Predicting Stock Price Crash Risk Using Ant Colony Optimization Technique

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Abstract

The study[1] aimed to assess the impact of disclosure of research and development (R&D) activities on predicting the stock price crash risk (SPCR) using Ant Colony Optimization (ACO). Our study was based on the quarterly data of Mina Pharm for Pharmaceuticals and

[1] This paper is based on dissertation titled" A proposed approach for predicting the Stock price by using the ant colony algorithm to support sustainable competitive advantage- an applied study" members of committee was: Prof. Laila Abd El - Hamid Lotfy Prof. Emad Saad Mohamed El-Saygh (Co-Chair) .Dr. Aliaa Abdel- Latif Ahmed Abed(Co-Chair)- A thesis from researcher Doaa Mohamed Sayed Ahmed- Assistant Lecturer to obtain a PhD in Accounting.

Chemical Industries, a pharmaceutical and healthcare sector company operating on the Egyptian Stock Exchange. We found that disclosure of Corporate R&D activities can effectively reduce the SPCR, particularly with a company with product diversification, cost reduction, and information transparency constraints. We propose a novel method for accurately predicting the SPCR through ACO. It also contributes to continuous improvement until the optimal solution is reached, supports sustainable competitive advantage, and adds to the existing body of literature.

Keywords: Research and Development activities, Stock Prices Crash Risk, Ant colony Optimization, Prediction.

I. INTRODUCTION

SPCR for companies is considered one of the most significant risks facing investors, companies, and all parties involved in the market, as it influences investor decision-making and risk management (Defond et al., 2015:11; Kim et al.,2015: 8). Therefore, we aimed to determine the SPCR and its associated factors. It is also regarded as a crucial indicator of the company's current concerns (Ahmed, 2019:10). SPCR is defined as the possibility of a significant decline in the company's stock price, as indicated by a negative deviation or skewness in the distribution of the stock's return over a period of time (Abdul Majeed, 2019: 79; Zhu, 2016; Fakhari, 2018; Choi & Park, 2022). SPCR occurs when the distribution of stock returns shows a negative deviation, i.e., the negative stock returns exceed the number of positive returns (Kim et al., 2014: 2).

The unpredictability of SPCR is attributed to the lack of consistency and transparency in information between management and stakeholders. A significant number of studies (Chang et al., 2017; Zichoa et al., 2018; Xuejun et al., 2019; Khalil et al., 2019; Li & Wu, 2023) demonstrated a significant relationship between the disclosure of bad news and the unpredictability of SPCR. There are additional reasons, including inconsistency of financial information among users of financial statements, insufficient disclosure and complexity of financial reports (Kim et al., 2015), managers storing bad news, non-disclosure of some negative information and preventing it, and the theory of differences of opinion. The latter divides investors into two types, an optimistic and a pessimistic, with each believing that he has the most accurate information, as well as the risk of credit or default as a result of failure to meet its obligations, and the so-called information impediment model (Dichu et al., 2019:1; Ashiq et al., 2019:1; Abdul Majeed, 2019), refers to information asymmetry in the market.

Kim et al. (2011) suggested tax avoidance as a further reason, whereas Yin & Tain (2015) included short-selling restrictions and challenging market conditions such as strikes. The lack of transparency and uniformity of information, the size of the company, and the degree of financial leverage (Fakhari, 2018), in addition to the market value ratio to the book value of stockholders’ equity. Ibrahim (2016) stated that the excessive increase in research and development expenses is one of the reasons for SPCR. The liquidity of stocks (the ability to trade large amounts of company stocks at a low cost and in a short time) encourages managers not to disclose bad news for fear that investors will sell more stocks, which helps SPCR (Chang et al., 2017). Another reason is the “commercial credit to bank loans” debt structure” (Zichao, 2018).

Based on previous research findings, we conclude that the majority of studies on the causes of SPCR have focused on the following factors:

First: lack of adequate transparency and asymmetry of the information provided by the management to achieve personal interests, the most prominent of which was presenting a falsely positive image of the company. Second, the lack of good information would encourage the company to disclose, thereby enhancing its reputation and attracting more investors.

We believe that in order to reduce SPCR problems, such as bankruptcy, a large number of cases, and the permanent suspension of activity, the company must try to predict SPCR to avoid it and minimize its occurrence. Many studies have used accounting or non-accounting methods to calculate SPCR (Abdul Majeed, 2019: 79; Zhu, 2016; Fakhari, 2018; Choi & Park, 2022). In the current study, we integrate accounting and non-accounting methods to predict SPCR. We first calculate SPCR and then predict the future risks of SPCR using one of the non-accounting methods (ACO).

Accounting literature focused on stock returns to calculate SPCR. In this regard, one of the two alternatives can depend on: either the weekly return, in the case if the risk measurement is for data for a financial year, or on the daily return in the case if the risk measurement is for Data for a period of less than one year (e.g., quarterly) (Kim et al., 2011; Habib et al., 2018). The accounting methods used to predict SPCR were detailed in our study. With regard to the non-accounting method, it utilizes ACO to predict SPCR. The concept of ACO is based on observations of interesting ant behavior in search of food, specifically how to find the shortest path between food sources and its nest. (Al-Saqal &Abdullah, 2014: 88, Ahmed et al., 2019: 51). SPCR is predicted by providing a graph showing the modeling of the set of components (possible solutions) in the form of vertices or edges to represent the optimization problem. Based on this representation, an artificial ant adopts a solution by moving along the graph and selecting the components of the solution (Bouktif&Awad, 2013: 840; Ahmed et al., 2019: 51). We found that the most crucial factor that can reduce SPCR is the disclosure of information, along the emergence of developments and challenges of digital transformation and the tendency of companies to adopt entrepreneurship, and apply its principles by innovating new products or operations or improving existing processes and products. In addition, R&D carried out by companies leads to good information that can be disclosed to reduce SPCR. For clarity, the main problem can be wording in answering the main question: Does disclosure of R&D affect the ability to predict SPCR?

II. LITERATURE REVIEW AND RESEARCH HYPOTHESIS

Disclosure of information on the costs of R&D provides an effective channel for investors to learn about the company’s most recent activities of the company and the possibility of its success and enhance the transparency of information (Park, 2018:877). In addition, R&D information is an essential reference to know the aspects of spending for the capital invested in the company, which leads to attracting more interest from stakeholders such as financial analysts, existing and new investors, auditors, the press, and banks, thereby promoting the company to more disclosure of information to reduce information asymmetry. According to Zhou & Pan (2018), there is an inverse relationship between companies' inputs in R&D and SPCR. Zhou & Pan (2018) explained that when a company needs capital to spend on R&D, it seeks to provide more information to gain investor confidence. Simultaneously, investors will seek more information about companies prior to investing, reducing information asymmetry and thereby decreasing the SPCR. Ali (2020) clarified the significance of disclosing R&D costs, which benefits users of reports and financial statements. In support of this, Ahmed (2015) provides the following illustrations:

1. Reducing information asymmetry may enhance the company's value, reduce the cost of capital and improve liquidity, which is the result of gaining investors' confidence and satisfaction with the company's performance. It is also considered the primary factor in reducing and limiting SPCR. Where information asymmetry between the company and the capital market and between informed and uninformed investors can be reduced by increasing voluntary disclosure and company transparency (Joshua &Jeff, 2019: 331), Merkley (2014) reveals a negative relationship between narrative disclosure of R&D and information asymmetry, suggesting that the disclosure of R&D as an effective tool to reduce information asymmetry.

2. Reducing agency costs: Higher levels of disclosure increase external control and enhance market discipline, which in turn limits the ability of managers to achieve private benefits against the interest of external stockholders, and thus stockholders can ease monitoring through voluntary disclosure (Riddha et al.,2022; Leonardo&Kathryn,2022; Shuping et al.,2022; Ilan&Xiaojing,2021) which reduces problems agency and improves the reputation of the company. Managers likely have incentives to provide more information related to R&D to reduce agency problems.

3. Balancing Limited Disclosure Requirements for R&D: Voluntary disclosure is an effective tool in bridging mandatory reporting effectiveness gaps (Dain et al., 2022; Anil & Ram ,2022) when obligatory disclosure requirements are few, as limited disclosure related to R&D cannot provide sufficient information for effective evaluation of the results. Merkley, (2014) states that the unique characteristics of R&D and the limited disclosure imposed by accounting standards lead to the problem of information asymmetry. Hence, managers have the incentive to provide more disclosure of R&D, which improves the company's transparency.

Research Hypothesis

Hypothesis: There is a significant difference between disclosure about the costs of R&D and the predictive ability of SPCR.

Explanation Hypothesis:

There is a relationship between R&D and reduced SPCR, and we hypothesize that more investment in R&D leads to reduced SPCR. In addition, it is evident that companies with an urgent need for R&D, with strong funding constraints and a weak external supervision environment, are more likely to disclose information and not store it, thereby reducing SPCR.

