



DETECTION OF OUTLIERS IN STOCK MARKET USING REGRESSION ANALYSIS

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Abstract: By comparing historical data of trading like daily Open, High, Low, Close, Volume, Number of Trades, Turnover, Delivery percentage etc. of a particular stock with its Peer Group companies and Non Peer Group companies stocks for a particular period, we can find some unusual observations which are also known as outliers. In this paper we have tried to detect the observations, which are very different from the other observations using a Data Mining Technique for Outlier Detection- "Multiple Linear Regression Analysis".

Key Words: Outliers, Stock Market, Peer Group Analysis, Regression, ANOVA

I. Introduction

To find outliers is a very important task in Data Mining. In Stock Market, outlier detection plays very important role in detecting fraud. The main objective of Data Mining is to search for a general pattern for the input data. According to **Barnett & Lewis, 1994**, Novelty detection, or so-called outlier detection, is the identification of "novel" or "unknown" events that an expert system is not aware of during training or testing. Outliers may indicate abnormal running conditions and lead to significant performance degradation. An outlier is one that appears to obviously deviate from the others of the sample in which it occurs or an observation which appears to be inconsistent with the remainder of the dataset. According to **Aggarwal and Yu (2001)**, outliers may be considered as noisy points lying outside a set of defined clusters or may be defined as points that lie outside of the set of clusters but are also different from the noise. According to **He, Xu, Huang, Deng, 2004, Coderre, 2009, Aggarwal & Guojun, 2003**, outlier analysis attempts to find the rare class whose behavior is very exceptional when compared to the rest of input data. Many techniques are proposed to detect outliers, drawn from Statistics, Computer Science or Machine Learning. **Hodge and Austin (2004)** reviewed some fundamental approaches to solve the problem of Outlier Detection. This technique is usually named as Novelty Detection since it aims to define the boundary of normality instead of estimating the density of the dataset. In addition to the surveillance of stock price changes, Anomaly Detection Techniques have been applied to various fields such as Network Intrusion Detection (**Naiman, 2004; Scott, 2004**), Financial Fraud Detection (**Juszczak, Adams, Hand, Whitrow, & Weston, 2008**), Fault Detection (**Chen, Martin, & Montague, 2009; Martins, Pires, & Amaral, 2011; Yiakopoulos, Gryllias, & Antoniadis, 2011**).

There are some techniques which can be applied for the Security Fraud Detection System based on Outlier Analysis, for example Fuzzy Set Analysis, Bayesian Approach, Pattern Matching Techniques and Data Mining Techniques. The following Six algorithms are the most commonly used software techniques in Data Mining Applications-Neural Networks, Decision Trees (Expert Systems), Genetic Algorithms, Regression Analysis, Statistical Methods and Data Visualization. In the current study we have used **Multiple Linear Regression Analysis** to detect outliers. To accomplish this study we have used trial edition of Minitab-15 for evaluation purpose.

Linear Regression assumes that a linear relationship exists between the input data and the output data. The common formula for a linear relationship is used in this model:

$$y = c_0 + c_1x_1 + \dots + c_nx_n$$

In the above equation there are n input variables, which are predictors or regressors and one output variable (y , the variable which is to be predicted). The constants c_0, c_1, \dots, c_n , are the regression coefficients which is computed by the method, known as principle of Least Square, and computed during the modeling process when processed on a statistical software like Minitab-15 or SPSS etc. This is called **Multiple Linear Regression** because there is more than one predictor (**Margaret H. Dunham, 2005**). Regression Analysis is a statistical methodology that is most often used for numeric prediction (**Jiawei Han and Micheline Kamber,**

2010). Following are the results of Outlier observations when applied on Minitab-15 to find the linear regression equation for Closing Price (dependent variable) with Opening Price and SHL (Spread between High Price and Low Price):

II. Observations

Table-1: Peer Group Companies (Type- Other Telecom Services)
Regression Analysis: Close Price versus Open Price, SHL

