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A Model for Price Manipulation Prediction Case Study: Tehran Stock Exchange

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Abstract

Price manipulation in the Tehran Stock Exchange has been one of the most widely discussed issues among academic and professional practitioners in recent years. In this article, we first calculated the abnormal Returns- significance difference between actual and risk-based adjusted expected returns- by using an autoregressive test, for all 130 accepted firms in the Tehran stock market during 2002-2006, which seemed to be manipulated, since they had experienced great fluctuations in their stock prices. For any firm, if changes in share prices are not at random and/or its stock prices are autocorrelated with the past ones, it can be concluded that the firm is under a price manipulation. In the next stage, we have developed a binary logit regression model for predicting the firms' price manipulation based on four factors i.e. the information transparency, the liquidity of the shares, the size (capital) of the firm and the P/E ratio. Finally, the model efficiency for predicting price manipulation in the Tehran Stock Exchange is validated by using appropriate statistical tests such as, The Wald, Likelihoods Function, and the Wilk's Lambda tests. The results showed that the model is efficient and robust for predicting the price manipulation (P<0.05, Wilk's Lambda=0.205; Cox & Snell R^2=0.792 ,0.799; -2Log likelihood= 27.49).

Keywords: Price manipulation, Liquidity of stock, Information transparency, Stock-price tolerance, Free floating stock, Tehran Stock Exchange, Binary regression model

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1. Introduction

Historically, the possibility of stock-price manipulation has always been a fundamental problem in the world's financial markets. Soon after the first Stock Exchange founded in Amsterdam, the Netherlands at the beginning of the seventeenth century, brokers discovered that they could profitably manipulate stock prices.

Based on being how much provided with decent anti-manipulation laws and supervising tools, the manipulation in the world's financial markets has been different in its size and kind.

The review of the evidence indicates that although the issue of manipulation had been of the most prominent challenges faced by the developed modern markets in the early 20th century, due to the enforcement of decent laws and effective monitoring mechanisms, almost many ways of manipulation have been controlled. On the contrary, most of the new emerging markets are exposed to every forms of manipulation due to unsupported law systems and supervising mechanisms which is a prominent factor for the lack of development in their capital market and public trust to these markets.

Consequently, lack of long-term participation of capitalists, intense stock-price vacillations, short-term perspective for investment and the fainted role of it in economic development are the implications that are reflected enormously in the economy of these countries. Although the traditional forms of manipulation have been limited in modern markets, new forms of manipulation, due to the development of the communication networks and effective trading tools have been emerging in these countries.

In this article, we intend to present an empirical model to predict price manipulation. For our purpose, we design a binary regression model and collect the data needed for the model from Tehran's Stock Exchange market during 2002-2006. Finally we test the efficiency and robustness of the proposed model by performing proper statistical tests.

2. A review of the existing literature

The US Securities and Exchange Commission (SEC) describes stock manipulation as a practice whereby owners of a company or others such as brokerage firms or investment companies take actions to increase or decrease the value of that stock, solely so they can buy or sell shares at a profit. It is typically illegal and widely considered to be unethical. For example, the CEO of a company may give a false, gloomy prediction of the company's future earnings in order to drive prices down so that he can purchase stock at a reduced price.

There are many ways of stock price manipulation. Merrick and Narayan (2003), study Tokyo and New York Stock Exchanges, and show that price manipulation can fall naturally into three categories. The first can be described as information-based manipulation, that is, manipulation based on releasing

false information or spreading false rumors. The operation of trading pools in the United States during the 1920s gives examples of information-based manipulation. A group of investors would combine to form a pool: first to buy a stock, then to spread favorable rumors about the firm, and finally to sell out at a profit. The striking cases of Enron and WorldCom in 2001 might also be attributed to information-based manipulation. The second category of manipulation can be described as action-based manipulation, that is, manipulation based on actions that change the actual or perceived value of the assets. Examples of action-based manipulation are the Harlem Railway and American Steel and Wire Company.

The third category of manipulation that is much more difficult to eradicate is trade-based manipulation. It occurs when a trader attempts to manipulate a stock simply by buying and then selling, without taking any publicly observable actions to alter the value of the firm or releasing false information to change the price. This type of manipulation could be of great importance empirically. Hedge funds often buy and then sell large blocks of stock, even though they are apparently not interested in taking over the firm.

