JOURNAL OF
EMERGING INVESTIGATORS

Article

Constructing an equally weighted stock portfolio based on systematic risk (beta)

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SUMMARY

Many people worldwide make investments in different categories, especially stocks, to save and gain more money. The purpose of this study was to show the relationship between the beta (a measure of systematic risk) and returns on selected stocks from six different industries. Besides that, our goal was to determine if, while building a long-term portfolio, picking stocks from various sectors is efficient enough to outperform an overall market. We selected stocks from six industries - technology, pharmaceutical, energy, automobile, banking, and consumer staples sectors - from 2006 through 2020 for comparison. We calculated beta for each stock and sector using the Capital Asset Pricing Model (CAPM). These results were consistent with the hypothesis and demonstrated that above-average beta stocks from most sectors showed higher returns than below-average beta stocks and the market. Sector-wise, compared to the market and low beta stocks, higher beta stocks in the technology, pharmaceuticals, and consumer staples sectors displayed higher returns. Whereas in the automobile and energy sector, above-average beta stocks did perform better than lower beta stocks; however, they underperformed compared to the market. In the banking sector, above-average beta stocks did not perform very well. Overall, these results suggest that using above-average beta stocks from different sectors could be a viable way to build a profitable stock portfolio. Our model's uniqueness is to balance the total portfolio, reducing risk not to drop drastically even if few sectors fluctuate by calculating a systematic risk beta for each sector and each stock within the sectors.

INTRODUCTION

In the 21st century, especially in the United States of America, the stock market is a common platform for hundreds of millions of people to invest and save money through their earnings. According to Forbes, more than 50% of Americans invest money in the stock market (1). However, there is a lot of risk and uncertainty if investors may not maintain a balanced portfolio.

Stocks are investments that provide stockholders with shares or ownership of a company (2). Companies offer these shares to investors to raise the capital for expanding their business. The company's stock price fluctuates up and down based on its revenue, profits, liabilities, product launches, and overall market volatility. People worldwide try to invest and save their money with the hope of generating more incredible wealth in the future.

Mathematical models in finance are generally used to anticipate market fluctuation as well as minimize risk and monetary loss when investing in a stock. Such models include Discounted Cash Flow Model, Arbitrage Pricing Theory, and Capital Asset Pricing Model (CAPM). These models are designed based on a wide range of statistical data, such as, but not limited to, previous stock prices, revenue, and future catalysts which are analyzed thoroughly to determine whether a stock is a good investment and should be included in a portfolio to gain higher profits (3). Furthermore, when building a portfolio of stocks, risk diversification is often required. Diversification is when investors incorporate various quality stocks from different industries or sectors to prevent their portfolio from drastic movements, especially from sudden plummeting (4). None of the approaches of portfolio management are perfect as the stock market and other investment avenues can be very unpredictable due to various factors, such as world events, like a pandemic or war, and a company's specific risk, classified as the unsystematic risk which is distinct to one company or industry (5). We conducted this study based on the data collected from technology, pharmaceuticals, energy, automobiles, banking, and consumer staples sectors to show the relationship between the beta (coefficient of systematic risk) and the market returns and to see whether using beta to build a stock portfolio would be a viable option for investors.

Beta is essentially a measure of systematic risk; the greater it is, the more volatility compared to the market is displayed by that stock, allowing it to have higher returns in all sectors (6). Thus, we hypothesized that if the beta of the individual stocks in the portfolio exceeds its sectoral average, then over a ten-year time frame from 2010-2020, the total portfolio will have higher returns when compared to the market and the portfolio of stocks whose beta is lower than the respective sectoral average. Out of the six sectors studied, the above-average beta stocks from the technology, pharmaceutical, and automobile sectors should perform better and show high returns compared to the other sectors and market or Standard & Poor's 500 Stock Price Index (S&P 500) within the same industry due to solid research and development

with innovation and product development portfolios.

To test our hypothesis, all the sectors were equally weighted, meaning that the same amount of money was invested in each sector. Furthermore, the selected stocks portfolio was passively managed and thus were a part of the long-term portfolio (at least ten years). In a passively managed portfolio, once a stock is bought at a particular price point, there will be no new buying or selling even if the price fluctuates significantly during that chosen period.

