ROBUST CAPITAL ASSET PRICING MODEL ESTIMATION THROUGH CROSS-VALIDATION

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ABSTRACT

Limitations of Capital Asset Pricing Model (CAPM) continue to present inconsistent empirical results despite its firm mathematical foundations provided in recent studies. In this thesis, we examine how estimation errors of the CAPM could be minimized using the cross-validation technique, a concept that is widely applied in machine learning (CV-CAPM). We apply our approach to test the assumption of CAPM as a well-diversified portfolio model with data from S&P500 and Dow Jones Industrial Average (DJIA). Our results from the CV-CAPM validate that both S&P500 and DJIA are well-diversified market indices with statistically insignificant variation in unsystematic risks during and after the 2007 financial crisis. Furthermore, the CV-CAPM provides the smallest root mean square errors and mean absolute deviations compared to the traditional CAPM.

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DEDICATION

This thesis is dedicated to:

1. My Savior Jesus Christ;
2. My parents Diarra Sakouvogui and Sogni Koivogui;
3. My lovely siblings: Kaissa Sakouvogui and Victor Yoko Sakouvogui;
4. My fabulous girlfriend Genevieve Guilavogui from City University London U.K;
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1. INTRODUCTION

Capital Asset Pricing Model (CAPM), a mean-variance portfolio model was introduced in the late 1950s and 1960s (Markowitz (1959), Treynor (1962), Sharpe (1964)). Since then, considerable attention has been given to the portfolio theory of CAPM. Of these, Black (1972) showed that the market portfolio is mean-variance efficient under different assumptions. Levy and Markowitz (1979) provided a firm mathematical foundation with proofs that utility can be correctly approximated with mean and variance, as in CAPM. Since its introduction, CAPM has been extensively used for asset pricing in financial economics. The attraction of CAPM lies in its simple form (linear and one factor), power and ability to predict and measure the systematic risk (β), and the relation between the expected returns and the risks of an asset (Fama and Kenneth 2004).

CAPM, a single-index model, has been refined several times with the development of: 1) a time-series regression test (Jensen, 1968 and Black, et al., 1972), 2) an intertemporal CAPM (ICAPM) (Merton, 1973), 3) applicable proxies in empirical testing (Roll, 1977), 4) probability distributions of CAPM moments (Kraus and Litzenberger, 1983), 5) a 3-factor security market line (Schnabel, 1985), 6) a multiple index models such as Arbitrage Pricing Theory (Fama and French, 1992), 7) a conditional CAPM with human income and time-varying risk aversion (Jagannathan and Wang, 1996), 8) an unconditional Four-Moment CAPM (Hwang and Satchell, 1999), 9) bid and ask spread and CAPM (Jacoby et al., 2000), 10) a conditional CAPM with a stochastic discount factor approach (Lettau and Ludvigson, 2001), 11) a skewness and kurtosis test for cross-section analysis (Dittmar, 2002), 12) a performance analysis for unconditional and conditional asset pricing models (Fletcher and Kihanda, 2005), 13) an extension of the standard CAPM to higher moments (Tucker and Guermat, 2016), and 14) a kernel weighted time varying parameter regression approach.

Despite multiple extensions and developments of CAPM, problems with inconsistent empirical findings still persist (Barry, 1987; Miles and Timmermann, 1996; and Tucker and Guermat 2016). Researchers who exposed the statistical difficulties inherent to CAPM have provided empirical results that are inconclusive, in addition to biases present during the manual partition of the data. However, with the recent development of computers, Sawyer (2016) suggested that, advanced technologic possibilities with machine learning (ML) could help with the verification/falsification of financial models. Hence, CAPM with self-refining algorithms aided by ML and a cross validation (CV) technique could provide better insight to the robust estimation of systematic risks. Moreover, since CV provides a significant departure from manual partitioning of the data, hence it could reduce errors or noise in the estimation of CAPM for better stability by minimizing the variance between observations and subsequently providing more efficient parameter estimates (Liu and Liao, 2016).

In this thesis, we examine how the estimation errors of CAPM could be minimized to improve the efficiency in risk-return analysis of empirical financial markets. Hence, our approach tests the efficient parameter estimates of CAPM by incorporating CV to improve the efficiency in risk-return analysis of S&P500 and Dow Jones Industrial Average Index (DJIA) over two periods: December 2007-June 2009 (during the financial crisis) and July 2009-June 2016 (post financial crisis). The S&P500 and DJIA provide examples of many versus fewer firms in a market index portfolio.

The present study adds to the literature of CAPM by examining the theory of diversification during and post financial crisis with four main objectives:

1. We use CV technique to partition the periods of the data into a training component and a testing component. This technique minimizes the variance between observations and results in a more efficient CAPM method (Liu and Liao, 2016). It is a significant departure from a manual partitioning of the data. Advances in the field of ML (CV) provide a more robust prediction of CAPM parameters.

2. We provide a framework to test the normality assumption of CAPM. It is efficient to apply CAPM to data exhibiting the first two moments rather than applying it to data with higher moments.

3. We build a predictive CAPM model and then use the model to test whether S&P500 and DJIA are well-diversified market indexes by estimating their risk reduction capabilities. Since CAPM is a time series regression model, the predictive modeling should incorporate a statistical approach that is built on predicting function from the observed data. The use of CV criterion could ensure this process by providing a satisfactory variance in the estimates. We provide a framework to incorporate and evaluate the attributes of diversification (Fraser et

al., 2002). Additionally, we apply our approach to test one of the assumptions of CAPM as a well-diversified portfolio model.

4. We provide a robustness test by comparing the performance of the CV CAPM and the traditional CAPM by the estimation of their respective mean absolute deviation (MAD) and root mean square error (RMSE).

This thesis is organized into six chapters. Chapter 2 deals with the literature review. In this chapter, we introduce the concept of portfolio diversification, systematic, and unsystematic risks and provide a background of ML techniques and efficiency in estimation. Chapter 3 deals with the methodology. Chapter 4 provides the description of the data sets. In this chapter, we describe S&P500 and DJIA and their attributes. In Chapter 5, we present and discuss the results of our analysis. Finally, a brief conclusion and suggestions for further research are discussed in Chapter 6.

