

MOODY'S MEGA MATH CHALLENGE 2007

CRACKING THE CODE:

A Mathematical Solution to the Stock Market

Team #109

March 3, 2007

Summary

The stock market has seemingly endless investment opportunities. However, to make sound investments, a knowledge of indicators of stock quality is essential. In order to accurately base investments on these indicators and to maximize profits on a \$30,000 investment, a mathematical method has been developed.

To determine the quality of a given firm in terms of investment (Q), three relationships were established. In Portfolio 1, Q was determined by the equation $Q = A + B - C - D$. In Portfolio 2, Q was represented by the equation $Q = 3A + 5B - 5C - 3D$. In Portfolio 3, $Q = 3A + 5B - 5E - 3D$. After the initial elimination round, the overall soundness of buying stock in terms of its expected profitability for the purposes of a one-year investment (P) was determined for the four remaining firms. To determine how much to invest in each of the four corporations, a proportion was developed to allocate efficiently the money available.

After testing an extensive mathematical model and reviewing stock market data from the past three years, we find that the probability of profit is high.

Restatement of the Problem

The stock market can provide a multitude of opportunities in which the public sector can invest. Unpredictable fluctuations in stock prices may cause these investments to be weighted with large risks; however, through comprehensive research, savvy stockholders can get rich quick and follow the American dream. Stock markets usually follow movements in the economy and in company earnings, allowing financial analysts to predict future trends.

The knowledge of indicators of stock quality as well as information pertaining to individual business revenues and marketing plans are essential to making sound investments. An increase in the Free Cash Flow and Return on Invested Capital (ROIC), paired with a decrease P/E ratio and P/S ratio, and a beta value near one would be indications of a sound investment. However, scandal and poor management decisions can increase the risk involved and completely nullify educated decisions. Moreover, past corporate decisions and previous earnings can provide a foreshadowing of future progression.

All stock options in this project are situated in the information and software technology fields. As a result, many of the options are in direct competition. As such, it is imperative to follow trends in greater detail and choose companies that show prospect in rising above the competition. Corporations may become more competitive when new business contracts form and new products are released.

Certain indicators of stock quality may be more suggestive of a stock's value. In conjunction with the value of these determined indicators, each analyst brings a different prospective to an investment decision.

List of Assumptions and Justifications

1. The market and market sector will be generally rising.

It will be assumed that over the course of the year the market will follow an upward trend, and that the same will be true of companies that provide information technologies. This assumption is made due to the fact that the stocks provided all reside within a coinciding market sector, which in turn lacks the breadth of choice necessary to create a diverse investment strategy.

2. Constant rate of inflation.

Since the yearly rate of inflation affects the depreciation of the real value of stocks, it must be assumed that a constant rate of inflation will be pertinent throughout the time in which the stocks will be held. For the past 5 years, from 2002–2006, the average inflation rate was 2.63% a year, which will be assumed to remain constant throughout the year of 2007.

3. Economic fluctuation will not be accounted for.

Due to the relative universality in sector-wide recessions, it will be assumed that certain outside factors will not affect business, mainly the buying behaviors of consumers in regards to the economy. This would fluctuate due to increases or decreases in disposable income. This is not to say that the actions of individual companies which affect buying behavior will not be taken into account. Such a case would in fact qualify an investment as sound or unsound.

4. Options other than buying and selling are not available.

Due to the nature of the investment, stock options such as selling covered calls on the shares purchased or short selling have been ruled out as viable in this situation. Therefore, the only investment options that will be taken into consideration are the simple buying and selling of stocks.

5. Assumption of sound business practices.

It cannot be postulated whether unsound business practices will or will not occur, as it is almost impossible for an investor to gain such knowledge legally. For these reasons it will be assumed that, in the case of the stocks chosen, moral and sound business practices will be maintained for the duration of the year for which the stocks will be held.

MODEL DESIGN:

Identification of Variables

The main variables to be considered in this project are: Free Cash Flow, ROIC, P/E ratio, P/S ratio, and Asset Turnover. Beta will be considered as a secondary variable in the evaluation.