Relationship of innovation behavior in R&D to SPCR:

The main reason for SPCR is the accumulation of bad news. This storage and non-disclosure of negative information will suddenly appear at once, causing SPCR, leading to a massive impact on the capital market and consequently of SPCR (Jin & Myers, 2006:263; Hutton et al., 2009: 71; Kim et al., 2011: 640).

Therefore, the solution to this problem lies in improving the transparency and quality of information and reducing management's bias for self-interest. The literature on the consequences of activities in companies mainly focuses on the following aspects:

1) Investment in R&D as one of the innovation inputs improves the company's ability to produce patents as one of the innovation outputs, and this investment has a strong relationship with improving the company's performance. Jia (2018:159) found that companies with a significant investment in innovation are less exposed to SPCR, as companies engaged in innovation and R&D have good information and news about the achievements they are making and therefore have a great incentive to publish this information, resulting in less accumulation of negative news that leads to SPCR.

2) Innovation and investment in R&D affect the value of the company (Ragab, 2017: 147; Ali, 2020:17) provided that there is a strong relationship between R&D and the market value of the company because R&D operations aim to innovate new products or improve existing products, which requires more costs to achieve this goal, which attracts the attention and interest of management, as it is one of the

strategic matters that affect the company's market value, especially in a fiercely competitive market, which leads to improving the company's reputation. It maintains the value of its stocks and is not exposed to SPCR.

3) Market reaction to R&D, as the disclosure of information on R&D may lead to a similar response from competing companies, thereby disseminating good information about the companies' activities.

4) R&D is considered a long-term investment with a high cost at the company level. Therefore, it is impossible to neglect the disclosure of R&D, which conveys important internal messages about the company.

Relationship between disclosure of R&D and reduced SPCR:

Managers view patents as one of the outcomes of R&D because they are good indicators of the company's ability to gain the confidence of stockholders and external parties (Bhattachrya & Ritter, 1983: 36). Hsu & Ziedonis (2013:763) illustrate that patents arising from R&D are associated with a lower cost of debt, and obtaining capital, and ease of access to public funding, and increase investor's confidence in the company as evidence of the quality of work, especially companies that invest heavily in R&D, increases information transparency (Ben-Nasr et al., 2019:3), and reduces its inconsistency. Therefore, it reduces SPCR since it is difficult for managers to hide negative information with a high degree of information transparency. As a result, it does not accumulate, and thus SPCR decreases.

The link between R&D and reducing the SPCR.

The link between R&D and reducing the SPCR is not only related to the transparency of information and the qualities of managers. According to (Li et al., 2019: 4), the CEO's age influences his decision-making. If the manager were younger, he would have greater motivation and courage to undertake investment projects, as well as an adventurous spirit to increase R&D, thereby reducing SPCR. Fu&Zhang (2019:3) have demonstrated that managers with values, ethics, culture, and thoughts reduce SPCR, with the manager with culture being aware of the significance of investing in R&D.

III. RESEARCH DESIGN

Samples and Data Sources

Our study sample includes: Studying the data of the Mina Pharm Company for Pharmaceuticals and Chemical Industries from the pharmaceutical sector and operating on the Egyptian Stock Exchange.

Design of the Model

On the basis of the purpose of the research, the model is designed as follow with reference to existing documents (Zhu, 2016; Lim et al., 2016; Kim& Zhang, 2016; Habib et al., 2018; Ahmed, 2019; Abdul Majeed, 2019):

Before disclosing R&D costs:

$$\text{Crash Risk}_{it} = \partial_0 + \partial_1 \times \text{Audit it} + \partial_2 \times \text{Size}_{it} + \partial_3 \times \text{ROA}_{it} + \partial_4 \times \text{MTB}_{it} + \partial_5 \times \text{AbsDa}_{it} + \varepsilon_{it}$$

After disclosing R&D costs:

$$\text{Crash Risk}_{it} = \partial_0 + \partial_1 \times \text{R\&D}_{it} + \partial_2 \times \text{Audit}_{it} + \partial_3 \times \text{Size}_{it} + \partial_4 \times \text{ROA}_{it} + \partial_5 \times \text{MTB}_{it} + \partial_6 \times \text{AbsDa}_{it} + \varepsilon_{it}$$

Where: ∂_0 constant regression model.- Crash risk is the probability of crash risk of the stock price of Mina Pharm for Pharmaceuticals and Chemical Industries and it is measured by NCSKEW method, and it represents the dependent variable in the previous equation- Audit is an audit quality variable- Size Variable company size- ROA is a variable rate of return on assets- MTB is a variable ratio of market value to book value of equity- AbsDa is the accrual quality variable used to denote the quality of accounting information. the year of **t**. And Control represents control variables, while $\varepsilon_{i,t}$ random disturbance.

Variable Definition

- *Accounting methods for calculating SPCR*

The accounting literature has presented four ways to measure SPCR, all of which depend on the company's stock returns, which is part of the expanded market model (Chen et al., 2001). This ensures that these metrics reflect company-specific rather than market-specific factors (Habib et al., 2018). It depends on either the daily return or the weekly return on the stock, where the daily return is used when measuring SPCR for periods less than a fiscal year (quarterly or semi-annual). By taking the difference between the closing price and the opening price for this stock and dividing it by the opening price (Abdul Majeed, 2019: 100).

Growth in stock price = closing price - opening price ÷opening price

As for the weekly return on the stock, it will be relied upon if the data for the period that is being relied upon to measure the risks of SPCR is for a full financial year, which is what the current study will depend on using it. So it will be covered in some detail:

The starting point when measuring the risk of SPCR is to perform the following Expanded Market Model regression equation

$$r_{it}= \partial_i+\beta_1\ rm_{it-2}+ \beta_2\ rm_{it-1}+ \beta_3\ rm_{it}+\beta_4\ rm_{it+1}+\beta_5\ rm_{it+2}+\varepsilon_{it}$$

r is the earnings per stock of company **i** in week **t**. rm_{it} represents the return on the stock market index during week **t**.

Since the residuals or error coefficient $\varepsilon_{i\tau}$ in the previous highly skewed equation is converted to an almost symmetrical distribution (Abdul Majeed, 2019), the next step is to calculate the weekly return of firm **i** in week **t** by calculating the natural logarithm of one plus the error coefficient $\varepsilon_{i\tau}$ found in the previous equation (Habib et al., 2018; Khalil et al., 2019; Fu & Zhang, 2019; Li & Lou, 2020)

$$\mathbf{W_{i.t} = LN\ (1+ \varepsilon_{i,\tau})}$$

After that, SPCR are predicted using one of the four methods:

a. Standard deviation of weekly stock returns.

If the value of the standard deviation of the average weekly stock returns is in the range of 3.09, it gives one valid measure of SPCR, and it is zero if it is less than that, and each standard deviation of 3.09 gives a frequency distribution of 0.1% and is an indicator of SPCR.

b. The Negative Skew Coefficient Method for Distribution of Weekly Returns NCSKEW.

It measures the ratio between the conditional negative deviation of the third moment of weekly stock returns and the standard deviation of the weekly stock returns to the third power, and is calculated by the following equation; (Kim et al., 2011; Habib et al., 2018; Ibrahim, 2016; Abdel-Moataal, 2019; Abdul Majeed, 2019)

$$\mathbf{NCSKEW = -[\ n(n_{-1})^{3/2}\pounds w^{3}{}_{i.t}\ ]/\ [(n_{-1})(n_{-2})(\pounds w^{2}{}_{i.t})^{3/2}]}$$

$\mathbf{W_{i.t}}$ represents the weekly returns on **i**. Company's stock.

The higher the negative skewness coefficient of the weekly returns of company i's stock during period **t** (which means the higher the negative skew or leftward skewness in the dividend distribution), the greater or higher SPCR.

c. DUVOL stock's weekly returns volatility scale.

First, company's circumstances are analyzed, in terms of sales and profit forecasts for companies in various industries. Second, analysis of the industry or sector to which the company belongs. last stage is the analysis of the economic conditions under which different industries operate (Ahmed ,2013: 27). and this measure is based on evaluating the weekly returns of each company over the period of time measured into two groups, the first group is the low group (down -weeks), which is the group of observations that fell below the average calculated returns for the period under measurement. The second group is the high group (up- weeks), which is the group of observations that exceed this mean, then the deviation is calculated for each group separately, and the value of the scale of volatility from bottom to top is the natural logarithm of the ratio of the standard deviation of the sum of low observations to the standard deviation of the sum of observations high (Mohammadi, 2020; Habib et al., 2018).

$$\mathbf{SPCR_{i.t} = Log[\ (Nd_{-1})£down\ W^2_{i.t} / (Nu_{-1})£up\ W^2_{i.t}]}$$

Nd Low Weekly Views**. Nu** High Weekly Views.

d. Implied Volatility (IV-SKEW).