2. LITERATURE REVIEW

Capital Asset Pricing Model (CAPM), introduced by Treynor (1962) and developed by Sharpe (1964), Lintner (1965), and Black (1972) to model the mean-variance concept of Markowitz (1959), assumes that the return on the stocks are positive and linearly related to the excess returns. Using Markowitz (1952, 1959) and Tobin (1958), Sharpe (1964), Lintner (1965), and Black (1972) developed the theoretical frameworks about diversification and modern portfolio theory. In theory, since an asset or a portfolio is measured by its risk, β is then a sufficient indicator of the return expected on holding any security. This means that the excess return of the market portfolio is sufficient. Hence, the risk-return relationship is through the slope factor, β.

The rationale behind CAPM is the idea investors should choose a portfolio that minimizes the return risk at any given expected return and maximizes the expected return and any risk level (Fama and French, 2003). However, the choice has been unbiased because of the drawbacks of the traditional CAPM. In the early stage, Mayers (1972) while applying CAPM restricted trading of risky assets, transaction costs, and information asymmetries. Black (1972) considered assumption of unrestricted risk free lending and borrowing as unrealistic and showed that market portfolio is mean-variance-efficient under different assumption. Basu (1977) found that returns on high earnings price ratio stocks are higher than what CAPM can predict. Banz (1981) argued that returns on small stocks are higher when these are sorted by market cap than CAPM prediction. Reinganum (1981) examined whether securities with different estimated betas systematically experience different average rates of return. In addition, Rosenberg et al., (1985) proved that stocks with high B M equity ratios have quite high returns. Fama and French (1992, 1996) concluded that any of price ratios have alike information about expected return.

During the years, CAPM has undergone few changes and different frameworks have been proposed. Jensen (1968) introduced time-series regression test, which has rejected functionality of the version of CAPM designed by Sharpe and Lintner. Merton (1973) proposed the inter-temporal capital asset pricing model (ICAPM). Roll (1977) stated that CAPM model has never been tested properly and it will never be, as there are plenty of proxies used in the empirical testing, which are not sufficient source. Kraus and Litzenberger (1983) developed sufficient conditions on probability distributions for three moments (mean, variance, and skewness) consumption-oriented CAPM. Schnabel (1985) extended the traditional CAPM by deriving a new 3-factor security market line while taking to account investor cash demands, share liquidation costs, and dividends as a means of meeting the cash demands and reducing the liquidation costs.

Fama and French (2004) found the possible reason for the empirical failure of CAPM in the simplifying of the assumptions or invalidity of testing the model. Another problem, which was considered by Fama and French (2004) was the misinterpretation of couple of definitions, such as market portfolio. Moreover, empirical testing of the model has revealed plenty of shortcomings such as imprecise estimates of β when regressing cross-sectional data and inefficient data partition. Fama and French (2004) and Vendrame et al., (2016) concluded that by extending the standard CAPM to higher moments adds to its power in explaining average stock returns. Baillie and Cho (2016) proposed adding a kernel weighted time varying parameter regression approach by considering the variation in the euro-dollar rate from an I-CAPM perspective.

2.1. Market Index and Measure of Portfolio Diversification

In the area of financial economics, diversification is a tool for reducing risk. Portfolio diversification, a concept developed by Markowitz (1959), based on the mean and variance analysis, can be measured using different methods. A well-known method to measure portfolio diversification is the correlation among assets. A study by Cholette et al., (2011) defined diversification in terms of measures related to correlation. The authors accessed the level of dependence between financial indices using pearson correlation with fixed marginal rates. Cholette et al., (2011) concluded that a lower dependence is possible when the marginal rates are fixed, implying greater diversification. However, the correlation coefficient does not adequately measure the risk between assets nor the risk of a portfolio. Meucci (2009) used another qualitative measure of portfolio diversification in which a portfolio is well-diversified if it is not heavily exposed to individual shock risk. Other measures of portfolio diversification include the Herfindahl Index and the Value-at-Risk.

The determinants of diversification could be grouped into three major factors: (i) the number of assets in a portfolio, (ii) the correlation between assets, and (iii) the economies of scale. Ibbotson (2010) concluded that the manner that assets are allocated is important in the concept of minimizing risk, but nowhere near 90 % of the variation in returns is caused by the specific asset allocation mix. Moreover, empirical studies by Perold (2004) and Hight (2010) indicated that diversification is directly associated to the correlation of all assets composing a portfolio and the risks associated with that portfolio. Furthermore, the total risk of a portfolio decreases when the number of financial instruments in the portfolio increases (Frahm and Wiechers, 2011). Consequently, portfolio risk decreases as the number of assets in a portfolio increases.

2.2. Market Risks

In finance, risks and returns are the two words that are frequently used in the same sentence (Reilly 2000). There are two types of risk: systematic risk and unsystematic risk. In the theory of CAPM, the systematic risk is defined as non-diversifiable risk. Beta is the measure of systematic risk, whereas unsystematic risk can only be reduced through diversification. A study by Elton et al., (2003) indicated that if the market is well-diversified, the unsystematic risk is not relevant. In a recent study, Drobetz et al., (2016) concluded that stock market betas are the only sensible measures for investors because they measured the risk component of investors who hold a fully diversified portfolio. Furthermore, institutions could control the exposures of unsystematic risk by selecting certain securities in certain industries (Bennett and Sias, 2006). In addition, Jacoby et al., (2000) implemented CAPM model based on bid and ask spread then they demonstrated that the measure of systematic risk should incorporate liquidity costs.

A study by Dennis and Mayhew (2002) found that stocks with larger betas tend to have a more negative skewness in risk-neutral density. This implies that individual stock option prices tend to be more negative for stocks that have larger betas, suggesting that market risk is important in pricing individual stock options. Another study shows that the power of macroeconomic variables when explaining stock prices increases with increasing time length (Fama, 1990). Furthermore, it is possible to obtain different beta estimates for the same stock at different intervals (Handa et al., 1989). However, there are two different results with data segmentation (Handa et al., 1993). First, Handa et al., (1993) rejected CAPM when daily returns data were used. Second, Handa et al., (1993) failed to reject CAPM when using the yearly return. Despite recent developments in CAPM, fewer studies have focused on the partition of the data and minimizing errors or noise in its estimation. Hence, we provide a framework for consistent ranking with the CAPM and a market index.