1. Free Cash Flow is calculated by either subtracting capital expenditures from cash flow (net earnings before depreciation) or by dividing cash flow by the number of shares of stocks. This value represents cash which is not required for operations or for reinvestment, and can be used to pay dividends, buy back stock, or pay debts. A higher free cash flow value is typical of a firm that is financially stable.
2. Return on Invested Capital (ROIC), shown as a percentage, is the total net income for the past four quarters (one fiscal year) divided by the invested capital over that period. As opposed to other determinates of company strength, such as Return on Equity (ROE), the ROIC incorporates debt into its denominator, exposing firms that borrow heavily in order to boost returns. A higher ROIC is indicative of a “quality” company; investing in a quality company can be considered sound.
3. The Price to Earnings (P/E) ratio is a measure of how expensive a stock is relative to its profits. This is a commonly used method of establishing the value of a given stock, as a high P/E indicates a low return on an expensive stock.
4. The Price to Sales (P/S) ratio, which is similar to the P/E ratio, relates price per share of stock to the revenue per share of stock. Because sales are less influenced by accounting subjectivity than earnings, sales are often regarded as a more reliable measure of income.
5. Asset Turnover is the amount each dollar of assets has generated in dollars of revenue. Asset turnover can be calculated by dividing the revenue by the total assets of a firm. This factor is indicative of the return of the stock and, therefore, a key factor in determining sound investments.
6. Beta, β , measures the volatility of a stock. Although it is often thought of as a measure of risk, it does have limitations. Strictly speaking, beta depicts the movement of a stock relative to the market movement. When $\beta=1$, the given stock fluctuated with the market. A β value less than one represents the volatility of a stock that fluctuated more than the overall market;

conversely, a β value greater than one represents a stock that fluctuated less than the overall market. This evaluation often hurts companies that have grown stable over the past three years because it is based on past volatility. Still, it is important as a secondary factor.

Identification of Relationships between Variables

Define: The average cash flow value of the 18 stocks provided, excluding any outlying values or values that lie more than one-and-a-half times the inter-quartile range above the third quartile or below the first, as A' . Also, the corresponding cash flow values from any stock which contained an outlier in that, or any other, category were disregarded in finding this average. This change was made because these stocks would skew the mean of A, B, C, and D, and was carried out for computing the values of B, C, and D as well.

Define: The average ROIC value of the 18 stocks provided, excluding any outlying values, as B' .

Define: The average P/E value of the 18 stocks provided, excluding and outlying values, as C' .

Define: The average P/S value of the 18 stocks provided, excluding and outlying values, as D' .

Define: The given input value of cash flow for a particular stock as W.

Define: The given input value of ROIC for a particular stock as X.

Define: The given input value of P/E for a particular stock as Y.

Define: The given input value of P/S for a particular stock as Z.

$$((W-A')/A')*100 = A$$

$$((X-B')/B')*100 = B$$

$$((Y-C')/C')*100 = C$$

$$((Z-D')/D')*100 = D$$

A, B, C, and D are determined by finding the percentage by which each given input value for W, X, Y, and Z differs from A' , B' , C' , and D' respectively and multiplying the resulting value by 100.

Define: The arbitrary index number for the “quality” of a given stock as a one-year investment according to the given equation based solely upon the factors of the value of cash flow, ROIC, P/E, and P/S as Q.

Define: k_x as a given coefficient.

$$Q = (k_1 * A) + (k_2 * B) - (k_3 * C) - (k_4 * D)$$

Since relatively high cash flow and ROIC values are considered to be positive indicators of a stock’s worth, A and B are added to form the first half of the equation. Conversely, since high P/E and P/S values are considered to be negative indicators of a stock’s worth, they are added, at which time that entire quantity is subtracted from the value of A plus B. This equation yields an arbitrary value, Q, that when compared to other Q values allows a manner of comparing similar investments.

Define: The given input value of β for a particular stock as V.

Define: The overall soundness of buying a stock in terms of its expected profitability for the purposes of a one year investment as P.

$$Q * V = P$$

Since the “Q” value related to a stock indicates how sound of an investment it is, and the given β value of stock indicates the volatility, when the “Q” value is multiplied by the β value, an overall index number is created that represents the soundness of an investment in terms of expected profitability over the course of one year, which is represented by the value “P.”

Define: P1, P2, P3, and P4 as the top four P values related to the “top 4” stocks in accordance with the given equations.

Define: PT as the total of the P values of the “top 4” stocks.

$$(P_1 + P_2 + P_3 + P_4) = PT$$

The “top four” stocks P values are added to achieve an arbitrary number, PT.

Define: The total amount of capital that is open for investment as T.

Define: The percentage of total capital that should be invested in a particular stock as F_x .

$$((P_x - PT)/PT) * T = F_x$$

The percentage of the arbitrary number PT which a given P value makes up is the percentage of the total capital available to invest which should be invested in a given stock.

Identification of Relationships between Variables Specifically for Portfolio 3

Define: The average asset turnover rate for the 18 stocks provided, excluding any outlying values, as E' .