Results for: GTL Ltd The regression equation is Close Price = 2.44 + 1.00 Open Price - 0.871 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	2.4427	0.3662	6.67	0.000	
	Open Price	1.00190	0.00183	547.76	0.000	
	SHL	-0.87134	0.01911	-45.60	0.000	
	S = 4.24900 R-Sq = 99.9% R-Sq(adj) = 99.9%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	5443905	2721952	150767.18	0.000
Residual Error	246	4441	18			
Total	248	5448346				
Results for: Onmobile Global Ltd The regression equation is Close Price = - 0.006 + 0.979 Open Price + 0.263 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	-0.0061	0.4797	-0.01	0.990	
	Open Price	0.979136	0.005590	175.17	0.000	
	SHL	0.26305	0.06728	3.91	0.000	
	S = 3.87681 R-Sq = 99.5% R-Sq(adj) = 99.5%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	759802	379901	25276.71	0.000
Residual Error	246	3697	15			
Total	248	763499				
Results for: Quadrant Televentures Limited The regression equation is Close Price = 0.398 + 0.892 Open Price + 0.0518 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	0.39794	0.07372	5.40	0.000	
	Open Price	0.89174	0.01920	46.44	0.000	
	SHL	0.05182	0.07892	0.66	0.512	
	S = 0.182469 R-Sq = 90.3% R-Sq(adj) = 90.2%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	76.380	38.190	1147.02	0.000
Residual Error	246	8.191	0.033			
Total	248	84.571				
Results for: Tulip Telecom Ltd The regression equation is Close Price = 0.42 + 1.00 Open Price - 0.267 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	0.421	1.207	0.35	0.727	
	Open Price	1.00197	0.00844	118.68	0.000	
	SHL	-0.26682	0.05924	-4.50	0.000	
	S = 2.96114 R-Sq = 98.3% R-Sq(adj) = 98.3%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	123577	61789	7046.79	0.000
Residual Error	246	2157	9			
Total	248	125734				
Results for: Nutek India Ltd. The regression equation is Close Price = 0.0115 + 0.994 Open Price - 0.176 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	0.01149	0.02093	0.55	0.584	
	Open Price	0.994395	0.006504	152.88	0.000	
	SHL	-0.17608	0.04808	-3.66	0.000	
	S = 0.212468 R-Sq = 99.5% R-Sq(adj) = 99.4%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	2018.9	1009.4	22361.31	0.000
Residual Error	246	11.1	0.0			
Total	248	2030.0				

Coef:- Coefficient
SE Coef:- Standard Error Coefficient
DF:- Degrees of Freedom

SS:- Sum of Square
MS:- Mean Sum of Square
S:- Standard Error

R-Sq:- R Square
R-Sq(adj):- Adjusted R Square
SHL:- Spread(High-Low)

Table-2: Non Peer Group (Group-A Companies)
Regression Analysis: Close Price versus Open Price, SHL