Implied volatility is measured by the market price of the option and the strike price according to the Black-Scholes model. The study of (Kim & Zhang, 2014: 858 ; Habib et al., 2018: 216) stated that the implied volatility is the difference between the volatility of the market price of the put option .In which the market price is greater than the strike price (OTM Put, referred to in the form IV_{OTMP}) and the call option (in which the market price is equal to the strike price ATM Call, referred to as IV_{ATMC}).

$$\mathbf{IV\text{-}SKEW = IV_{OTMP} - IV_{ATMC}}$$

OTMP: put option contract as it lies between delta values of -0.375: -0.125

ATMC: call option contract as it is located between delta values of 0.375: 0.625.

- *Non-accounting methods for predicting SPCR*

One of the non-accounting methods used in predicting SPCR is the Ant Colony Optimization ,which is considered one of the swarm intelligence models, as it is one of the harmonic models inspired by the natural movement of the mirage that can be incorporated into artificial intelligence systems, and it is a very modern technology that uses to find solutions to the problems related to distribution control (Saeed& Hassan, 2015: 647)**,** and it is considered one of the most important algorithms that help in finding the optimal solution through graphs and operations research, and it is one of the effective ways to predict SPCR, i.e. the behavior of stock prices up and down.

Other Control Variables

First control variable: quality of the audit

Audit quality variable is used for the purpose of controlling the impact of audit quality, and it is measured through the use of a dummy variable that takes (1) if the external auditor represents a member of the auditing offices of the Big Four or a partner in them, and takes the value (zero) if it is different It is symbolized by audit (Mohammadi, 2020: 56, Lim et al., 2016: 2106)

In our study, the Mina Pharm Company for Pharmaceuticals and Chemical Industries was reviewed in the period (2004-2007) by an auditor who does not represent one of the big four offices, so the value of the audit quality variable will be (zero) only.

As for the period (2017-2021), its accounts were audited by two auditing firms, one of whom is (Ernst & Young Global), so the value will be (1)

Second control variable: size of the company

The company size variable has been used to control the impact of the company's size on SPCR, and it is measured by taking the natural logarithm of total assets at the end of each fiscal year for Mina Pharm for Pharmaceuticals and Chemical Industries, and this variable is expressed as Size. Studies (Kim et al., 2011:30; Defond et al., 2015:20; Zhu, 2016:360; Lim et al., 2016:2106; Abdul Majeed, 2019: 104) that the relationship between the size of the company and SPCR The stock has a negative relationship, meaning the greater the size of the company, the lower SPCR.

Third Regulatory Variable: ROA:

The variable rate of return on assets was chosen in order to control its impact on SPCR. This variable is used to judge the company's financial performance during the financial year. It is measured by (annual net profit / the total value of assets). Studies of (Kim et al., 2011:30; Defond et al., 2015: 20; Zhu, 2016: 360; Lim et al., 2016: 2106; Abdul Majeed, 2019: 107) proved that there is a positive relationship between the rate of return on assets and SPCR.

Fourth Regulatory Variable: MTB:

This ratio reflects the growth opportunities available to the company, and it was measured by dividing (market value/book value) of the Mina Pharm Company for Pharmaceuticals and Chemical Industries at the end of the fiscal year, and symbolized by the symbol MTB, and a study has proven both (Kim et al., 2011: 30; Defond et al., 2015: 20; Zhu, 2016: 360; Lim etal., 2016: 2106; Abdul Majeed, 2019: 107) that there is a positive relationship between this ratio and SPCR.

Fifth Controlling Variable: AbsDa:

This variable is used to measure the quality of the accounting information that included in the financial reports in terms of credibility and the benefit achieves for its users, while it is free from material distortions and presenting it in a timely manner to achieve its relative importance for each user, as well as preparing and presenting it in accordance with legal, regulatory, professional and technical standards, which helps to achieve its objective.

The modified accrual quality model was used based on the model (Hutton et al., 2009; Zhu, 2016), where this variable was measured as the absolute value of the optional accruals calculations using the following regression equation.

$$\frac{TA_{it}}{Assets_{t-1}} = \partial_0 \times \frac{1}{Assets_{t-1}} + \partial_1 \times \frac{\Delta REV_{it} - \Delta REC_{it}}{Assets_{t-1}} + \partial 2 \times \frac{PP\&E_{it}}{Assets_{t-1}} + \varepsilon_{it}$$

where it represents:

TA$_{it}$: Total Accounts Accrual is equal to The difference between Total Accruals and cash flows from the operating activities of Mina Pharm for Pharmaceuticals and Chemical Industries in year t.

Assets $_{t-1}$: Total assets at the beginning of the company's financial period.

ΔREV: it is the change in total revenue which is equal to:

(Revenues of the current year - Revenues of the previous year) ÷ Revenues of the previous year

Δ REC$_{it}$**:** change in total accounts receivable which is equal to:

(Total accounts receivable for the current year - Total accounts receivable for the previous year) ÷ Total accounts receivable for the previous year

$PP\&E_{it}$ represents the company's total property, plant and equipment at the end of the current year.

ε_{it} represents the residuals or the error term in the regression equation, and it represents the absolute value of the optional accruals is the value of the residuals.

Zhu (2016:393) has proven that there is a positive relationship between the benefits variable, Tables (1) and (2) represent the values of the independent, dependent, and control variables, which were calculated based on the previous equations.

IV. EMPIRICAL ANALYSIS

Descriptive statistics of the data:

We described the data of the study, where the following paragraphs include the test of the normal distribution of the data, the test of flatness and skewness, as well as the test of the extreme data, to ensure the quality of the collected data, as follows:

- *Testing the normal distribution of the data:*

The analysis of the normal distribution of the data is one of the most important tests in multivariate analysis, which in turn means to what extent the distribution of the data of the sample under study converges with the normal distribution of the data from the statistical perspective (**Hair et al., 2010**). The normal distribution of the data can be tested through two indicators, The first is called Skewness: It is the extent to which the data are close to the mean value, and the second indicator is called Kurtosis: It is the extent to which the distribution of data for the sample is statistically high or low compared to the normal distribution curve (De Vaus, 2002:3), and according to Curran, et al.,(1996:2) The data is considered to be normally distributed when the skewness value is less than (2), and the skew value is less than (7). table (3) displays the skewness and splaying value for each of the variables used.

- *Extreme data test:*

The outliers for multiple variables are data with numerical values that deviate from the normal values of the variables (Garson, 2012), and outliers arise as a result of several reasons, namely: error in data collection or entry, errors in sampling, or deliberate errors in the answers of the surveyor. Of them (Osborne and Overbay, 2004), Mahalanobis D2 test was used to determine the presence of extreme data or not, and this indicator states that if the value of D2 is higher than 3.5, the statement is considered extreme, and this test was done using the program SPSS 24, Table (4) Normal distribution of the data.

Forms of the normal distribution of the study variables:

Figure (1) explains and illustrates forms of the normal distribution.

- *Arithmetic means and standard deviations of the study variables:*

Table (٥) clear that there is a convergence between the arithmetic averages of all the variables of the study based on the total values of the sample vocabulary.

- *The two-way linear correlation coefficients between the study variables:*

To determine the significance of the correlation between the study variables, Pearson's two-way correlation test was performed. Table (٦) shows the coefficients of the two-way linear correlation between the study variables.

– *Polylinearity test:*

The multilinearity test is used to identify the linear relationship between the previous variables. Table (٧) shows the results of the multilinearity test for the independent variables.

Data analysis and the use of ant colonies in predicting the impact of R&D on SPCR rates:

– *Mathematical representation of SPCR:*

In order to find the impact of R&D and their disclosure on SPCR, it is necessary to find the relationship between SPCR and the most influential factors (control variables) in addition to the new factor (R&D) which is desired to be studied. The equation that represents SPCR in the absence of taking into account the disclosure of R&D costs can be represented by equation (1), which is a linear equation and is the first model in our study:

$$Crash\ risk = a_0 + a_1 X_{audit} + a_2 X_{size} + a_3 X_{ROA} + 4_2 X_{MTB} + a_5 X_{AbsDa} + \varepsilon$$

(1)

And the coefficients a_0, a_1, a_2, a_3, a_4, a_5 represent the impact of each of these factors and the extent of their relationship. Factors with a positive sign increase SPCR and vice versa. And for the mathematical representation to be accurate, it is necessary to find the best values for the transactions, which will be deduced based on the quarterly data of the company to be studied. In order for the values to be more correct and accurate, equation (1) is used only with the data before the process of disclosing the R&D data. While the symbol Ɛ represents the error in representing the equation, which is in the form of a normal distribution with a theoretical mean of zero and a standard deviation that is calculated after finding the best value for the coefficients.

