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Constructing a Portfolio

Novel Mathematical Models for Profit Optimization

Team #096

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Summary

Our goal was to assemble a portfolio of up to six computer software and services stocks so as to achieve a maximum profit when they are sold one year after purchase. We were provided with four stock quality indicators and one stock volatility indicator. In order to determine the best possible portfolio, we developed three novel mathematical model.

The first model is based solely on the indicator data given to us and assumes that each indicator is an equally important predictor of future stock performance. We created an equation and developed computer programs to determine the Quality Assessment (QA) score of each stock and identify the six stocks with the highest QA score. Based on this model, we would choose to purchase 151 shares of CAI, 645 shares of QADI, 129 shares of COGN, 165 shares of BMC, 142 shares of MSFT, and 159 shares of SRX.

The second model is an adjustment of the first to place greater emphasis on the ROIC and P/E ratio than on the other indicators, an adjustment based on the suggestion that these are two strong indicators of the value of a stock. Variable coefficients were placed in front of the ROIC and P/E ratio terms of the QA equation in order to increase their relative effect on the QA scores. According to this model, we would purchase either 124 shares of CAI, 194 shares of MSFT, 640 shares of QADI, 165 shares of BMC, 119 shares of COGN, and 240 shares of ORCL, or 215 shares of MSFT, 110 shares of CAI, 634 shares of QADI, 164 shares of BMC, 113 shares of COGN, and 263 shares of ORCL, depending on which weighting factors are chosen.

The third model replaces a volatility term based on β with one that incorporates the concepts of Reward-to-Risk ratio and the Security Market Line. This leads to a better measure of volatility. Based on this model, we would choose to purchase 208 shares of MSFT, 679 shares of QADI, 111 shares of CAI, 159 shares of BMC, 111 shares of COGN, and 264 shares of ORCL.

If one model must be chosen, it would be the third. When we examine the results of all three models, we conclude that the best portfolio contains MSFT, CAI, QADI, BMC, COGN, and ORCL in some proportion.

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The Problem

Our team has been given $30,000 to create a portfolio. We can invest in up to six stocks chosen from a group of eighteen computer software and services companies. For each stock, we have been provided with the price per share, four indicators of stock quality, and one indicator of stock risk or volatility. Our ultimate goal is to purchase a combination of stocks so as to maximize the net profit when we sell the stocks one year after the purchase date. We achieve this through a series of original mathematical models.

Descriptions of the Indicators

I. Free Cash Flow

The Free Cash Flow (FCF) is the ratio of cash flow to the number of shares of the stock. In other words, it represents the cash per share not required for operations of re-investment. It measures a company's financial strength.

II. Return on Invested Capital

The Return on Invested Capital (ROIC) is the ratio of net income to invested capital. A high ROIC indicates a strong company.

III. Price to Earnings Ratio

The Price-to-Earnings Ratio (P/E) is the ratio of the price per share of stock to the earnings per share of stock. Since it is clearly beneficial for each share to generate more earnings than the share cost, a low P/E ratio makes for an attractive stock.

IV. Price to Sales Ratio

The Price-to-Sales Ratio (P/S) is the ratio of the price per share of stock to the revenue per share of stock. Since sales are more stable than earnings, the P/S ratio is a good indicator of the value of a stock. Therefore, a low P/S ratio indicates a good value investment.

V. Beta Coefficient

The Beta Coefficient (β), unlike the indicators above, does not measure stock quality. Rather, it is a measure of risk or volatility. $\beta = 1$ indicates that the price of the stock is moving with the overall market, $\beta > 1$ indicates that the stock moved more drastically than the overall market, and $\beta < 1$ indicates that the stock moved less than the overall market.

Optimal Values of the Indicators

In order to develop a mathematical model to assess the quality and earning potential of a stock, it is necessary to determine the optimal value for each indicator. The following charts (Fig. 1) show the optimal values of each indicator as a percent of the industry average. Bars filled in at the center represent values near the industry average. Bars filled in left of center represent less attractive values. Bars filled in right of center represent more attractive values, with the unit furthest to the right signifying the optimal value of the indicator. These baselines for the optimal values are utilized in the equation for stock quality that is presented later.

Indicators For Which Higher Figures Indicate Greater Strength

Free Cash Flow (FCF)

> 50% higher than industry avg.
25-50% higher than industry avg.
75-125% of industry avg.
25-50% lower than industry avg.
> 50% lower than industry avg.