2.3. Cross Validation and Efficiency Measures

In this thesis, a new approach is proposed in order to estimate the systematic risk (β) in CAPM. This method is based on the theory of ML, a technique that combines statistics and computer science in order to learn from data. ML is divided into three categories: supervised learning, unsupervised learning and reinforcement learning. The idea behind ML is to first select a candidate model then estimate the parameters of the model by using a learning algorithm and available data (Yaochu and Sendhoff, 2008) through partitioning the data into training data and test data.

Partitioning the data is an important part for evaluating ML algorithms. There are different ways to partition the data. A good starting point is the Pareto principle (80-20). An application of a ML technique to high dimensional data resulted in a random split where 70% of the data were used for training the model and the 30% for testing the model (Thottakkara et al., 2016).

A contribution of this paper is to partition the data such that variance (training or testing) is minimized. An established method that can minimize the variance while partitioning the data into training data and test data is the CV method in conjuncture with package zoo in R language. A special case of CV technique is the k fold CV method. This method is used to separate the data into K partitions of equal sizes (or of almost equal sizes if the total observations are an even number). For each of the k^{th} iteration, the training data are defined as $k - 1$ subset samples whereas the left out subset sample is defined as the testing data. CV is frequently applied for model selection, variable selection and model estimation in a variety of applications (Colby and Bair 2013; Ramezani et. al., 2014).

3. METHODOLOGY

3.1. Traditional Capital Asset Pricing Model

In the market portfolio **M**, CAPM expresses the relationship between the expected return of an asset i and its systematic risk (Barry, 1980) as:

$$R_i = r_f + \frac{E(R_M - r_f)}{\sigma_M^2} c\sigma_i\sigma_M, \tag{3.1}$$

where R_i is the expected return of asset i. r_f is the risk free rate. $E(R_M)$ and σ_M^2 are the expected return and variance, respectively of the market portfolio. $c\sigma_i\sigma_M$ is the covariance between the return of the risky asset i and the return of the market portfolio with σ_i as the standard deviation of an asset i and c, the correlation coefficient. For the estimation of β, equation (3.1) is modified such as:

$$E(R_i) = R_f + \beta_i(E(R_M) - R_f), \tag{3.2}$$

where $\beta_i = \frac{c\sigma_{(M,i)}}{(\sigma_M^2)}$. For a given asset i, σ_i^2 tells about the risk associated with its own fluctuation about its mean rate of return. From the mathematically representation of CAPM in equation (3.2), three conditions exist for β_i: First, if β_i =1 then E(R_i) = E(R_M), second, if β_i >1 then E(R_i) > E(R_M), and third, if $\beta_i < 1$ then E(R_i) < E(R_M).

In the absence of data on expectations, Black et al., (1972) introduced a time series test of CAPM. The test is based on the time series regression of excess portfolio returns on excess market returns. For an asset i in a sequence indexed by the time subscript, t, the CAPM regression is represented as:

$$R_{it} = \alpha_{it} + \beta_i \times R_{mt} + \varepsilon_{it}, \tag{3.3}$$

where

$$R_{it} = r_{it} - r_{ft}, \tag{3.4}$$

and

$$R_{mt} = r_{mt} - r_{ft}. \tag{3.5}$$

R_{it} is the excess return of stock i at time t. R_{mt} is the average risk premium at time t. r_{it} is the rate of return on asset i at time t. r_{ft} is the risk free rate on asset at time t. α_i is the estimated intercept of stock i. r_{mt} is the rate of return of the market at time t. β_i is the estimated systematic risk of stock i. ϵ_{it} is the random disturbance of stock i and $\varepsilon_{it} \overset{iid}{\sim} N(0, \sigma^2_{\varepsilon_i})$.

Consider a portfolio of n risky stocks with weights $w_i, \ldots, w_n$ and rate of return r_i. Then with the return of the portfolio, $r_p = \sum_{i=1}^{n} w_i r_i$, the portfolio systematic risk (β_p) is given by:

$$\begin{aligned} \beta_p &= \left[\frac{r_p, r_M)}{\sigma^2_M}\right] \\ &= \left[\frac{\sum_{i=1}^{n} w_i \sigma_i}{\sigma^2_M}\right] \\ &= \sum_{i=1}^{n} w_i \beta_i \end{aligned} \tag{3.6}$$

Clearly, equation (3.6) is only estimable in the presence of the weight associated with each stock i conditional on equation (3.2). Hence, the regression estimation of β_p of the traditional CAPM in a sequence indexed by the time subscript t, is expressed as:

$$R_{pt} = \alpha_p + \beta_p \times R_{mt} + \varepsilon_{pt}, \tag{3.7}$$

where R_{pt} is excess return of portfolio p at time t. R_{mt} is the average risk premium at time t. r_{pt} is the rate of return on the portfolio p at time t. r_{ft} is the risk free rate on stock. α_p is the intercept of the portfolio p. r_{mt} is the rate of return of the market at time t. β_p is the systematic risk of the portfolio p. ε_{pt} is the random disturbance of portfolio p at time t and $\varepsilon_{pt} \overset{iid}{\sim} N(0, \sigma^2_{\varepsilon_p})$ with $E(\varepsilon_{pt})=$ 0.

Contrary to the traditional CAPM that may not provide an efficient estimation of β_i and β_p, a contribution of this thesis is to partition the data such that variances between the observations of the daily excess returns (training and testing) are minimized. Moreover, the relationship between β_i and r_i is explained by the Security Market Line (SML). Figure 3.1 displays the graph of the SML. In Figure 3.1, the y-axis represents the expected return of the stock and the x-axis represents the systematic risks.

