Providing a Model for Forecasting the Stock Price Crash Risk in Tehran Stock Exchange on the basis of EXTR-SIGMA & NCSKEW

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Submit: 25/12/2019 Accept: 19/05/2020

ABSTRACT
Stock price crash have been described as a severe negative event in stock returns, causing major losses in shareholders' wealth and a loss of confidence in the capital market. This study sought to investigate the stock price crash risk of 114 companies listed on Tehran Stock Exchange within the years 2009 to 2018 on the basis of Bradshaw et al EXTR-SIGMA (2010) and Chen et al. NCSKEW (2001) criterion. Accordingly, the researcher first calculated the stock prices crash risk based on two different criterion and then tested the internal and external factors of the company on crash risk. The statistical model used in this study encompassed regression model and the data type is panel data type. Based on the findings of the present study, there is a significant relationship between the dependent variables (the first and the second criteria for calculating and predicting stock price crash), the factors within the company (company features and financial ratios) and external factors such as dollar market price, volume of shares traded, Iranian oil price and global gold price

Keywords:
stock crash risk, EXTR-SIGMA, stock price, Chen model.

1. Introduction

Due to the constant changes environmental conditions bring about, they confront institutions with opportunities or threats. External opportunities and threats are economic, social, cultural, ecological, environmental, political, legal, governmental, technological, and competitive events and trends that can benefit or harm the organization in the future and are to a large extent beyond the control power of the organization. In financial texts, investment is the commitment of money or other resources in the hope of earning future benefits. Investors always prefer more future returns, but there are risks involved. This is the traditional risk-return confrontation, which states that if an investor requires a higher expected return, they must also accept greater risk. Assessing financial assets is one of the most challenging areas of financial knowledge. The basis of this lies in the identification of factors that have a high explanatory power to explain changes in return on assets. The paradigm governing asset pricing in classical finance has become the source of two main types of experimental studies in this area: First, studies that attempt to enumerate risk-taking factors, and second, studies that assume the adequacy and accuracy of comprehensive risk factors under different pricing models, and attempt to explain the different dimensions of such models (Doloo, 2016). But what is beyond the paradigm governing pricing is the drastic price changes that are sometimes referred to as price crash or falling. Due to the crash in global stock market, the issue of stock price crash has become a hot topic in finance. Stock price crash and different views on the sudden changes in stock prices in recent years, especially after the 2008 financial crisis, have attracted much attention. These changes occur mainly in the form of stock price crash and stock price jumps. Given the importance that investors place on their stock returns, the phenomenon of stock crash, which leads to a sharp decline in returns, has been the focus of more researchers than the jump. In general, the stock price crash risk is an adverse event that is defined as a sharp negative return on a stock. Such an event can lead to significant losses in investor wealth and a loss of investor confidence in the capital market. Given the lack of a complete market, the decisions that investors make are not entirely reliable, and the occurrence of events not seen in the planning stage can influence the capability of the investors to achieve the goals set out beforehand. That is why it is necessary for investors to somehow secure themselves against possible future events, especially in relation to stock prices. One way for investors to invest is to use stock price forecasting models. As briefly mentioned above, various researchers have stated various factors regarding the sharp stock price crash. However, what remains unknown is to provide a model for predicting stock price crash. In other words, using a model that is able to predict the stock price crash risk at various times can make a great contribution to investors in making investment decisions. In this study, the researchers strive to provide a model to predict stock price crash risk by examining various factors affecting stock price crash.