ROIC

> 30% higher than industry avg.
10-30% higher than industry avg.
90-110% of industry avg.
10-30% lower than industry avg.
> 30% lower than industry avg.

Indicators For Which Lower Figures Indicate Greater Strength

P/E Ratio

> 50% lower than industry avg.
25-50% lower than industry avg.
75-125% of industry avg.
25-50% higher than industry avg.
> 50% higher than industry avg.

P/S Ratio

> 50% lower than industry avg.
25-50% lower than industry avg.
75-125% of industry avg.
25-100% higher than ind. avg.
> 100% higher than industry avg.

Fig. 1 (Charts taken from (1))**:** The top bar for each of the four indicators gives the bottom level for achieving the optimal value of that indicator. The values indicated by the top bars were used to develop the original stock quality equation that appears later.

Model One: Quality Assessment Model

Our first attempt to select six stocks to form a portfolio was based purely on the four stock quality indicators and one stock volatility indicator provided. First, we determine that it is beneficial to invest in the maximum of six different stocks. By producing a larger, more balanced portfolio, we eliminate much of the risk associated with an individual stock performing poorly.

To construct a mathematical model, we developed an equation called the Quality Assessment (QA) equation (Fig. 2). One assumption underlying this equation is that the list of eighteen stocks provided to us is a representative microcosm of the computer software and services industry as a whole. Based on this assumption, the industry average for the ROIC is equal to the average ROIC of the eighteen stocks provided, the industry average for β is equal to the β of the eighteen stocks, and so on. A second assumption is that the four quality indicators are all equally significant predictors of stock quality. Due to this assumption, the ratios of the indicators to their averages contained in the equation are preceded by coefficients that standardize them to be equally weighted. For example, the first term is divided by 1.5 because the chart for FCF in Fig. 1 indicates that the baseline for the optimal value for FCF is 50% higher than the industry average. In other words, for all four quality indicators, a ratio that matches the optimal value baseline from Fig. 1 yields a term in the QA equation equal to 1. The β term is based on the assumption that the average β of the eighteen stocks is desirable. The inclusion of absolute value means that large deviations from the average β are factored in negatively. The QA equation is shown below in Fig. 2:

$$\text{QA} = \frac{\left(\dfrac{FCF}{AvgFCF}\right)}{1.5} + \frac{\left(\dfrac{ROIC}{AvgROIC}\right)}{1.3} + 2\left(1 - \frac{P/E}{AvgP/E}\right) + 2\left(1 - \frac{P/S}{AvgP/S}\right) - \left|\beta - Avg\beta\right|$$

Fig. 2: The Quality Assessment (QA) equation. Coefficients such as 1.5, 1.3, and 2 ensure that the four quality indicators are weighted equally, according to the assumption. Large deviations of β from its average are viewed as undesirable.

Calculating the QA for Each Stock

We calculated the QA for each of the eighteen stocks using our QA equation. To accomplish these calculations, we constructed computer programs using the JAVA programming language. These programs, provided in *Appendix A*, obtain the values of the indicators for each stock from a text file and substitute them into the QA equation to calculate the QA. They then print the abbreviations of the eighteen stocks in descending order of their QA scores, which are printed alongside the abbreviations. The QA results are summarized in Table 1.

Table 1: A summary of the QA scores of all eighteen stocks. The stocks with the six highest QA scores are shown in bold red font.

Stock	QA Score
CAI	**4.033**
QADI	**2.977**
COGN	**2.934**
BMC	**2.842**
MSFT	**2.268**
SRX	**2.159**
SPSS	2.108
ORCL	1.777
MFE	1.383
CDNS	1.310
SYMC	1.097
MSCS	1.006
CTXS	.875
INFY	- .415
ADBE	- .496
NUAN	- 2.038
ADVS	- 3.478
RHT	- 5.030

The results of the computer programs were checked manually and confirmed. In addition, an intuitive examination of the eighteen stocks shows that the data in Table 1 is indeed reasonable. For example, stock CAI has a very high FCF and extremely low P/E and P/S ratios, making its great QA score believable. RHT has a low FCF figure and very high P/E and P/S ratios, a recipe for a low QA score such as the one it obtained.