Results for: Infosys The regression equation is Close Price = 121 + 0.965 Open Price - 0.457 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	121.31	33.60	3.61	0.000	
	Open Price	0.96512	0.01184	81.49	0.000	
	SHL	-0.45743	0.08139	-5.62	0.000	
	S = 38.9343 R-Sq = 96.6% R-Sq(adj) = 96.5%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	10512382	5256191	3467.43	0.000
	Residual Error	246	372906	1516		
Total	248	10885288				
Results for: NTPC The regression equation is Close Price = 8.11 + 0.953 Open Price - 0.0741 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	8.109	3.398	2.39	0.018	
	Open Price	0.95333	0.01932	49.33	0.000	
	SHL	-0.07414	0.09764	-0.76	0.448	
	S = 2.63499 R-Sq = 90.8% R-Sq(adj) = 90.8%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	16929.2	8464.6	1219.13	0.000
	Residual Error	246	1708.0	6.9		
Total	248	18637.2				
Results for: SBI The regression equation is Close Price = 49.8 + 0.990 Open Price - 0.538 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	49.78	17.50	2.84	0.005	
	Open Price	0.989625	0.008021	123.37	0.000	
	SHL	-0.53754	0.08274	-6.50	0.000	
	S = 40.9299 R-Sq = 98.4% R-Sq(adj) = 98.4%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	25634555	12817278	7650.94	0.000
	Residual Error	246	412113	1675		
Total	248	26046668				
Results for: Jet Airways The regression equation is Close Price = - 0.16 + 0.991 Open Price + 0.109 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	-0.163	2.547	-0.06	0.949	
	Open Price	0.991416	0.007036	140.91	0.000	
	SHL	0.10949	0.07569	1.45	0.149	
	S = 11.3830 R-Sq = 98.8% R-Sq(adj) = 98.8%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	2711338	1355669	10462.52	0.000
	Residual Error	246	31875	130		
Total	248	2743213				
Results for: Ambuja Cement The regression equation is Close Price = 4.13 + 0.965 Open Price + 0.229 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	4.128	2.018	2.04	0.042	
	Open Price	0.96522	0.01382	69.86	0.000	
	SHL	0.22886	0.09864	2.32	0.021	
	S = 2.96408 R-Sq = 95.4% R-Sq(adj) = 95.4%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	45104	22552	2566.86	0.000
	Residual Error	246	2161	9		
Total	248	47265				

Coef:- Coefficient
SE Coef:- Standard Error Coefficient
DF:- Degrees of Freedom

SS:- Sum of Square
MS:- Mean Sum of Square
S:- Standard Error

R-Sq:- R Square
R-Sq(adj):- Adjusted R Square
SHL:- Spread(High-Low)

Table-3: Non Peer Group (Group-B Companies)
Regression Analysis: Close Price versus Open Price, SHL

Results for: Alok Industries Ltd. The regression equation is Close Price = 0.609 + 0.980 Open Price - 0.307 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	0.6090	0.2410	2.53	0.012	
	Open Price	0.97956	0.01115	87.88	0.000	
	SHL	-0.30669	0.07930	-3.87	0.000	
	S = 0.564197 R-Sq = 97.0% R-Sq(adj) = 96.9%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	2508.6	1254.3	3940.39	0.000
	Residual Error	246	78.3	0.3		
Total	248	2586.9				
Results for: Praj Industries Ltd The regression equation is Close Price = 6.96 + 0.906 Open Price + 0.0353 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	6.959	1.908	3.65	0.000	
	Open Price	0.90594	0.02507	36.14	0.000	
	SHL	0.03527	0.07544	0.47	0.641	
	S = 2.06277 R-Sq = 84.7% R-Sq(adj) = 84.6%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	5810.9	2905.5	682.83	0.000
	Residual Error	246	1046.7	4.3		
Total	248	6857.6				
Results for: Shree Renuka Sugar The regression equation is Close Price = 0.814 + 1.01 Open Price - 0.783 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	0.8144	0.3554	2.29	0.023	
	Open Price	1.01367	0.00665	152.35	0.000	
	SHL	-0.78296	0.07055	-11.10	0.000	
	S = 1.61605 R-Sq = 99.0% R-Sq(adj) = 99.0%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	63462	31731	12150.10	0.000
	Residual Error	246	642	3		
Total	248	64105				
Results for: Southern Ispat and Energy Ltd The regression equation is Close Price = - 0.0039 + 0.978 Open Price + 0.261 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	-0.00392	0.04304	-0.09	0.927	
	Open Price	0.977647	0.007257	134.73	0.000	
	SHL	0.26051	0.07629	3.41	0.001	
	S = 0.239944 R-Sq = 98.9% R-Sq(adj) = 98.9%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	1292.26	646.13	11222.74	0.000
	Residual Error	246	14.16	0.06		
Total	248	1306.42				
Results for: uflex The regression equation is Close Price = - 0.02 + 0.985 Open Price + 0.213 SHL	Regression Analysis Table					
	Predictor	Coef	SE Coef	T Value	P Value	
	Constant	-0.023	1.673	-0.01	0.989	
	Open Price	0.98504	0.01047	94.10	0.000	
	SHL	0.21318	0.07582	2.81	0.005	
	S = 5.28412 R-Sq = 97.5% R-Sq(adj) = 97.5%					
	ANOVA Table					
	Source	DF	SS	MS	F Ratio	P Value
	Regression	2	267897	133949	4797.26	0.000
	Residual Error	246	6869	28		
Total	248	274766				