2. Literature Review

Stock price crash have been described as a severe negative event in stock returns, causing major losses in shareholders' wealth and a loss of confidence in the capital market. The definition of stock price crash has three distinct features: A) Stock price crash is a very large and unusual change in stock prices that occurs without a major economic event. B) These very large changes are negative. C) Stock price crash is a contagious phenomenon in the market. This means that the decline in stock prices is not limited to a specific stock, but includes all types of stocks on the market (Tanani et al., 2015). Regarding the first feature, Hong and Stein state that many of the major changes that took place in the s & p500 index after World War II, and especially the market crash in October 1987, were not due to the disclosure of news about a considerable and significant event. The second feature of the above definition is due to an empirical and significant asymmetry in changes in market returns, meaning that large changes in price have been more in the form of decrease and less in the form of increase. This asymmetry can be clearly seen through direct observation of historical data on market returns. An examination of the above-mentioned data shows that of the 10 major changes in the s & p500 index since 1947, nine have declined, and that stock returns over time have shown negative volatility or asymmetric fluctuations. The third characteristic of stock price crash is that the phenomenon spreads to all market stocks. Kelly (1994) postulated that the study of historical data trends on the price of stock options shows that in cases where the stock price index has been declining, the correlation between different types of bargain purchase options has increased. Blanchard and Watson, in explaining the phenomenon of negative stock return volatility, introduced the stock price accidental bubble model. A model that is able to predict the stock price crash risk well at various times can be a great contribution to investors in making investment decisions. In so doing, in this research, the researchers strive to provide a model for forecasting stock price crash risk by examining various factors contributing to stock price crash. Factors influencing stock prices can generally be divided into three groups: environmental or macro factors, industry-related factors (the industry in which the company operates), and internal factors.

Environmental or macro factors: Environmental factors here are factors that are not in the control of the company itself and depend on the overall economic and political system.

Industry-related factors: Companies listed on the stock exchange are a very broad industry. The petrochemical, refinery, base metals, automotive, cement, mass, and other industries are just a few of them. Each of these industries has its own factors and effects that must be considered separately in the industry.

Internal factors: The third category, which is also very important, is related to the company's internal factors.

The impact of macroeconomic variables on stock market performance has always been considered an important issue, given the significant impact of micro and macro variables on the stock market, financial analysts are always striving to identify the most important variables contributing to market performance so that they can provide better predictions. Therefore, this study provides a model for predicting stock price crash on the Tehran Stock Exchange using two criteria of Bradshaw et al EXTR-SIGMA (2010) and Chen et al. NCSKEW (2001) criteria based on macroeconomic variables and internal characteristics of companies.

In their study, Delshad and Tehrani (2015) examined the role of managerial characteristics on the stock price crash risk of companies listed on Tehran Stock Exchange. The research findings showed that among the various managerial features, the two characteristics of short-sightedness of managers and accuracy of management forecasting have had the most impact on stock price crash in the surveyed companies. In addition, along with the increase in management's short-sightedness, the share price of the surveyed companies has increased significantly, and thus the capital market has shown a significant response to the management's short-sightedness by increasing the company's stock price decline. Other findings showed that stock price declines have declined with increasing accuracy of management forecasting. Moreover, with increasing optimism of management, amelioration of management structure and increase of management ability, the rate of stock price crash of sample companies has been reduced and higher conservative actions of managers have been associated with increasing stock price crash risk; however, none of the results were statistically significant.

In a study entitled "Effects of volatility shocks on the dynamic linkages between exchange rate, interest rate and the stock market: The case of Turkey", Sensoy et al. (2014) found that short-term exchange rate fluctuations affect interest rates and stock markets. Tripathi and Seth (2014) examined stock market performance and macroeconomic variables in the stock market. The study was conducted in France between 2005 and 2013. The results showed that the three variables of inflation rate, interest rate and exchange rate were the three variables contributing to the stock market. Inflation rate was negatively correlated with stock market performance, and ultimately the relationship between interest rate and stock market performance was negative.

Shaghaghi and PakMaram (2019) examined the role of institutional quality in forecasting the total stock price index in developing and developed countries. The results of the study in different countries revealed that the components of institutional quality had a positive and significant effect on the overall stock price index and also identifying institutional weaknesses in developing and developed countries could be a way to ameliorate investment in capital market.

Razmian and Fallahshams (2020) evaluated the relationship between stock price crash risk and corporate business strategy and overvaluation in companies listed on the Tehran Stock Exchange. The results showed that the improvement of business strategies would increase profitability and thus reduce the stock price crash risk, and also overvaluation of stocks would increase the stock price crash risk.

3. Methodology

a. Research method

This study is an applied research. The primary objective of applied research is to develop applied knowledge in a specific field. In terms of data collection, the research is descriptive. Descriptive research can be divided into survey, correlation, action research, case study, and retrospective study. This research is correlational and the scale of data measurement is relative.