Our Investments

To determine the amount of money to invest in each of the top six shares identified in Table 1, we simply divided the $30,000 between the six stocks proportionally to their QA scores. The sum of the QA scores for the top six stocks is 17.213, so the amount of money invested in each of these stocks is equal to its QA score divided by 17.123, multiplied by $30,000. Then, since only whole shares can be purchased, we divided the amount of money invested in each stock by the price of that stock to determine the number of shares of that stock to purchase. The amount of money invested in each stock and number of shares of that stock purchased are given in Table 2.

Table 2: The amount of money to invested in each of the top six stocks and the number of shares of each stock purchased, based on our QA model.

Stock	Money Invested (Rounded to Nearest $)	Number of Shares
CAI	$7029	151
QADI	$5189	645
COGN	$5114	129
BMC	$4953	165
MSFT	$3953	142
SRX	$3763	159

Therefore, according to our original QA model and calculations, **we purchase 151 shares of CAI, 645 shares of QADI, 129 shares of COGN, 165 shares of BMC, 142 shares of MSFT, and 159 shares of SRX.**

Model Two: Quality Assessment Model Adjusted to More Heavily Weight the ROIC and the P/E Ratio

The information we were provided states that recent results suggest that a relatively high ROIC and relatively low P/E ratio are strong indicators of the value in a stock. To account for these findings, we adjusted the coefficients of the QA equation to weight the ROIC and the P/E ratio more heavily than the three other indicators. The computer programs were edited to include variable coefficients so that the coefficients in front of the ROIC and P/E ratio terms could be varied. We tested two combinations of the two variable coefficients, first where the coefficients of both the ROIC and P/E ratio terms were multiplied by 2.0 and then where the two coefficients were multiplied by 3.0 (in the equation in Fig. 3, C_1 and C_2 were set equal to 2.0 and then 3.0). The two conditions operate respectively under the assumptions that the ROIC and P/E ratio are twice as significant as the other indicators and that the ROIC and P/E ratio are three times as significant as the other indicators. Fig. 3 shows the adjusted QA equation.

$$QA = \frac{\left(\frac{FCF}{AvgFCF}\right)}{1.5} + \frac{C_1\left(\frac{ROIC}{AvgROIC}\right)}{1.3} + C_2 2\left(1 - \frac{P/E}{AvgP/E}\right) + 2\left(1 - \frac{P/S}{AvgP/S}\right) - \left|\beta - Avg\beta\right|$$

Fig. 3: The adjusted QA equation is similar to the first QA equation featured in Fig. 2, but note the addition of the variable coefficients C_1 and C_2. By adjusting these variable coefficients, the ROIC and P/E ratios can be weighted more heavily.

Calculating the Adjusted QA for Each Stock

The adjusted QA for each of the eighteen stocks was calculated by the same computer programs used earlier, except the program now included the adjusted QA equation. Realize that the actual QA scores from the original model cannot be compared with those of the adjusted model, only the order of the stocks can be compared. The adjusted QA scores for $C_1 = C_2 = 2.0$ and for $C_1 = C_2 = 3.0$ are displayed in Table 3.

Table 3: The adjusted QA scores for each of the eighteen stocks, for scenarios where ROIC and P/E are weighted by two times and where ROIC and weighted by three times. The adjusted QA scores cannot be compared to the original QA scores; only the order of the stocks can be usefully compared. For each scenario, the top six stocks are displayed in bold red font.

$C_1 = C_2 = 2.0$		$C_1 = C_2 = 3.0$	
Stock	**QA Score**	**Stock**	**QA Score**
CAI	**5.222**	**MSFT**	**7.492**
MSFT	**4.880**	**CAI**	**6.410**
QADI	**4.688**	**QADI**	**6.399**
BMC	**4.491**	**BMC**	**6.140**
COGN	**4.293**	**COGN**	**5.652**
ORCL	**3.648**	**ORCL**	**5.518**
SRX	3.355	SRX	4.551

SPSS	2.890	SPSS	3.673
MFE	2.375	CDNS	3.433
CDNS	2.372	MFE	3.366
CTXS	2.109	CTXS	3.342
SYMC	1.886	INFY	3.235
INFY	1.410	SYMC	2.675
MSCS	1.373	MSCS	1.741
ADBE	9.0	ADBE	6.78
NUAN	-2.724	NUAN	-3.410
ADVS	-6.289	RHT	-8.793
RHT	-6.912	ADVS	-9.101

The results in Table 3 above were confirmed manually and appear reasonable. Overall, weighting the ROIC and P/E ratio terms by factors of two and three did not affect the order of the stocks to a dramatic extent. However, some stocks did in fact shift one or two places. For the most part, though, the order of the stocks remained basically similar to the order observed for the original QA model. The only new member in the top six stocks is ORCL, which replaced SRX for the sixth spot. The slight shifting within the top six stocks will result in different apportionment of our $30,000 between the six stocks we have chosen.

