

Forecasting Stock Price Manipulation in Capital Market

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Abstract—The aim of the article is extending and developing econometrics and network structure based methods which are able to distinguish price manipulation in Tehran stock exchange. The principal goal of the present study is to offer model for approximating price manipulation in Tehran stock exchange. In order to do so by applying separation method a sample consisting of 397 companies accepted at Tehran stock exchange were selected and information related to their price and volume of trades during years 2001 until 2009 were collected and then through performing runs test, skewness test and duration correlative test the selected companies were divided into 2 sets of manipulated and non manipulated companies. In the next stage by investigating cumulative return process and volume of trades in manipulated companies, the date of starting price manipulation was specified and in this way the logit model, artificial neural network, multiple discriminant analysis and by using information related to size of company, clarity of information, ratio of P/E and liquidity of stock one year prior price manipulation; a model for forecasting price manipulation of stocks of companies present in Tehran stock exchange were designed. At the end the power of forecasting models were studied by using data of test set. Whereas the power of forecasting logit model for test set was 92.1%, for artificial neural network was 94.1% and multi audit analysis model was 90.2%; therefore all of the 3 aforesaid models has high power to forecast price manipulation and there is no considerable difference among forecasting power of these 3 models.

Keywords—Price Manipulation, Liquidity, Size of Company, Floating Stock, Information Clarity

I. INTRODUCTION

ONE of the most controversial and important issues that goes back to formation of first capital market in its modern form(Netherland, Amsterdam) is discussion of price manipulation in financial markets. The issue of price manipulation in financial markets in favor of personal benefits has always present and its intensity and weakness in market during different periods and in accordance with completion and benefiting them from suitable anti manipulation laws and supervision tools is different. Evidences confirm that although the discussion of stock manipulation in first 20th century was among main challenges of present day developed markets, due to enacting suitable laws and effective supervision mechanisms; many of different forms of stock manipulation in

these countries was limited. In contrast most of the newly established markets due to failure in their legal system and supervision mechanism are greatly faced with different forms of manipulation which is regarded as one of the most important factors in lack of completing capital market and lack of public trust to such markets. Consequently no continuous and long term presence of investors, temporarily fluctuations, short term point of view toward investment and its unimportant role in economic development are among unsuitable consequences that are vastly reflected at macroeconomic aspect of such countries. Although the traditional problem of manipulation in such markets is limited, growth and development of communication networks and modern exchange tools, results in rising modern problem due to manipulation in such markets. In this article, it is attempted that by explaining formation of price manipulation and purposeful change of stock price and also observing process of effective assumed variables, to offer model for discriminating real prices from unreal prices through artificial intelligence model and econometrics models.

II. LITERATURE REVIEW

The issue of market manipulation goes back to the same time as formation of the first stock exchange. Although nowadays due to enacting suitable laws and covering many cases which results in confusion of logical balance of price of stock in advanced financial markets, market manipulation in such financial systems may seems to be very difficult. It is incorrect to assume that the discussion of market manipulation in such markets in a solved issue, since in modern financial markets most of the manipulations are performed due to complicated and complete hidden methods in which recognizing and applying regulations for them is a difficult task. In contrast in newly established financial markets which lack of effective supervision systems to prevent from market manipulation, the process of market manipulation and influencing price of stocks vastly performs in different modes by persons having enough ability [1]. Among the first researches in the field of price manipulation is research of Hart in the year 1977 in which officially analyzed price manipulation by using from econometrics models in asset market. Hart has studied conditions in which profitability stock-jobbing occurs at non-possible mode. He found out that if market may not be at stable balance and demand functions may be non-linear, the stock jobbers are enabled to perform profitability trades. Jarrow [2] has extended Hart analysis to possible condition and has obtained the same results. He indicated that Price Momentum may be as a result of stock-

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jobbing activities. He has remembered that increasing price in one period due to trade of stock-jobbers results in increasing price in future periods. In addition he had indicated that profitability manipulation is possible when stock-jobber is able to corner the market. In both of the aforesaid researches, investors demand function rather than influenced by suitable maximizing behavior is regarded to be independent. Therefore it is not obvious that how and under which conditions the process of manipulation is compatible with logic. Allen and Gale [3] developed model by using asymmetric information in which all of the market factors have logical expectation and seek to maximize their suitability. Through more limited framework in which price was under legal regulations, they indicated that manipulating profitability price is possible even in case of having no temporarily change of price and impossibility of cornering market. Therefore they offered model consisting of 3 traders: mass of logical investors, a great informed trader and a great manipulation as great trader by having confidential information. In their model the insufficient investor's information and asymmetric information in market is regarded as principal factor of price manipulation. Investors do not have enough trust in relation to goal of great trader for buying stock, his awareness from high innate value of stock and price manipulation and this the exact factor which results in profitability of manipulation. Wu and Aggarwal [4] upon studying empirical evidences of price manipulation in U.S.A have developed Allen and Gale model. They found out that in a market full of manipulation great numbers of people intend to acquire information and there is close competition on stock and under this mode, the conditions of entering manipulation in stocks and decreasing market asset may facilitate. They found out that informed people from inner information of companies such as high managers of companies, brokers, stock subscribers, wholesale stock with highest possibility are regarded as price manipulators of stocks. Stocks with low possibility of liquidity have higher possibility of being exposed to price manipulation and price manipulation results in increasing price fluctuation. Also they concluded that price of stock increases during manipulation period and decreases after manipulation period. When manipulator sells the price and liquidity of stock may be higher than time of purchase, therefore they offered model and concluded that manipulation may have important influence on market effectiveness. Mahoney [5] has studied average behavior of price of transacted stock by using coalition sets during years 1928 until 1929 and has obtained few evidences of coalition trades with the goal of manipulating stocks. Also Jarrow [6] has studied effects of stock market originated from market manipulation. Merrick et al. [7] by studying New York and Tokyo stock have identified 3 different methods of price manipulation whereas follows:

A. Information Based Manipulation

Within thin strategy the manipulators by publishing deceiving information or fictitious rumors try to manipulate

price of stock. Among obvious instances of this type of manipulating price of stock we may refer to coalition trades in U.S.A during 1920's. In this strategy a set of investors by establishing a coalition try to purchase stock and then by publishing desired rumors in relation to company, finally the aforesaid stock will be sold on wholesale basis with higher price and in this way they obtain profit. Obvious instances for this type of manipulation include Enron and Worldcom in the year 2001 which are related to information based manipulation.

B. Action Based Manipulation

Actions other than trades that influence real value or understood value of assets and do not change them are called action based manipulation. For example, Bangoli and Lipman [8] have studied action based manipulation in price of stock by using suggestive price for ownership of stock. In this model manipulator of stock try to own stock and then suggest higher price for the owned stock that under such condition the price of stock may increased in market. Therefore manipulator of stock may be enabling to sell its stocks. Finally after selling stock by manipulator of stock, it may not result in suggestive price for purchasing stock.

C. Trade Based Manipulation

This type of manipulation occurs when a great trader and a set of traders simply by gradual purchase of stock and creating false demand and then reselling stock on wholesale basis try to manipulate price of stock. Whereas main section of fund trades and investment companies are regarded as great blocks of stock, therefore recognizing and discovering trade based manipulation is difficult task.

Deb et al. [9] studied that whether limitations of price in capital market is suitable or not. They used from game theory which indicated that if costs of supervision and revision in capital market increases, under such mode applying price limitation may be useful. Of course laws in relation to price limitations may results in less disclosure of economic information and preparing opportunity for corruption and ineffectiveness of law. If the system of capital market may be ineffective naturally the costs increases. Market static based mechanism may have positive and negative feedbacks for capital market. Blume et al. [10] published result of their researches under title of discovering forgery and manipulation. They confirmed that forecasting market is very sensitive toward diversion and manipulation. These diversions and manipulations in money are indicated at this market. The forecasting policy of market is very effective. Therefore political games may be regarded as one of the effective factors on price manipulation in this type of markets. Discussion of market manipulation is an important issue and the present article intends to recognize market manipulation, money game and market forecast. Hinterman [11] has dealt with market power to recognize manipulation in different markets and in this relation the method of publishing stock and stock timing is studied. The conclusion of study indicates that method of

stock allocation in different markets may be regarded as potential factor in price manipulation. Lo et al. [12] conducted another important study in the year 2010. Their research indicated that effective mechanism and correct structure of government in a sample market such as Shanghai-China may be regarded as impediment against dominance of company managers for deceiving activity in a correct structure. Government may act as analyzer and preventive force from deceiving activity of companies for price manipulation in stock. Transfer pricing and profit management are among issues that companies may utilize them in the way of their benefits. Takayama [13] has suggested a dynamic solution for confronting with market faced with manipulation. This dynamic solution assesses and concludes different trades at different time periods. He moves in such markets by selecting special stocks. Comerton-Ford and Putnins [14] offered results of another important study. On this basis effect of manipulating final price in an empirical market, social damages and losing trust among persons active in market is evaluated. The phenomena of price manipulation considerably accompanies with market liquidity and price reduction in long term. Also a logical solution is raised for confronting market with manipulations and market diseases. Comerton [15] has conducted research in 2 stock exchanges of America and Canada under title of Measuring Final Price Manipulation. In this research the effects of manipulation at end of trade days on form and characteristic of trade is evaluated that has negative effect on authenticity and fairness of price and in accordance with variables such as volume of trades and capital return period the possibility and intensity index for this type of manipulation is mentioned. Palishkar and Apte [16] indicated that there are some set agreements and collusions which results in price manipulation and its related diseases. Results of studies arrange algorithms and diagrams which forecast and recognize market diseases. In addition under different modes of price the cases suspicious to collusion are candidate and in accordance with defined indices the desired algorithm for these cases may be assessed. Garvey et al. [17] had research in relation to manipulation. Their research compared suitability of price of stock in long term and short term periods within motivation contracts for management and concludes that traders have higher information management performance at short term market and in such markets the security for price manipulation by management is less and the suitable limit is that there is somehow abstract guarantee by management for traders against fluctuation in price of stock within short term. Another important research was on emails were received by persons, encouraging them to purchase stocks. The mentioned research has been managed by Hanke and Hauser [18]. This article studies that whether emails are effective on variables such as expected return, flow return and price of stock. Also they create false market that influences on stock liquidity. Hanson et al. [19] published the conclusion of their study. In their research they had dealt with effect of price manipulation in future market is forecasted and assessed and type of behavior for persons who want to deceive public