Gathering basic and raw data is of particular importance in any type of research. The initial information required for this study was collected from different sources according to their type, as well as for the sections related to the subject literature, internal and external records of research from library sources and for collecting financial and accounting information related to stock prices in different years and months, stock numbers, book value of shareholders' equity, stock day value, dividend dividends, etc. were used.

b. Research questions

According to the arguments in the statement of the problem, the following questions have been formulated to examine the relationship between internal and environmental factors with stock price crash of companies listed on the Tehran Stock Exchange.

RQ 1: Do the specific characteristics of companies affect the stock price crash risk?

RQ 2: Do macroeconomic factors contribute to the stock price crash risk?

RQ 3: Given the above factors and their relationship with the stock price crash risk, can a model be provided to forecast the stock price crash risk on the Tehran Stock Exchange?

c. Research models

In this study, the stock price crash risk has been taken into account as a dependent variable. If the company's stock returns are lower than the market's overall return on a particular financial period, the likelihood of a stock price decline during that period increases. $Crashrisk_{it}$ is the risk of a stock crash, which will be measured using two detailed criteria (EXTR-SIGMA and NCSKEW):

First criteria: The first criterion for stock price crash risk is EXTR-SIGMA. Bradshaw et al. (2010) stated that EXTR-SIGMA is used to create a quantitative and continuous criterion for measuring stock price crash risk. EXTR-SIGMA is also defined as the outlier returns according to the standard deviation of a particular company. The following equation will be used to calculate this variable:

(1)

$$EXTR\_SIGMA = -Min[(W-\overline{\varpi})/6_{w}$$

where EXTR_SIGMA is the maximum sigma, $\overline{\varpi}$ is the company's average specific return and 6_{w} is standard deviation of the company's specific monthly return

Second criteria: The second criterion for calculating stock price risk is NCSKEW: Chen et al. (2001) state that NCSKEW criterion controls asymmetric volatilities. Furthermore, the higher value of the criterion is in line with left skewness distribution. The following equation will be used to calculate this variable:

(2)

$$DUVOL_{jt} = -Log[n_u-1)\Sigma DOWN\ W^2{}_{j\theta}]/[n_d-1)\ \Sigma up\ W^2{}_{j\theta}]$$

where $DUVOL_{jt}$ is NCSKEW and n_u and n_d are the number of high and low months during the fiscal year of t, respectively.

It is worth noting that the data used in this study are annual data. Given that some of the variables used in this study, including independent variables related to internal factors, are among the variables that are prepared annually, to make them monthly, the linear interpolation method has been used as described in the following formula.

If we specify the coordinates of two points with (x0, y0) and (x1, y1), the value of y on this straight line is obtained from equation (3), below:

(3)

$$y = y_0+(x-x_0)\frac{\mathbf{y1-y0}}{\mathbf{x1-x0}}$$

d. Independent variables

In this study, the researchers examine and test two groups of variables inside the company and outside the company on the stock price crash risk. The most important variables within the company are as follows: Net profit margin, return on assets, return on equity, current ratio, quick ratio, receivable collection period of receipt, inventory to working capital ratio, fixed asset turnover ratio, total turnover, debt ratio, debt to net worth ratio, current debt to net worth ratio, property ratio, and debt-service coverage ratio.

Meanwhile, the most important external variables under study are: volume of shares traded, market day capitalization, dollar market price, world oil price, Iranian oil price, OPEC oil price, and world gold price.

e. Statistical model of testing the research questions

In the first research question, the researchers strive to examine the impact of internal and external factors on the stock price crash risk taking into consideration the first criterion; therefore, to investigate the effect of internal factors on the stock price crash risk, calculations based on each of the criteria (first and second) were run using statistical model 4:

(4)

$$Crash(m1)_{it} = a_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10} + \beta_{11} x_{11} + \beta_{12} x_{12} + \beta_{13} x_{13} + \beta_{14} x_{14} + \varepsilon_{it}$$

To investigate the effect of external factors on the stock price crash risk, calculations based on each of the criteria (first and second) were run using statistical model 5:

(5)

$$Crash(m1)_{it} = a_0 + \beta_1 y_1 + \beta_2 y_2 + \beta_3 y_3 + \beta_4 y_4 + \beta_5 y_5 + \beta_6 y_6 + \beta_7 y_7 + \varepsilon_{it}$$

In the above models:

Crash $(m1)_{it}$: is the dependent variable, computational variable for the stock price crash for company i in the year t, X_1 is net profit margin for company i in year t, X_2 is return on assets for company i in year t, X_3 is return on capital for company i in year t, X_4 is current ratio for company i in t year, X_5 is quick ratio for company i in year t, X_6 is receivable turnover for company i in year t, X_7 is inventory to working capital ratio for company i in year t, X_8 is fixed turnover assets for company i in year t, X_9 is total turnover for company i in year t, X_{10} is debt ratio for company i in year t, X_{11} is debt to net worth ratio for company i in year t, X_{12} is current debt to net worth ratio for company i in year t, X_{13} is property ratio for company i in year t, X_{14} is debt-service coverage ratio for company i in year t, Y_1 is volume of shares traded in year t, Y_2 is market day capitalization in year t, Y_3 is dollar market price in year t, Y_4 is global oil price in year t, Y_5 is Iranian oil price in year t, Y_6 is OPEC oil price in year t, and Y_7 is global gold price in year t.

In this study, Durbin-Watson and the Breusch-Godfrey tests were used to diagnose first-degree autocorrelation. In addition, in order to check the sedasticity of variance, the Breusch-Pagan-Godfrey test was used. Where the model suffered from heterosedasticity, Generalized Least Squares (GLS) method was used to estimate the model.

f.Statistical population and sampling

The statistical population of this study consisted of all companies listed on the Tehran Stock Exchange. Given that the researchers sought to examine the stock price crash risk on the Tehran Stock Exchange, all companies between 2009 and 2018 whose stock prices crashed on the stock exchange, and in other words, we witnessed the stock market crash, were entered into the research. In addition, given the objectives of this research, the sample companies should have the following characteristics:

1) The financial year of the companies should be the end of March.
2) Balance sheet information of companies should be available. In addition, the shares of companies do not have a negative or zero book value.
3) They do not have to stop trading for more than 5 months (at least for 7 months out of 12 months of one year).
4) The market value of companies should be available at the end of each year.
5) They should not be part of financial, investment and banking companies.

4.Results

a. Descriptive statistics of data

The total statistical sample studied during the research period encompassed 114 companies in different industries and given that the collected data was related to 10 years and the variables were calculated annually, the number of observations related to the mentioned variables was equal to 1140 i.e. 10*114.

b.Testing the research questions.

In this study, in order to investigate the lack of autocorrelation, Eviews software and Breusch-Godfery test were used. Where the model had autocorrelation, the generalized least squares (GLS) method was used to estimate the model.

Given that the probability of Breusch-Godfery test for autocorrelation in the first model (the model used for the first question testing) is less than 5%, the model has a problem of autocorrelation and is to solve it, generalized least squares method (GLS) is used to estimate the model.

The results of the Pagan-Godfery test indicate the presence of heteroscedasticity for the first regression models (model related to the second question) and the second (model related to the second question); therefore, in order to solve the problem of heteroscedasticity, the generalized least squares (GLS) method was used.

Table 1: Description of dependent variables

Description	M1	M2
Mean	0.058829	0.279565
Median	0.129532	0.27467
Maximum value	2.713337	2.292952
Minimum value	-3.09611	-3.9678
Standard deviation	0.901052	0.649658
Skewness	-0.41819	-0.37513
kurtosis	3.268634	5.156234
Observations	1140	1140
M_1: The first criterion for the stock price risk is the EXTR-SIGMA (Bradshaw et al., 2010) M_2: The second criterion for calculating the stock price risk is NCSKEW (Chen et al., 2001).		