Our Investments

For both the $C_1 = C_2 = 2.0$ and $C_1 = C_2 = 3.0$ scenarios, the amount of money invested in each stock and the number of shares purchased for each stock were determined the same way as they were found for the original QA model.

I. The Scenario $C_1 = C_2 = 2.0$

The sum of the adjusted QA scores for the top six stocks was 27.222, so the amount of money invested in each stock was equal to the QA score for that stock divided by 27.222, then multiplied by $30,000. Then, since only whole shares can be purchased, the amount of money invested in each stock was divided by the price of that stock to determine the number of shares of that stock to purchase. The amount of money invested in each stock and the number of shares of that stock purchased are given in Table 4.

Table 4: The amount of money to invested in each of the top six stocks and the number of shares of each stock purchased, based on our adjusted QA model with $C_1 = C_2 = 2.0$.

Stock	Money Invested (Rounded to Nearest $)	Number of Shares
CAI	$5755	124
MSFT	$5378	194
QADI	$5166	640
BMC	$4949	165
COGN	$4731	119
ORCL	$4020	240

Therefore, according to our adjusted QA model operating under the assumption that the ROIC and P/E ratio indicate stock quality twice as strongly as the other indicators, **we purchase 124 shares of CAI, 194 shares of MSFT, 640 shares of QADI, 165 shares of BMC, 119 shares of COGN, and 240 shares of ORCL.**

II. The Scenario $C_1 = C_2 = 3.0$

The sum of the adjusted QA scores for the top six stocks was 37.611, so the amount of money invested in each stock was equal to the adjusted QA score of that stock divided by 37.611, then multiplied by $30,000. Then, since only whole shares can be purchased, the amount of money invested in each stock was divided by the price of that stock to determine the number of shares of that stock to purchase. The amount of money invested in each stock and the number of shares of that stock purchased are provided in Table 5.

Table 5: The amount of money to invested in each of the top six stocks and the number of shares of each stock purchased, based on our adjusted QA model with $C_1 = C_2 = 2.0$.

Stock	Money Invested (Rounded to Nearest $)	Number of Shares
MSFT	$5976	215
CAI	$5113	110
QADI	$5104	634
BMC	$4898	164
COGN	$4508	113
ORCL	$4401	263

Therefore, according to our adjusted QA model operating under the assumption that the ROIC and P/E ratio indicate stock quality twice as strongly as the other indicators, **we purchase 215 shares of MSFT, 110 shares of CAI, 634 shares of QADI, 164 shares of BMC, 113 shares of COGN, and 263 shares of ORCL.**

Model Three: Quality Assessment Model Modified to Incorporate Reward-to-Risk Ratio in Place of β

Of the five indicators we were provided with, β is the most difficult to interpret and hardest to factor into a model. The fundamental problem with β is that it indicates nothing about whether the stock is moving upward at a faster pace than the overall market trend or moving downward at such a pace. A far better indicator is the Reward-to-Risk (Rew/Ris) ratio, which unlike β accounts for the direction in which the stock is moving.

The formula for the Rew/Ris ratio, which comes from the Capital Asset Pricing Model (CAPM), is shown in Fig. 4. An explanation of the formula is provided in the caption.

$$Rew\ /\ Ris = \frac{E(R_i) -\ R_f}{\beta} = E(R_m) - R_f$$

Fig. 4: The formula for the Rew/Ris ratio (from (2)). $E(R_i)$ is the expected return on the capital asset, R_f is the risk-free interest rate, and $E(R_m)$ is the expected return of the market. The expression including $E(R_i)$ applies to the individual capital asset while the expression including $E(R_m)$ applies to our market as a whole.

R_f, estimated by the one-year constant maturity treasury rate, is currently found to be 5.06% (3). This means that an investment in a government treasury bond would return 5.06% interest over one year with essentially no risk.