This study's explanatory variables consisted of the historical data of selected stock prices and the systematic risk calculated per each stock based on the stocks' prices from 2006 to 2009. The market is usually considered as one of the major stock indexes: Dow Jones Industrial averages (DJI) or S&P 500. Out of these two, we took the S&P 500 as the benchmark for our analysis (7). The historical annual return for the S&P 500 is generally around 10% when considering inflation, which makes it 7-8% (8).

Total risk consists of two components named as systematic and unsystematic risks. Systematic risk exists because of factors that affect the overall market – such as changes in the nation's economy, tax reforms by Congress, or a change in the world energy situation (9). These risks affect securities overall and, consequently, cannot be diversified away unlike unsystematic risk. In other words, even an investor who holds a well-diversified portfolio will be exposed to this type of risk. A diversified portfolio means that the investor will have different types of investments in different fields or industries. The second risk component, unsystematic risk, is specific to a particular company or industry and can be mitigated by diversifying one's portfolio. Examples for the second risk, unsystematic, could include manufacturing failure or changes in government regulations of a particular industry (10, 11).

Beta is used to measure the relationship between systemic risk and unsystematic risk, as well as how an individual stock or portfolio moves when compared to the market and its fluctuations. Mathematically, it can be defined as the covariance of a market's return and a stock's return. Furthermore, this is the formula commonly used to find beta for a stock:

$$\beta i = \text{Cov}(ri, rm) \div \text{Var}(rm) \qquad \text{(Equation 1)}$$

Beta can be found through linear regression of the market's returns and a stock's returns over a set period. The slope of the line of regression signifies the beta value, as beta represents the variance between the market and individual security (10). Therefore, as shown in Equation 1, beta (βi) is equal to the covariance of the returns of an individual stock (ri) and the returns for the market (rm), in this case, the S&P 500, for a set period divided by the variance of returns of the market. Variance is the mean of all the distances from each variable and the mean and is used to measure the spread of each data set (market risk premium) from the mean. Covariance measures the joint variability and direction between two variables or, in this case, the return of each stock and market risk premium (12). A necessary part of this study was to differentiate between high and low beta stocks in each sector.

According to risk-averse investors' behavior, there is an implied equilibrium relationship between risk and expected return for each security (13). When we are in so-called market equilibrium, a specific security is supposed to provide an expected return commensurate with its systematic risk (13). The greater the systematic risk of a security, the greater the return that investors will expect from it. The relationship between expected return and systematic risk, and the valuation of securities that follows, is the essence of Nobel laureate William Sharpe's CAPM (13). The CAPM is used to generate expected returns based on the systematic risk of a stock and cost of capital (14).

Each model represents a simplified representation of a reality based on specific assumptions. CAPM is based on the following assumptions (15): 1) Capital markets are efficient in that investors are well informed, 2) transactions costs are low, 3) there are negligible restrictions on investment, 4) no investor is large enough to affect the market price of a stock, and 5) investors are in general agreement about the likely performance of individual securities and that their expectations are based on a common holding period, say one year.

The CAPM model was first tested by Blume in 1971 and was found to provide a good prediction model (16). Since then, there have been many other studies and research related to the CAPM model, including supporting postulates from Black in 1972 and Fama and MacBeth in 1973 (17, 18). But there have been very few who have tested whether using this model and beta would create a viable portfolio.

In this study, the following was used for the formula for the CAPM:

$$Rit = Rf + \beta i\,(Rm - Rft) \qquad \text{(Equation 2)}$$

Rit is the expected return on a security. Rf is the risk-free rate, which is the theoretical rate of return of a stock or investment when there is zero risk over a time period calculated by subtracting how much the investment has inflated by the yield of the treasury bond for the time period. βi represents the beta of the investment, which is an approximation on the risk of the security when compared to the market and is calculated as shown in Equation 1. Rm is the expected return of the market or, in this case, the S&P 500 index, which is usually found through averaging historical returns and then applying that rate to future expectations (19). The risk-free rate (Rf) is subtracted from the expected market return to provide a quantitative display of the market risk premium, which is the return of the market expected above the treasury bond or risk-free rate (19).

