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Probability of stock price crash and the expected return of stock under sanctions

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Abstract

Sanctions increase managers' motivations to manage profits and the accumulation of bad news due to their negative impact on corporate profitability and cash flow. According to Jin and Myers (2006), this issue increases companies' stock price crash risk. The higher probability of stock price crashes indicates a stock price overvaluation. As a result, the expected return on such shares will be low. The current paper used the softmax model to calculate the probability of stock price crashes and the expected return calculated by the Fama-French three-factor model. The sample used in this paper includes 80 import- and export-oriented exchange companies from 2008-2021. The results of this paper indicate a positive and significant relationship between the sanctions variables and the probability of stock crashes. So, sanctions cause an increase in the accumulation of bad news and information asymmetry between managers and investors. The second part of the paper's results indicates a negative relationship between the probability of stock crashes and the expected return on the stocks in the Iranian capital market. Therefore, investors have relatively good analytical skills in the Iranian capital market due to its shallow depth and infrastructure problems. The results of this paper can be used in portfolio management to select stocks with a lower probability of crash and higher return.

Keywords: Crash risk, Expected return, Sanction, Softmax.

Introduction

According to political-economy theory, economic-political actions can influence the behavior of managers, auditors, and investors toward financial reporting. One of the significant political-economic actions in recent years has been the imposition of economic sanctions on Iran (arabi et al., 2017). Sanctions have led to declining efficiency, difficulties importing and exporting raw materials, and increased costs for exchange companies in Iran.

Managers during times of economic crisis use opportunistic reporting methods to provide a better picture of the company's situation, thereby leading to the accumulation of wrong information in the company. According to Jin and Myers (2006), Once the accumulated bad news reaches an overwhelming level that cannot be maintained, all bad news is suddenly released, leading to the stock price crash. Crash risk captures higher moments of the stock return distribution, i.e., extreme negative returns Callen and Fang (2015) (Kim et al., 2014). Understanding the cause of stock price crashes is significant because such risk cannot be reduced through portfolio diversification. Sanctions lead to

a company's market value and profitability decline, and low profitability can motivate managers to manage earnings (Arabi et al., 2017). According to the inadequate news concealment and stock price crash theories, earnings management behaviors allow managers to accumulate bad news, which finally leads to a stock price crash.

Because sanctions against Iran are unprecedented in severity, international studies are scarce. However, the effect of economic policy uncertainty on stock crash risk has been studied in recent years. So, the effect of sanctions on stock price crashes can be examined, such as the effect of economic policy uncertainty on stock price crash risk. According to Luo and Zhang (2020), economic policy uncertainty positively impacts the probability of stock crashes. In addition, according to Nagar et al. (2019), economic policy uncertainty exacerbates information asymmetry among the company's members in investors' decisions. As a result, investors 'reliance on the disclosure of company information in their investment decisions and managers' ability to manipulate revenues increases

The company's revenue growth during the sanctions period is due to rising inflation. It is more nominal because the government was forced to borrow from the central bank due to the budget deficit caused by the impossibility of selling enough oil and other export goods, leading to inflation. So, in the current paper, sales growth is considered an influential factor in the crash.

Hutton et al. (2009). Wang et al. (2020) and Yeung and Lento (2018) find that there is a negative relationship between the probability of stock crash risk and the debt ratio. Researchers argue that monitoring by institutional investors reduces the probability of accumulating bad news.

Jang and Kang (2019). Agnes Cheng et al. (2020). Usman Bashir et al. (2024) and other researchers introduced the SIZE factor into stock crash models. Some argue that firm size has a positive impact on financial reporting quality. Factors like establishing an effective internal control system and communication with large audit firms are regarded as its main factors. Some argue that the firm size hurts financial reporting quality. Factors like more significant pressure on large companies, more bargaining power of big companies with auditors, and a broader scope of application of accounting methods are regarded as its main factors (Nikoomaram & Nahandi, 2009).

The article by Chauhan et al. (2017) examines the role of stock liquidity as a governance mechanism to discipline managers to accumulate bad news. The article identifies two possible mechanisms through which stock liquidity reduces stock price crash risk: the threat of intervention and price

informativeness. According to their findings, in the intervention threat model, stock liquidity increases the power of major shareholders' intervention. Major shareholders can also pressure managers not to withhold bad news. The findings of the experimental studies support the threat of the intervention model and explain that stock liquidity has a significant negative impact on stock crashes of companies with a large number of major shareholders. Also, stock liquidity increases price informativeness, leading managers to avoid manipulating stock prices by accumulating bad news to increase short-term earnings.