Expected returns are generally calculated using data from the previous year. To calculate $E(R_i)$, we began by taking the difference between the March 2, 2006 and March 2, 2007 closing prices for each of the eighteen stocks. Then, we divided each difference by the March 2, 2006 closing price and multiplied by 100% to obtain $E(Ri)$ for that stock.

To calculate $E(R_m)$ we began by taking the difference between the March 2, 2006 and March 2, 2007 closing prices for each of the eighteen stocks. Then, we divided each difference by the March 2, 2006 closing price, multiplied the result by the average stock volume traded daily, and divided by the sum of the average stock volumes. Multiplying by 100%, we obtained $E(R_m)$. In this manner, we calculated a weighted average of the returns of each of the eighteen stocks in the market. This accounted for the fact that not all stocks are traded in equal quantity.

CAPM: Security Market Line

A common technique for representing the rewards of specific assets with respect to their volatilities is the Security Market Line (SML) based on the CAPM. It helps indicate whether a stock's expected returns are worth the risk of that stock. The x-axis of a SML is β and the y-axis is the expected return of the assets.

We generated an SML for our market of eighteen stocks by using $E(R_m)$ as the slope of the line and R_f as its y-intercept. Each individual stock was plotted in the axes with the SML. The vertical distance from the SML to the stock points is equal to $E(R_i)$ – Baseline, where Baseline is the y-value of the SML at that β. This is better than using only β because the more risky a stock gets, the more it must return for the Rew/Ris ratio to yield the same value. The SML with the eighteen stocks plotted is shown in Fig. 5.

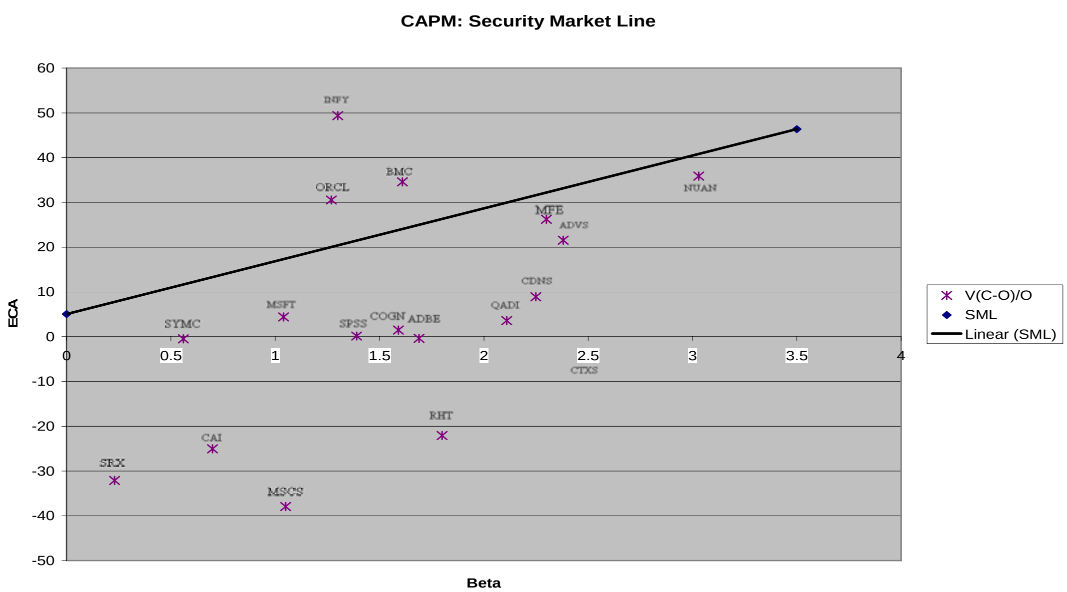

Fig. 5: The SML with individual stocks plotted.

Reward-to-Risk Ratios and the ECAR - Baseline Values

We used the formula in Fig. 4 to calculate the Rew/Ris ratio for each of the eighteen stocks. These calculations employed the part of the equation that applies to the individual capital asset. We used the SML plot to calculate $E(R_i)$ – Baseline for each stock. The Rew/Ris ratio and $E(R_i)$ – Baseline for each stock are displayed in Table 6.

Table 6: The Rew/Ris ratio and distance from the SML for each stock.