In the case of adding or disclosing the company's R&D values, the linear equation (1) is used by adding the R&D value and its own coefficient. Thus, the improved equation (2) becomes the equation used to find SPCR in the case of R&D.

$$Crash\ risk = a_0 + a_1 X_{audit} + a_2 X_{size} + a_3 X_{ROA} + a_4 \quad X_{MTB} + a_5 X_{AbsDa} + a_6 X_{R\&D} + \varepsilon$$

In this case, the transactions a_0, a_1, a_2, a_3, a_4, a_5, a_6 are extracted to represent the exact between SPCR and the studied transactions. In order to obtain accurate results, the quarterly values are used after disclosing the amount of R&D. The standard deviation of the error is extracted and calculated after finding the values of all the parameters.

– *Calculate the best values for the coefficients of the linear relationship and the mathematical proof*

The accuracy of calculating the coefficients in the proposed linear equation in both equation (1) and (2) is an important factor in the research. Therefore, it must be ensured that the values of the transactions will give the least possible error between the variables and SPCR. Linear algebra can be used to find the values of the coefficients in the best possible mathematical form. Suppose we have a number of values of M which correspond to SPCR. These points can be represented in the form of a matrix (3) in the absence of taking into account R&D, and this corresponds to equation (1):

$$\begin{bmatrix} CR(1) \\ CR(2) \\ \vdots \\ CR(M) \end{bmatrix} = \begin{bmatrix} 1 & X_{audit}(1) & X_{size}(1) & X_{ROA}(1) & X_{MTB}(1) & X_{AbsDa}(1) \\ 1 & X_{audit}(2) & X_{size}(2) & X_{ROA}(2) & X_{MTB}(2) & X_{AbsDa}(2) \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & X_{audit}(M) & X_{size}(M) & X_{ROA}(M) & X_{MTB}(M) & X_{AbsDa}(M) \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ \vdots \\ a_5 \end{bmatrix} \varepsilon$$

(3)

$$CH = XA$$

whereas:

$$CH = \begin{bmatrix} CR(1) \\ CR(2) \\ \vdots \\ CR(M) \end{bmatrix}, X = \begin{bmatrix} 1 & X_{audit}(1) & X_{size}(1) & X_{ROA}(1) & X_{MTB}(1) & X_{AbsDa}(1) \\ 1 & X_{audit}(2) & X_{size}(2) & X_{ROA}(2) & X_{MTB}(2) & X_{AbsDa}(2) \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & X_{audit}(M) & X_{size}(M) & X_{ROA}(M) & X_{MTB}(M) & X_{AbsDa}(M) \end{bmatrix}, A = \begin{bmatrix} a_0 \\ a_1 \\ \vdots \\ a_5 \end{bmatrix}$$

This equation can be solved in the form of matrices to find the best values of the coefficients using equation (4), which is mathematically proven that it obtains the best values of the coefficients and reduces the error.

$$A = ((X^T * X)^{-1} * X^T) * CH \quad \textbf{(4)}$$

In the case of adding R&D as a factor in the equation, the matrix X,A will be defined as shown below.

$$X = \begin{bmatrix} 1 & X_{audit}(1) & X_{size}(1) & X_{ROA}(1) & X_{MTB}(1) & X_{AbsDa}(1) & X_{R\&D}(1) \\ 1 & X_{audit}(2) & X_{size}(2) & X_{ROA}(2) & X_{MTB}(2) & X_{AbsDa}(2) & X_{R\&D}(2) \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & X_{audit}(M) & X_{size}(M) & X_{ROA}(M) & X_{MTB}(M) & X_{AbsDa}(M) & X_{R\&D}(M) \end{bmatrix}, A = \begin{bmatrix} a_0 \\ a_1 \\ \vdots \\ a_5 \\ a_6 \end{bmatrix}$$

In this case, the evidence is used after the process of disclosing the levels of R&D Extracting the best values for linear relationship coefficients and digital application.

To find the values of the transactions, data and the values of the transactions must be defined at the stage to be studied. Mina Pharm for Pharmaceuticals and Chemical Industries was selected and quarterly data was collected for the periods (2004-2007) before the R&D disclosure process and the period 2017-2021) after the R&D disclosure process. Table (٨) and Table (٩) show the values of these coefficients and the values of the matrix. Table (١٠) Coefficient values without R&D in both 2004-2007. Table (١١) Coefficient values with R&D in both 2017-2021. Table (١٢) shows the transaction values in this case for every two consecutive years. Table (١٣) shows the final values used in building the ant colony model. Figure (٢) shows the difference between the SPCR values in the absence of R&D and in light of the inclusion of R&D for the period (2004-2007).

Ant colony Optimization (ACO)

– *The mechanism of action of ACO:*

Deneubourg et al, (1990) studied an experiment known as the double bridge experiment, in which the ant colony was linked to a food source by two bridges of equal length. First, ants explored the surroundings of the colony and walked in random directions until they finally reached the food source, where the ants put the pheromone on the ground Along the way he took between the source of food and the nest, and during the search, the ants chose one of the two bridges at random, and although the length of the two bridges was equal in length, but the concentration of pheromone on the two bridges would be slightly different due to random fluctuations and this would bring more ants to this bridge, Which in turn will cause more pheromone to appear, eventually this bridge will become more attractive due to the higher amount of pheromone compared to the other bridge and over time the entire colony will follow this bridge (Khtar, 2019: 3)

The pheromone setting mechanism helps ants find the shortest path between the food source and the nest, so that when one of the bridges is shorter, the ants that move through the shortest path reach the food sooner and the pheromone concentration increases on the way back (Bouktif & Awad, 2013) A variant of the double bridge experience where one bridge is much longer than the other. In this case, the random fluctuations in the initial selection of the bridge are greatly reduced, and the second mechanism plays an important role. Specifically, ants that accidentally choose the short bridge are the first to reach the nest. A short bridge receives more pheromone earlier than a long bridge, and this fact increases the likelihood that more ants will choose it for transport to and from the food source. Figure 3 shows a schematic diagram of the double bridge experiment.

Joss et al (1989) introduced a model for evaluating the probability of an ant to select the first bridge (ϕ_1) in which μ_1 ants chose the first bridge and μ_2 ants chose the other bridge in a double bridge experiment as follows in Equation No. (5):

$$\phi_1 = \frac{(\mu_1 + z)^h}{(\mu_2 + z)^h + (\mu_1 + z)^h} \qquad 5$$

where ϕ_1 = the probability of the ant choosing the first bridge, μ_1 = the number of ants who chose the first bridge, μ_2 = the number of ants who chose the second bridge, and z and h = the parameters to be fitted to the experimental data.

Ants represent the solutions in ACO, and the ant path is a set of prediction variables that constitute a solution to the optimization problem in ACO, stock price crash. In other words, the ant's journey from the nest to the food represents a potential solution to the optimization problem.

Each ant has an efficiency in its path that corresponds to the value of the objective function of the optimization problem that reflects the length of its run. The better the efficiency of the ant (lower SPCR), and the shorter the length of the round. Each ant leaves a concentration of pheromone in a specific area of the prediction taking space according to a value of its efficiency that determines its trajectory. New ants (solutions) are made based on information left by previous ants in the prediction space. Table (14) lists the characteristics of ACO.

ACO begins by creating a set of random solutions made up of variables that affect SPCR, which are determined from a predetermined set of discrete values. The suitability of all solutions or in other words their functionality SPCR is evaluated in proportion to the solutions' efficiency values, pheromone concentrations are allocated to the prediction space (solutions with lower risks secrete a higher rate of hormones). The pheromone concentration shows desire. The parts of the prediction space that make appropriate solutions achieve greater pheromone concentration. The sum of the pheromone for a given value of the prediction variable is equal to all the pheromones left by all the ants with that value. New ant(s) are generated in the next computational step based on information retrieved from previous ants. New solutions are randomly generated using a stochastic function that determines the probability of the permissible values of each decision variable according to its pheromone. Values with a higher concentration of pheromone are more likely to be chosen. Pheromone concentrations are taken into account when creating new solutions after evaluating the efficiency of the newly created solutions, and if the termination criteria are not met, the algorithm ends. Figure (4) depicts the flow map of ACO.

Implementation of (ACO)

a. *Building the initial solution:*

An ant's path in any dimension of an N-dimensional space represents the prediction variable for an optimization problem. An ant is defined as a 1 x N array that describes an ant's path. This set is defined as follows in Equation 6:

$$Ant = X = (x_1, x_2, \ldots, x_i, \ldots, x_N) \qquad \textbf{6}$$

where X = the solution to the optimization problem, x_i = ith the prediction variable for the solution X, and N = the number of prediction variables, and the values of the prediction variable (x_1, x_2, x_3, ..., x_N) are chosen from a set of predefined values for the discrete problems, as ACO solves discrete field problems; Each independent variable takes i a value from a predetermined set of values VI as follows in equation (7):

$$V_i = \{v_{i,1}, v_{i,2}, \dots, v_{i,d}, \dots, v_{i,D_i}\}, \quad i = 1,2,\dots,N \qquad 7$$

where V_i = the set of predetermined values of the prediction variable, $v_{i,d}$ = the likely value of the prediction variable i, and D_i = the total number of possible values for the prediction variable i.