Agnes Cheng et al. (2020). Jang and Kang (2019), Das and Yaghoubi (2024), and Jia (2018) used the investor heterogeneity criterion (DTURN) in the stock crash risk.

Jang and Kang (2019) and Fang et al. (2022) used the generalized logit model to calculate the probability of stock crashes, in which the independent variables are influential factors in the probability of a stock crash, and the dependent variable is defined based on the rate of return of a particular amount. In the paper of Drobetz et al. (2020), the independent variable, or the crash, is calculated based on the deviation of average returns. However, the above model has the disadvantage that jumps and crashes are calculated separately so that the total probability for an event can be more than one.

In the current paper, a combination of two methods has been used to calculate crash and jump variables: The method of calculating the firm-specific returns of Kim et al. (2011) has been used for calculating the firm-specific stock returns, and by generalizing the model of Drobetz et al. (2020) in an equation, the state of the event is determined in terms of jump, crash or other.

According to Harvey and Siddique (2002), investors demand higher returns as a reward for crash risk acceptance due to investing in stocks with more skewness. The usual theories of asset pricing, in which a person demands a higher reward for accepting more risk, do not apply here. In other words, the deeper the market and the more aware investors are, they do not invest in stocks with a high crash probability.

In the current paper, since in the studies of stock price crashes, the specific sanctions conditions of the countries were not included in the modeling of stock crash predictors, the sanction variable was included in the mentioned models. Sanctions increase managers' motivations to manage profits and the accumulation of bad news due to their negative impact on corporate profitability and cash flow; according to Jin and Myers (2006) theory, this issue leads to increasing stock price crash risk in the companies the current

paper, the effects of sanctions on the probability of stock price crashes have been investigated using the softmax probability prediction model. The method of calculating the firm-specific returns of (Kim et al., 2011) has been used to calculate independent variables. By generalizing the model of Drobetz et al. (2020) in an equation, the state of the event is determined in terms of jump, crash, or other. The relationship between the probability of the stock price crash and the stock's expected return under sanctions and on the Tehran Stock Exchange is also examined.

Research Methodology

Data

The data used in the research were daily, monthly, and annual data of companies in the Industrial sector stocks from 2007-2021, including the automotive industry, petrochemical, refining, base metals, metal ores, and pharmaceuticals. Import- and export-oriented industries were selected to test the effects of sanctions. For this purpose, companies from selected industries that met the following conditions were eliminated, and the rest of the companies were selected:

1. Investment companies in selected industries did not have a sales volume variable.

2. Companies whose fiscal years were different from the 20th of March (The end of the solar year coincides with March 19 or 20) were removed because of the comparability of financial information.

3. Companies that needed more data in the mentioned period were eliminated.

Research data were collected using the text of financial statements and their explanatory notes, as well as information from the Rahavard Novin software, and integrated into the SQL server.

Normalization and generalization of data:

Fundamentally, entering raw data into the model reduces its speed and accuracy. To avoid such situations and standardize the data's value, the input data model should be normalized before estimating it. After normalization, the data were divided into training and testing categories to estimate and evaluate the model. The model used the training data to find the relationship between inputs and outputs.

Research Methods

Definition of price falls and price rises

This paper considers the probability of observing extreme negative returns in a stock crash. Moreover, the mentioned mode is defined as the stock rises .

First, to calculate the rises and falls of stock prices, according to the research of Kim et al. (2011), a specific return of each share was obtained by using the following equations:

$$r_{i,t} = \alpha_i + \beta_{1,i} r_{m,t-2} + \beta_{2,i}\, r_{m,t-l} + \beta_{3,i} r_{m,t} + \beta_{4i} r_{m,t+1} + \beta_{5,i}\, r_{m,t+2} + \varepsilon_{i,t} \quad (1)$$

$r_{i,t}$: return of share i in period t

$r_{m,t}$: market return in period t

The specific return of share i in period t was defined as follows:

$$R_{i,t} = \ln(1 + \varepsilon_{i,t}) \quad (2)$$

Where $\varepsilon_{i,t}$ is the residual return of equation one.