Define: The given input value of the asset turnover rate for a given stock as U.

$$((U - E')/E') * 100 = E$$

E is determined by finding the percentage by which the given input value for U differs from E' and multiplying the resulting value by 100.

$$Q = (k_1 * A) + (k_2 * B) + (k_3 * E) - (k_4 * D)$$

Since in this model high cash flow, ROIC, and asset turnover rates are considered to be positive indicators of a stocks worth, A, B, and C are added. Conversely, since a high P/S value is considered a negative indicator of a stocks worth, D is subtracted from the sum of A, B, and C.

DATA:

Justification of Portfolio 1

In choosing the stocks to populate Portfolio 1, in the equation $Q = (k_1 * A) + (k_2 * B) - (k_3 * C) - (k_4 * D)$, it was decided that $k_1 = k_2 = k_3 = k_4 = 1$. This means that it was considered in the creation of this portfolio that all four given indicators—cash flow, ROIC, P/E, and P/S—hold equal weight in the strength of a company and the value of its stocks to an investor. Through this assumption, stocks were chosen for purchase which were very well rounded in all of the given areas that are important to making investment decisions. In this way, it is highly likely that a positive outcome will result from investment. This positive outcome was further ensured by using the β value of a stock to proportionally increase or decrease the percentage of the total

capital that was invested in this stock. In this way, strong stocks that were likely to increase greatly in value were invested in more strongly, while strong stocks that were slightly less likely to increase in value were invested in less. In this way, the investments are legitimately diversified within the industry to prevent against excessive loss, while the capital still retains the capability of producing a favorable situation for a large percentage return over the course of the year.

Based on these calculations, a total of \$29959.15 was invested in the following corporations by purchasing 309 shares of BMC, 247 shares of CAI, 285 shares of MSFT, and 56 shares of SRX.

Portfolio 1

Stock	Price (\$/share)	Q*	β-value	P	% of Budget	\$ Available	# of Shares	\$ Spent
ADBE	38.66	- 142	1.69					
ADVS	34.88	- 331	2.38					
BMC	29.96	106	1.61	170.66	30.95	9286.10	309	9257.64
CAI	46.41	301	0.70	210.70	38.22	11464.79	247	11463.27
CDNS	19.65	-36	2.25					
CTXS	31.26	6	2.49					
COGN	39.78	99	1.59					
INFY	53.10	-24	1.30					
MSCS	12.54	- 130	1.05					
MFE	29.98	43	2.30					
MSFT	27.76	140	1.04	145.60	26.41	7922.52	285	7911.6
NUAN	13.97	- 263	3.03					
ORCL	16.71	15	1.27					
QADI	8.07	73	2.11					
RHT	22.01	- 460	1.80					
SPSS	33.50	12	1.39					
SRX	23.69	106	0.23	24.38	4.42	1326.59	56	1326.64
SYMC	16.90	-33	0.56					
TOTAL:				551.34				29959.15

*Q = A + B - C - D

Justification of Portfolio 2

In the choosing of stocks to populate Portfolio 2, in the equation $Q = (k_1 * A) + (k_2 * B) - (k_3 * C) - (k_4 * D)$, it was decided that $k_1 = k_4 = 3$ and $k_2 = k_3 = 5$. These coefficients were chosen due to the fact that, using the knowledge that high ROIC and low P/E values are strong indicators of the value of a stock, these indicators should be given more weight in the formation of the index numbers that represent stock value. The numbers 3 and 5 were used because these coefficients help to strongly differentiate the values of P/E and ROIC, which were given the coefficient of 5, in regards to P/S and cash flow, which were given the coefficient of 3, and therefore fluctuate the P values of each stock to reflect this. Given the true statement that ROIC and P/E are strong indicators of a stocks value, this new formula will give a more accurate rating of how much value a given stock would prove to have as a year-long investment in comparison to Portfolio 1. In terms of the use of β to discern the proportion of total capital that was invested in each stock, Portfolio 2 follows the same methods as Portfolio 1.

Based on these calculations, a total of \$29920.45 was invested in the following corporations by purchasing 278 shares of BMC, 163 shares of CAI, 168 shares of COGN, and 910 shares of QADI.