In this study, we calculated the systematic risk or beta, of each stock and sector and created above-average and below-

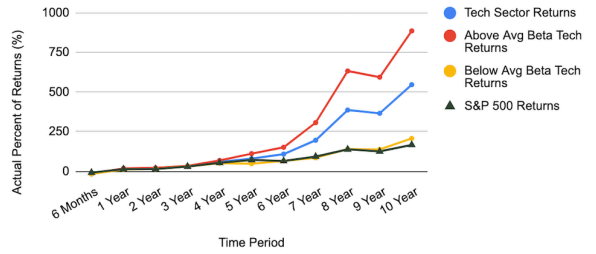

Figure 1: Technology sector data. Displays the relationship between percent of actual returns from 2010 to 2020 and stocks in the total sector (blue), above-average beta (red), below-average beta (yellow), and the S&P 500 (dark green with triangles) according to our calculations using CAPM. We chose five stocks to represent above-average beta (ADBE, NVDA, APPL, AMZN, CSCO) and five to represent below-average beta (MSFT, GOOG, ORCL, VZ, IBM).

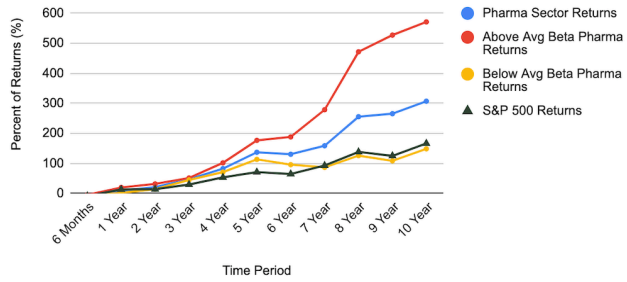

Figure 2: Pharmaceutical sector data. Displays the relationship between percent of actual returns from 2010 to 2020 and stocks in the total sector (blue), above-average beta (red), below-average beta (yellow), and the S&P 500 (green with triangles) according to our calculations using CAPM. We chose four stocks to represent above-average beta (CI, IDXX, ANTM, CVS) and four to represent below-average beta (JNJ, NVS, DVA, ABT).

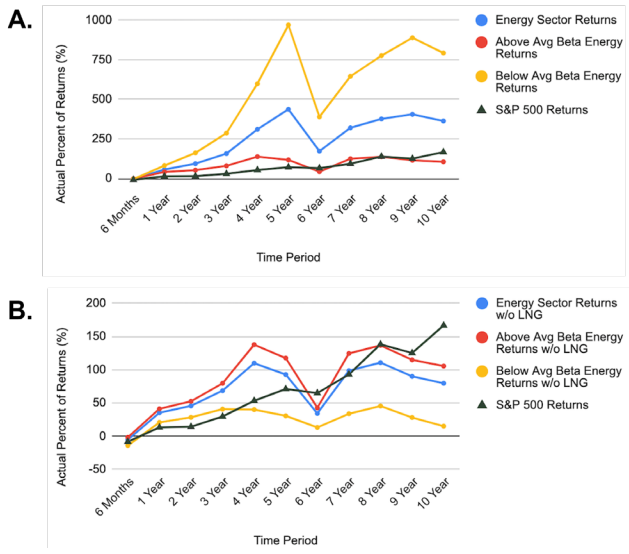

Figure 3: Energy sector data. Displays the relationship between percent of actual returns from 2010 to 2020 and stocks in the total sector (blue), above-average beta (red), below-average beta (yellow), and the S&P 500 (dark green with triangles) according to our calculations using CAPM. A) We chose four stocks to represent above-average beta (WMB, EOG, ODE, PXF) and four to represent below-average beta (HES, CVX, XOM, LNG). B) The stock LNG is removed from the study, causing three stocks to represent below-average beta (HES, CVX, XOM).

average beta stock groups for each sector and as a whole. We determined how stocks in each sector performed by studying and comparing each beta group with each other, the sector as a whole and the market, or S&P 500. We then combined all the sectors creating an above-average and below-average beta group for the total portfolio where we also compared the performance of the groups with the performance of the total stocks and market.

RESULTS

To test the hypothesis, we used stocks from all six sectors (technology, pharmaceuticals, energy, automobiles, banking, and consumer staples) for this study. Since this is an ex post facto study, we chose stocks to include in the analysis after collecting information on each sector's top stocks, most traded and viewed as of the end of 2020. We also considered the availability of data from 2006 onwards to calculate beta and actual returns in choosing each stock.

We first investigated the technology sector. This study was comprised of 10 specific stocks; above-average beta stocks are Adobe (ADBE), Nvidia (NVDA), Apple (APPL), Amazon (AMZN), Cisco (CSCO), and below-average beta stocks are Microsoft (MSFT), Google (GOOG), Oracle (ORCL), Verizon (VZ), International Business Machines (IBM). From seeing how each group of stocks performed, we can conclude that above-average beta demonstrated higher returns compared to lower beta stocks in the technology sector (Figure 1). This sector also showed around 600% additional returns over the market, or S&P 500. These high returns clearly support our hypothesis that higher beta translates into higher returns. This statement holds true for this sector as after the sixth year there is a significant increase in the returns of high beta stocks when compared with the returns of low beta stocks.