Then, by considering that the sum of the probabilities of events is equal to one and also assuming that price jumps and crashes occur when the monthly return negatively or positively deviates at least two standard deviations from the average price return, by generalizing the model of Drobetz et al. (2020), crashes and jumps in price were defined as follows:

$$\begin{cases} crash = 2 \;\; if \; R_{it} - \bar{R}_{it} < -2\sigma_{it} \\ jump = 1 \;\; if \; rR_{it} - \bar{R}_{it} > 2\sigma_{it} \\ \quad 0 \qquad\quad otherwie \end{cases} \quad (3)$$

r_{it}: Stock-specific return of firm i in period t

$\bar{r}_{it}$: The average stock-specific return of firm i in the last 12 months

σ_{it}: The Standard deviation of stock-specific return of firm i in the last 12 months

Softmax model

In the current paper, according to Jang and Kang (2019), the softmax model was used to estimate the probability of extreme negative returns on stock prices (stock price crashes) and the probability of extreme positive returns on stock prices (stock price jumps). Therefore, the probabilities of crashing stock prices and jumping stock prices over the next 12 months were modeled according to the following distribution:

$$Pr_t\left(Y_{i.t,t+12}=2\right)=\frac{\exp(\alpha_{-1}+\beta_{-1}X_{i,t})}{1+\exp\left(\alpha_{-1}+\beta_{-1}X_{i,t}\right)+\exp(\alpha_1+\beta_1X_{i,t})} \quad (4)$$

$$Pr_t\left(Y_{i.t,t+12}=1\right)=\frac{\exp(\alpha_1+\beta_1X_{i,t})}{1+\exp\left(\alpha_{-1}+\beta_{-1}X_{i,t}\right)+\exp(\alpha_1+\beta_1X_{i,t})} \quad (5)$$

Where $Y_{i.t,t+12}$ is a triple variable, its value is equal to two if the number of stock crashes during the period t+12 to t+1 is greater than or equal to the number of stock price rises and is equal to one, If the number of stock price jumps in the mentioned period is more than the number of stock price crashes. In other cases, the value of $Y_{i.t,t+12}$ will be zero. In the Definition of $Y_{i,t+12}$, the research of Hutton et al. (2009) is used. $X_{i,t}$ Represents explanatory variables at the end of month T, and the explanatory variables of the model were selected based on the previous studies in this field.

Due to the high dependence of the government budget on oil revenues and the targeting of oil exports in the sanctions of 2008 onwards, the virtual multiplicative variable of sanctions in the budget deficit has been used as a variable of sanctions.

Based on the work of Hutton et al. (2009), the variables of firm SIZE, the ratio of price to book value (PB), debt ratio, and return on assets (ROA) have been added to the model.

Based on the work of Chauhan et al. (2017), the Amihud illiquidity was added to the model and has the following formula:

$$Illiquidity_{i,q}=\frac{1}{D_{i,t}}\sum_{d=1}^{D}\frac{|ret_{i,d}|}{Volume_{i,d}} \quad (6)$$

Where $\mathrm{ret}_{i,d}$ and $Volume_{i,d}$ are the daily return of the share and the Rial value of the trading volume of the share i on day d. Moreover, D indicates the number of trading days per year.

Based on (Jang and Kang, 2019), investor heterogeneity (DTURN) variables, quantitative growth of production, and market returns were added to the model.

Because in the condition of sanctions, the prominent increase in companies' profits is from the increase of product prices, the average growth variable of product prices was also added to the model.

The relationship between expected returns and the probability of the stock crash

Following the work of Jang and Kong (2019), companies were classified into five groups based on the predicted probability of stock price crash at the end of month t (year-end) for the period t to t+12. The fifth group has the highest probability of a stock price crash. For each group, the return of the companies' portfolio was calculated in month t+2, and the regression relationship number (7) was estimated. For the Fama and French three-factor model, equation (7) was calculated using the following formula.

$$RET_{it} = a_i + B_i^{MKT} MKT_t + B_i^{SMB} SMB_t + B_i^{HLM} HML_t \quad (7)$$

In the above equation, RET_{it} is the portfolio return of group i in month t, MKT_t is the market excess return, SMB_t is the company size factor, HML_t is the book value to market factor in month t, it should be noted that i=1,2,3,,4,5.

Results

Research results

Descriptive Statistics:

To provide an overview of the essential characteristics of the calculated variables, Table 1 presents some of the concepts of descriptive statistics of these variables, including mean, median, standard deviation, and minimum and maximum observations.