decision is studied. There is risk threshold of this type of persons that are ready to accept feedbacks of this action and deal with its definition. The title of research that was published by Cai et al. [20] was a question as: What type of trade changes the price in newly established markets? This study insists on hidden trades and their consequences on newly established markets such as Shanghai-China stock exchange. This type of deceiving activities results in increasing or decreasing price of stock in set trades and accompanies with price manipulation. Hidden activity in this type of market is greater than developed markets and may result in losing trust to such markets. This article insists on creating mechanism for more disclosure of information and clarity in these markets. In the year 2005 some research were conducted at Pakistan stock exchange by Khwaja and Mian [21]. Studies in relation to Pakistan stock exchange indicated that the level of capital return of brokers is 50% to 90% higher than other investors. Also this study has dealt with role of mediator market in price manipulation and regards that having no supervision and control in aforesaid market is factor which results in non-fair prices and price manipulation. In addition it has dealt with set deceiving agreements in market as destructive factor in process of pricing and price balance. Chakraborty and Yilmaz [22] have conducted several studies and concluded that we are facing with several persons distributing rumors in market with the goal of distributing false information in favor of their benefit. Market shows slow reaction toward these receivers but finally market and its prices reach to balance, however most of the trades are performed before market balance and clarification. Informed traders after passing these fluctuations try to trade or to utilize from fluctuations. Chan et al. [23] has published the result of his studies in the year 2004 which is regarded as most famous studies in the field of price manipulation. His studies indicate that profit management has negative relationship among current withdraw from institute or future earnings. In addition this study developed studies in relation to executing methods to prevent from price manipulation process. It is observed in U.S.A that 39% of high profit stocks were in trades on behalf of companies in which their future profit was gone under manipulation by management. Palumbo [24] has published article by insisting on final decision to obtaining to information to make decision under uncertain condition. This final decision is following up fair defense system and having dual supervision structure both at stock exchange and at economic unit to decrease potential fields of manipulation. For example by offering legal solutions for having different fines for manipulation, much disclosure information for users of units will be collected and published for abnormal goals. This present article studies legal mechanisms in this field. Gerbash and Muller [25] have published the result of their studies. Their research offers motivation among politicians as dual mechanism. These 2 mechanisms include flexible allowance and democratic elections. Meanwhile there is informational market in which potential chance for reselecting politicians are evaluated. A cost is observed for this information and case

of manipulation at information market is observed. Their research is mainly dealt with social discussions that are corresponded to financial discussions. Another research [26] confirms that positioning strategy in market is effective on level of social welfare and production market. Within this strategy on the contrary of cost strategy the analysis is regarded as principle. These 2 strategies are compared together in different fields and their abilities are studied. Exit theory and its economic consequences are also studied. Knetsch et al. [27] have studied effect of legal tariffs in a special target market on auction basis. In addition the legal cases and its structures in similar markets are studied. He has indicated that legal problems in relation to markets prepare suitable grounds for price manipulation in market. In addition the inflexible weak and strong legal point studies price limitation. Finally modern activities and tools that are used in the way of tracking and preventing manipulation mechanisms in target market are mentioned from different aspects and its related weak and strong points are studied. Ruiz-Conde et al. [28] in his article has mentioned that marketing has some variables such as price and advertisement. Some factors in market such as manipulating invoices and market variables, leads the target market to its desired goals with respect to price at different conditions and different stocks. The present article by offering basic questions in relation to price manipulation seeks to find clear answers.

III. RESEARCH METHODOLOGY & EXECUTIVE RESEARCH METHODS

A. Research Method and Conceptual Model

The research methodology is correlation and regression analysis. Therefore at first by using runs test, self correlation and studying regression waste the abnormal return (meaningful difference among real return and expected return) in stock of 379 companies present in stock exchange during years 2001 until end of 2009 by having intense price fluctuations in some periods of time was studied and in this way the companies having price manipulation were recognized. Companies in which their process of price fluctuation was not random and price of their stock in any time period had self correlation with previous prices and by having meaningful abnormal return, indicate to have price manipulation in the aforesaid stock. In the next sections of the present research by using from artificial neural network and logit model, a model is designed for forecasting price manipulation. It is also used from data one year prior manipulation (sudden change in price of stock market). Independent variables and forecasting models for price manipulation are such as information clarity, stock liquidity, size of company (capital of company) and P/E ratio and dependant variable is price manipulation. The conceptual pattern that is used here to forecast manipulation is logit model and multi layer perceptron neural network. Within these models the independent variable may be at quantitative and qualitative scale, meanwhile the dependant variable has

double level. These 2 issues refer to membership in one set (companies having price manipulation). The dependant variable as per independent variable allocates zero and one. When dependant variable is one it means that price of stock is manipulated and when it is zero it means that the price of stock is not manipulated.