Hart (1997) is among the first to study price manipulation. He has analyzed manipulation formally in the context of dynamic models of asset markets. Hart considers conditions that under which profitable speculation is possible in a deterministic setting. He finds that if the stationary equilibrium is unstable or demand functions are nonlinear and satisfy some technical conditions, speculators can trade profitably. Jarrow (1992) extends Hart's analysis to a stochastic setting and drives similar results. He shows that profitable speculation is possible if there is price momentum so that an increase in price caused by the speculator's trade at one date tends to increase prices at future dates. In addition, he shows that profitable manipulation is possible if the speculator can corner the market. In both articles, the form of the investors' demand functions is taken as exogenous, rather than being derived from expected utility-maximizing behavior. So, it is not clear whether and under what conditions manipulation is consistent with rationality.

Allen and Gale (1992) also examine price manipulation and develop a model with asymmetric information where all agents have rational expectations and maximize expected utility. Also, they work in a finite horizon framework, where bubbles are ruled out by construction and show that profitable price manipulation is possible, even though there is no price momentum and no possibility of a corner. The Allen and Gale model has three types of traders, a continuum of identical rational investors, a large informed trader, and a large manipulator who observes whether the informed trader has the private information. The manipulator has a small but positive probability to enter the market and to mimic the informed trader’s action when the informed trader actually has no private information. The manipulator is able to achieve a

positive profit under certain conditions because there can exist a pooling equilibrium in which the investors are uncertain whether a large trader who buys shares is a manipulator or an informed trader.

Aggarwal and Wu (2003) present a theory and some empirical evidence on stock price manipulation in the United States. Extending the framework of Allen and Gale (1992), they consider what happens when a manipulator can trade in the presence of other rational traders who seek out information about the stock's true value. In a market with manipulators, they show more information seekers imply a greater competition for shares, making it easier for a manipulator to enter the market and potentially worsening market efficiency.

Mahoney (2005), however, studies the average price behavior of stocks traded by pools in 1928 and 1929 and argues that there is little evidence that pools were engaged in manipulation.

Jarrow (2005) studies the impact that derivative security markets have on market manipulation.

Bagnoli and Lipman (2004) investigate action-based manipulation using take-over bids. In their model, a manipulator acquires stock in a firm and then announces a take-over bid. This leads to a price run up of the firm's stock. The manipulator therefore is able to sell his stock at the higher price. Of course, the bid is dropped eventually.

There are several other writers, like Bomel (2003); Lipmane and bangoli (2003)**;** Huberman and Stanzel (2003)**;** Yadav and Naik (2003)**;** Jiang and Chen (2003); investigating manipulation and its effects and implications. There is no or little theoretical and empirical literature on the price manipulation prediction**.**

3. Methodology

As we pointed out in the introduction, our main objective in this article is to present a regression model to predict price manipulation in Tehran Stock Exchange. Before formulating a regression model, we should prepare a list of the firms which were manipulated from the firms accepted in the Tehran Stock Exchange. As there is no records of manipulated and non-manipulated firms in the Tehran Stock Exchange registered by any official authority, we first prepared a draft list of those firms selected from all accepted firms in the Tehran Stock Exchange during 2002-2006, which had experienced great fluctuations in their stock prices, and had also been faced with either a rise in their prices more than 100% or a decrease to 50% (100 firms selected out of 130). Then by performing some appropriate statistical tests such as serial correlation tests, and autoregressive model for drawing residuals, the manipulated and non-manipulated ones were definitely recognized.

In the next stage, a regression model can be formulated to predict the status of the firms' prices manipulation (i.e. manipulated and non-manipulated). The logistic regression equation has the form:

$$Z_i = \ln\left(\frac{p_i}{1 - p_i}\right) = \beta_0 + \sum_{i=1}^{n} \beta_i . x_i$$

Where

ln represents the natural (Napierian) logarithm (e). Z_i denotes a binary (bipolar) dependant variable- which refers here to the status of price manipulation in a firm. This variable has two categories: Manipulated and Non-manipulated. This function is the so-called 'logit' function from where this regression has taken its name. The procedure for modeling a logistic model is determining the actual percentages for an event as a function of the X and finding the best constant and coefficients fitting the different percentages.