The solution is represented as a graph that links the prediction variables to each other to determine the path or solution as shown in Figure (5). The number of graph layers is equal to the number of prediction variables, and the number of nodes in a given layer equals the number of discrete possible values allowed for the corresponding design variable; Thus each node on the graph is associated with a separate allowable value of the design variable.

ACO starts by randomly generating a matrix of size M x N (where M and N denote the size of the population of solutions and the number of prediction variables, respectively). Hence, the randomly generated matrix of solutions is as follows in equation (8) (there are rows or solutions M, and each solution has a decision variable N):

$$Population = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_j \\ \vdots \\ X_M \end{bmatrix} = \begin{bmatrix} x_{1,1} & x_{1,2} & \cdots & x_{1,i} & \cdots & x_{1,N} \\ x_{2,1} & x_{2,2} & \cdots & x_{2,i} & \cdots & x_{2,N} \\ & & & \vdots & & \\ x_{j,1} & x_{j,2} & \cdots & x_{j,i} & \cdots & x_{j,N} \\ & & & \vdots & & \\ x_{M,1} & x_{M,2} & \cdots & x_{M,i} & \cdots & x_{M,N} \end{bmatrix} \qquad 8$$

Where X_j = j, x, and i = ith the prediction variable for the solution j, and M = the number of solutions, the value of x_j, i is selected randomly from the set of V_i.

b. Put the values of pheromones for each variable:

Unlike most other meta- and evolutionary algorithms, ACO allocates desire in prediction space rather than solutions to find the best region of the prediction space or the best combination of prediction variables. Most descriptive and evolutionary algorithms generate new solutions using old solutions, for example, by mixing old solutions or by creating new solutions next to old ones. ACO looks at different points of the forecast space and adds information to the forecast space. New solutions are randomly generated based on existing information to predict, ACO assigns a pheromone concentration to the value of each decision variable according to the efficiency of the solution. The more efficient the solution, the higher the pheromone concentration and vice versa, meaning that values that provide better solutions achieve higher pheromone concentration than values that make for less efficient solutions.

N matrices of size $1 \times D_i$ are used to allocate a pheromone to the prediction space so that each is assigned to a single prediction variable as follows in equation (9):

$$C_i = \left(c_{i,1}, c_{i,2}, \ldots, c_{i,d}, \ldots, c_{i,D_i}\right), \quad i = 1,2,\ldots,N \qquad 9$$

where C_i = pheromone matrix for the prediction variable i and $c_{i,\ d}$ = pheromone concentration for the potential dth value of the prediction variable i.

The elements of the C matrix equal zero at the beginning of the computational optimization, and they are updated during the computational search, taking into account the positive values. The objective of the pheromone update is to increase the pheromone concentration for the values of the good or better prediction variable. The pheromone assignment is achieved by:

1. Reducing all pheromone values through pheromone evaporation.
2. Increase pheromone levels associated with a selection of good solutions.

The solutions (ants) are generated and their fitness values evaluated. The pheromone concentration of the potential dth value of the prediction variable is updated as follows in Equation (10)

$$c_{i,d}^{(new)} = (1-\rho)\times c_{i,d} + \sum_{j=1}^{M} \Delta c_{i,d}^{(j)}, \quad d = 1,2,\ldots,D_i, \quad i = 1,2,\ldots,N \qquad 10$$

where c = new pheromone concentration of the possible dth value of the prediction variable, ρ = evaporation rate, and ($\Delta c_{i\ d}$)= the amount of pheromone placed on the possible dth value of the prediction variable ith by the jth ant. The value of ($c_{i\ d}$) corresponds to the fit value of solution j, and it is estimated as follows in equation (11) in the minimization problem:

$$\Delta c_{i,d}^{j} = \begin{cases} \dfrac{Q}{F(X_j)} & if\ x_{j,i} = v_{i,d} \\ 0 & if\ Otherwise \end{cases}, \quad j = 1,2,\ldots,M, \quad i = 1,2,\ldots,N, \quad d = 1,2,\ldots,D_i \qquad 11$$

where Q = constant value and $F(X_j)$ = value of fit of solution j.

c. *Finding the new values of the variables:*

New solutions are generated through a stochastic process. Each decision variable i is assigned a value with a probability that depends on the pheromone concentration. Specifically, the probability $P_{i,\ d}$ is assigned to each possible value d of the prediction variable i as follows in equation (12):

$$P_{i,d} = \frac{(c_{i,d})^{\alpha} \times (\eta_{i,d})^{\beta}}{\sum_{k=1}^{D_i} \left[(c_{i,k})^{\alpha} \times (\eta_{i,k})^{\beta} \right]}, \quad d = 1,2,\ldots,D_i, \quad i = 1,2,\ldots,N$$ 12

where $P_{i,d}$ = probability of choosing the ith potential dth value ($v_{i,d}$) for the ith prediction variable, i, d = indicative value of the ith potential dth value of the prediction variable, and α = parameters that control the relative importance of pheromone versus exploratory information ($\eta_{i,d}$), the exploratory information also shows the desire to select the possible values that help computational research in the prediction space more efficiently. For example, when the purpose is to reduce SPCR, it should look for R&D value at which SPCR is reduced. Thus, a high probability of choosing R&D is higher.

Since the choice of parameters α makes this feature optional, and the sum of the probabilities of the possible values for each predictor variable equals one represented in equation (13):

$$\sum_{d=1}^{D_i} P_{i,d} = 1, \quad i = 1,2,\ldots,N$$ 13

The values of the prediction variables for a new solution are randomly selected based on the evaluated probabilities. This is done by:

First: Calculate the cumulative probability of all possible values for each variable in the prediction process as follows in equation (14):

$$\psi_{i,r} = \sum_{d=1}^{r} P_{i,d}, \quad i = 1,2,\ldots,N, \quad r = 1,2,\ldots,D_i$$ 14

where $\psi_{i, r}$ = the cumulative probability of the r-possible value of the prediction variable i.

Second: a random number is generated in the range [0:1]. If Rand is less than i, 1, the first value ($v_{i, 1}$) is specified; Otherwise the value of r is specified such that Rand is greater than i r and 1 and less than or equal to $\psi_{i, r}$ (i r, 1 Rand i r). This procedure assigns a random value from the set V_i to each decision variable i of solution j. If the $v_{i, d}$ component of the set is assigned to the prediction variable ith of the new solution j , we have the regeneration in this case into the variables by equation (15):

$$x'_{j,i} = v_{i,d}, \quad i = 1,2,\ldots,N, \quad j = 1,2,\ldots,M \tag{15}$$

where x_j i = the new value of the prediction variable i for the new solution j.

The new solutions are generated after evaluating all the prediction variables as in equation (16):

$$X_j^{(new)} = (x'_{j,1}, x'_{j,2}, \ldots, x'_{j,i}, \ldots, x'_{j,N}), \quad j = 1,2,\ldots,M \tag{16}$$

in which $(X_j)^{new}$ = new solution j. The newly created M solutions replace all the old ones.

d. ACO ant colony stop algorithm:

The improvement process continues in the ant raging until the best value of the variables is reached, which guarantees the least SPCR, after which the algorithm stops after ensuring the best solution.

V. CONCLUION

With regard to the optimum value for R&D, we have found that ACO is one of the computer methods used to determine the best value for the variable in order to minimize SPCR. It can be concluded that the absolute relationship between SPCR and R&D is always an inverse relationship. Therefore, utilizing ACO has proven effective in maximizing R&D value, thereby reducing SPCR.

Since R&D should not exceed a specific value, known as the maximum value that cannot be skipped, this condition was set in ACO, and it always took the path that puts greater values in R&D and always stopped at the maximum value allowed.

While previous research revealed that the optimal solution is using linear programming, which is based on a purely mathematical basis, and it has been previously calculated by congruence in the two solutions between the linear programming, which represents the mathematical solution, and ACO. Our research shows that ACO efficiency is evident in determining and selecting the maximum allowable value of R&D costs and reducing SPCR.

Our study concluded that the accuracy of predicting SPCR using ACO and the disclosure of R&D reduced SPCR, as it provided a new disclosure channel in which important information is disclosed that improves the company's reputation and results in new innovations in The products and services provided by the company, guaranteeing a sustainable competitive position in the market, distinguishing it from its counterparts from companies operating in the same sector.