B. Logit Model

Comerton [15] conducted study in relation Australia stock exchange in which binary logit model is used for forecasting price manipulation. Findings of research indicate that this model has acceptable efficiency. The general form of logit regression model that is used in the present research is defined as:

$$Z_i = \text{Ln} \left(\frac{P_i}{1 - P_i} \right) = \beta_0 + \sum_{i=1}^n \beta_i X_i + \varepsilon_i \quad (1)$$

In the aforesaid equation, Ln indicates natural logarithm. Based on aforesaid model, approximating possibility of price manipulation of stock is calculated based on following relation:

$$P_i = \pi_i(x_1, x_2, \dots, x_k) = \frac{e^{\beta_0 + \sum_{i=1}^k \beta_i x_i}}{1 + e^{\beta_0 + \sum_{i=1}^k \beta_i x_i}} \quad (2)$$

C. Topology and Training Neural Network

For the present study multi layer feed forward neural network(MLFN) is used with back propagation(BP) in which through different structures and by using trial and error method and according to other studies in a structure network with 5 input, 25 neuron in middle layer and one output having best response were selected. The aforesaid network as per company, 5 independent variables was introduced to network (input) and as per variable, a dependant variable as 0 or 1 was fed to network. After training network the possibility of studying ability of forecasting model was specified. The reason of selecting MLFN in the present and similar research is ability of modeling complicated communication by using simple functions. This issue was proved at many applied research. Network was trained by using nearly 90% of data and model test was taken by 10% of data. Data for training weight were specified by several repetitions and then they were executed for test data. Repeating training and weight process in this test was observed as 25000. Advantage of artificial neural network is that after each repetition the efficiency of system on evaluating data is assessed and in case of having negative efficiency and possible error the process of training will stop.

D. Multiple Discriminant Analysis (MDA)

An MDA function is regression equation that introduces membership of data in classification set. This function is

linear compound among forecaster variables in model with the goal of discriminating members of different sets through offering different privileges to set members. Therefore the aforesaid function indicates that each of the data belongs to which set. For example if goal is forecasting price manipulation, the MDA function offers the best forecasting on whether they are member at manipulated or non-manipulated sets. The principal idea of multiple discriminant analysis models is to specify different sets and classification based on average variables. In order to do so the ratio of variance among sets and variance inside of sets is calculated. If this ratio may be high the average sets may have meaningful difference among independent variables and they may classify at discriminating sets. The general form of MDA model is whereas follows:

$$Z = \alpha + \sum_{i=1}^k \beta_i X_i \quad (3)$$

In which X_i is independent variable or forecaster of dependant variable (price manipulation) and Z is dependant variable (discriminator of manipulated and non-manipulated companies).

E. Statistical Universe & Time Domain of Research

Statistical universe that is used for designing mode is all companies accepted at Tehran stock exchange. Time domain of the present research is first of year 2001 until 2009. The reason of selecting aforesaid time domain is that price of stock in most of the companies accepted at stock exchange were gone under severe fluctuation during aforesaid period and maybe the reason is price manipulation.

F. Sampling Method

Sampling method of the present research is judgmental. Judgmental sampling requires selecting data which have the best conditions for offering information. Whereas it is not long past from approving new law of stock exchange on Dec 2005 and until now many of such activities are not discovered by supervisor organizations and there was no supervisor institution to recognize and introduce manipulated companies and person in charge of market manipulation, companies that their annual return had increased more than 100% and their annual return had decreased more than 50%, were selected as companies having possibility of manipulating their price of stocks. Then by performing runs test, self correlation for price of stock, waste, companies were divided into 2 sets of manipulated and non-manipulated companies.

IV. RESEARCH HYPOTHESIS

First Principal Hypothesis: Forecasting price manipulation of a company based on size of company (capital of company), stock liquidity rank, P/E ratio, status of information clarity, status of floating (structure of shareholder) is possible through logit model.

Subsidiary hypothesis of research based on aforesaid

hypothesis are whereas follows:

First Subsidiary Hypothesis: There is inverse relationship among liquidity and manipulation price of stock

Second Subsidiary Hypothesis: There is inverse relationship among information clarity and manipulation price of stock

Third Subsidiary Hypothesis: There is inverse relationship among size of company and manipulation

Fourth Subsidiary Hypothesis: There is meaningful difference among structure of shareholders and manipulation price of stock

Fifth Subsidiary Hypothesis: There is inverse relationship among P/E ratio and manipulation price of stock

Second Principal Hypothesis: Forecasting price manipulation of company based on size of company (capital of company), stock liquidity rank, P/E ratio, status of information clarity, status of floating (structure of shareholder) is possible through neural network model

Third Principal Hypothesis: Forecasting price manipulation of company based on size of company (capital of company), stock liquidity rank, P/E ratio, status of information clarity, status of floating (structure of shareholder) is possible through multi discriminating analysis model

V. DEFINITION OF VARIABLES & THEIR CALCULATION

According to goal of research the dependant variable in the present article is status of price manipulation at Tehran stock exchange. This variable is double value and divides elements of society into 2 sets of manipulated and non-manipulated. Independent variables of research include size of company, P/E ratio, stock liquidity rank, P/E ratio, status of information clarity and status of floating (structure of shareholder). Among studies that have used from aforesaid variables to forecast price manipulation in stock exchange is studies of Aggarwal, Wu, Allen and Gale [3, 4]. Operational definition for each of the aforesaid variables is whereas follows:

Size of Company: In the present research size of company is specified based on natural logarithm for capital of company.

P/E Ratio: This ratio indicates expectations of market from perspective of growth in future profit of company. In order to calculate this ratio, the current price for company's stock in market is divided on forecasted net profit of each stock. P/E ratio is continuous variable in which in order to design model it used from P/E ratio one year prior time of manipulation.

Stock Liquidity Rank: Stock liquidity rank of company accepted at stock exchange is calculated through six factors including number of days of trade, number of purchasers, number of traded stocks, volume of trades, number of trades and average present value of capital. Liquidity rank of company is specified based on average harmony of these factors. If the calculated average may be higher, the liquidity rank of company may be higher.