For our second empirical study, we included eight stocks from the pharmaceutical sector. The above-average beta stocks are Cigna (CI), Idexx (IDXX), Anthem (ANTM), and CVS Pharmacy (CVS), and below-average beta stocks are Johnson & Johnson (JNJ), Novartis (NVS), DaVita (DVA), and Abbott (ABT). The results demonstrated that above-average beta stocks have yielded higher returns than the below-average beta stocks and even outperformed compared to the market (Figure 2). The results support our main hypothesis of the study.

Our third study was on the energy sector. In this study, we selected eight specific stocks. Out of that Williams Companies (WMB); EOG Resources (EOG); Oneok (OKE); Pioneer Natural Resources (PXF) are above-average and Hess Corp (HES); Chevron Corporation (CVX); Exxon Mobil (XOM); Cheniere Energy (LNG) are below-average category stocks. In this sector, the lower beta stocks significantly outperformed the higher beta stocks as well as the S&P 500 (Figure 3A). However, after sifting through the data, one of the lower beta stocks, LNG, was found as an outlier because it made upwards of 2000% gains in the 10-year time span, which was almost ten times that of the next best performing

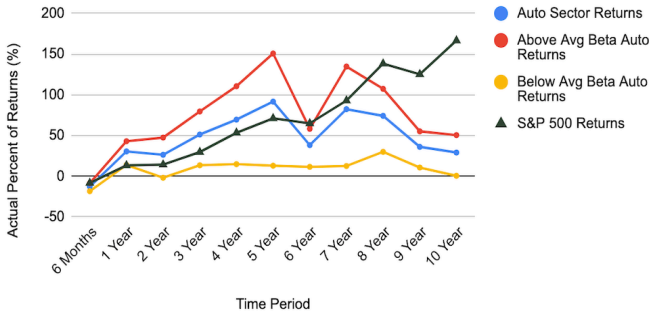

Figure 4: Automobile sector data. Displays the relationship between percent of actual returns from 2010 to 2020 and stocks in the total sector (blue), above-average beta (red), below-average beta (yellow), and the S&P 500 (dark green with triangles) according to our calculations using CAPM. We chose four stocks to represent above-average beta (F, TTM, HOG, PAG) and three to represent below-average beta (NSANY, HMC, TM).

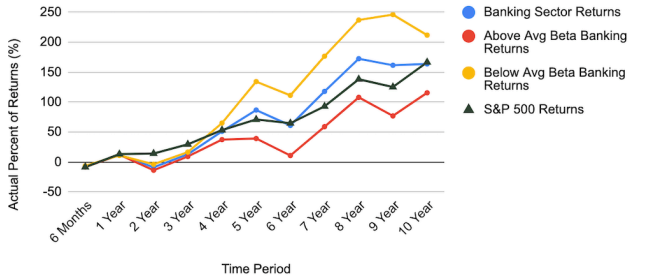

Figure 5: Banking sector data. Displays the relationship between percent of actual returns from 2010 to 2020 and stocks in the total sector (blue), above-average beta (red), below-average beta (yellow), and the S&P 500 (dark green with triangles) according to our calculations using CAPM. We chose four stocks to represent above-average beta (BAC, AXP, MS, GS) and four to represent below-average beta (WFC, JPM, UVE, BRKB).

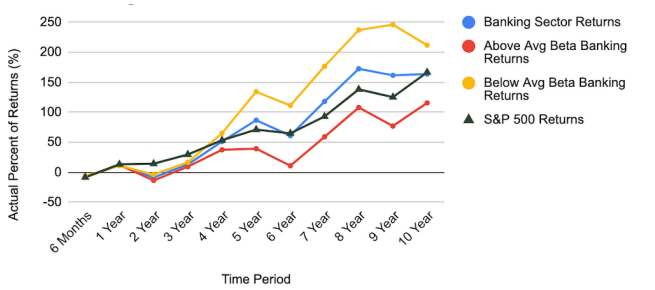

Figure 6: Consumer staples sector data. Displays the relationship between percent of actual returns from 2010 to 2020 and stocks in the total sector (blue), above-average beta (red), below-average beta (yellow), and the S&P 500 (dark green with triangles) according to our calculations using CAPM. We chose four stocks to represent above-average beta (SBUX, COST, KO, MDLZ) and four to represent

stock in the same sector. For better analytical understanding, we provided the results for the energy sector with and without LNG (Figure 3B). When LNG is taken out of consideration, the above-average beta stocks have now displayed greater returns than the lower beta stocks. Data for the energy sector without LNG was included when building the total portfolio.