Furthermore, we provide the maximum (maximum value) of R&D, which should not exceed the value of R&D, at which SPCR is at its lowest value. This value is equal to the company under study, 17,174,534 Egyptian pounds, and the minimum acceptable of the costs of R&D, after which there is SPCR in the stock price (4422819 Egyptian pounds).

Therefore, the hypothesis is accepted: there is a statistically significant relationship between predicting SPCR and disclosing R&D using ACO.

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Table(1)

2004			2005				2006				20	
second	Third	fourth	first	second	Third	fourth	first	second	Third	fourth	first	second
2.44949	2.44949	2.44949	2.44949	2.44949	2.44949	2.44957	2.44975	2.44956	2.44954	2.44979	4.08161	4.16177
—	—	—	—	—	—	—	—	—	—	—	—	—
0	0	0	0	0	0	0	0	0	0	0	0	0
8.420623025	8.447324545	8.415870097	8.458823819	8.479418071	8.48424478	8.4778575	8.4868527	8.49573946	8.533507494	8.533000068	8.593948134	8.582729036
0.02004343	0.04653712	0.07489004	0.03897418	0.11723559	0.12642728	0.09075084	0.02741728	0.03643501	0.10281835	0.11897849	0.03013187	0.05476751
0.834	0.834	0.834	0.834	0.834	0.758	0.758	0.758	0.758	0.758	0.758	0	0
0.0583419	0.0934935	0.0394524	0.0705262	0.138828	0.1328921	0.1249855	0.0140862	0.0197263	0.068919	0.0316515	-0.0010638	0.0035401

Table (1) represents the values of the variables for the period from 2004-2007, which is the period before the disclosure of R&D costs.

Table(2)

variab	2017				2018				2019				2020				2021			
	first	second	Third	fourth	first	second	Third	fourth	first	second	Third	fourth	first	Second	Third	fourth	first	second	Third	fourth
SPCR	4.24264	3.68501	2.78511	3.17197	3.62507	1.31973	2.79220	2.54230	2.51393	3.09928	3.47502	3.04262	2.59231	2.96850	3.73286	-3.89992	4.15130	4.14985	3.21110	3.67340
R&D	7.07948388	6.80436736	6.929837894	7.234884962	7.062218717	7.219062509	6.955543779	7.091789492	6.703543712	7.042491914	6.820846509	6.872867059	6.820846509	6.795101063	6.695316858	6.645699167	6.789146977	6.75488109	6.855373943	7.181931809
AUDIT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SIZE	9.096699754	9.130174864	9.186488903	9.19418639	9.209411127	9.243459801	9.242756311	9.209411127	3.226335866	9.215243078	9.23084017	9.217648703	9.226021609	9.242919259	9.2628743156	9.309277763	9.350049272	9.370690297	9.389029708	9.387074414
ROA	.006179595	0.012567735	0.001407762	0.039588678	0.008192057	0.022554246	0.02438936	0.044531107	0.003848046	0.007299564	0.009355377	0.027889999	0.010981837	0.015590404	0.02781702	0.07091519	0.025870227	0.040719046	0.029441476	0.020430674
MTB	7.1	5.347	6.68	8.031	9.95	10.497	9.1	8.8	8.5	8.5	8.495	8.495	7.891	8.17	7.7	8.029	10.064	9.578	10.674	10.635
Abs Da	0.0104849	0.6123701	0.0049761	0.1445561	-0.0003483	-0.0002875	-0.0003239	-0.0002966	-0.000011	0.0058167	-0.0003178	-0.0002963	-0.0002874	-0.0002667	-0.0002487	-0.0002227	0.0116497	0.0385878	0.0147848	-0.0001973

Table (2) represents the values of Variables for the periods from 2017-2021, which is the period after the disclosure of R&D costs.

Table(3)

Variable	degree of torsion	degree of flatness
1. SPCR	٣.٥٠٦-	١٧.٤٥٧
2. R&D	٠.٢٢٩-	٢.٠٥٩-
3. AUDIT	٠.٢٣٣-	٢.٠٦٤-
4. SIZE	٠.٢٣٣-	٢.٠٦٣-
5. ROA	١.٠٥٥	٠.٠٥٣
6. MTB	٠.٠٧٠-	١.٨٨١-
7. AbsDa	٤.٥٢٢	٢٣.٤٩٣

table (3) displays the skewness and splaying value for each of the variables used, most of the torsion and flatness values for all study variables fall within the permissible range represented by torsion values less than 2, and flatness values less than 7, in addition to the negative impact of the abnormal distribution decreasing as the sample size rises, and given that the data are subject to The study is larger than (50 observations) (De Vaus, 2002:4; Hair et al., 2016:; Gujarati, 2014) and this principle is consistent with the size of the study sample, in addition to the use of the maximum likelihood method in the hypothesis test, which It is characterized by its ability to address deviations in the normal distribution of the data (Iacobucci, 2009:374; Hair et al., 2016; Garson, 2012), and then the data for the sample that was collected is considered a normal distribution.

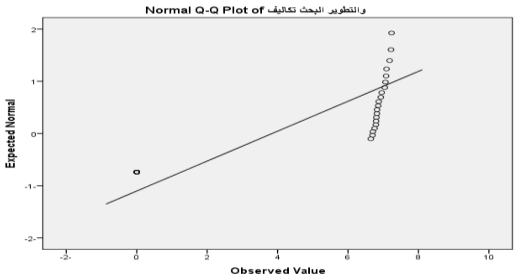
Table (4)

Variable	Kolmogorov-Smirnov	Shapiro-Wilk
1. SPCR	٠.٣٣٩	٠.٦٢٥
2. R&D	٠.٣٤٥	٠.٦٦٠
3. AUDIT	٠.٣٦٧	٠.٦٣٣
4. SIZE	٠.٣٥٨	٠.٦٤٢
5. ROA	٠.١٨٥	٠.٨٦٦
6. MTB	٠.٢٨٩	٠.٧٩٩
7. AbsDa	٠.٣١٥	٠.٤٥٦

Table (4) clear that the values of (D2/df) are less than (3.5), and then the sample data for the current study is considered free from the problem of data exaggeration.

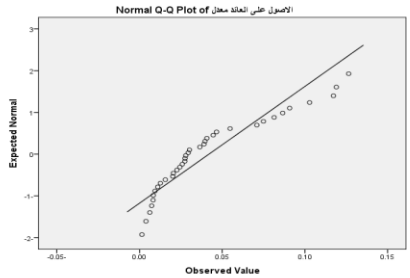
Variable

R&D

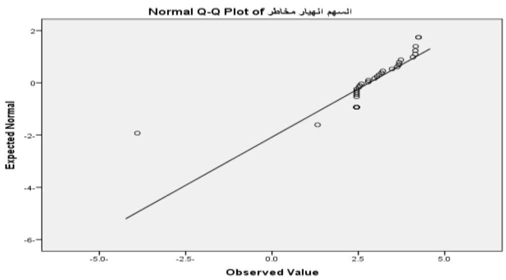


Variable

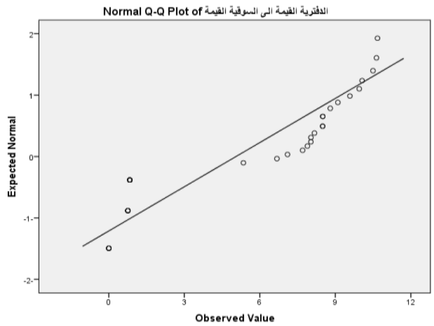
ROA



SPCR



MTB



AUDIT AbsDa SIZE

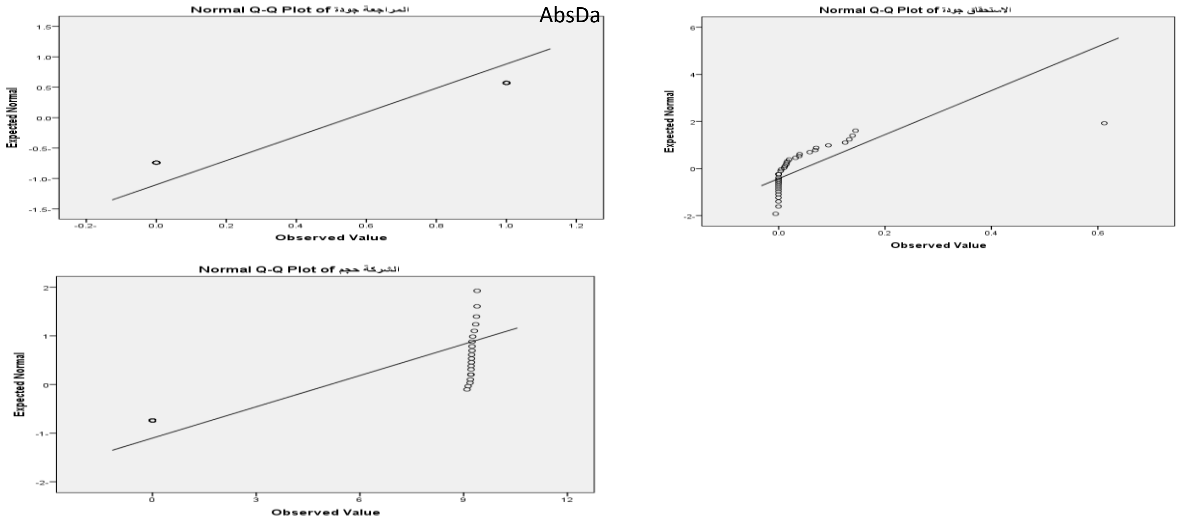


Figure (1) forms of the normal distribution

Table(5)