Based on aforesaid factors the stock exchange organization daily announces rank of each company. Liquidity rank for

stock of company in stock exchange is calculated by the following formula:

$$Liquidity = \frac{1}{\frac{1}{V} + \frac{1}{D} + \frac{1}{F} + \frac{1}{B} + \frac{1}{C} + \frac{1}{N}} \quad (4)$$

In this formula V is volume of trades in a specified period, D is number of days of trade in a specified period, F is average number of trade per day, B is average number of purchasers per day, N is average number of trades per day and C is average value of capital per period

Status of Information Clarity: This index indicates volume and enrichment of published information in relation to companies. Scale of this variable is ranking and in order to calculate it, the companies are ranked based on level and quality of officially published information. Aforesaid ranking is performed by stock exchange organization through taxonomy method for all companies by using factors including observing regulations of stock exchange in relation to disclosure of information, volume of published information and quality of offered information in report and scholars use from this ranking for designing model.

Status of Floating for Company's Stock: This index indicates structure of shareholder in company and shows the percentage of company's stock that is permanently under trade and percentage of company's stock that is blocked by wholesale shareholders. Floating percentage of company's stock is calculated through stock exchange organization. In the present research the status of floating company's stock is defined as rank scale in the following table:

TABLE I
 RANK FOR STATUS OF EACH FLOATING STOCK IN MARKET

Floating Percentage	Floating Status	Floating Rank
Max 5%	Very low	1
5% to 15%	Low	2
15% to 30%	Average	3
30% to 50%	High	4
More than 50%	Very high	5

VI. HYPOTHESIS TEST & STATISTICAL ANALYSIS

In the present research in order to find out manipulation it is used from runs test, skewness test, kurtosis test and duration test and then independent variables are used as input to fit neural network models and logistic regression. Companies are also divided into 2 sets of manipulated and non-manipulated. In this way first the general return (extracted from stock exchange software) is observed for all companies and then after performing related tests, companies are classified as 2 aforesaid sets. The independent variables for each company during one year prior manipulation were collected and its

effect on dependant variable that is occurrence or non-occurrence of manipulation is tested. Doing this in the first step requires preparing data.

a. Price Manipulation Behavioral Pattern of Stock

Holley [29] by studying process of manipulated companies during years 1927 until 1992 in New York and London stock exchange, found out that there are similar behavioral patterns of price manipulation. Based on his opinion manipulating price of a stock in stock exchange may be divided into 4 stages whereas follows:

- 1) Stage of forming coalition among manipulators and collusion for creating false demand in market
- 2) Considerable and continuous increase in price of stock due to increase of demand in comparison to supplying stock in market
- 3) Exit of manipulators from stock market or selling stock to applicants on wholesale basis
- 4) Considerable decrease of demand and volume of trades in relation to desired stock and consequently dropping price of stock to lower price before manipulation

By observing process of stock price of companies that has possibility of price manipulation in Tehran stock exchange, we will find out that pattern of price manipulation in Tehran stock exchange is similar to other stock exchanges. In the above diagram the process for price of stock related to test company is indicated. Related tests on process of price of this stock indicate price manipulation of desired stock up to 95% certainty.

b. Data Gathering

In order to perform aforesaid tests, first total return of companies accepted at Tehran stock exchange is extracted on daily and monthly basis. These data were used to perform tests such as skewness, kurtosis, runs and duration correlation.

c. Runs Test

One of the tests for specifying manipulation in price of company's stocks is runs test. Within this test if return runs may be more positive or negative than desired runs, it indicates non-random pattern in process of stock price and consequently rising price manipulation. In formation of runs the daily return lower than average has negative sign and daily return higher than average has positive sign. Each runs includes sequence of one or several positive and negative signs i.e. sign is changed when a new runs is started. Total number of positive and negative signs in time series is counted and after this stage the number of desired runs and their standard deviation is calculated through following formula.

$$E(R) = \frac{2(n_1)(n_2)}{n_1 + n_2} + 1 \quad (5)$$

$$\delta = \sqrt{\frac{2n_1n_2[2(n_1n_2) - n_1 - n_2]}{(n_1 + n_2)^2(n_1 + n_2 - 1)}} \quad (6)$$

In which n_1 is number of positive return and n_2 is negative return. Then meaningfulness of difference in number of counted runs with number of expected runs for random variable is studied by T-test. If statistics of test (difference among number of counted runs and number of expected runs divided on standard deviation of runs) may be among critical range, in this way number of runs may not have meaningful difference with number of expected runs and it is concluded that length of runs is not different with length of random or independent runs. Therefore there is no possibility of manipulation. However if statistics of test may not be among critical range, it means that number of counted runs has meaningful difference with number of expected runs. If number of counted runs may meaningfully lower than number of expected runs, it is concluded that length of runs for time series is so long that it is not compatible with random and independent data and there is possibility of manipulation. Table II offers results of manipulation test for one of the selected sample companies.