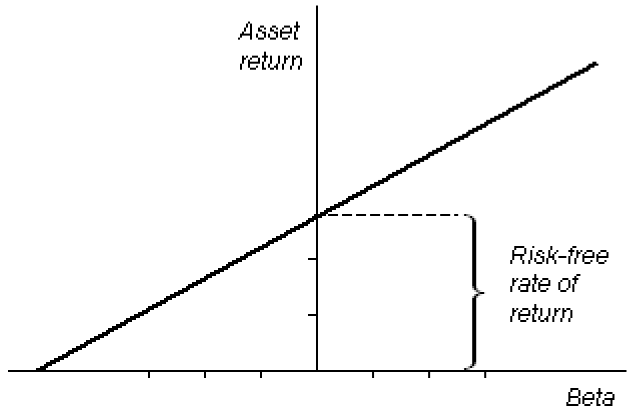


Figure 3.1. Security Market Line

The assumptions of CAPM are the following:

1. Investors hold diversified portfolios - It means that investors will only require a return for the systematic risk of their portfolios, since unsystematic risk has been removed and can be ignored.

2. Single period transaction horizon - A standardized holding period is assumed by CAPM.

3. Investors can borrow and lend at the risk-free rate of return - It is made by portfolio theory, from which CAPM was developed, and provides a minimum level of return required by investors. The risk-free rate of return corresponds to the intersection of the SML and the y-axis represents the expected return of a stock.

4. Perfect capital market - All securities are valued correctly and that their returns will be plotted on to SML. A perfect capital market requires the following: that there are no taxes or transaction costs; that perfect information is freely available to all investors who, as a result, have the same expectations; that all investors are risk averse, rational and desire to maximize their own utility; and that there are a large number of buyers and sellers in the market.

3.2. CV based Capital Asset Pricing Model

The idea behind ML is to first select a candidate model-that is CAPM and then estimate the parameters using a learning algorithm and available data (Yaochu and Sendhoff, 2008). Given the dataset D_j=(X_{ij}, Y_{ij}), $i = 1, 2, ...n,$, $j = 1$ and 2 such as: 1=during the financial crsis and

2= post financial crisis, the goal is to test if the risk associated with the S&P500 and DJIA are minimized in a well-diversified portfolio, using CAPM model T. In ML, each D_j is partitioned into two subsets of data such that $D_j = D_{1j} \cup D_{2j}$. T is then used to estimate β_i and β_p of both the training component, $D_2 j$, and the testing component, D_{1j}. Assuming that the observations of the daily excess returns are independent and using the k-fold CV (KFCV),[1] D_{1j} is divided into κ_j partitions such that $D_j = \cup_{(\kappa=1,j=1)}^{\kappa_j} D_{kj}$. Each partition of D_j is defined as a fold. T is trained on κ_j-1 folds and κ_j^{th} is used for testing the validity of T (Clarke, Fokoue, and Zhang 2009).

Without loss of generosity of the financial crisis, let $\kappa : \{1, \ldots, n\} \longmapsto \{1, \ldots, K\}$ define an indexing that relates to the random partition of observation i. Denote $\hat{T}^{-\kappa(i)}$ the fitted model on the remaining κ-1 folds, $\hat{R}^{-\kappa(i)}$ the predicted value of the left-κ-out observations of the daily excess return. Hastie et al., (2001) defined the prediction error of KFCV as:

$$KFCV = \frac{1}{n} \sum_{i=1}^{n} (R_i - \hat{R}^{-\kappa(i)})^2. \tag{3.8}$$

This process is then repeated until each fold occurs exactly once for the testing data. Therefore, at the end of KFCV, the systematic risks are estimated separately for the training and testing components of the daily excess returns.[2] KFCV is frequently applied for model selection to obtain the training error and the testing error, variable selection and model estimation in a variety of applications (Colby and Bair 2013). It is clear from equation (3.8) that the objective of KFCV is to provide the minimum prediction error defined in equation (3.7). Hence equation (3.7) can be referred to as the loss function which is essentially MSE in the estimation of the daily excess return of a stock on the risk premium.

For models indexed by parameter $\delta \in \omega$ with estimated $\hat{T}_{\delta}^{-\kappa(i)}$ evaluated on the k^{th} fold, Hastie et al., (2001) defined the optimal $\hat{\delta}$ as:

$$\hat{\delta} = \min_{\delta} \frac{1}{n} \sum_{i=1}^{n} (R_i - \hat{R}^{-\kappa(i)})^2. \tag{3.9}$$

[1]The authors used KFCV to partition each time period into k-fold so that we could estimate independently the systematic risks of the training and testing components of the S&P500 and DJIA.

[2]KFCV is used as a resampling technique for estimating the systematic risks separately for the stationary training and testing data.

Therefore, for an index of the random partition κ, equation (3.3) can be rewritten as:

$$\hat{R}_{it} = \alpha_{it} + \beta_i \times R^{\kappa}_{mt} + \varepsilon_{it}. \tag{3.10}$$

In equation (3.9) for different κ, α_i, and β_i can take any value. Hence, the optimal κ is found using equation (3.9) which leads to the smallest predictor error or MSE. Thereafter, the bias and variance in the daily excess return data could be reduced, which will lead to the optimal performance of the systematic risk of the training and testing components of the daily excess return of S&P500 and DJIA. Additionally, for κ=1, the process is referred to as leave-one-out CV. Hence, for each i, define $\hat{R}^{-i}$ the predicted value of the left-one-out observation, the leave-one-out CV (LOOCV) estimate error is:

$$LOOCV = \frac{1}{n}\sum_{i=1}^{n}(R_i - \hat{R}^{-i})^2. \tag{3.11}$$

Clearly, equation (3.11) is computationally expensive for large sample because the researcher needs to use every observation at least once in the training component. In the next subsection, assuming that the optimal κ of KFCV is found which led to the minimum MSE, we will present equation (3.3) using the training and testing components of the daily excess return. We will further make the proposition that CV CAPM (ML-CAPM) would be more efficient than the traditional CAPM.

3.2.1. Cross-Validation (CV)

Proposition: CV technique will improve the efficient estimation of CAPM.

