27	L27	L27	L36	L36	L36
4	L16	L16	L16	L16	L32	L32	L32	L32	L32	–	–				
5	L25	L25	L25	L25	L25	L50	L50	L50	L50	L50	L50				

Fig. 2: Array Selector

4.1 Selection of suitable experimental design

Taguchi provides many typical OAs. An OA is a collection of evenly distributed (minimum) trials. A significant number of decision variables are represented by this subset of the factors space. Figure 2 demonstrates how to choose OA, which is based on the greatest number of elements and levels. This study reveals that OA L9, L18, and L27 are sufficient to conduct an experiment since the three components are altered at three levels [30, 32,32]. Selection of a suitable OA depends on the underlined input factors and their levels

4.2 Factors with Levels

The cost of capital (K_c), dividends (d) and the price of the share at the beginning (P_o).all affect the value of the share price. Table 1 displays the selected levels and taken into consideration input elements. It would take 27 tests to implement an FFD for three components at three levels. The minimum number of experiments needed to execute the Taguchi OA for the same set of parameters is depicted in Figure 2. Three datasets were used in the current study to find the optimum ideal condition where the share values are highest. To predict the share price using Modigliani and Miller's approach, the data set in Table 1 is sufficient.

Table 1 : The Observed Data of Various Factors

Levels	(P_o)	(K_c)	(d)
1	150	0.10	10
2	200	0.20	20
3	252	0.25	30

4.3 Objectives of the Study

The current study has been carried out to achieve the following objectives. I. To identify the factors that are having a significant impact on share price. II. To demonstrate the use of the Taguchi method in identifying the optimal combination among the various factors. III. To measure the percentage contribution of each input factor on the share price.

5 Result and analysis

Less number of experiments are conducted using Taguchi methodologies, and statistical techniques like ANOVA, regression analysis, and ANOM are used to determine the ideal conditions under which share price is the highest. ANOVA is also used to calculate the percentage contribution of each and every input factor to share price.

Table 2 displays the experimental design for choices utilising Taguchi L9 OA. There are nine different experiments, each with a set level. The Taguchi L9 OA approach was used in the experimental setup to examine the effects of three parameters (cost of capital (K_c), dividends (d), the price of the share at the beginning (P_o)) each taken at three levels. Table 2 lists the outcomes (values of share price (P_1)) of three replications.

Table 2 : Taguchi L9 DOE with the Results

Experiments	(P_o)	(K_c)	(d)	(P_1)
1	150	0.10	10	155
2	150	0.20	20	160
3	150	0.25	30	157.5
4	1200	0.10	20	200
5	200	0.2	30	210
6	200	0.25	10	240
7	252	0.10	30	247.2
8	252	0.20	10	292.4
9	252	0.25	20	295

6 Analysis of Mean (ANOM)

ANOM is used to determine the ideal values for each input factor. It is a statistical method for comparing scale measures including means, proportions, variances, and others. When there are a large number of gatherings, this method can also be used effectively as an alternative comparison test. An improved knowledge of the input factors can be achieved with the use of ANOM. The average of each response for each input factor at each level is displayed in the ANOM table. Based on the delta value, which determines the rank, it determines which input elements have a significant impact on the response variable. The difference between the maximum and minimum response averages for each factor level is used to calculate delta. Additionally, ANOM offers the most advantageous combinations of numerous input factors at various levels where the value of response is greatest. The best outcomes are obtained when using the higher average

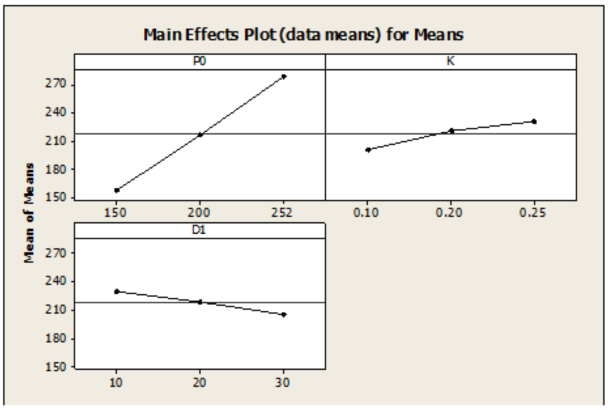

Fig. 3: Main Effects Plot for Mean

Fig. 4: Optimal Combination

of each input component. The Minitab Software calculates a distinct average for each combination of factor levels for the provided experimental data [33].

Table 3 : Average response and ranking of factor effects of the price of the share at the end (P_1)

Levels	(P_o)	(K_c)	(d)
1	157.5	200.7	229.1
2	216.7	220.8	218.3
3	278.2	230.8	204.9
Delta	120.7	30.1	24.2
Rank	1	2	3

The mean value of the share price for each input factors at various levels was calculated and is given in Table 3. Figure 3 displays the major effect plot for the average response. The study is carried out with the goal of identifying the influencing factors and the ideal concentrations of each. All input elements have some impact on share price, according to the ranks shown in Table 3, but the price of the share at the beginning (P_o) has the biggest impact, as demonstrated by rank 1 in Figure 3.

6.1 Predict the Optimum Combination

One of the objectives of the current study is to find the optimal setting of the share values. For maximization of share value, the optimal setting is chosen based on the higher value of factors at their levels presented in Table 3. For share value (from Table 3) P_3 K_3 d_1 The above-mentioned combination of input factors at different levels provided a higher value of the share price.