According to the equation, the value of the probability of an event (P_i)- e.g. price manipulation- is calculated by reversing the Logit Equation as below:

$$P_i = \Pi_i (x_1, x_2, ..., x_n) = \frac{e^{\beta_0 + \sum_{i=1}^{k} \beta_i . x_i}}{1 + e^{\beta_0 + \sum_{i=1}^{k} \beta_i . x_i}}$$

Where

X_i denotes independent variables, which are applied to predict price manipulation. These variables, according to Aggarwal and Wu (2004) and Allen and Gale (1992) are:

- Ratio of P/E (x_1).This index represents the market's expectations from the growth perspective and profitable future of the firm. For this, the current value of the firm's shares (P) is divided by the predicted net profit of each share (E).
- Firm's Size/capital (x_2). Size of the firm is determined by natural (Napierian) logarithm of the firm capital.
- Status of the firm's Stock Liquidity (x_3).This is calculated by harmonic mean of 6 factors, the number of the days which the firm's share is being traded, the volume and value of the firm's share, how many times the firm's share is being traded, and the daily average of the firm's capital value. The higher the average, the better. The Status of the firm's Stock Liquidity is reported every day by Tehran Securities and exchange organization.
- Status of information Transparency(x_4). This represents the richness of information exposed by the firms. The scale of this variable is in a rank-ordered and for that the firms are ranked on the basis of quality and quantity of the formally announced information. The ranking is done for all firms by Tehran Securities and Exchange Organization to the extent the firm has kept

the rules of Securities and Exchange Organization in terms of information exposure, and the volume and quality of information exposes. For our model this ranking is being used.

- Status of the firm's Stocks floating (x_5).This shows the percentage of the firm's shares which is floated, i.e. traded regularly (freely) in the market, and the percentage which is blocked by stockholders. This percentage has been calculated by Tehran Securities and Exchange Organization. In this research, floating situation of the shares is defined in rank-ordered scale. Table 1. Shows the defined ranks for the firms on floating.

Table1Ranking of the firms based on status of their stock floating

Percentage of floating	Max 5%	5- 15%	15- 30%	30- 50%	More than 50%
Status of floating	Very low	low	Medium	high	Very high
Rank of floating	1	2	3	4	5

In a binary regression model, independent variables, which are applied to predict the independent variable, can be both quantitative and qualitative whereas, the dependent variable, which is to be predicted, is categorical and dichotomy, that is to say, it takes only two status. Numerically, it accepts two values of 0 and 1. When the dependent variable takes one (1), it means that the dependent variable exists (e.g. manipulated) and when it takes zero (0), it indicates to non-existence of the dependent variable (e.g. non-manipulated). In a logistic regression model, the term of chance is used for dependent variable. Statistically, chance means the probability of an event occurring (P_i) to the probability of lack of occurring ($1-P_i$). Normally, the probability varies between zero and one whereas the chance could be more than one. Another important element in logistic regression model is called logit that is the natural logarithm of chance. The data for the formulating the model is gathered from a year before the firm is manipulated.

For formulating the above model for predicting price manipulation in Tehran Stock Exchange, we have used a backward method and test the efficiency and robustness of the model by using significance testing of coefficient (Wald's test), liklihood test, and Wilk's Lambda. All data analysis is also done by SPSS.

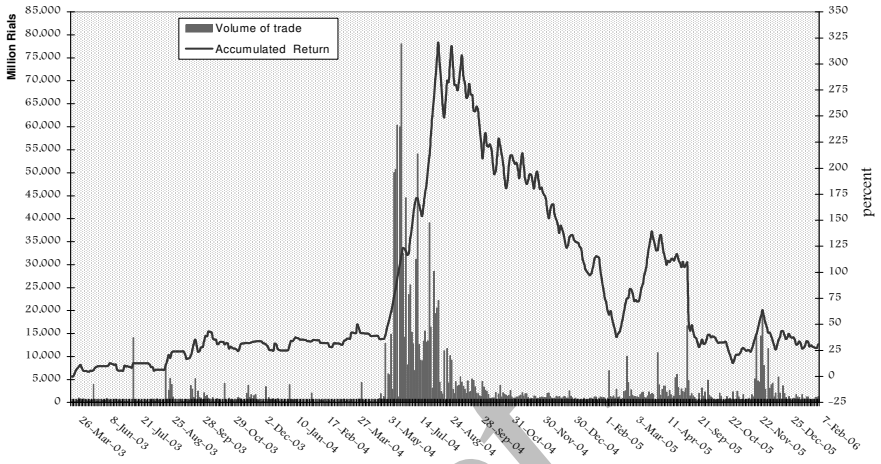
4. Results

4-1. A behavioral pattern of price manipulation in the Tehran Stock Exchange

Halley (1993), by comparing the trends in those firms recognized as manipulated in the New York and London stock exchanges, found that in almost most of the cases the price manipulation follows a similar pattern. The results in the Tehran Stock Exchange are consistent with the model and suggest that the

market manipulation in the Tehran Stock Exchange is the same as the others. The following chart shows this trend for a manipulated firm in the Tehran Stock Exchange which was studied during 2002-2006.