Portfolio 2

Stock	Price (\$/share)	Q*	β -value	P	% of Budget	\$ Available	# of Shares	\$ Spent
ADBE	38.66	-506	1.69					
ADVS	34.88	-1557	2.38					
BMC	29.96	456	1.61	734.16	27.81	8343.30	278	8328.88
CAI	46.41	954	0.70	667.80	25.30	7589.15	163	7564.83
CDNS	19.65	-166	2.25					
CTXS	31.26	57	2.49					
COGN	39.78	372	1.59	591.48	22.41	6721.82	168	6683.04
INFY	53.10	267	1.30					
MSCS	12.54	-570	1.05					
MFE	29.98	103	2.30					
MSFT	27.76	287	1.04					
NUAN	13.97	-1151	3.03					
ORCL	16.71	196	1.27					
QADI	8.07	342	2.11	646.38	24.49	7345.73	910	7343.7
RHT	22.01	-1807	1.80					
SPSS	33.50	-21	1.39					
SRX	23.69	331	0.23					
SYMC	16.90	-220	0.56					
TOTAL:				2639.8			TOTAL:	29920.45

* $Q = 3A + 5B - 5C - 3D$

Justification for Portfolio 3

In choosing the stocks to populate Portfolio 3, in the equation $Q = (k_1 * A) + (k_2 * B) + (k_3 * E) - (k_4 * D)$, it was decided that $k_1 = k_3 = 3$ and $k_2 = k_4 = 5$. This was because after more analysis it is now considered that in fact P/S is a better indicator of the value of a stock than P/E. This is because P/S is derived from sales, as compared to earnings for P/E, which is considered to be a more reliable indicator of business health. Therefore, P/S receives P/E's 5 coefficient to convey this change in importance. Also, it is felt that the Asset Turnover rate could be a better indicator of a favorable stock as compared to P/E, and for this reason it replaces P/E as the third factor in the equation used to rate each individual stock. In terms of the use of β to discern the proportion of total capital that was invested in each stock, Portfolio 3 follows the same methods as Portfolio 1.

Based on these calculations, a total of \$29894.29 was invested in the following corporations by purchasing 198 shares of CAI, 128 shares of INFY, 1471 shares of QADI, and 86 shares of SRX.

Portfolio 3

Stock	Price (\$/share)	Q*	β -value	P	% of Income	\$ Available	# of Shares	\$ Spent
ADBE	38.66	-714	1.69					
ADVS	34.88	-588	2.38					
BMC	29.96	374	1.61					
CAI	46.41	1329	0.70	930.30	30.78	9234.63	198	9189.18
CDNS	19.65	-462	2.25					
CTXS	31.26	-32	2.49					
COGN	39.78	428	1.59					
INFY	53.10	530	1.30	689.00	22.80	6839.37	128	6796.8
MSCS	12.54	-459	1.05					
MFE	29.98	-30	2.30					
MSFT	27.76	119	1.04					
NUAN	13.97	-	3.03					
ORCL	16.71	-29	1.27					
QADI	8.07	633	2.11	1196.37	39.59	11875.78	1471	11870.97
RHT	22.01	-	1.80					
SPSS	33.50	206	1.39					
SRX	23.69	898	0.23	206.54	6.83	2050.22	86	2037.34
SYMC	16.90	-413	0.56					
TOTAL:				3022.21				29894.29

* $Q = 3A + 5B + 3E - 5D$

How to Validate the Mathematical Model

The most accurate method to validate a forecasted model would obviously be to allow time to elapse. Of course, this would require the passage of a significant amount of time, so that future stock prices could be compared exactly one year from the starting date. This would help verify the soundest investments for that year. The accuracy of the model would then be determined by comparing the net percentage gains of the stocks with those predicted to be the most profitable investments, based upon the given indicator values.

However, it is quite possible to test the mathematical model in the present. A random sample of 100 stocks could be compiled, and based on the previous year's indicators of stock quality, it would be possible to rank the sample from least profitable to most profitable using only the model. Subsequently, the stocks can be ranked from least profitable to most profitable based on the difference between the known current price and the price one year prior. Then, the two lists can be compared to determine the accuracy of the mathematical model as a predictor of a profitable method of investing in the stock market.

The model presented is not considered to be a way to give a stock a number that will qualify it as a money maker or not, but simply a method of creating a sound investment strategy using the concepts of mathematics.

Conclusion

In regards to the final decision to invest using the portfolios created, the decision was made to invest using the strategy of Portfolio 2, which calls for investment in 278 shares of BMC Software Inc. (BMC), 163 shares of Caci International Inc. (CAI), 168 shares of COGNOS Inc. (COGN), and 910 shares of QAD Inc. This profile was chosen because it takes into account the different values that the indicators most likely hold, and it uses relevant and proven indicators to boot.