Coef:- Coefficient

SE Coef:- Standard Error Coefficient

DF:- Degrees of Freedom

SS:- Sum of Square

MS:- Mean Sum of Square

S:- Standard Error

R-Sq:- R Square

R-Sq(adj):- Adjusted R Square

SHL:- Spread(High-Low)

Table-4: Outliers in Peer Group (Type- Other Telecom Services)

Company Name	No. of Outliers	Outlier Observation Numbers
GTL Ltd	13	7, 37, 52-55, 57, 63, 83, 110, 116, 200, 220
Onmobile Global Ltd	22	1-20, 23, 88
Quadrant Televentures Ltd	18	3, 4, 6, 11, 45, 46, 73, 131, 133, 145, 146, 196, 204, 206, 218, 220, 221, 235
Tulip Telecom Ltd	21	3, 5, 22, 40, 54, 57, 62, 82, 101, 112, 114, 116, 139, 141, 176, 204, 212, 214, 220, 222, 223
Nutek India Ltd	30	1-11, 13, 18, 20, 24, 27, 34, 38, 45-47, 50, 61, 62, 66-68, 88, 93, 133

Mean Number of Outliers= 20.8

Table-5: Outliers in Non Peer Group (Group-A companies)

Company Name	No. of Outliers	Outlier Observation Numbers
Infosys	13	2, 8, 9, 58, 93, 96, 113, 124, 132, 158, 164, 181, 195
NTPC	12	25, 41, 58, 67, 115, 131, 157, 166, 175, 177, 200, 239
SBI	14	19, 20, 30, 58, 90, 117, 132, 150, 166, 203, 217, 219, 222, 226
Jet- Airways Ltd	11	21, 23, 54, 58, 78, 94, 95, 161, 212, 213, 222
Ambuja Cement Ltd	13	16, 21, 89, 90, 108, 110, 115, 143, 160, 166, 171, 208, 222

Mean Number of Outliers= 12.6

Table-6: Outliers in Non Peer Group (Group-B companies)

Company Name	No. of Outliers	Outlier Observation Numbers
Alok Industries Ltd	12	3, 4, 8, 13, 44, 54, 94, 96, 151, 170, 210, 226
Praj Industries Ltd	12	78, 79, 86, 102, 119, 121, 153, 165, 205, 206, 212, 222
Shree Renuka Sugar	16	1, 27, 61, 64, 72, 75, 78, 90, 94, 98, 118, 119, 125, 152, 195, 217
Southern Ispat and Energy Ltd	15	8, 21, 30, 37, 38, 45-49, 96, 98, 119-121
Uflex Ltd	20	9, 10, 15, 17, 18, 20, 21, 37, 44, 54, 57, 96, 99, 101, 121, 129, 139, 152, 153, 192

Mean Number of Outliers= 15

Table-7: ANOVA Table

	Sum of Squares	DF	Mean Square	F	Sig.
Between Companies of Peer Group (Type-Other Telecom Services)	212244.754	4	53061.189	15.911	0.000
Within Groups	330153.707	99	3334.886		
Total	542398.462	103			