Chart 1. Trend for price and Volume traded for a manipulated firm in the Tehran's stock market, during 2002-2006



4-2. The results for testing the abnormal returns in firms' prices

Considering the abnormal returns in a firm's stock prices is a way to realize if the firm is manipulated. The abnormal returns of the selected firms in the Tehran Stock Exchange are determined by the residuals of an estimated autoregressive model added with two lags, as follows:

$$R_t = \gamma_0 + \gamma_1 R_{t-1} + \gamma_2 R_{t-2} + \gamma_3 \varepsilon_{t-1} + \varepsilon_t$$

Where

R_t, denotes daily nominal returns; R_{t-1} and R_{t-2} represent the first and second lags of the 'R' variable; ε_{t-1} is the first moving average of the error component of the model.

The optimal lags of 'AR' and 'MR' in the model are calculated by using Box-Jenkins. The results show that 'ARMA (2,1)',i.e. 2 output lags in addition to one residual lag, is the best condition that we can estimate the autoregressive model for drawing residuals.

Before estimating autoregressive model for drawing residuals, all time series were TESTED for stationarity. The use of non-stationary data can lead to spurious regression. For testing the series for stationarity, we have used the unit roots tests. The most frequently used test for unit roots is the augmented Dickey-

Fuller regression (ADF), which we have used for our purpose. The results are shown in table 2., for only two firms:

Table2. Tests results for serial correlation of residuals and unit-root

Returns	Firms	Serial correlation test of residuals Probability	Unit-roots test ADF statistic
Daily returns	**Firm A**	0.71	-11.2
	Firm B	0.68	-11.5
Weekly returns	**Firm A**	0.96	-4.2
	Firm B	0.70	-3.4
Note:Critical values for unit root test, in daily returns, is -3.43, -2.86, -2.57 respectively for α=1%, 5% and 10% and for weekly returns are -3.54, -2.91, -2.59 for α=1%, 5% and 10%. In serial correlation test of residuals, null hypothesis is confirmed if p-value<0.05.			

If the observed F-statistic is less than critical F-test, the null hypothesis is accepted, and we can conclude that no autocorrelation is seen between residuals. This shows that the model is optimally estimated. As shown in table 2., the probability of accepting the null hypothesis is more than 5% (P>0.05) and we can say the null hypothesis is accepted: there is no serial autocorrelation between residuals of the model.

Generally, we calculated the residuals of the autoregressive model-as indicating of abnormal returns for every share price of the selected firms. Then we set apart the residuals into two positive and negative orders. Each order is numbered and the length of each is counted. The firms with a significant longer positive order than their negative one show that it is manipulated.

4-3. The results of the model formulated (fitted) for predicting the price manipulation in the Tehran Stock Exchange

We used a backward method to formulate (draw) the model for the Tehran Stock Exchange. In this method, the binary logit regression with all 5 itsvariables is considered and then the variables with trivial correlation are omitted. In other words SPSS starts with a saturated model and then omits the non-significant variables in the model. The results of the final drawn model are shown below:

$$Ln\left(\frac{p_i}{1-p_i}\right) = -0/008\ X_2 + 0/041\ X_3 - 1/379\ X_4 + 0/762\ X_5$$

$$p_i = \pi(x_1,\ldots x_5) = \frac{e^{-0/008\ X_2 + 0/041\ X_3 - 1/379\ X_4 + 0/762\ X_5}}{1 + e^{-0/008\ X_2 + 0/041\ X_3 - 1/379\ X_4 + 0/762\ X_5}}$$

Where

P_i denotes the probability of a share price i is manipulated in the Tehran Stock Exchange.

As shown in the model, the four variables, namely firm's size/capital (x_2), firm's Stock Liquidity (x_3), firm's information Transparency (x_4), firm's stocks floating (x_5), are regarded significant for predicting the price manipulation in the Tehran Stock Exchange. Based on the backward method, the firm's ratio of P/E is not significant in the final model. In other words, the ratio is regarded as a trivial factor for predicting the price manipulation.

The summarized results of significant testing of the model are shown in table 3. Based on the Wald's statistic, and the calculated error level (p-value<0.05), it can be concluded with 95% confidence that all the variables in the final model are meaningful.