Portfolio 1 esteems the different indicators unilaterally, and therefore does not meet our requirements as a sound investment practice because some indicators are better than others at determining profitability. Likewise, Portfolio 3 is flawed, mainly because of the inclusion of the asset turnover rate of the given companies due to limited research that supports this indicator. Although it is asserted that the asset turnover rate of a company is a good indicator of the company's strength, it is not as well proven as the P/E value, and therefore makes for a slightly more risky investment. Therefore this profile is disregarded in favor a more trusted investment style such as Portfolio 2.

Appendix A: A History of Share Price





Price of Share (dollars)



Price of Share (dollars)



Price of Share (dollars)



Price of Share (dollars)

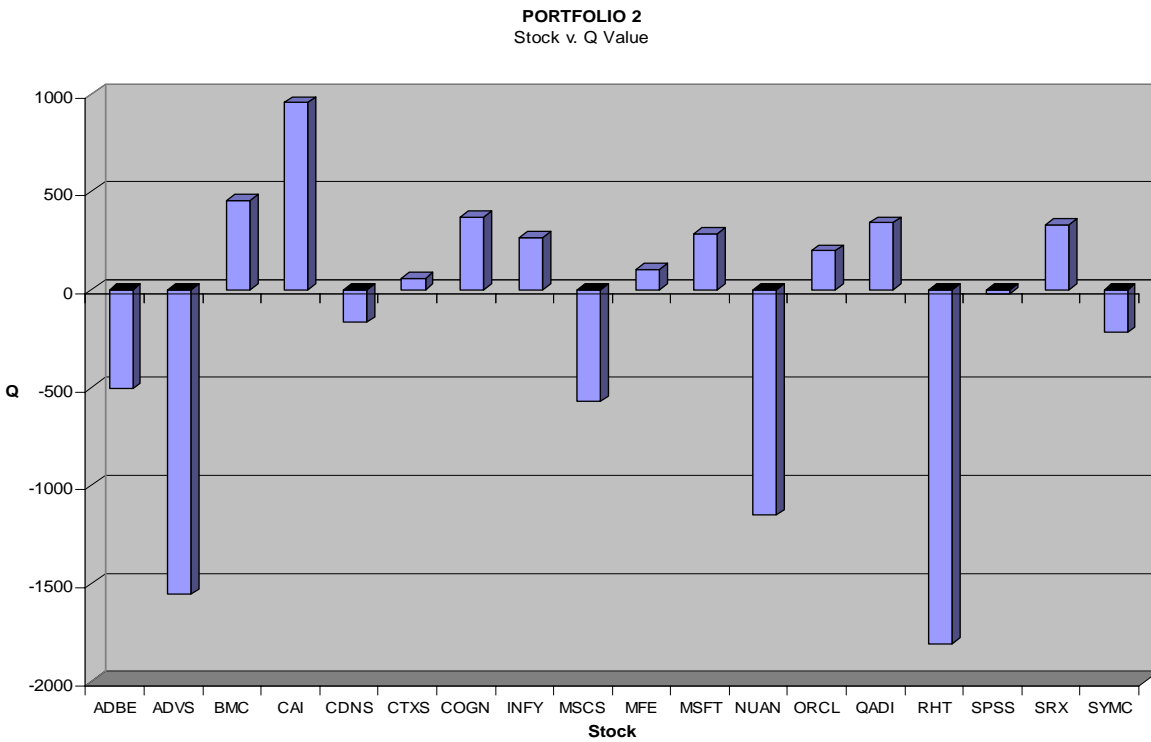
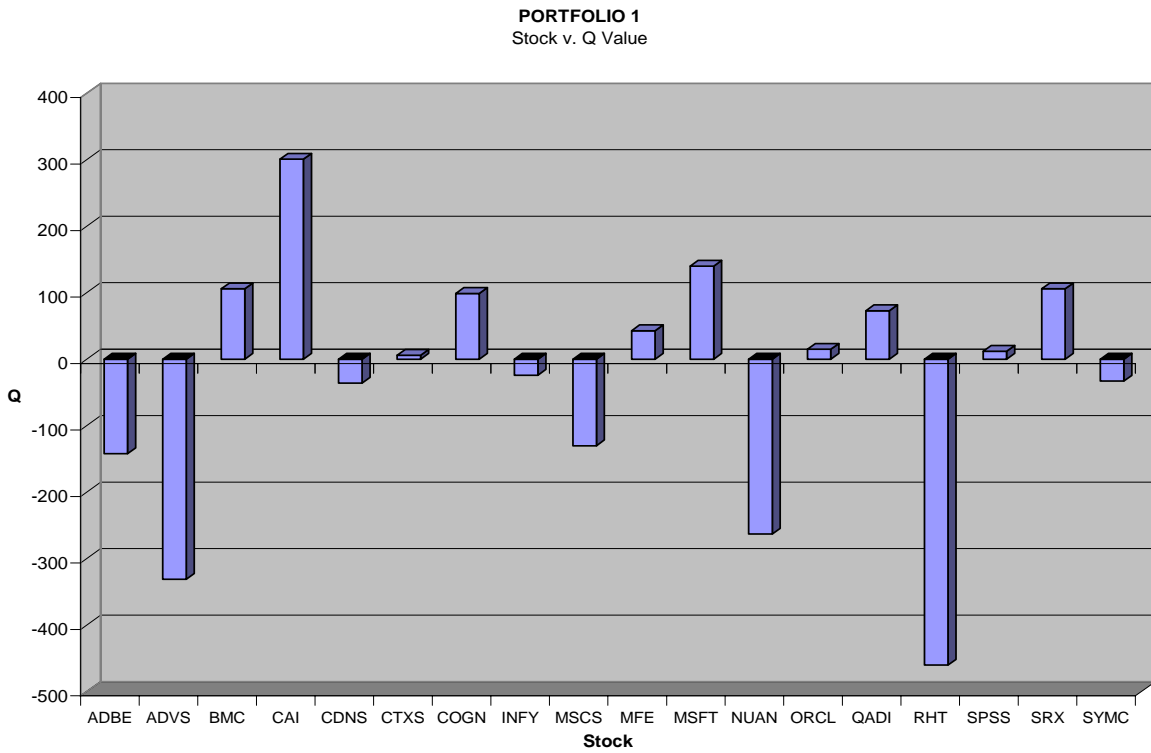