Table 2: The results of Levin, Lin, and Chu (LLC) stationary test

Model/Criterion	RQ	statistic	P-Value	Result
M1	First	16.786	0.000	Autocorrelation
	Second	0.245857	0.782	Lack of autocorrelation
M2	First	1.6364	0.195	Lack of autocorrelation
	Second	0.78818	0.455	Lack of autocorrelation
M_1: The first criterion for the stock price risk is the EXTR-SIGMA (Bradshaw et al., 2010) M_2: The second criterion for calculating the stock price risk is NCSKEW (Chen et al., 2001).				

Table 3: Results of Breusch-Pagan-Godfery (BPG) test

Model/Criterion	RQ	statistic	P-Value	Result
M1	First	0.6475	0.826	Lack of heteroscedasticity
	Second	5.1709	0.000	heteroscedasticity
M2	First	0.5459	0.906	Lack of heteroscedasticity
	Second	2.6731	0.0095	heteroscedasticity
M_1: The first criterion for the stock price risk is the EXTR-SIGMA (Bradshaw et al., 2010) M_2: The second criterion for calculating the stock price risk is NCSKEW (Chen et al., 2001).				

The results of F-Limer test for the surveyed companies are summarized in Table 4 separately for the question models. If the test results are less than the 5% error level, the null hypothesis i.e. there are no cross-sectional effects is rejected.

The results of Hausman test are given in Table 5, which indicates the acceptance of the null hypothesis using random effects model; therefore, the use of random effects for the companies studied in the above models is confirmed according to the results.

Table 4: F-Limer test results to identify the panel data model

Model/criterion	RQ	Statistic	DF	P-Value	Result (Regression approach)
M1	First	294.649691	113	0.000	Panel
	Second	164.858326	113	0.001	Panel
M2	First	150.771765	113	0.010	Panel
	Second	138.715065	113	0.0506	Panel
M_1: The first criterion for the stock price risk is the EXTR-SIGMA (Bradshaw et al., 2010) M_2: The second criterion for calculating the stock price risk is NCSKEW (Chen et al., 2001).					

Table 5: Hausman test results to determine fixed and random effects model

Model/criterion	RQ	Statistic	DF	P-Value	Result (Regression approach)
M۱	First	6.146464	14	0.963	Random effects
	Second	11.282038	7	0.127	Random effects
M۲	First	18.18953	14	0.198	Random effects
	Second	7.806648	7	0.3500	Random effects
M_1: The first criterion for the stock price risk is the EXTR-SIGMA (Bradshaw et al., 2010) M_2: The second criterion for calculating the stock price risk is NCSKEW (Chen et al., 2001).					

Table 6: Final results of the internal variables test on the first criterion of the stock price risk calculation

Regression model: Panel	Type of effects: Random effects	Number of intervals: 114	Number of periods: 10 years	Number of observations: 1140
criterion	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
X1	-0/00115	0/00049	-2/337301	0/020
X2	0/00371	0/00267	1/391926	0/164
X3	0/00041	0/00006	6/709558	0/000
X4	0/04595	0/05537	0/829951	0/407
X5	-0/06010	0/04400	-1/365884	0/172
X6	0/00010	0/00006	1/658619	0/098
X7	0/00018	0/00010	1/774772	0/076
X8	-0/00367	0/00655	-0/560781	0/058
X9	-0/01451	0/05011	-0/289477	0/772
X10	-0/16331	0/11800	-1/383958	0/167
X11	-0/00388	0/01303	-0/297778	0/766
X12	0/00870	0/01446	0/601746	0/548
X13	0/00019	0/00010	1/909385	0/057
X14	-0/00007	0/00018	-0/426653	0/670
C	0/076343	0/107371	0/711018	0/477
R^2 /Adjusted R^2	0/144	0/143	Durbin-Watson	2/010
X_1 is net profit margin, X_2 is return on assets, X_3 is return on capital, X_4 is current ratio, X_5 is quick ratio, X_6 is receivable turnover, X_7 is inventory to working capital ratio, X_8 is fixed turnover assets, X_9 is total turnover, X_{10} is debt ratio, X_{11} is debt to net worth ratio, X_{12} is current debt to net worth ratio, X_{13} is property ratio, X_{14} is debt-service coverage ratio				

Given the results of the first research question on the stock price crash risk (the first criterion for calculating the stock price crash risk), it can be acknowledged that the variables X_1, X_3, X_6, X_7, X_{13}, and X_8 contribute to the dependent variable i.e. the first criterion for calculating the stock price crash risk. This effect is negative for X_1 and X_8 variables, whereas it is positive and significant for other variables.