Conjecture of the proposition For the example of S&P500 and DJIA, the application of CV requires the researcher to partition the two periods of the S&P500 and DJIA into a training and testing components while minimizing the variance/errors between the observations of the associated period. The application of CV requires us to partition each time period of the data into a training and testing component while minimizing the error between the data points. After transformation of each time period into daily excess return, the time-series regression test of CAPM for the training data[3] subscript tr, composed of stock i in a sequence indexed by the time subscript t, the CAPM's time-series regression test is:

$$R_{tr_{it}} = \alpha_{tr_i} + \beta_{tr_i} \times R_{mt} + \varepsilon_{tr_{it}}, \tag{3.12}$$

[3] Forecasting/prediction, a time series CV technique, which is different from the traditional k-fold CV is used.

where $R_{tr_{it}}$ =$r_{tr_{it}} - r_{tr_{it}}$, $R_{mt} = r_{mt} - r_{ft}$. $R_{tr_{it}}$ is the excess return of stock i at time t. R_{mt} is the average risk premium at time t. $r_{tr_{it}}$ is the rate of return on stock i at time t. r_{ft} is the risk free rate on a stock at time t. α_{tr_i} is the intercept of a stock i that will be estimated. r_{mt} is the rate of return of the market at time t. β_{tr_i} is the systematic risk of a stock i. $\varepsilon_{tr_{it}}$ is the random disturbance of a stock i at time t and $\varepsilon_{tr_{it}}$ $N(0, \sigma^2_{\varepsilon_{it}})$. The time series regression of the training portfolio beta (β_{tr_p}) is:

$$R_{tr_{pt}} = \alpha_{tr_p} + \beta_{tr_p} \times R_{mt} + \varepsilon_{tr_{pt}}, \tag{3.13}$$

where $R_{tr_{pt}}$ is excess return of the training portfolio p at time t. R_{mt} is the average risk premium at time t. r_{pt} is the rate of return on the portfolio p at time t. r_{ft} is the risk free rate on stock. α_{tr_p} is the intercept of the training portfolio p. r_{mt} is the rate of return of the market at time t. β_{tr_p} is the systematic risk of the training portfolio p. $\varepsilon_{tr_{pt}}$ is the random disturbance of the training portfolio p at time t and $\varepsilon_{pt} \overset{iid}{\sim} N(0, \sigma^2_{\varepsilon_p})$.

For the testing data, subscript te, the CAPM's time-series regression test of a stock i at time t is:

$$R_{te_{it}} = \alpha_{te_i} + \beta_{te_i} \times R_{mt} + \varepsilon_{te_{it}} \tag{3.14}$$

where $R_{te_{it}}$ =$r_{te_{it}} - r_{testing_{it}}$. $R_{te_{it}}$ is the excess return of stock i at time t. R_{mt} is the average risk premium at time t. $r_{te_{it}}$ is the rate of return on stock at time t. i r_{ft} is the risk free rate on stock. α_{te_i} is the intercept of stock i that will be estimated. r_{mt} is the rate of return of the market at time t. β_{te_i} is the systematic risk of stock i that will be estimated. $\varepsilon_{te_{it}}$ is the random disturbance of stock i at time t and $\varepsilon_{te_{it}} \overset{iid}{\sim} N(0, \sigma^2_{\varepsilon_{it}})$. The second step is to calculate the portfolios' betas. Equation (3.15) is used to estimate the testing portfolio beta (β_{te_p}) of CV-CAPM:

$$R_{te_{pt}} = \alpha_{te_p} + \beta_{te_p} \times R_{mt} + \varepsilon_{te_{pt}}, \tag{3.15}$$

where $R_{te_{pt}}$ is the excess return of the testing portfolio p at time t. R_{mt} is the average risk premium at time t. r_{pt} is the rate of return on the portfolio p at time t. r_{ft} is the risk free rate on stock. α_{te_p} is the intercept of the testing portfolio p. r_{mt} is the rate of return of the market at time t. β_{te_p} is the systematic risk of the testing portfolio p. $\varepsilon_{te_{pt}}$ is the random disturbance of the testing portfolio p at time t and $\varepsilon_{pt} \overset{iid}{\sim} N(0, \sigma^2_{\varepsilon_p})$. Table 3.1 provides the statistical tests associated with the tradional and CV CAPM.

Table 3.1. Statistical Tests

Method	Individual alpha	Joint alpha
CV CAPM (training data)	H_o: $\alpha_{train_i}= 0$ H_a: $\alpha_{train_i} \neq 0$ $t = \frac{\hat{\alpha_{train_i}}}{S.E(\hat{\alpha_{train_i}})}$	H_o: $\alpha_{train_i}=...=\alpha_{train_Z}= 0$ H_a: $\alpha_{train_i} \neq 0$ $F = \frac{\frac{\sum_{i=1}^{n}(\hat{y}_i-\bar{y})^2}{K}}{\frac{\sum_{i=1}^{n}(y_i-\hat{y})^2}{n-K-1}}$
CV CAPM (testing data)	H_o: $\alpha_{test_i}= 0$ H_a: $\alpha_{test_i} \neq 0$ $t = \frac{\hat{\alpha_{test_i}}}{S.E(\hat{\alpha_{test_i}})}$	H_o: $\alpha_{test_i}=...=\alpha_{test_Z}= 0$ H_a: $\alpha_{test_i} \neq 0$ $F = \frac{\frac{\sum_{i=1}^{n}(\hat{y}_i-\bar{y})^2}{K}}{\frac{\sum_{i=1}^{n}(y_i-\hat{y})^2}{n-K-1}}$

Z= 142 for S&P500 and 29 for DJIA. Train: Training data. Test: Testing data. K: number of predictors.

This thesis proposes a method of partitioning S&P500 and DJIA into training and testing data before applying the theory of CAPM. To validate our methodology, we access the performance of the CV CAPM and the traditional CAPM through the calcuation of the following information criteria: Root Mean Squared Error (RMSE) and Mean Absolute Deviation (MAD) for DJIA and S&P500.[4] We make the following conjectures to test our proposition of efficiency:

$$RMSE_{CV} = \sqrt{\frac{1}{K}\sum_{k=1}^{K}(y_{i_{CV}} - \hat{y}_{i_{CV}})^2} \leq RMSE_{CAPM} = \sqrt{\frac{1}{K}\sum_{k=1}^{K}(y_{i_{CAPM}} - \hat{y}_{i_{CAPM}})^2} \quad (3.16)$$

$$MAD_{CV} = \frac{1}{K}\sum_{k=1}^{K}|(y_{i_{CV}} - \hat{y}_{i_{CV}})| \leq MAD_{CAPM} = \frac{1}{K}\sum_{k=1}^{K}|(y_{i_{CAPM}} - \hat{y}_{i_{CAPM}})| \quad (3.17)$$

[4]When forecasting or predicting the parameters of trained model on test data, the application of traditional k-fold CV to time dependent data is not valid. In case of time series/time dependent data used for forecasting/prediction, a time series CV technique, which is different from the traditional k-fold CV is used.