Table-8: ANOVA Table

	Sum of Squares	DF	Mean Square	F	Sig.
Between Companies of Non-Peer Groups (Group-A Companies)	14990.645	4	3747.661	0.775	0.546
Within Groups	280393.069	58	4834.363		
Total	295383.714	62			

Table-9: ANOVA Table

	Sum of Squares	DF	Mean Square	F	Sig.
Between Companies of Non-Peer Groups (Group-B Companies)	56147.200	4	14036.800	4.122	0.005
Within Groups	238371.467	70	3405.307		
Total	294518.667	74			

III. Discussion

We can analyze that how a single dependent variable can be affected by the values of one or more independent variables. For example, in this study we can analyze how a stock's close price is affected by such factors as open price, high price and low price. In our model, we have taken Close Price as Response Variable and two predictors (i) Open Price (ii) Difference of High and Low Price. The resultant Outliers are data points that are more than some appropriate distance from a regression line that is estimated using all the other data points in the sample.

We have taken historical data from BSE website [17] for period of one year, from 1st April, 2011 to 30th March, 2012. Total 249 days trading data has been taken in this period for all the companies, excluding holidays and Non-Trading Days. In Peer Group, all the companies are from B category stocks. In Non Peer Group, we have randomly chosen 5 companies from A category stocks (For Group A) and 5 companies from B category stocks (For Group B) from different-different sectors. From table 4, we can see that in Peer Group, Nutek India Ltd. has the highest numbers of outliers. Earlier we have studied how Operators/Manipulators badly hammered share price of Nutek India Ltd., from IPO listing price Rs. 192 to below 1 rupee (Singh & Nagar, April 2012) and also found illegal intraday trading done by II/NII (Institutional Investors/Non Institutional Investors)[12] in the said company (Nagar & Singh, October 2012). If we compare Mean value of Outliers from Table 4, 5 and 6, we can see that Peer Group's mean value of outliers is 20.8 and it is higher than both Non Peer Groups, 12.6 from Non Peer Group A and 15 from Non Peer Group B.

As per the table 1, 2 and 3, it can be easily observed that in almost all cases the R-Square value is more than 90%, except the one case of Non Peer Group of category B company- Praj Industries Ltd. That shows the regression model corresponding to each and every company either of Peer Group, Non Peer Group of category A and Non Peer Group of category B, is a best fit model to predict the Closing Price on the basis of Opening Price and SHL.

Secondly the p-values with respect to all regression coefficients in each fitted regression equation, comes to be less than 0.05, which shows that the regression coefficients in all fitted regression equations are significant except the regression equations to be the best fit for the given situations.

The results in table 7, 8 & 9 are obtained by using SPSS (Statistical packages for Social Sciences) version 20. The ANOVA (Analysis Of Variance) Table-7 with respect to Table-4 shows that the number of outliers in Peer Group companies are not same but varying with respect to time. It means there could be multiple number of factors, that varies with respect to time, to generate the outliers of all these 5 Peer Group companies, at various time points (p-value <0.05). On the other hand the outliers in Non Peer Group companies are not more than 15 on an average. The ANOVA Table-8 with respect to Table-5 shows that the outlier observation numbers are not varying much similar between the companies as compared to time of occurrence of outlier(p-value >0.05). The ANOVA Table-9 constructed with respect to Table-6 shows that the observations occur at significantly varying time (p-value <0.05) but the variation, within the outlier observation numbers of each company, is insignificant.

IV. Conclusion

The main objective of the current study is to find outliers in historical data of stock market using Multiple Regression Analysis. We have analyzed and studied 15 stocks by collecting historical data of a certain period from BSE website. We have detected outliers stock wise and then compared these outliers with its Peer Group to find out whether the results are almost similar or different, and further compared the Peer Group with Non Peer Groups of Category A and Category B stocks and found that category A stocks has lesser outliers in comparison of category B stocks. As all the stocks from Peer Group are from category B stocks, so we have further compared Peer Group with Non Peer Group of category B stocks, and found still Peer Group stocks have more outliers.

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