As a result, it can be argued that net profit margins and fixed asset turnover have a negative and significant relationship with the stock price crash risk and capital return variables, receivable collection period, and inventory to working capital ratio have a positive and significant relationship with the stock price crash risk.

In addition, according to the statistics of Durbin-Watson (2.01), it can be admitted that the results obtained do not have the problem of first order autocorrelation. Also, considering the coefficient of determination of the above model, it can be claimed that the mentioned variables explain only 14% of the stock price crash risk, so in addition to these variables, other variables should be considered as well.

Based on the information obtained from this research and the results given in Table 7, all external variables of the company have an effect on the dependent variable of the research i.e. the stock price crash risk. In other words, it can be claimed that external variables are variables affecting the stock price crash risk and that investors should pay close attention to this issue when investing. The variables of the volume of shares traded, the price of the dollar market and the global price of oil have a negative and inverse effect on the stock price crash risk based on the first criterion. In addition, according to the statistics of Durbin-Watson (2.042), it can be acknowledged that the results obtained do not have the problem of first order autocorrelation. Also, given the coefficient of determination of the above model, it can be claimed that the mentioned variables explain only 19% of the dispersion of the stock price crash risk, so in addition to these variables, other variables should also be taken into consideration.

Table 7: Final results of the test of external variables on the first criterion of calculating the stock price crash risk

Regression model: Panel	Type of effects: Random effects	Number of intervals: 114	Number of periods: 10 years	Number of observations: 1140
Criteria	**Coefficient**	**Std. Error**	**t-Statistic**	**.Prob**
Y1	0/00000	0/00000	-5/702816	0/000
Y2	0/03584	0/00979	3/661753	0/000
Y3	-0/00001	0/00000	-10/3392	0/000
Y4	-0/08295	0/00819	-10/13195	0/000
Y5	0/04844	0/00743	6/521342	0/000
Y6	0/04496	0/00451	9/979372	0/000
Y7	0/00053	0/00020	2/637664	0/009
C	-1/40837	0/37946	-3/711484	0/000
R2/Adjusted R^2	0/196	0/19	Durbin-Watson	2/042
Y_1 is volume of shares traded, Y_2 is market day capitalization, Y_3 is dollar market price, Y_4 is global oil price, Y_5 is Iranian oil price, Y_6 is OPEC oil price, and Y_7 is global gold price				

Table 8: Final results of internal variable test on the second criterion of the stock price crash risk

Regression model: Panel	Type of effects: Random effects	Number of intervals: 114	Number of periods: 10 years	Number of observations: 1140
Criteria	**Coefficient**	**Std. Error**	**t-Statistic**	**.Prob**
X1	-0/002138	0/000507	-4/215644	0/000
X2	0/003384	0/001214	2/786084	0/005
X3	0/000082	0/000100	0/818161	0/413
X4	-0/121408	0/072676	-1/670529	0/095
X5	0/092207	0/069124	1/333943	0/183
X6	0/000210	0/000071	2/953664	0/003
X7	0/000178	0/000151	1/184036	0/237
X8	0/006412	0/003574	1/794269	0/073

Regression model: Panel	Type of effects: Random effects	Number of intervals: 114	Number of periods: 10 years	Number of observations: 1140
Criteria	**Coefficient**	**Std. Error**	**t-Statistic**	**.Prob**
X9	-0/054647	0/048478	-1/127241	0/260
X10	-0/174942	0/140474	-1/245373	0/213
X11	-0/033600	0/012695	-2/646617	0/008
X12	0/038382	0/014976	2/562969	0/011
X13	-0/000132	0/000071	-1/864049	0/063
X14	0/000048	0/000131	0/365196	0/715
C	0/446812	0/118384	3/774273	0/000
R2/Adjusted R^2	0/221	0/2102	Durbin-Watson	1/988
X_1 is net profit margin, X_2 is return on assets, X_3 is return on capital, X_4 is current ratio, X_5 is quick ratio, X_6 is receivable turnover, X_7 is inventory to working capital ratio, X_8 is fixed turnover assets, X_9 is total turnover, X_{10} is debt ratio, X_{11} is debt to net worth ratio, X_{12} is current debt to net worth ratio, X_{13} is property ratio, X_{14} is debt-service coverage ratio				