4. EMPIRICAL APPLICATION OF PORTFOLIO RISK AND DIVERSIFICATION

The National Bureau of Economic Research reported that the peak in economic activity of the U.S. recession began in December 2007 and ended in June 2009. During this analysis, we consider two asset classes: S&P500 and Dow Jones Industrial Average (DJIA). The S&P500 and DJIA, two of the most active financial markets in the U.S are composed respectively of 500 and 30 different companies that are chosen by the editors of the Wall Street Journal.

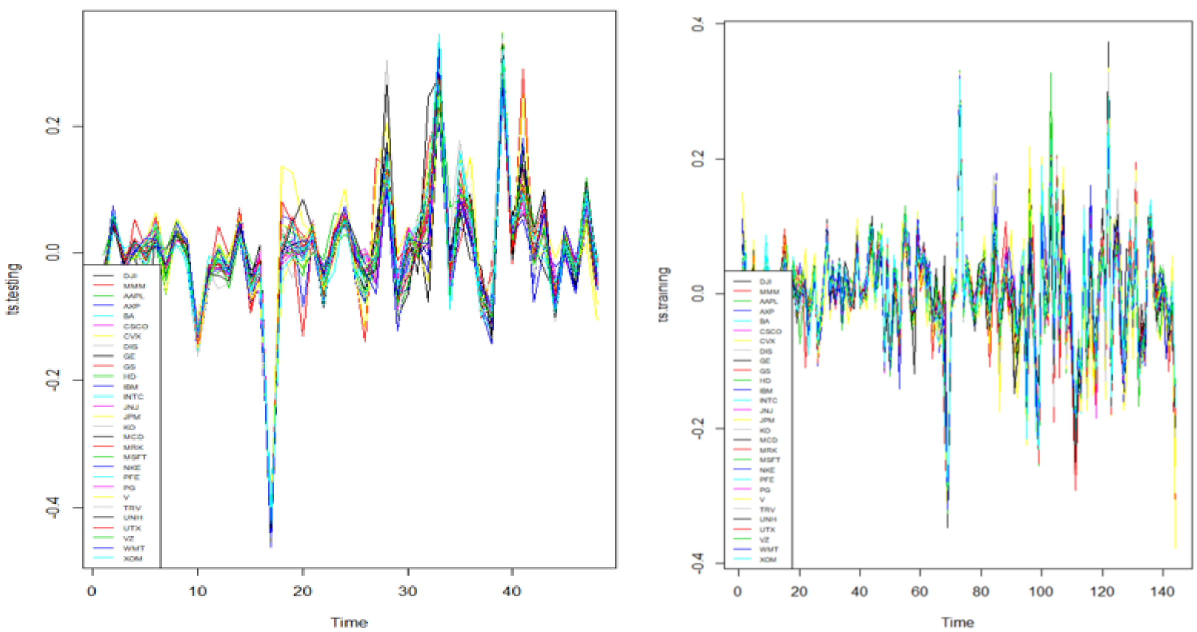
This study uses the daily-adjusted closing prices of 142 companies randomly sampled from S&P500 and 28 of the 30 companies listed in DJIA. Data are retrieved from yahoo.finance and covers the period from December 2007 to June 2009 (during the financial crisis), and July 2009 to June 2016 (post financial crisis). The daily T-bills interest rate is used as a proxy for the risk-free rate and the daily closing prices of S&P500 and DJIA as proxies for the market returns. The return of each asset and the market index are calculated as:

$$r_{it} = \log\left[\frac{R_{it}}{R_{it-1}}\right] \tag{4.1}$$

$$r_{mt} = \log\left[\frac{R_{t}}{R_{t-1}}\right] \tag{4.2}$$

where r_{it} is the logarithm daily return of stock i. R_t is the daily price of stock i at time t. R_{t-1} is the daily price of stock i at time $t-1$. r_{mt} is the logarithm daily return of the market index.

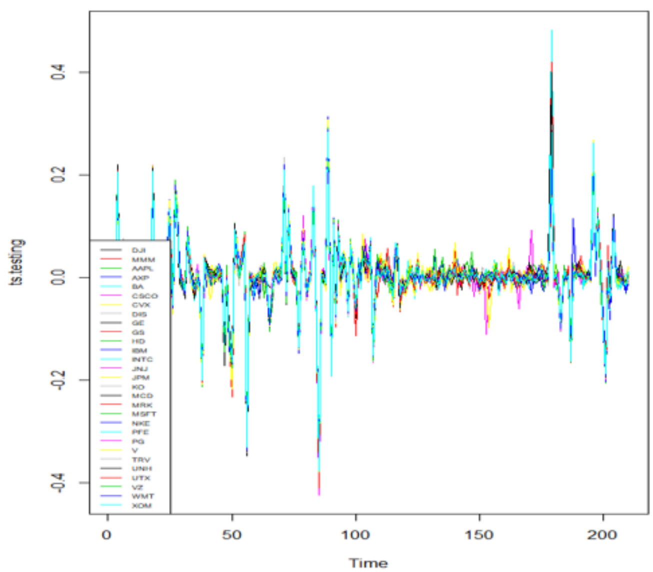
During this analysis, the four-fold CV technique was used to partition the daily excess returns of each period into training and testing data in order to estimate the systematic risks. The CV technique has been used by Kunst (2008) for forecasting the time series of commodity prices for model selection. Kunst (2008) concluded that the CV technique for model selection deserves attention if dynamic structure can be assumed. After partitioning the daily excess return, since both the training data and test data were stationary and followed a Gaussian distribution, the time series regression test of CAPM is conducted.[1] This test is used to empirically validate or contradict the proposition that the risks associated with the S&P500 and DJIA are low in a well-diversified portfolio. For this research, the analysis was done using R language with the package zoo developed by Zeileis et al., (2016) for ordered indexes that can handle an irregular financial time series of numeric vectors. Figures 4.1, and 4.2 show the pattern of the daily excess return of DJIA during December 2007-June 2009 and July 2009-June 2016. Figures 4.3, and 4.4 display the pattern of the daily excess return of S&P500 during December 2007-June 2009 and July 2009-June 2016.