The fourth empirical study shows the results for the automobile sector. This sector comprises seven specific stocks. The above-average beta stocks are Ford Motor Company (F), Tata

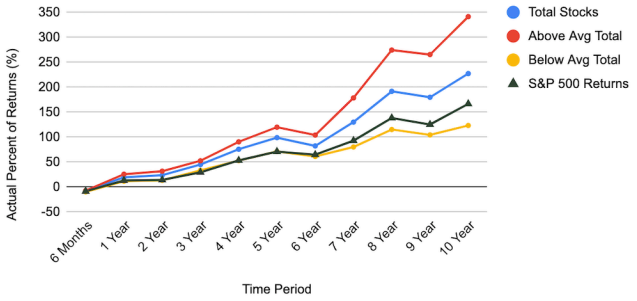

Figure 7: Total portfolio of all sectors. Illustrates the relationship between percent of actual returns from 2010 to 2020 when all sectors are combined for the total stocks studied (blue), above-average beta stocks (red), below-average beta stocks (yellow), and the S&P 500 (dark green with triangles).

Motors (TTM), Harley Davidson Motor Company (HOG), and Penske Automotive (PAG), and below-average beta stocks are Nissan Motor Company (NSANY), Honda Motor Company (HMC), and Toyota Motor Corporation (TM). We selected only seven stocks compared to eight in other sectors due to the lack of data on Yahoo Finance dating back from 2006. The automobile sector was outperformed by the market after ten years, as the market displayed much higher returns than the total average automobile sector returns (Figure 4). However, until year 7, which was 2016, the above-average beta stocks outperformed and had the highest returns compared to below-average beta, total sector, and S&P 500. Although the returns dropped in the 10th year for the auto stocks, above-average beta stocks continued to demonstrate higher returns than the below-average beta stocks.

The fifth empirical study focused on the banking sector, which comprises eight stocks. The above-average beta stocks are Bank of America (BAC), American Express (AXP), Morgan Stanley (MS), and Goldman Sachs (GS), and below-average beta stocks are Wells Fargo & Company (WFC), JPMorgan Chase & Co. (JPM), Universal Insurance Holding (UVE) and Berkshire Hathaway (BRKB). Our results revealed that below-average beta stocks significantly outperformed both the above-average beta stocks as well as the S&P 500 (Figure 5). The overall sector displayed similar returns to the market as of 2020.

In our last consumer staples sector study, we selected eight stocks and showed the relationship between above-average beta, below-average beta, S&P 500, and total sector returns in Figure 6. The above-average beta stocks are Starbucks (SBUX), Costco (COST), Coca Cola (KO), and Mondelez (MDLZ), and below-average beta stocks are Nestle (NSRGY), General Mills (GIS), Hershey (HSY), and Walmart (WMT). The above-average beta stocks had the greatest returns in the consumer staples sector, which supports our hypothesis (Figure 6). Moreover, the market returns and the below-average beta stocks were closely entwined in this industry, with the S&P 500 having marginally higher returns than the below-average beta stocks (Figure 6).

All sectors are equally weighted when calculating the total

averages, which means that each sector would theoretically consist of the same amount of money originally invested. Overall, the total stocks combined had positive returns. The above-average beta stocks from all sectors had higher returns compared to the market and outperformed the below-average beta stocks at all points of time (Figure 7).

DISCUSSION

While building a portfolio for our empirical study, only those securities with a beta value greater than the industry average were primarily considered. The reason for this consideration was mainly because of our hypothesis, stocks with above-average betas yielded higher returns. However, we compared the performance of the selected stocks with the average return of all the stocks, the below-average stocks, and the market. The high beta stocks outperformed the low beta stocks and the market for all ten years, which is in accordance with the initial hypothesis.