Based on the results of testing the first research question on the second criterion for calculating the stock price crash risk, it can be acknowledged that the variables X_1, X_2, X_4, X_6, X_8 X_{11}, X_{13} and X_{12} have a significant relationship with the stock price crash risk calculation based on the second criterion; In addition, this relationship is negative and inverse for variables X_1, X_4, X_{13}, and X_{11}. In other words, it can be acknowledged that variables including net profit margin, current ratio, and debt to net worth ratio have a negative and inverse relationship with the stock price crash risk based on the second criterion. Also, according to Durbin-Watson statistics (1.988), it can be concluded that the results do not have the problem of first order autocorrelation. Also, considering the coefficient of determination of the above model, it can be claimed that the mentioned variables explain only 22% of the stock price crash risk; therefore, in addition to these variables, other variables should be considered as well.

Table 9 shows the results of the second research question on the second criterion for calculating the stock price crash risk. Based on the results of the second research test on the second criterion, the calculation of the stock price crash risk, three variables of volume of shares traded, dollar market price and global gold price affect the stock price crash risk. The effects of the two variables of volume of shares traded and global gold price are negative, whereas they are positive about the dollar market price. Also, according to Durbin-Watson statistics (2.015), it can be concluded that the results do not have the problem of first order autocorrelation. Also, considering the coefficient of determination of the above model, it can be claimed that the mentioned variables explain only 21% of the stock price crash risk, so in addition to these variables, other variables should also be considered.

Table 9: Final results of the test of external variables on the second criterion for calculating the stock price crash risk

Regression model: Panel	Type of effects: Random effects	Number of intervals: 114	Number of periods: 10 years	Number of observations: 1140
criteria	**Coefficient**	**Std. Error**	**t-Statistic**	**.Prob**
Y1	0.00000	0.00000	-1/569134	0/012
Y2	-0.00031	0.01900	-0/016332	0/987
Y3	0.00000	0.00000	0/942509	0/035
Y4	-0.00823	0.00681	-1/208504	0/227
Y5	-0.00073	0.00580	-0/126577	0/899
Y6	0.01188	0.00749	1/584511	0/113
Y7	0.00000	0.00022	-0/003138	0/048
C	0.10802	0.53466	0/202034	0/840
R2/Adjusted R^2	0/215	0/209	Durbin-Watson	2/015
Y_1 is volume of shares traded, Y_2 is market day capitalization, Y_3 is dollar market price, Y_4 is global oil price, Y_5 is Iranian oil price, Y_6 is OPEC oil price, and Y_7 is global gold price.				

This study sought to investigate the impact of internal and external factors on the stock price crash risk. What was described above is the effect of internal and external factors on the dependent variable (two criteria for calculating the stock price crash risk). In the third question, the researchers strive to provide a model for calculating the stock price crash risk, so the following question is considered:

Given the above factors and their relationship with the stock price crash risk, can we provide a model for predicting the stock price crash risk on the Tehran Stock Exchange?

Based on the information provided in Tables 6 and 7, the model that can be proposed to predict the stock price crash risk based on the first criterion is as follows:

$$CrashRisk(M_1)=-1.408365-0.001153X_1+0.000412X_3+0.0001X_6+0.000183X_7-0.003672X_8+0.000187X_{13}-0.000000000332Y_1+0.035835Y_2-0.00000617Y_3-0.082953Y_4+0.048435Y_5+0.044959Y_6+0.000534Y_7 \quad (6)$$

As it is clear from the above, what is effective in predicting the stock price crash risk based on the first criteria are both internal and external factors.