6.2 Validation of Optimal Combination

To validate the optimal combination for share price, the study selects some combination with the highest values of share price from Table 2, i.e., experiment 7 and apart from this, some other random experiments R1 (P_3 K_2 d_3), R2 (P_3 K_1 d_2), and R3 (P_2 K_2 d_1),) are selected for universality and that does not lie in Table 2 as shown in Table 4. It is presented in Figure 4 that the optimal combination (P_3 K_3 d_1= 305) provides the maximum value for a share price.

Table 4 : Random Experiments

Random Experiment	(P_1)
R1	272.4
R2	257.2
R3	230

Table 5 : Coefficient

Predictort	Coef	SE Coef	T	P
Constant	-32.556	5.404	-6.02	0.002
P_0	1.18333	0.02082	56.85	0.000
K_e	230	13.90	14.44	0.00
D_1	-1.2117	0.1062	-11.41	0.00

The P-values (for input factors) is approximately equal to 0 and it concludes that the result is statistically significant. In other words, the relationship between the input factors and the response variable is statistically significant as shown in Table 5.

Table 6 : Fit Data

S=2.60062	Adj.R=99.9	Sq(adj) = 99.8

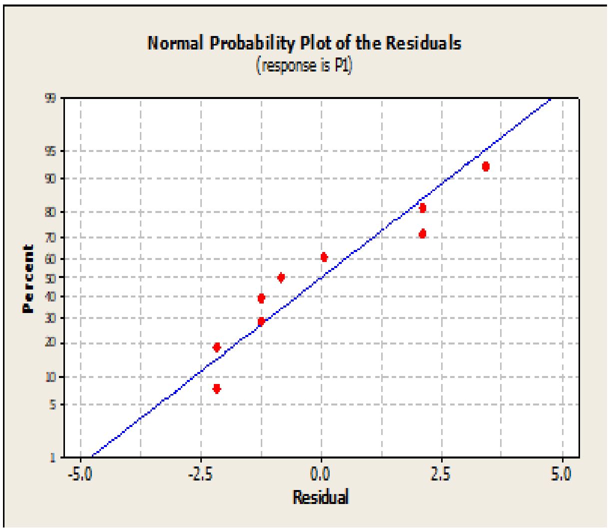

Fig. 5: Normal Plot

Table 7 : Percentage Contribution for Share Price

Source	DF	Seq SS	Percentage Contribution
P_0	2	21855.5	90.38817846
K_e	2	1409.3	5.828466972
D_1	2	884.3	3.657215173
Residual Error	2	30.3	
Total	8	24179.6	

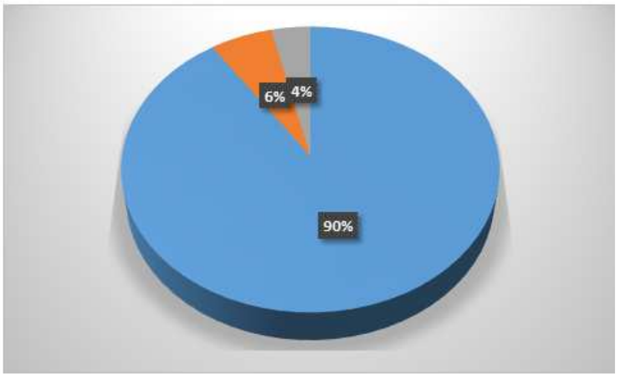

Fig. 6: Contribution Percentage of the Share Price

Table 6, shows that Adj. R - square value of a share price is 99.9. It means that the fitted model is the best fit for the data.

The normal probability plot of the share price are shown in Figure 5. A normal probability plot vs. Residual (Figure 5) shows the residuals lie close to the straight line which implies that residuals are normally distributed and giving support that the terms mentioned in the model are significant.

6.3 Analysis of Variance (ANOVA)

ANOVA is performed on trial outputs to comprehend the impact of configuration factors on option values. It is studied at a 95 percent degree of confidence. ANOVA is an effective data analysis technique to get the accurate measurement of contribution on output response by each factor. From Table 5, it is already concluded that the relationship between input factors and the response variable is statistically significant. Table 7 display the percentage contribution of factor that impacts share value. The percentage contribution can be calculated by Adjusted (Adj.) sum of squares divided by total Adj. sum of squares displays the percentage contribution of each input factors [33].

7 Conclusion and Discussion

The impact of three input parameters (the cost of capital (K_c), dividends (d) and the price of the share at the beginning (P_o)) on the price of the share at the end of the period was calculated using the Taguchi technique L9. Analyses such as ANOVA, regression, and ANOM were employed to assess the experimental findings. The ANOM discovered P_3 K_3 d_1 to be the best combination for the share price at the end of the term. The regression coefficients indicate that the price of the share at the beginning (P_o) and cost of capital (K_c) impact positively on the price of the share at the end of the period. The ANOVA measured the percentage contribution of each factor on response variable and it was identified that the factor the price of the share at the beginning (P_o) impacts maximum on a share value with 90 percent, cost of capital with 6 percent and the dividend with 4 percent of its contribution on the price of the share at the end of the period. The factors in the order of affecting from highest are given as: the price of the share at the beginning -¿ cost of capital -¿ the dividend for a given set of data. It shall be noticed that the percentage contribution and significance of the independent variables change depending on the level values assigned. It is the designer's responsibility to set proper level values. Taguchi orthogonal will be further exposed to other fields like industries, health, the construction sector, biological science, physics, etc.

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