As it is observed for the aforesaid companies, the value of daily return and monthly return and z value is out of accepted

TABLE II
 SAMPLE RESULTS OF RUNS TEST
 CRITICAL VALUES: LEVEL OF CERTAINTY 95% 1.96 AND LEVEL OF CERTAINTY 99% 2.58

	Daily Return	Monthly Return
Level of return	-0.2058	-0.4150
Level of return < case	117	19
Level of return ≥ case	186	89
Total cases	303	108
Number of runs	101	19
z	-5.229	-4.470

return range and therefore this company is among 165 companies suspected to manipulation.

d. Skewness & Kurtosis

Another method for discriminating possibility of manipulating company's stock is to use from skewness, kurtosis and their return series. If daily return of companies accepted at stock exchange with time domain of research(9 year period from 2001 until 2009) may have meaningful skewness coefficient less than normal level and kurtosis higher than normal level, it is possible to have price manipulation in that company. Table III indicates results of this test for one of the selected sample companies:

TABLE III
 SAMPLE RESULTS OF TEST RELATED TO SKEWNESS AND KURTOSIS COEFFICIENTS

	Daily Return
No of Data	303
Skewness	-2.899
Kurtosis	33.614

Critical Values: Kurtosis coefficient and normal distribution is equal to zero and skewness coefficient is equal to three

Statistics of test for skewness coefficient is 3 times higher than standard deviation and kurtosis coefficient is 2 times higher than standard deviation.

e. Duration Correlative Tests

In duration correlative test, having long runs of abnormal positive or negative return indicates price manipulation in stock of company i.e. while manipulation the possibility that abnormal positive or negative return s ends with increasing length of period is very low. In order to perform this test we use from danger function in which bulb period has negative slope.

$$h(t_i) = \frac{1}{1 + e^{-(\alpha + \beta \ln i)}}, \beta > 0 \quad (7)$$

In the above equation $h(t_i)$ is possibility of manipulation and its value is between zero and one. While fitting model for negative runs the value of $h(t_i)$ is observed as one and for positive runs this value is observed zero. In the above formula $\ln i$ indicates natural logarithm for length of positive and negative runs. If in this test β may be negative it indicates possibility of manipulation. In order to perform duration correlative test first abnormal return of data shall be specified. Abnormal return is extracted through self description model wastes. The optimum number in self description model is obtained by Box- Jenkins method. Jenkins is a method in which at AR the optimum number is obtained by self description coefficient meaningful test. First time series self description model is approximated and then based on Box-Jenkins method, the optimum number of AR and MR may be calculated. Results of Box- Jenkins method indicates that ARMA (2, 1) model i.e. model with 2 return delays with one waste delay is regarded as best model. Abnormal return includes the following regression wastes such as

$$R_t = \gamma_0 + \gamma_1 R_{t-1} + \gamma_2 R_{t-2} + \eta_{t-1} \varepsilon_{t-1}^2 + \varepsilon_t \quad (8)$$

In which R_t is daily nominal return, R_{t-1} and R_{t-2} is first and second delays and variable ε_{t-1} is first mobile average as part of model error. In the present research before approximating self description model to extract wastes, it used from durability test for all time series. If the desired time

series is not durable, due to rising false regression problem it is not possible to use from self description model. For durability test it is used from same root tests. One of the most common same root tests is Diki-Fuller test that is used in the present research. As case study results of test related to time series of daily stock return of 2 companies is offered in table 4. If the amount of statistics is less than F critical statistical amounts, the zero hypotheses in relation to correlation of wastes is accepted i.e. in this way we accept that wastes have self correlation which means that model is approximated as optimum abnormal return.

TABLE IV
SUMMARY OF RESULTS OF WASTE SERIAL CORRELATION TEST AND SAME ROOT TEST

Companies	Model Waste Serial Correlation Test		ADF Statistics Test
	Possibility	Same Root Test	
Daily Return	First Company	0.71	-11.2
	Second Company	0.068	-11.5

Remarks: In same root test, the critical values for daily return of meaningful level are 1% and 5% as -2.86 and -2.57. As it is indicated from table 4, in the approximated equation the possibility of accepting zero hypotheses is more than 5%; therefore zero hypotheses in relation lack of having serial self correlation in wastes of model is accepted.

In the present research after approximating above self description model, the waste of model as abnormal return for stock related to each of the sample companies may calculate and obtained abnormal return as positive and negative runs are separated. Positive and negative runs are separately numbered and then duration correlative test is performed for specifying price manipulation. Then logarithm equation for above danger function is approximated through positive and negative runs and duration of runs and its parameters are obtained. Table V indicates sample output of parameters for danger function (α , β). In duration correlative test the meaningfulness of β coefficient is tested at approximating danger function. In order to perform this test it has used from Wald Test. Zero hypothesis of this test $\beta=1$ is $(1-\beta) = 0$. If level of meaningfulness (p-value) is less than 0.05, the zero hypothesis concerning that β is equal to one is rejected and it is concluded that such company has price manipulation. This test was performed on return sequence of all companies and it was indicated that 95 companies had negative danger function slope i.e. such companies has price manipulation. In the other companies the zero hypotheses was confirmed and β was equal to one and therefore there was no price manipulation. After performing duration correlative test and final division of companies into 2 sets of manipulated and non-manipulated, based on diagram the process of return and volume of trades in manipulated companies and time of starting manipulation was specified.