Price of Share (dollars)

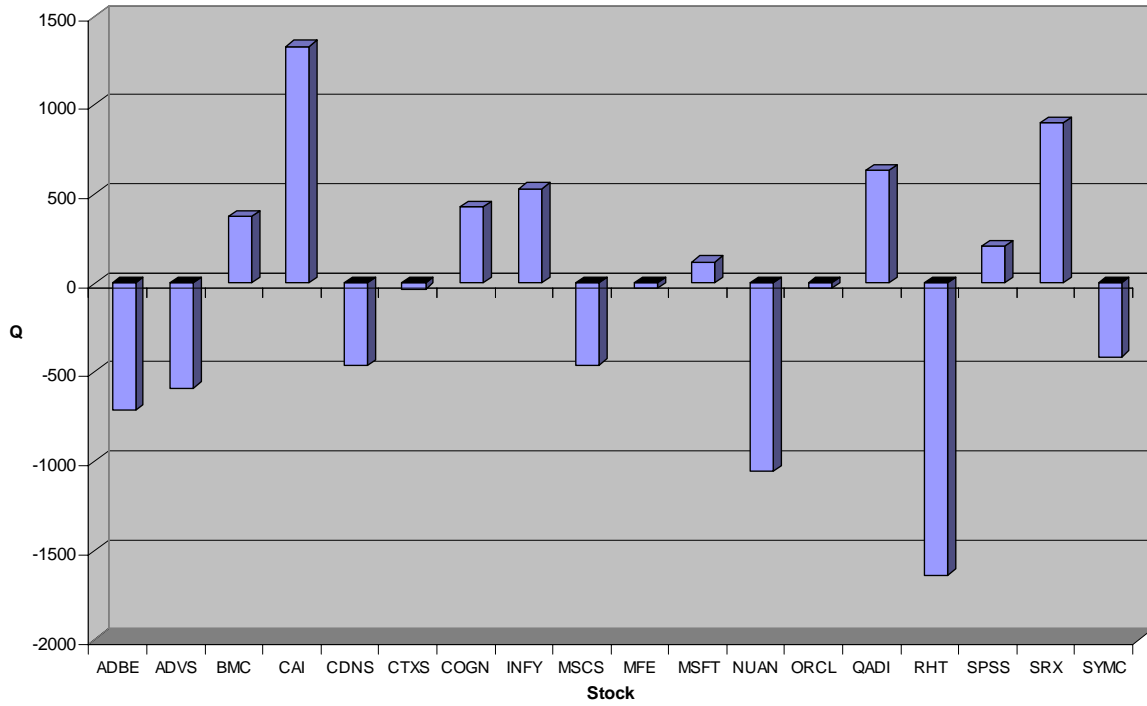


Price of Share (dollars)