Variable	standard deviations	arithmetic mean
1. SPCR	١,٣٥٤	٢,٨١١
2. R&D	٣,٤٨٨	٣,٨٤٤
3. AUDIT	٠,٥٠٤	٠,٥٦
4. SIZE	٤,٦٦٠	٥,١٣٧
5. ROA	٠,٠٣٥٧	٠,٠٤١
6. MTB	٤,١٦٨٦	٥,٠٥١٧
7. AbsDa	٠,١,٧٠	٠,٠٤٥٥

Table(٥)clear that there is a convergence between the arithmetic averages of all the variables of the study based on the total values of the sample vocabulary, and this indicates a clear awareness of the sample vocabulary for all the study variables, and the standard deviations of the variables that are all less than the correct one indicate that there is a great deal of agreement in the study sample. While the standard deviation values greater than the correct one indicate that there is a degree of difference in the vocabulary of the study sample.

Table(6)

	R&D	SPCR	AUDIT	SIZE	ROA	MTB	AbsDa
1.	١						
2.	٠,٠٣٥	١					
3.	**٠,٩	٠,٠٢٧	١				
4.	**٠,٩	٠,٠٢٦	**٠,٩	١			
5.	**٠,٦٢-	٠,٢٤-	**٠,٦١٩-	- **٠,٦١٧	١		
6.	**٠,٩	٠,٠٢٠	**٠,٩	**٠,٩	**٠,٥٨٠-	١	
7.	٠,٠٤٧-	٠,٠٧٦	٠,٠٤٤-	٠,٠٤٨-	٠,١١٠	٠,١٦٢-	١

Table (٦) shows the coefficients of the two-way linear correlation between the study variables.

Table(7)

Variable	Tolerance	Vif
R&D	0.001	753.403
AUDIT	0.001	699.366
ROA	0.587	1.703
MTB	0.043	23.256
AbsDa	0.741	1.349

Table (٧) shows the results of the multilinearity test for the independent variables of the study.

Table (8)

year		CH	X_{audit}	X_{size}	X_{ROA}	X_{MTB}	X_{AbsDa}
٠٤	١	2.449489743	0	8.391636	0.008324	0.834	0.0165112
	٢	2.449489743	0	8.420623	0.020043	0.834	0.0583419
	٣	2.449489743	0	8.447325	0.046537	0.834	0.0934935
	٤	2.449489743	0	8.41587	0.07489	0.834	0.0394524
٠٥	١	2.449489743	0	8.458824	0.038974	0.834	0.0705262
	٢	2.449489743	0	8.479418	0.117236	0.834	0.138828
	٣	2.449489743	0	8.484245	0.126427	0.834	0.1328921
	٤	2.449567627	0	8.477852	0.090751	0.758	0.1249855
٠٦	١	2.449746297	0	8.486853	0.027417	0.758	0.0140862
	٢	2.449559856	0	8.495739	0.036435	0.758	0.0197263
	٣	2.449538087	0	8.533507	0.102818	0.758	0.068919
	٤	2.449791178	0	8.533	0.118978	0.758	0.0316515
٠٧	١	4.081608615	0	8.593948	0.030132	0	-.0010638
	٢	4.161769786	0	8.582729	0.054768	0	0.0035401
	٣	4.242640687	0	8.574984	0.081398	0	-.0009817

٤	0	0	8.597979	0.086565	0	-.0011965

Table (9)

year		CH	X_{audit}	X_{size}	X_{ROA}	X_{MTB}	X_{AbsDa}	$X_{R\&D}$
٢٠١٧	١	4.242640687	1	9.0967	0.00618	7.1	0.0104849	7.079484
	٢	3.685007842	1	9.130175	0.012568	5.347	0.6123701	6.804367
	٣	2.785112295	1	9.186489	0.001408	6.68	0.0049761	6.929838
	٤	3.171965412	1	9.194186	0.039589	8.031	0.1445561	7.234885
٢٠١٨	١	3.625069112	1	9.209411	0.008192	9.95	-0.0003483	7.062219
	٢	1.319732123	1	9.24346	0.022554	10.497	-0.0002875	7.219063
	٣	2.792196325	1	9.242756	0.024389	9.1	-0.0003239	6.955544
	٤	2.542301913	1	9.209411	0.044531	8.8	-0.0002966	7.091789
٢٠١٩	١	2.513933427	1	9.226336	0.003848	8.5	-0.0000011	6.703544
	٢	3.099283043	1	9.215243	0.0073	8.5	0.0058167	7.042492
	٣	3.475019107	1	9.23084	0.009355	8.495	-0.0003178	6.820847
	٤	3.042620912	1	9.217649	0.02789	8.495	-0.0002963	6.872867
٢٠٢٠	١	2.592314824	1	9.226022	0.010982	7.891	-0.0002874	6.824037
	٢	2.968495802	1	9.242919	0.01559	8.17	-0.0002667	6.795101
	٣	3.732858303	1	9.262874	0.027482	7.7	-0.0002487	6.695317
	٤	-.899920866	1	9.309278	0.070915	8.029	-0.0002227	6.645699
٢٠٢١	١	4.151298293	1	9.350049	0.02587	10.064	0.0116497	6.789147
	٢	4.149852597	1	9.37069	0.040719	9.578	0.0385878	6.754881
	٣	3.211102624	1	9.38903	0.029441	10.674	0.0147848	6.855374
	٤	3.673401506	1	9.387074	0.020431	10.635	-0.0001973	7.181932

Table (٨) and Table (٩) show the values of these coefficients and the values of the matrix.

Using the available data, it is possible to find the values of the transactions in both the disclosure and non-disclosure cases, as shown in Table (٨) and (٩). It can be noted that the value of the audit parameter is zero, because its value is constant for all years.

Table (10) Coefficient values without R&D in both 2004-2007.

constant	X_{audit}	X_{size}	X_{ROA}	X_{MTB}	X_{AbsDa}
a_0	a_1	a_2	a_3	a_4	a_5
٤,٥٨٨١-	٠	0.955929	-7.80261	-1.0739	4.855884
	E mean			E STD	
	-2.56E-11			0.9048	

It is clear from Table (١٠) that the relationship may be direct between disclosure of R&D costs and the risks of SPCR. In order to ensure that the relationship is correct, the data were taken consecutively for every two consecutive years, and R&D coefficients were found.

Table (11) Coefficient values with R&D in both 2017-2021.

constant	X_{audit}	X_{size}	X_{ROA}	X_{MTB}	X_{AbsDa}	$X_{R\&D}$
a_0	a_1	a_2	a_3	a_4	a_5	a_6
-65.6773	٠	6.140212	-70.6644	0.074032	2.992414	**1.816477**
	E mean			E STD		
	-5.41E-11			1.2642		

Table (12).

year factor	constant a_0	X_{audit} a_1	X_{size} a_2	X_{ROA} a_3	X_{MTB} a_4	X_{AbsDa} a_5	$X_{R\&D}$ a_6
٢٠١٨-٢٠١٩	194.7591	٠	-19.0424	8.396215	0.231353	-0.45801	**-2.6641**
2018-2019	134.3132	٠	-18.3629	-77.5433	-1.90784	-447.815	**8.14527**
2019-2020	227.3203	٠	-25.6561	-71.4228	-2.05832	-250.984	**4.49583**
2020-2021	-771.55	٠	92.40665	-256.341	-3.42534	15.72183	**-7.0547**

Table (١٢) shows the transaction values in this case for every two consecutive years. Table (١٢). clear that the values of research and development coefficients were inverse in all the years that were not included in the data for the year 2019. By investigation this year, the company had the highest costs of research and development R&D, with a very high rate, during the period of search for a vaccine for the virus. Corona, which led to a high risk rate in SPCR of the stock price, and the Egyptian Stock Exchange was greatly affected by the Corona pandemic in global stock exchanges, and it was closed for long periods and therefore all operating companies were affected.

The SPCR of the stock price after successful operations and reaching the desired results, for example, obtaining the Corona vaccine in order to increase profits and sales.