TABLE V
SAMPLE RESULTS OF DURATION CORRELATIVE TEST

Danger Function Rate	Negative		Positive		Length of Runs
	No of Runs	Danger Function Rate	No of Runs	Danger Function Rate	
0.26	6	6	6	6	1
0.7	12	10	10	10	2
0.4	2	3	3	3	3
0.33	1	1	1	1	4
0.5	1	1	1	1	5
0	0	0	0	0	6
1	1	1	1	1	7
		1	1	1	8
-0.63		-0.6			Log Logistic Test
0.71		0.48			α
0.017		0.023			β
					P-value(β)

In the final step value of independent variables of each company during one year prior date of manipulation was collected and its effect on dependant variable that is occurrence or non-occurrence of manipulation was tested. Studying ability of forecasting manipulation was performed through neural network model and regression and at the end the ability of model for forecasting manipulation was evaluated. The variables that were used here include: P/E ratio, size of company, speed for trade floating, information clarity and structure of shareholders.

f. Results of Studying & Test for Efficiency of Logit Model in Forecasting Stock Price Manipulation in Tehran Stock Exchange

One of the hypotheses of the present research is to have ability of forecasting price manipulation by using binary logistic regression model. Summary of logit model is offered in the following table

TABLE VI
SUMMARY OF RESULTS OF EVALUATING AND MODEL TEST

Level of Meaningfulness	Wald Statistics	Standard Deviation	Coefficients	Variable
0.00	44.970	0.108	-0.723	Company stock natural logarithm(x_1)
0.00	70.253	0.003	0.027	Information clarity(x_2)
0.017	5.724	0.068	-0.162	P/E(x_3)
0.001	11.407	0.011	0.038	Stock liquidity(x_4)
0.003	8.577	0.229	0.671	Floating stock(x_5)

According to Wald statistics and level of calculated error the coefficient of variables (p -value <0.01) by having 99% certainty claims that all of the defined variables in final model are meaningful. Log likelihood and calculated specifying coefficient of model indicates suitable ability of model to forecast price manipulation in Tehran stock exchange (table VII).

TABLE VII
SUMMARY OF RESULTS FOR EFFICIENCY OF MODEL

Step	Log Likelihood	Cox & Snell R Square
1	27.49	0.792
2	27.19	0.799

Among other required tests for specifying ability of forecasting model is Wilk's Lambda. This statistics is used for inner correlation ability of variables which are used at logit regression model. In logit regression if the level of correlation is higher the result may be more trustable. Wilk's Lambda is result of sum of inner set squares to total squares. This value indicates variance ratio of audit grades that may not explain by sets. According to previous researches by Altman in the field of forecasting bankruptcy, it was indicated that values higher than 0.9, are low discriminating ability of independent variables that are defined in model. According to Wilk's Lambda and Khido by 99% certainty it is possible to claim that the designed model has suitable inner ability for forecasting price manipulation.

TABLE VIII
SUMMARY FOR LOGIT ANALYSIS WITH INNER CORRELATION METHOD OF MODEL'S VARIABLES

Level of Meaningfulness	Degree of Freedom	Khido	Wilk's Lambda	Step
1	0.205	137.4	2	0.000
2	0.161	177.2	3	0.000

Results for forecasting Ability of Logit Model

One method for specifying ability of forecasting model is to compare real amounts of manipulated companies with forecasted amounts. In this model the less forecasting error the higher efficiency. According to data in evaluating model (300 companies), forecasting ability of manipulated companies was 92% and total forecasting ability of model was 88%. In order to assess extending ability of model the data there were not used at evaluating model shall be used. Therefore last year information of 79 companies that was not used at evaluating model was used and results of forecasting in comparison with observed reality at this sample (sample mode) is provided as table IX. According to correct forecasting percentage of model related to data of test set, it is possible to claim that extending ability of model for forecasting price manipulation in Tehran stock exchange is at suitable level.

TABLE IX
CORRECT FORECASTING PERCENTAGE

Correct Forecasting Percentage	2nd Type Error	1st Type Error	No of Errors	Forecasting by 1st Model	No of Observation	Set
93.3%		6.7%	2	28	30	Non-Manipulated
87.5%	12.5%		1	7	8	Manipulated
92.1%	12.5%	6.7%				Sum

g. Data Analysis in Neural Network Model

Training Artificial Neural Network Based on Data 1 Year Prior Manipulation in Training Set

In order to design and evaluate neural network, we have used from Multilayer Perceptron (MLP) and Backpropagation. In order to study and select the best model the number of different middle layers are studied and finally mode with 5 inputs (P/E ratio, size of company, speed of flowing trades, information clarity and structure of shareholders), one double amount output (one as having manipulation and zero as not having manipulation) and 27 neurons as middle layer was regarded as more effective mode. In the following figure the model for designing network is indicated:

TABLE X
RESULTS OF STUDY ABILITY OF FORECASTING ARTIFICIAL INTELLEGENCE MODEL

Correct Forecasting Percentage	2nd Type Error	1st Type Error	No of Errors	Forecasting by 1st Model	No of Observation	Set
96.7%		6.7%	1	29	30	Non-Manipulated
87.5%	12.5%		1	7	8	Manipulated
94.1%	12.5%	6.7%				Sum

The output of MATLAB software is offered in diagrams 2 and 3. In the MATLAB software data are divided into 2 sets as Training Set (80% of data), Validation Set (10% of data) and Test Set (10% of data). Training network is performed through data of first set and in the next stage, validation and network test is performed through test set. As it is obvious in diagram, network at the end of 15th stage is obtained acceptable level of error and on network test the forecasting percentage for training set was 94.1%.