Stock	Rew/Ris Ratio	$E(R_i)$ – Baseline
ADBE	-3.22	-25.39
ADVS	6.94	-11.57
BMC	18.34	10.53
CAI	-42.98	-38.34
CDNS	1.72	-22.69
CTXS	-3.96	-39.25
COGN	-2.24	-22.32
INFY	34.08	28.97
MSCS	-40.93	-55.37
MFE	9.21	-5.97
MSFT	-.60	-12.89
NUAN	10.18	-4.92
ORCL	20.07	10.50
QADI	-.69	-26.36
RHT	-15.08	-48.39
SPSS	-3.53	-21.31
SRX	-161.65	-39.89
SYMC	-9.88	-12.14

QA Adjusted to Include the $E(R_i)$ – Baseline

The β term from the previous two QA formulas was replaced by a term based on the $E(R_i)$ – Baseline. Since a positive value of this term indicates an attractive investment, this term was added rather than subtracted. Therefore, the term is simply the ratio of the stock's $E(R_i)$ – Baseline to the average $E(R_i)$ – Baseline of the eighteen stocks. The new QA formula appears in Fig. 6.

$$QA = \frac{\left(\frac{FCF}{AvgFCF}\right)}{1.5} + \frac{\left(\frac{ROIC}{AvgROIC}\right)}{1.3} + 2\left(1 - \frac{P/E}{AvgP/E}\right) + 2\left(1 - \frac{P/S}{AvgP/S}\right) - \left(\frac{E(R_i) - B}{Avg(E(R_i) - B)}\right)$$

Fig. 6: The new QA equation with a final term based on $E(R_i)$ – Baseline rather than β. In the equation, B stands for Baseline.

Calculating the New QA for Each Stock

The change in the final term of the QA formula was incorporated into the computer programs used to calculate the QA score for each stock. The QA results for the new formula are displayed in Table 7.

Table 7: QA scores using the model that replaces β with the Rew/Ris ratio and $E(R_i)$ – Baseline. The top six stocks are shown in bold red font.

Stock	QA Score
MSFT	**8.702**
QADI	**8.229**
CAI	**7.747**
BMC	**7.157**
COGN	**6.656**
ORCL	**6.642**
SRX	6.064
CTXS	5.790
MFE	5.505
CDNS	5.490
SPSS	4.751
INFY	4.348
SYMC	4.065
MSCS	2.947
ADBE	1.825
NUAN	-8.5
ADVS	-6.833
RHT	-7.467

This addendum to the model did not significantly affect the top six stocks. The six stocks are the same as the top six stocks as identified by the previous model. The only change within the top six is the order in which they appear.

Our Investments

We determined the amount of money to invest in each stock and the number of shares of each stock to purchase using the same method that was described previously. The sum of the QA scores for the top six stocks is 45.133, so the amount of money invested in each stock is equal to its QA score divided by 45.133, then multiplied by $30,000. The amount of money invested in each stock and the number of shares of each stock purchased are given in Table 8.

Table 8: The amount of money invested in each stock and the number of shares of each stock purchased, all based on the new QA formula.

Stock	Money Invested (Rounded to Nearest $)	Number of Shares
MSFT	$5784	208
QADI	$5470	679
CAI	$5149	111
BMC	$4757	159
COGN	$4424	111
ORCL	$4415	264

According to the QA formula that incorporates the concept of the Rew/Ris ratio, **we purchase 208 shares of MSFT, 679 shares of QADI, 111 shares of CAI, 159 shares of BMC, 111 shares of COGN, and 264 shares of ORCL.**

Testing the Three Models

Our methodology for testing the three mathematical models we have presented would use historical data to determine how well these predictions would have worked if they were made in the past. For example, how well would these mathematical models predict the performance of a stock from 2002 through 2006 if predictions were made using these models at the opening of 2002?

To find how successful our models would have been, we would track the performance of our "top six" choices over the course of several years to see if they were in fact the top six stocks, and in what order.

As a further way to test the models, one could create a stock market simulation to project future stock performance.

Conclusion

We believe that the third model is the best choice.

Based on the mathematical models presented in this paper, the six stocks purchased should certainly included the five stocks MSFT, CAI, QADI, BMC, and COGN. These five stocks appeared in every "top six" list produced by the models. The sixth stock purchased should be either ORCL or SRX. This choice depends on which model is employed, but we would suggest purchasing ORCL since it appears in two of the three models, both of which had been refined since the original model.