Table 1. Descriptive statistics results

Variable	mean	Std	min	25%	50%	75%	max
Size	9.97	33.7	0.03	0.41	1.1	4.05	456.9
book to price	0.43	0.98	-14.28	0.24	0.41	0.69	3.03
market return	0.53	0.62	-0.21	0.03	0.28	0.86	1.91
production growth	0.18	1.94	-1.22	-0.11	0.03	0.16	35.72
debt ratio	0.62	0.27	0.00	0.46	0.61	0.74	2.70
DTURN	0.00	0.03	-0.19	-0.01	0.00	0.01	0.20
NCSKEW(t-1)	-0.29	0.96	-3.45	-0.86	-0.30	0.30	3.06
Amihud_Illiquidity	0.27	1.22	0.00	0.00	0.00	0.01	12.07
sales growth	0.30	0.58	-0.90	0.01	0.21	0.48	7.50
Sanction	418015	806512	-606443	0	226168	294381	2710450

Comparing the median and mean of quantitative growth of production variables, it was concluded that companies have experienced very low quantitative growth in the mentioned period, which coincided with the nuclear sanctions against Iran.

Also, by comparing the median of quantitative growth and the average sales growth, we can conclude that in the conditions of sanctions, the growth of companies' profits has often been due to rising inflation.

The correlation matrix

Table 2 is a correlation matrix between variables. According to the table, there is a positive relationship between market returns and the variable of sanctions. A negative relationship exists between the debt ratio and the book to price ratio. No significant correlation was observed between other variables.

Table 2. Correlation matrix

variable	size	book to price	market return	production growth	debt ratio	sanction	DTURN	NCSKEW(t-1)	Amihud_Il liquidity	sales growth
size	1									
book to price	-0.01	1								
market return	0.13	-0.16	1							
production growth	-0.01	-0.01	0.02	1						
debt ratio	-0.14	-0.54	-0.05	-0.03	1					
sanction	0.08	-0.15	0.71	0.00	-0.08	1				
DTURN	-0.01	-0.04	0.23	0.00	-0.02	0.12	1			
NCSKEW (t-1)	0.07	0.08	0.02	-0.02	0.00	0.10	-0.04	1		
Amihud_Il liquidity	-0.05	0.09	-0.08	0.00	0.01	-0.05	-0.05	0.03	1	
sales growth	0.06	-0.03	0.30	0.10	-0.17	0.37	0.12	-0.03	-0.031	1

Estimate the price crash by using the Softmax model

Table 3 shows the results of the estimates in terms of price crashes and jumps. The standard deviation categorized by firm and month was calculated following the paper of Jang & Kang (2019) to consider the correlation between time series and cross-sectional data.

In estimating the probability of crashes, market return, debt ratio, sanction, and NCSKEW (t-1) variables at less than 5% are significant, and the DTURN variable at 10% is significant. In estimating the probability of jumping, book to price, debt ratio, and DTURN variables at 5% and the NCSSKEW (t-1) at 10% is significant. The estimated coefficient for crashes is negative for the sanction variable, indicating that price crashes are more likely to occur as the sanction is increased. For debt ratio, DTURN, and NCSKEW (t-1), the signs of estimated parameters for crash and jackpots are identical, which implies that stocks with high crash probability also tend to have high jackpot probability.

Table 3. Results of Estimation by using the Softmax model

crash=1	coef	std err	t	p>|t|	[0.025	0.975]
const	-0.5905	0.150	-3.935	0.002	-0.917	-0.264
size	-0.0749	0.227	-0.330	0.747	-0.570	0.420
book to pice	0.3354	0.116	2.889	0.014	0.082	0.588
market return	-0.0349	0.176	-0.198	0.847	-0.419	0.349
production growth	0.0519	0.97	0.538	0.600	-0.158	0.262
debt ratio	0.2930	0.078	3.772	0.003	0.124	0.462
sanction	0.0363	0.212	0.171	0.867	-0.425	0.498
DTURN	-0.1954	0.087	-2.254	0.044	-0.384	-0.007
NCSKEW(t-1)	0.1980	0.092	2.144	0.053	-0.003	0.399
Amihud_Iliquidity	-0.910	0.136	-0.671	0.515	-0.387	0.204
sales growth	-0.928	0.096	-0.966	0.353	-0.302	0.116
crash=2	coef	std err	t	p>|t|	[0.025	0.975]
const	-1.1845	0.162	-7.306	0.000	-1.538	-0.831
size	0.0941	0.257	0.367	0.720	-0.465	0.653
book to pice	0.1513	0.123	1.233	0.241	-0.116	0.419
market return	-0.3167	0.154	-2.055	0.062	-0.652	0.019
production growth	0.1089	0.117	0.928	0.372	-0.147	0.365
debt ratio	0.2504	0.077	3.246	0.007	0.082	0.418
sanction	0.5598	0.189	2.958	0.012	0.147	0.972
DTURN	-0.2196	0.097	-2.267	0.043	-0.431	-0.009
NCSKEW(t-1)	0.2078	0.070	2.979	0.012	0.056	0.360
Amihud_Iliquidity	0.1566	0.095	1.643	0.126	-0.051	0.364
sales growth	-0.0298	0.115	-0.258	0.801	-0.281	0.222