When looking more closely at the results, the technology, pharmaceutical, and consumer staples industries all had similar movements in the period of ten years: the above-average beta stocks outperformed both the below-average beta stocks and the S&P 500. There is a general idea applied that high betas mean that there would be higher systematic risk, which is unavoidable even with diversification, necessitating higher returns for the risk premium to be undertaken. Ultimately, in these sectors, investing more aggressively into stocks with higher betas has shown to produce higher returns.

In the case of the banking sector, the empirical study revealed that below-average beta led us to higher returns. There may be several reasons for these results, which could be a matter of further investigation. However, it can be surmised that one of the main reasons for this sector to have safer, more defensive stocks produce higher returns, is that this industry is regulated by many institutional investors throughout the country. Furthermore, the banking industry cannot oblige too high risk in order to prevent a huge downfall or meltdown of the financial sector, especially after the 2007 financial crisis that began with the collapse of Lehman Brothers, a global investment bank which went bankrupt, accelerating the mortgage crisis.

Unlike the other sectors, the energy and automobile sectors were both outperformed by the S&P 500. While initially in the energy sector, the below-average beta stocks demonstrated returns significantly higher than the market and above-average beta stocks due to an over 2000% improvement of Cheniere energy (LNG). This increase of LNG was due to the discovery and exportation of huge liquefied natural gas reserves. When LNG was excluded, the energy sector showed results similar to the automobile industry. Since beta is based on historical prices, it does not take into account some factors which may influence an investor to purchase a stock, such as new discoveries or technological innovation that might lead to sudden higher operational efficiency and greater profitability.

However, it should be underlined that research was undertaken for a limited number of companies and for only the time period from 2006–2020. In future studies to generalize the research outcomes for the whole industry, we believe that the pool of companies from each industry should be monitored further, and more stocks in different periods should be taken into consideration. Besides that, there are two industries out of selected six – banking and energy, for which our hypothesis was not supported. Although we have discussed the potential reasons for these outcomes, it should be researched in the future to determine if the trend holds.

MATERIALS AND METHODS

First, to build a portfolio and determine systematic risks' influence on a portfolio, we searched for various sectors and chose stocks for this study. Ten stocks selected from each of the technology, pharmaceuticals, energy, automobiles, banking, and consumer staples sectors. All the stocks chosen from each sector are top stocks, meaning that they were the most traded and viewed by several investors until the end of 2020. After choosing the stocks, the monthly historical data for each stock, the S&P 500 (market), and the 10-year U.S Treasury bond data for 2006-2020 were all downloaded from Yahoo Finance. The stock data was then sorted into Excel sheets based on each sector. It was then cleaned up, keeping only the date and closing price in the Excel sheet, respectively. In Column C, we found the monthly return percentage of past data by using the formula:

$$\text{Ln } (p2/p1) * 100 \quad \text{(Equation 2)}$$

In Column D, we pasted the closing prices of the S&P 500. The 10-year U.S. Treasury bond data from 2006-2009 was inserted into Column F and divided by 12 for monthly risk-free rate for that period and averaged for all calculations after 2010. Then, in Column G, we subtracted the risk-free rate from the monthly stock returns, and in Column H, we calculated the market risk-free premium by subtracting the risk-free rate from the S&P 500 monthly return. All of these previous calculations are a part of the CAPM model and were imperative to calculate the beta for each stock, which was found by calculating the slope of the regression line between the monthly stock returns sans risk-free rate found in Column G and the market risk-free premium found in Column H. We then calculated the actual percentage of returns for each stock after the start of 2010 in another column.

The mean beta for each sector was next found by adding up all the beta coefficients for the stocks in the sector and dividing it by the number of stocks. We then separated stocks into groups of above- and below-average beta, and for each stock and the S&P 500 data, we organized the percent returns at 6 months and each year after 2010 into new spreadsheet data. Next, we found the mean total sectoral returns, mean above-average beta returns, and mean below-average beta

returns by averaging the returns of all the stocks at each period for each group for which we were trying to find the mean. All the new data with the averages for each beta group, total sector, and the S&P 500, were graphed for each sector using excel software. We then found the mean of the average sectoral returns for all the beta groups and market to create the final portfolio. Ultimately, in order to test our hypothesis and conduct the study, we analyzed the returns of each stock by sector, the graphs of each sector displaying the returns of each group, and the final portfolio graph.

ACKNOWLEDGMENTS

We would like to thank Mr. Illyas Mohammed for his help in selecting the stocks for this study.

Received: April 11, 2021
Accepted: August 20, 2021
Published: October 15, 2021

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