h. Results of Designing and Testing Efficiency of Multi Audit Analysis Model in Forecasting Stock Price Manipulation in Tehran Stock Exchange

One of the hypotheses of the present research is ability of forecasting price manipulation in stock of companies by using multi audit analysis model. In order to test this hypothesis first of all data one year prior manipulation in price of stock of companies as training model are designed and audit analysis

model for manipulated and non-manipulated companies are whereas follows:

TABLE XI
COEFFICIENTS FOR EVALUATED ANALYSED MODEL

Z(Variables for Grouping companies)		
	Coefficients of Independent Variable for Non-Manipulated Companies	Coefficients of Independent Variable for Manipulated Companies
Clarity (x ₂)	0.023	0.069
Liquidity (x ₄)	0.088	0.135
Floating Stock	2.771	3.558
Width from Origin	-6.690	-18.364

As it is obvious, in multi audit analysis model, ability of grouping and discriminating manipulated companies from non-manipulated companies is only possible through variables such as clarity of information, liquidity and floating stock. The variables such as size of company, P/E ratio were not meaningful and are not suitable for discriminating manipulated companies from non-manipulated companies. Based on information of table 11, the discrimination line equation for non-manipulated companies (z₀) and manipulated companies (z₁) is whereas follows:

$$Z_0 = -6.69 + 0.023 X_2 + 0.088 X_4 + 2.771 X_5 \quad (9)$$

$$Z_1 = -18.364 + 0.069 X_2 + 0.135 X_4 + 3.558 X_5 \quad (10)$$

For meaningfulness of audit analysis, from difference of 2 above equation a new equation is obtained whereas follows:

$$Z_1 - Z_0 = -11.674 + 0.046 X_2 + 0.047 X_4 + 0.787 X_5 \quad (11)$$

By putting different amounts of independent variables in this equation and specifying value of Z₁-Z₀, it is possible to specify where price of stock has gone under manipulation or not. If the sum is higher than zero it indicates that possibly price of stock in such company is manipulated and vice versa is sum is lower than zero it indicates that possibly price of stock in such company is not manipulated. According to results of test, Box's M and F statistics it is indicated that covariance among groups is different and it is possible to use from multi audit analysis model. According to Wilks' Lambda in order to specify inner ability for each of the variables in model and calculated Khido, it is indicated that designed model has suitable inner ability for forecasting manipulated prices.

TABLE XII
CALCULATED VARIABLES

Step	Wilk's Lambda	Khido	Degree of Freedom	Level of Meaningfulness
1	0.370	373.403	3	0.000

1-8-6 Results of ability for forecasting model of multi audit analysis

TABLE XIII
CORRECT FORECASTING PERCENTAGE OF MODEL

Correct Forecasting Percentage	2nd Type Error	1st Type Error	No of Errors	Forecasting by 1st Model	No of Observation	Set
90%		10%	3	27	30	Non-Manipulated
90.5%	9.5%		1	7	8	Manipulated
90.2%	9.5%	10%				Sum

According to correct forecasting percentage of model related to data of test set, it is possible to claim that extending ability of model for forecasting price manipulation in Tehran stock exchange is at suitable level (90.2%).

VII. CONCLUSION

The principal goal of the present research is to offer model to forecast manipulation in price of stock of companies accepted at Tehran stock exchange. Therefore based on findings variables such as size of company, ratio of price to earnings, clarity of information, stock liquidity and shareholder structure of company are introduced as determinant factors for price manipulation and through suitable tests in meaningfulness model their relationship with econometrics was studied. Also in order to forecast price manipulation some models such as logistic regression, artificial neural network and multi audit analysis were used. In order to design model, the sample was divided into 2 groups of manipulated and non-manipulated companies with occurrence possibility of 100% for manipulated companies and zero possibility for non-manipulated companies by using runs test, skewness test, kurtosis test and duration correlative and the according to information extracted from these 2 groups, logit model, artificial neural network and multi audit analysis was evaluated. In order to evaluate logit model and audit analysis it was used from step to step method. Neural network model consisted of a type of multilayer perceptron and in order to evaluate it is used from backpropagation. In order to evaluate models it is used from one year prior information of 379 companies accepted at stock exchange. Results of meaningfulness test for logistic regression through statistics indicated direct relationship among floating stock, information clarity and liquidity for stock of companies with price manipulation and inverse relationship among size of company and P/E ratio with price manipulation. Meanwhile multi audit analysis model regarded that variables such as size of company and P/E ratio are ineffective on forecasting price manipulation. Also results of research indicated that all of the 3 models have high ability in forecasting price manipulation and meanwhile there is not considerable difference among these models in relation to ability of forecasting. According to findings of research there is price manipulation at Tehran stock exchange and some of its principal reasons are shallow

market, disorganized market and having no legal following up. Therefore it is recommended that persons in charge of this affair by more insisting on laws and improving level of market clarity and efficiency through different methods of database to create conditions to minimize ability of misusing secrets of market and holders of information. In spite of punishments that are observed in text of law, until now no serious punishment is executed and forcible behavior with phenomena of price manipulation was very low. Whereas it is a must to have serious behavior, the obligation to execute laws shall be stricter. In this research, several models were used for classifying and grouping manipulated companies from non-manipulated companies. It is suggested to test other models for market of Iran such as double step clustering genetic algorithm, average clustering, hierarchy clustering, tree, adjacent closeness, etc.

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