Based on the information provided in Tables 8 and 9, the second criterion for calculating the stock price crash risk is the criterion of NCSKEW, according to which the following model can be used to predict the stock price crash risk calculated based on the second criterion:

$$CrashRisk(M_2)=0.446812-0.002138X_1+0.003384X_2-0.121408X_4+0.00021X_6+0.006412X_8-0.0336X_{11}+0.038382X_{12}-0.000132X_{13}-0.000000000106Y_1+0.00000108Y_3-0.000000679Y_7 \quad (7)$$

The model proposed for the second criterion for calculating the stock price crash risk, as in previous criteria, emphasizes the internal and external factors contributing to the stock price crash risk.

Given the criteria and factors influencing each of the criteria for calculating the stock price crash risk, it can be acknowledged that if the researchers seek to provide a general model of factors contributing to the stock price crash risk theoretically (based on the findings of current research), the following model is recommended:

$$CrashRisk=C+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_6+\beta_6X_7+\beta_7X_8+\beta_8X_9+\beta_9X_{10}+\beta_{10}X_{11}+\beta_{11}X_{12}+\beta_{12}X_{13}+\beta_{13}X_{14}+\beta_{14}Y_1+\beta_{15}Y_2+\beta_{16}Y_3+\beta_{17}Y_4+\beta_{18}Y_5+\beta_{19}Y_6+\beta_{20}Y_7 \quad (8)$$

In the above model:
CrashRisk is a computational variable for the stock price crash risk that can be calculated based on various criteria.

X_1 is net profit margin, X_2 is return on assets, X_3 is return on capital, X_4 is current ratio, X_5 is quick ratio, X_6 is receivable turnover, X_7 is inventory to working capital ratio, X_8 is fixed turnover assets, X_9 is total turnover, X_{10} is debt ratio, X_{11} is debt to net worth ratio, X_{12} is current debt to net worth ratio, X_{13} is property ratio, X_{14} is debt-service coverage ratio, Y_1 is volume of shares traded, Y_2 is market day capitalization, Y_3 is dollar market price, Y_4 is global oil price, Y_5 is Iranian oil price, Y_6 is OPEC oil price, and Y_7 is global gold price.

Moreover, the coefficients of each of the above (6)
factors and the type of direct and indirect relationship with the stock price crash risk can vary depending on the type of criteria that an investor or researcher uses to calculate risk.

5. Discussion and Conclusion

The current study set out to investigate the impact of internal and external factors on the stock price crash risk. The results of this study showed that the net profit margin and fixed assets turnover negative and significant relationship with the stock price crash risk, whereas variables of return on capital, receivable asset period, inventory to working capital ratio, and property ratio had a positive and significant relationship with the stock price crash risk. Moreover, all external variables affect the dependent variable of the research i.e. the stock price crash risk. The variables of the volume of the shares traded, the dollar market price and the global oil price have a negative and inverse effect on the stock price crash risk based on the first criteria.

Given that the second criteria used to test the stock price crash risk is NCSKEW criteria. Based on the results, it can be stated that variables such as net profit margin, current ratio, and debt to net worth ratio are negatively and inversely related to the stock price crash risk based on the second criteria. Also, according to Durbin-Watson statistics (1.988), it can be concluded that the results do not have the problem of first order autocorrelation. Also, considering the coefficient of determination of the above model, it can be claimed that the mentioned variables explain only 22% of the stock price crash risk; therefore, in addition to these variables, other variables should be considered as well. Three variables of the volume of shares traded, dollar market price, and global gold price affect the stock price crash risk with the negative effect of the two variables of the volume of shares traded and the global gold price, and the positive effect of dollar market price. Also, according to Durbin-Watson statistics (2.015), it can be concluded that the results do not have the problem of first order autocorrelation.

To test our hypotheses, we used firm-year observations from 114 Companies listed in Tehran Stock Exchange during the period of 2009-2018 on the basis of Bradshaw et al EXTR-SIGMA (2010) and Chen et al. NCSKEW (2001) criterion..

The most important limitation of the research is as follows: lack of rich library resources, incomplete exchange information of some companies.

Based on the results of this research and the coefficients of the factors affecting the dependent variable, it can be concluded that in addition to above factors, other factors should also affect the risk of stock fall, so investors are advised to pay attention to them.

It is also suggested that this research be conducted in future research according to different industries and the results of different groups be compared.

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