FINAL CHOICES: MSFT, CAI, QADI, BMC, COGN, and ORCL

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Appendix A

Source Code for Computer Programs to Calculate QA Scores

Compiled using JAVA jdk1.5.0_07

```
import java.util.Scanner; //Import the Scanner class
import java.util.ArrayList; //Import the ArrayList class
public class Market2 //Stock Market v2.0
{
        public static class Stock implements Comparable //defines Stock class
        {
                public static double[] sum = new double[6]; //the sum of all values for each indicator
                public static double[] avg = new double[6]; //each of the numbers in the above array

        //divided by the number of stocks
                public static int number = 0; //the number of stock objects created
                public String name; //the stock's name
                public double [] stats; //the list of attributes, it looks like
                                                                        //[price, cash flow, ROIC, P/E, P/S,
Beta]

                public int value; //the stock's Quality Assessment (QA)

                public final double CF = 1.0, ROIC = 1.0, PE = 1.0, PS = 1.0, BETA = 1.0;
                //a list of coefficients. We weight each attribute by a certain amount
                //note: we cannot compare QA's for different sets of coefficients
                public Stock(String s) //given the line of text read in from text file, initialize the Stock
object
                {
                        String [] pieces = s.split("[\t]"); //break up the string around tabs
                        stats =  new double[pieces.length - 1]; //initialize stats
                        name =  pieces[0]; //assign the name
                        for(int x = 1; x < pieces.length; x++) //translate the Strings to decimal numbers
                        {
                                stats[x - 1] = Double.parseDouble(pieces[x]);
                                sum[x - 1] += stats[x-1]; //add this Stock's attributes to the Sum array
                        }
                        number++; //number of stocks increased by 1
                }
                public int calcValue()
                {
                        double d = CF * (stats[1] / avg[1]) / 1.5 + ROIC * (stats[2] / avg[2]) / 1.3 + PE *
(2- 2 * stats[3] /avg[3]) + PS *(2- 2 * stats[4] /avg[4]) - BETA * Math.abs(stats[5] - avg[5]);
                        //refer to paper for explanation of above equation, which is used to determine
QA
                        return value =(int)(1000 * d); //instead of giving a value of 4.293, for example,
this gives 4293.
                                                                                        //but first,
 assign the QA to "value"
                }
                public int compareTo(Object c) //necessary for Arrays.sort(Comparable c)
                {
                        return value - ((Stock)c).value; //if the QA is higher, give a positive result,
                                                                                        //if it is
lower, give a negative result, and if they are equal, give 0
```

```
        }
        public static void update() //simply updates the avg array
        {
            for(int x = 0; x < 6; x++) //runs through avg, computing the averages
                avg[x] = sum[x] / number;
        }
    }
    public static void main(String [] args) //the function that runs
    {
        Scanner in = null; //declares "in" as a Scanner object used for obtaining info from the
files
        try {in = new Scanner(new java.io.File("Stock.txt"));} //attempt to create the scanner
        //if there is no file, let the user know and exit
        catch(Throwable t){System.err.println("Could not find file."); System.exit(1);}
        Stock [] arr; //declares arr as an array of Stocks
        ArrayList<String> a = new ArrayList<String>(); //creates an adjustable array of Strings
        while(in.hasNext()) //if we haven't reached the end of the file...
        {
            a.add(in.nextLine()); //...add the line to our array
        }
        arr = new Stock[a.size()]; //set the size of arr to the number of Stocks created
        for(int x = 0; x < a.size(); x++) //loop through the array and create the Stock objects
            arr[x] = new Stock(a.get(x));

        Stock.update(); //updates the average statistics

        for(int x = 0; x < a.size(); x++) //calculate the QA for each Stock
            arr[x].calcValue();

        java.util.Arrays.sort(arr); //sort the Stocks by QA (low to high)
        for(int x = arr.length - 1; x >= 0; x--)//print out the Stocks (backwards, from high to low)
        {
            //print out the stocks in a format like "1) MSFT: 4358"
            System.out.println(arr.length - x + ") " + arr[x].name + ": " + arr[x].value);
            if(x == arr.length - 6) //if we just printed the 6th stock, let the user know that our
                                                        //top 6 are above the line.
                System.out.println("--------End of Top 6--------");
        }
    }
}
```

Notes:

For the second model, changes were made to the QA equation as explained in the report.