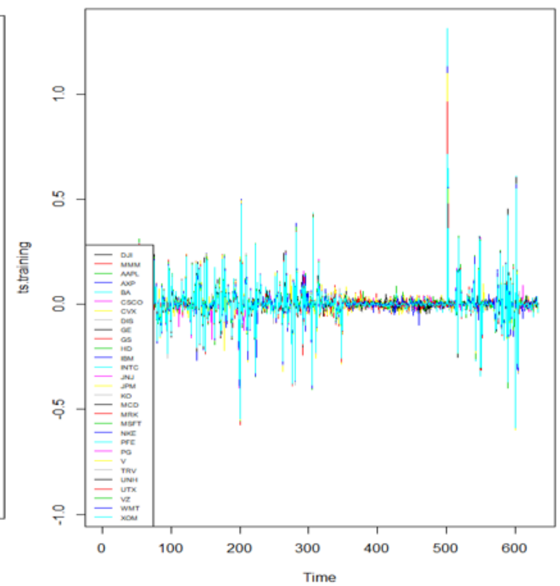
(a) Testing data (b) Training data

Figure 4.1. DJIA Daily Excess Return: December 2007-June 2009

[1]We estimated the beta coefficient for each asset and the portfolio betas for both the training data and the test data across each period using the monthly excess returns (return on the market index minus the risk-free rate).