In order to avoid using 2019 data and using accurate data in calculating linear equation coefficients, the 2019 data were neglected while deducing the coefficients

Table (13).

constant a_0	X_{audit} a_1	X_{size} a_2	X_{ROA} a_3	X_{MTB} a_4	X_{AbsDa} a_5	$X_{R\&D}$ a_6
113.9623	0	-12.4442	-83.3589	1.448537	5.02752	**-0.89323**
	E mean			E STD		
	4.0210e-11			1.2170		

Table No. (١٣) shows the final values used in building the ant colony model. As it can be seen from the table that the research and development coefficient is (negative).

This means that the more the company spends in research and development activities, the lower the risk of SPCR.

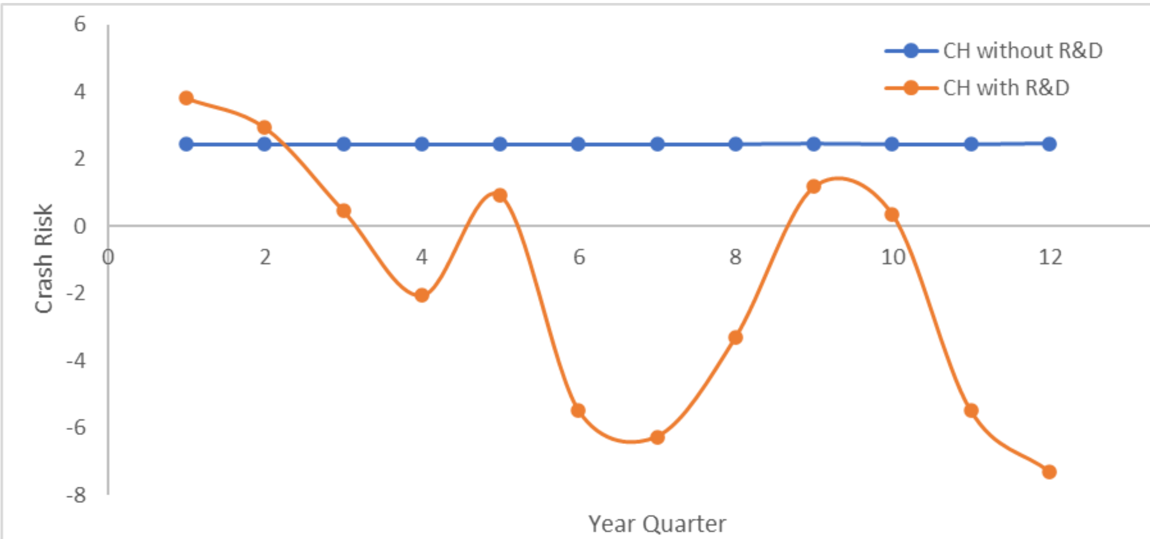


Figure (٢) The SPCR rate for the years 2004-2007 in light of the disclosure of R&D

Figure (٢) shows the difference between the SPCR values in the absence of R&D and in light of the inclusion of research and development for the period (2004-2007).

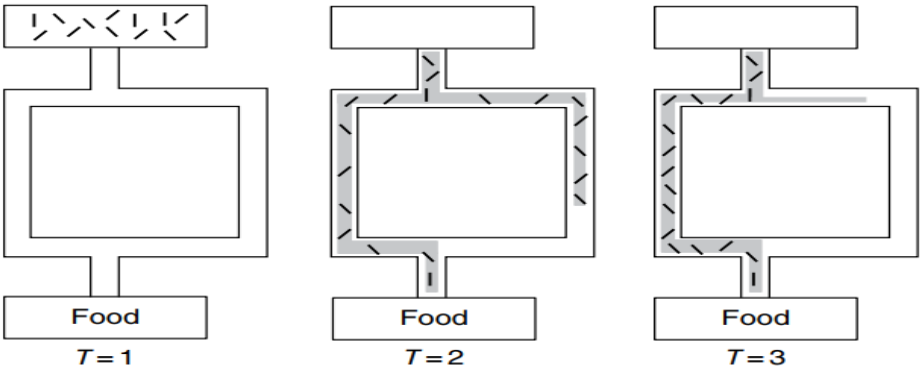


Figure 3 schematic diagram of the double bridge experiment.

Table (14)

General algorithm (see Section 2.13)	Ant colony optimization
Decision variable	Track path of ant
Solution	Ant
Old solution	Old ant
New solution	New ant
Best solution	–
Fitness function	Pheromone
Initial solution	Random ant
Selection	–
Process of generating new solutions	Based-information stochastic mechanism

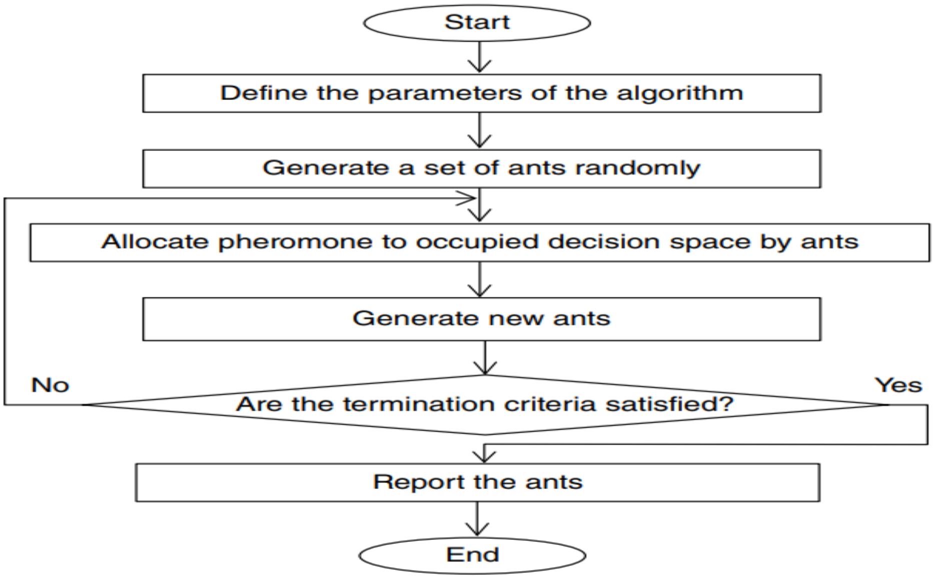


Figure (4) flow map of the ACO ant colony algorithm

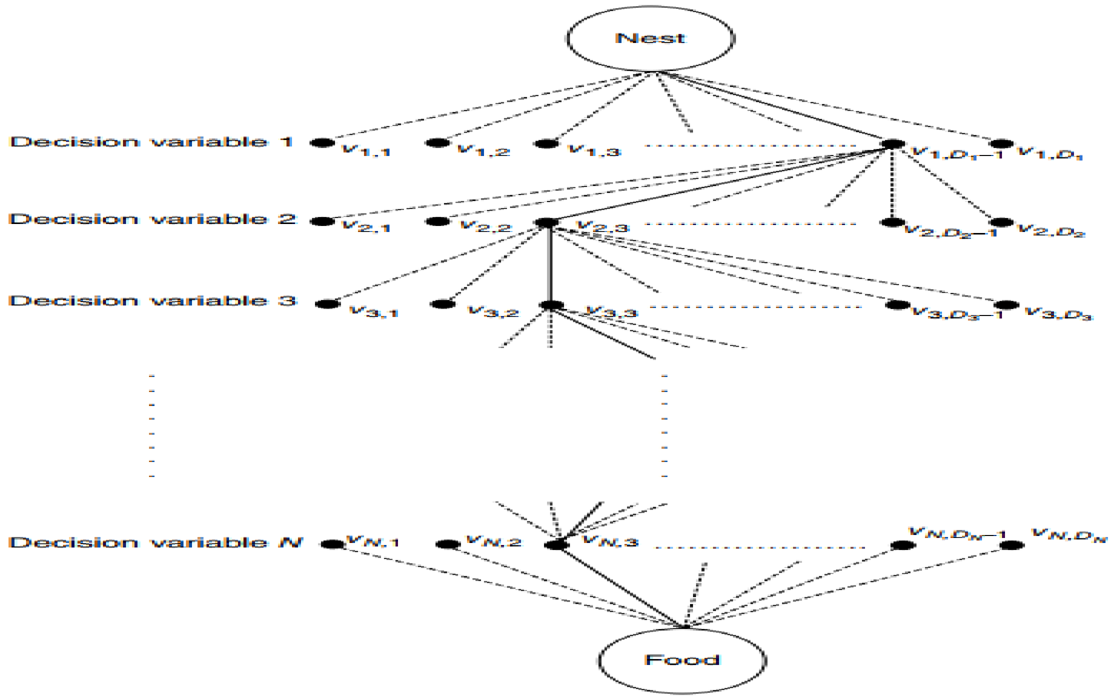


Figure5: The process of making a prediction and optimizing the values of variables in the ant colony algorithm