The relationship between the probability of a stock crash and the expected return on the stock

Table 4 shows the relationship between the probability of a stock price crash and the expected return on the stock. The stocks are divided into five categories based on the probability of crashes. The relationship between the probability of a stock crash and the expected return on the stock in T + 2 months was calculated and reported based on the alpha of the Fama-French three-factor models. Based on the table below, as the probability of a stock crash increases, the relationship between the probability of a stock crash and the expected return on the stock in Iranian markets decreases.

Table 4. Relation between crash risk and expected return

	1	2	3	4	5
Equal-weighted portfolios sorted by Crash					
Three-factor α	0.060	0.048	0.049	0.035	0.032
Pvalue	0.000003	0.000372	0.000092	0.005967	0.032003

Discussion

The current paper investigates the relationship between the probability of a stock crash and the expected return on the stock and the effective factors in the probability of a stock crash under sanctions in companies listed on the Tehran Stock Exchange.

The effective factors in the probability of the stock crash

Based on the paper of Hutton et al. (2009), The reason for the crash in the stock price of a particular company is the accumulation of bad news by company managers; when the accumulation of bad information reaches such a level that it can no longer be maintained, the news is quickly published and causes the stock price crash. The current paper will examine the factors that affect the probability of a stock crash through these two channels. The sanctions have a positive effect on the stock crash. Under pressure from sanctions, companies in the capital market face difficulties in export/import and rising costs; these can increase managers' motivation to divert financial information to smooth revenue or reduce short-term pressure. Sanctions also increase information asymmetries between a company's internal members and investors, increasing investors 'reliance on information disclosure and managers' ability to manipulate revenue.

According to research results, there is a positive relationship between debt ratio and stock crash risk. In Iran, banks give debts to companies and have no monitoring of their function of them. Thus, companies with higher debt ratios experience higher crash risk. The above result is inconsistent with the study of (Wang et al., 2020).

There is a negative relationship between the probability of a stock crash and market return in the last year. Some of the growth of most stock prices is related to the total growth of the market.

There is a negative relationship between the investor heterogeneity (DTURN) variables and the probability of a stock crash. The higher the average share turnover over the last year, the higher the stock liquidity. Moreover, this reduces the probability of a stock crash. The above result is consistent with the studies of Duan and Lin (2022) and Jang and Kang (2019), but in the mentioned research, the above variable is not significant.

The relationship between the probability of the stock crash and the expected return on the stock

According to Table 3, the alpha of the groups with a higher probability of crash is lower. Many researchers believe that the reason for this abnormal relationship is mispricing. The probability of a stock price crash checks the probability of the stock price being overvalued. The higher the probability of a stock crash, the greater the probability of its price being overvalued. Therefore, we will have a price correction in the future, and its return will be lower. The result is consistent with the studies of Jang and Kang (2019).

Conclusion

This study examined the factors that affect the probability of a stock crash and the relationship between the probability of a stock crash and the expected return on the stock in 2008-2021 on the Iran Stock Exchange.

Sanctions create a crisis in economic conditions. Managers during times of economic crisis use opportunistic reporting methods to provide a better picture of the company's situation, thereby leading to the accumulation of bad information in the company. According to Jin and Myers (2006), Once the accumulated bad news reaches an overwhelming level that cannot be maintained, all bad news is suddenly released, leading to the stock price crash. In the listed companies in this paper, sanctions motivate managers to accumulate information by creating fluctuations in revenues and cash flows

and increasing costs. So, they increase the probability of a stock crash.

According to this paper's results, there is a negative relationship between the probability of a stock crash and the expected return on the stock. Many attribute the lower expected returns of stocks with a higher probability of crash to the overvaluation of maintained stock prices, which should be adjusted. Considering the negative relationship between the probability of a stock crash and the expected return on the stock in this paper, it can be concluded that investors have decision-making rationality in the Iranian stock market despite its infancy and shallow depth

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