Appendix B: Relationships for Calculated Data

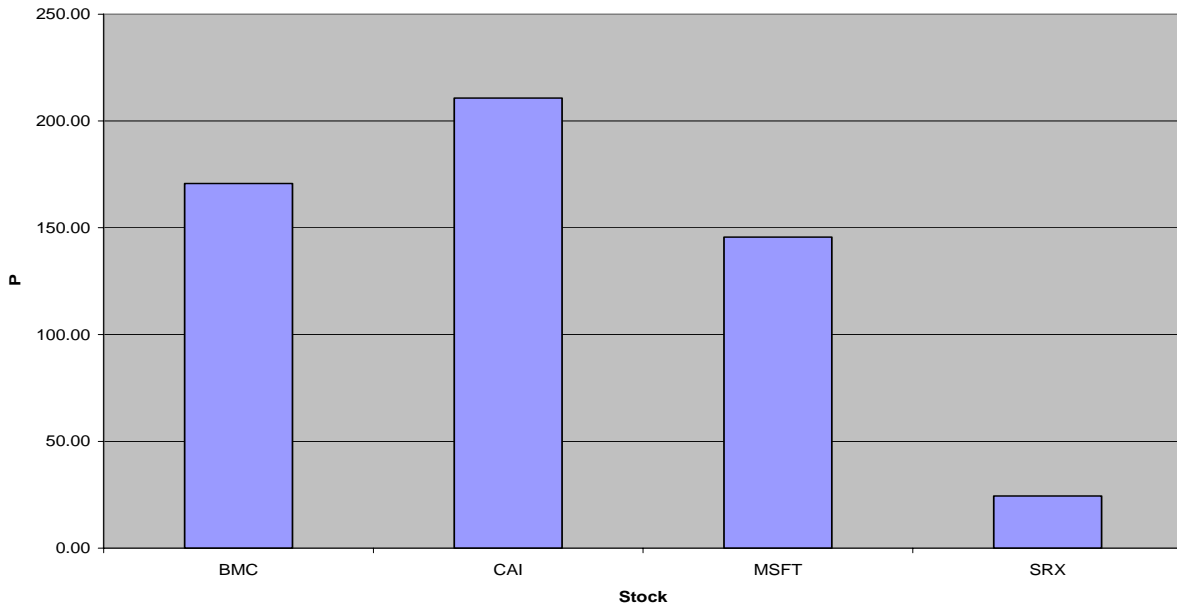


PORTFOLIO 3
Stock v. Q Value

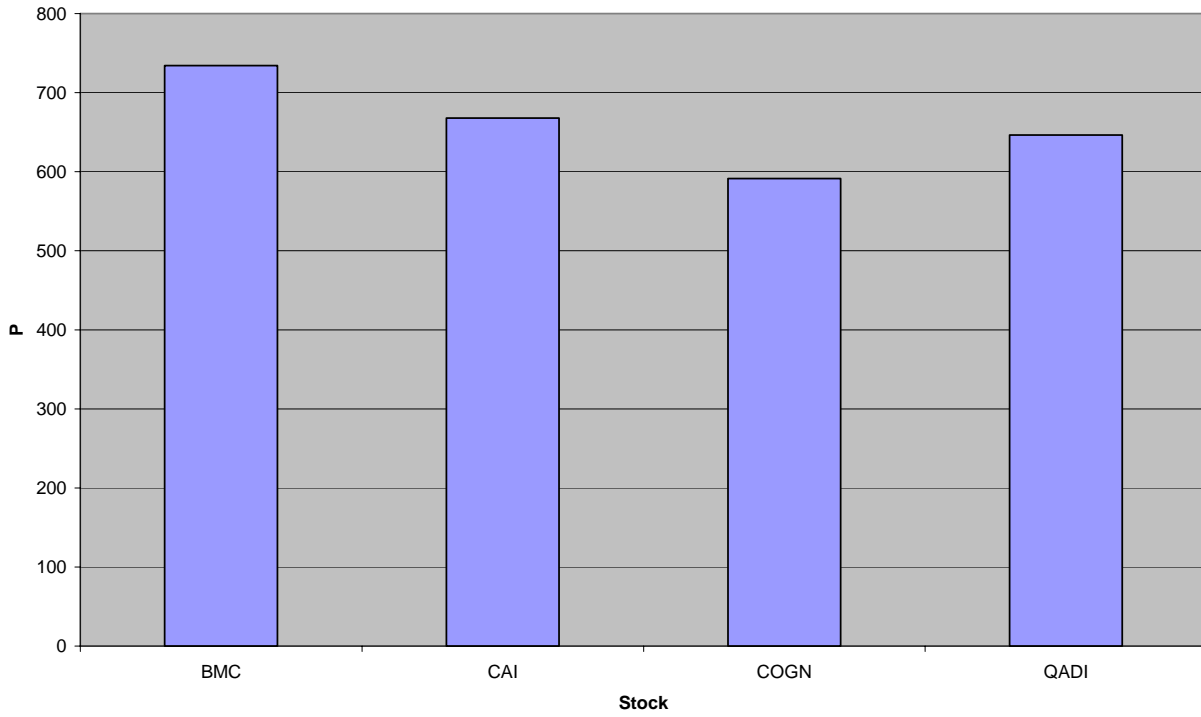


Appendix C: Relationships for Calculated Data

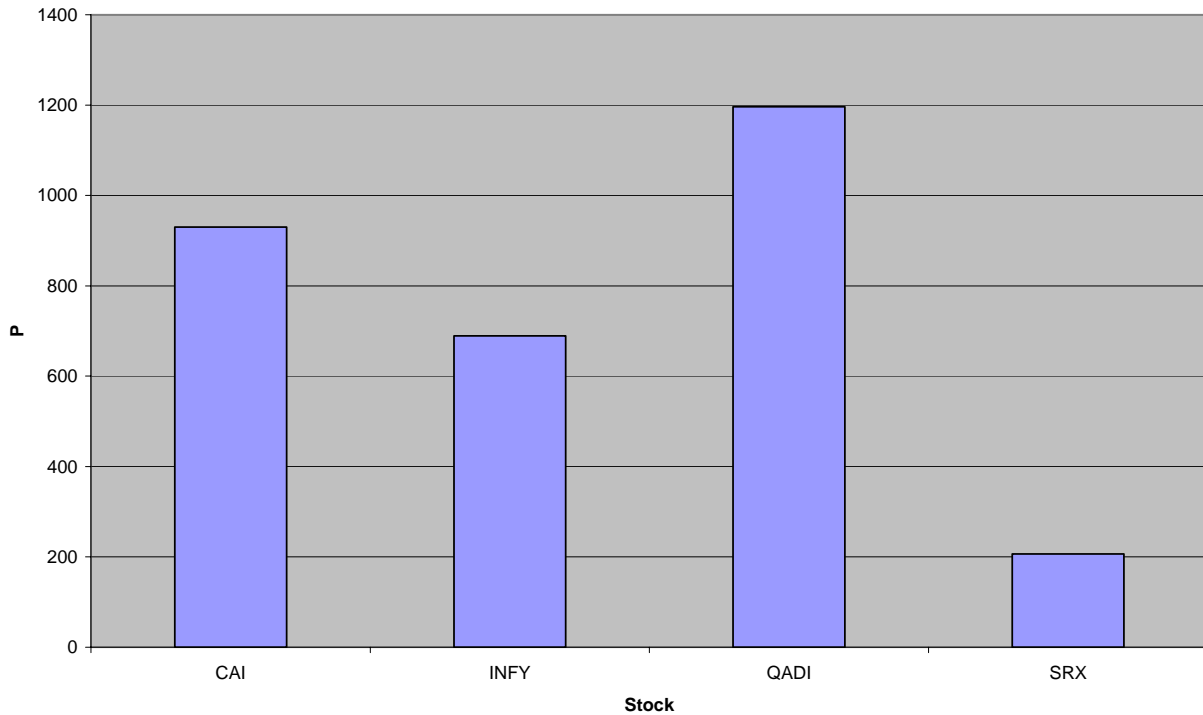
PORTFOLIO 1
P Values for Selected Stocks



PORTFOLIO 2
P Values for Selected Stocks



PORTFOLIO 3
P Values for Selected Stocks



References

Bloomberg.Com. 3 Mar. 2007 <bloomberg.com>.

"Investing, Saving and Personal Finance." SmartMoney. Dow Jones & Company, Inc. and Hearst SM Partnership. 3 Mar. 2007 <www.smartmoney.com>.

McEachern, William A. Economics: a Contemporary Introduction. 6e ed. United States: Thomson South-Western, 2003.

"Stock Exchange." World Book. 22 vols. Chicago: World Book, Inc., 2002.

"Asset Turnover." Wikipedia. Wikipedia Foundation, Inc. 3 Mar. 2007 <http://en.wikipedia.org/wiki/Asset_turnover>

McMahon, Lisa M. "InflationData.Com." Intergalactic Web Designers. 3 Mar. 2007 <http://inflationdata.com/inflation/inflation_rate/HistoricalInflation.aspx>.