Tabel 3. The Results for significant testing of the Model fitted

Variables	Coefficients	S.D.	Wald's statistic	Sig. level
Firm's size(x_2)	-0.008	0.004	-4.365	0.037
Firm's Stock Liquidity (x_3)	0.041	0.014	8.588	0.003
Information Transparency (x_4)	-1.379	0.485	-7.441	0.006
Firm's Stocks floating (x_5)	0.762	0.380	3.690	0.045

4-4. The results for power of variables in predicting the model

We, also, determined the power of each variable in predicting the price manipulation. To do so, the second power of correlation is calculated, that shows the correlation between the primary values of variables and the values drawn from the model. The more correlated each variable is with the model, the more effect/power has on the model. Table 4., shows the results.

Tabel 4. The results for power of variables in the model

Variables	Effect power
Information Transparency (x_4)	0.875
Firm's Stock Liquidity (x_3)	0.738
Firm's Stocks floating (x_5)	0.587
Firm's size/capital(x_2)	0.398

4-5. Test results for the Robustness/efficiency of the model formulated The robustness and efficiency of the model for predicting the price manipulation in the Tehran Stock Exchange is tested by different statistical tests. Based on likelihood statistic (-2log likelihood) and Cox & Snell's determination coefficients (R^2) shown in table 5., it shows a relatively high power of the model for predicting the price manipulation in Tehran Stock exchange.

Tabel 5. Test results for model efficiency

step	Cox & Snell R2	-2Log likelihood
1	27.49	0.792
2	27.19	0.799

The efficiency of the model is also calculated by Wilk's Lambda. This statistic is used for testing the intercorrelation power of the variables used in the logit regression. The higher the correlation, the more powerful the model would be. In some previous researches, like Altman done on bankruptcy, show that the value of higher than 0.9 for this statistic, indicates the independent variables have a weak differentiating power in the model. The results of Wilk's Lambda test is shown in table 6.

Tabel 6. Test results for Logit model by intercorrelation between the variables of the model

step	Wilk's Lambda	Chi-Squrae	d.f	Sig. Level
1	0.205	137/4	2	0.000
2	0.161	177.2	3	0.000

Based on calculated Wilk's Lambda and Chi-square statictics, we can conclude, with 95% confidence, that the formulated model shows a good power for price manipulation prediction in the Tehran Stock Exchange.

Finally, the robustness of the model is also tested by comparing the actual manipulated firms with the manipulated firms predicted by the model. The lower the prediction error, the more efficient and robust the model would be. The calculations show that the prediction power of the model fitted for the selected firms is 92% for the manipulated firms and 82% for both manipulated and non-manipulated firms. To generalize the model for other firms not selected in our research, we predicted the status of price manipulation in those firms by the model. The results are shown in table 7.

Tabel 7. Test results for model power prediction

Prediction / Actual	Manipulated	Non-manipulated	% right prediction
manipulated	3	7	%70
Non-anipulated	15	5	%75
The Total prediction power of the model		%73.3	

As the model prediction power is high for the control group (firms not selected for fitting the model), we can conclude that the model generalizability for predicting the price manipulation in the Tehran Stock Exchange is above the average.

5. Conclusions

Price manipulation in the Tehran Stock Exchange has been one of the most widely discussed issues among academic and professional practitioners. Before the new rules being passed by the official authorities by the end of 2004, when this research was carrying under execution by the research team, due to the lack

of legal and controlling systems, the tendency toward price manipulation had been risen up. Based on our research, two forms of manipulations have been observed in the Tehran Stock Exchange: Trade-based manipulation and information-based manipulation and most of the time the manipulation appeared in a form of combination of the two (Result 4-1). Based on the binary logit model formulated, we showed that the small firms, and firms with weak information transparency and low stock liquidity in the Tehran Stock Exchange, are more probable to be manipulated (Result 4-2). The results are consistent with Aggarawal and Wu (2004). Statistical tests performed on the model, showed that prediction of price manipulation based on the four variables, the firm's size, the firm's Stock Liquidity, the firm's information transparency, and the firm's stocks floating situation, has sufficient power and generalizability for using in the Tehran Stock Exchange (Result 4-3). The statistical results also showed that non-transparency of information exposure by the firms is the most important reason of the price manipulation in the Tehran Stock Exchange (Result 4-3). Thus it is strongly suggested that authorities try to promote existing information systems and encourage the firms to disclose their information on time. Another important finding of the research is that the size of the firms in addition to non-transparent information can help to increase the motives to manipulate the prices in the market between the traders (Result 4-3). Therefore, it is suggested that the traded stocks prices tolerance for small firms to be decreased.

Finally, we tried to demonstrate that a logit regression model is efficient for predicting the stock prices manipulation in the Tehran Stock market, but it is also suggested to do some other researches to investigate the efficiency of other models especially artificial neural networks and genetic algorithms.

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