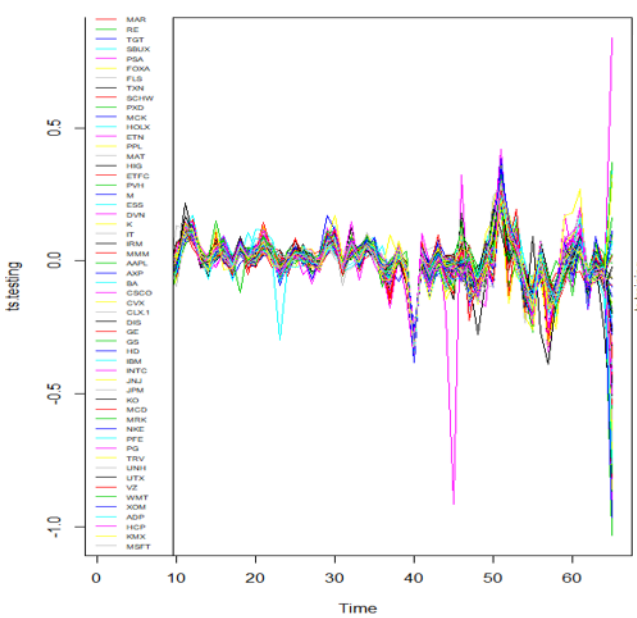


(a) Testing data

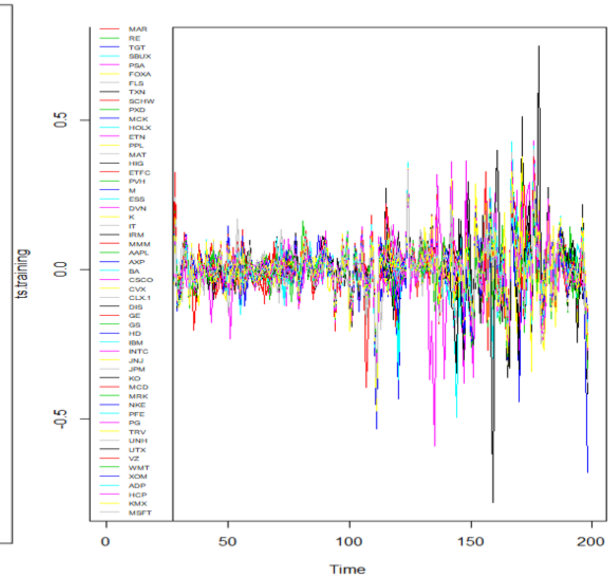


(b) Training data

Figure 4.2. DJIA Daily Excess Return: July 2009-June 2016

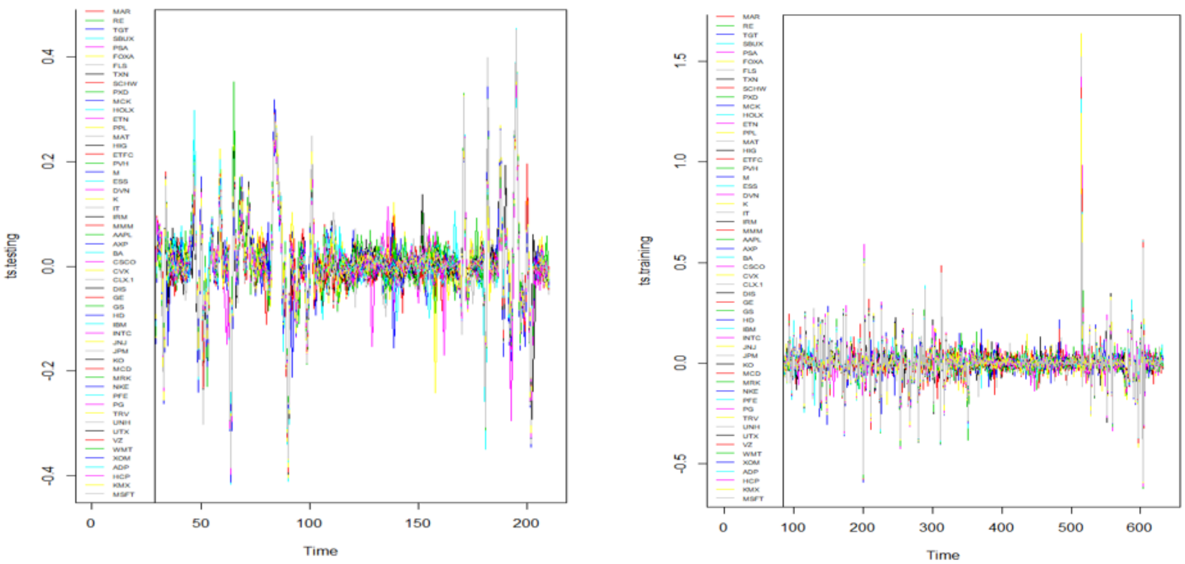


(a) Testing data



(b) Training data

Figure 4.3. S&P500 Daily Excess Return: December 2007-June 2009



(a) Testing data (b) Training data

Figure 4.4. S&P500 Daily Excess Return: July 2009-June 2016

5. RESULTS AND DISCUSSIONS

5.1. Distribution of the Training and Testing Components

The application of CAPM is based on the assumption that the data follows a Gaussian distribution. The mean-variance test is conducted over the training and testing components of S&P500 and DJIA for the periods of December 2007-June 2009 and July 2009-June 2016. Tables 5.1 and 5.2 present the three theoretical distributions that are valid representation of the training and testing data of DJIA over December 2007-June 2009 and July 2009-June 2016 respectively. For S&P500, three theoretical distributions represent the period of December 2007- June and July 2009-June 2016 of the training and testing data. Concerning, DJIA and S&P500, those distributions are normal, uniform and logistic.

In this essence, the theoretical densities plots are provided in terms of DJIA in Figures 5.1 and 5.2 and S&P500 in Figures 5.3 and 5.4. These results are viable to choose among the candidates distributions but it it does not tell us the best distribution among the candidates.[1] Two statistical tests that address the issue of finding the best distributions among a set of candidate distributions are Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).

Tables 5.1 and 5.2 present the AIC and BIC values for selecting the distribution function of DJIA and S&P500 over the training and testing data respectively. Hence, the distribution with the lowest BIC value is preferred, whereas in terms of AIC, the distribution with the highest AIC is preferred. Both criterions indicate contrasting results. That is, AIC indicates that the normal distribution is better than the logistic distribution and accoroding to BIC, the logistic distribution is better than normal distribution. Additionally, by examining the theoretical densities plots over the training and testing over the periods of December 2007-June 2009 and July 2009-June 2016, we conclude that the training and testing data of each period follow a normal distribution (Figures 5.1-5.2 for DJIA and Figures 5.3-5.4 for S&P500).

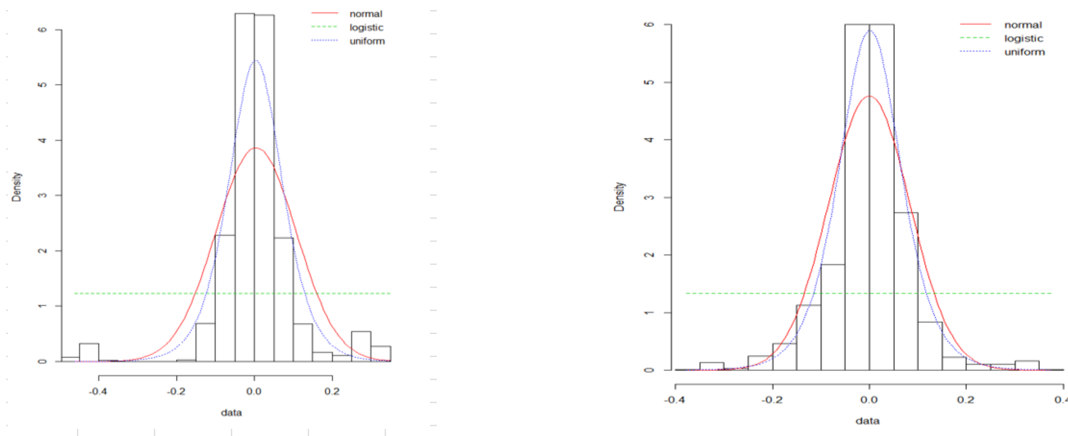
[1] From Figures 5.1-5.4, the Cullen and Frey graphs in terms of the skewness and kurtosis are available upon request for the distributions that represent the daily excess return of DJIA and S&P500.

Table 5.1. Model Selecction Criteria of DJIA

	December 2007-June 2009		July 2009-June 2016	
Criteria	Normal	Logistic	Normal	Logistic
	Training data			
AIC	-281	-315	-1126	-1394
BIC	-275	-309	-1117	-1385
	Testing data			
AIC	-114	-119	-327	-398
BIC	-110	-115	-321	-392

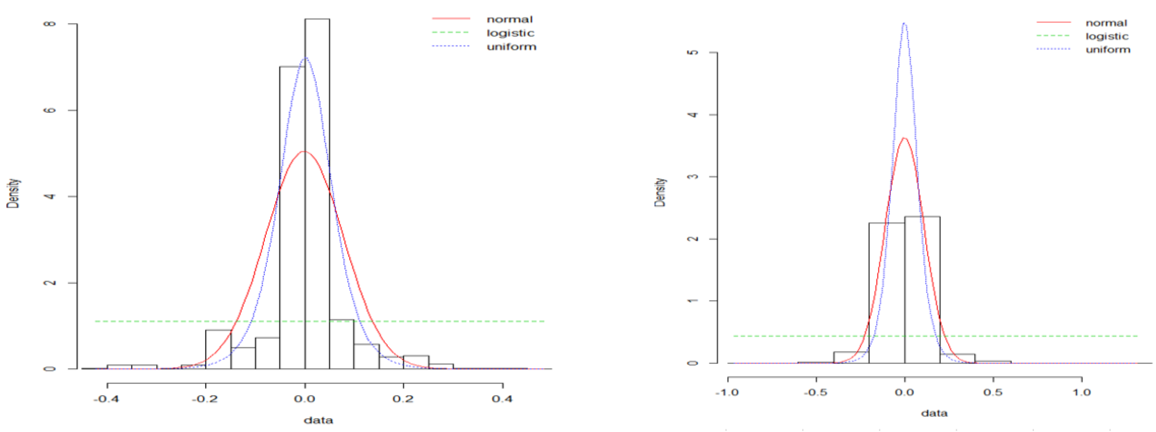
Table 5.2. Model Selecction Criteria of S&P500

	December 2007-June 2009		July 2009-June 2016	
Criteria	Normal	Logistic	Normal	Logistic
	Training data			
AIC	-360	-396	-1134	-1380
BIC	-353	-389	-1125	-1170
	Testing data			
AIC	-157	-160	-326	-387
BIC	-153	-155	-319	-381



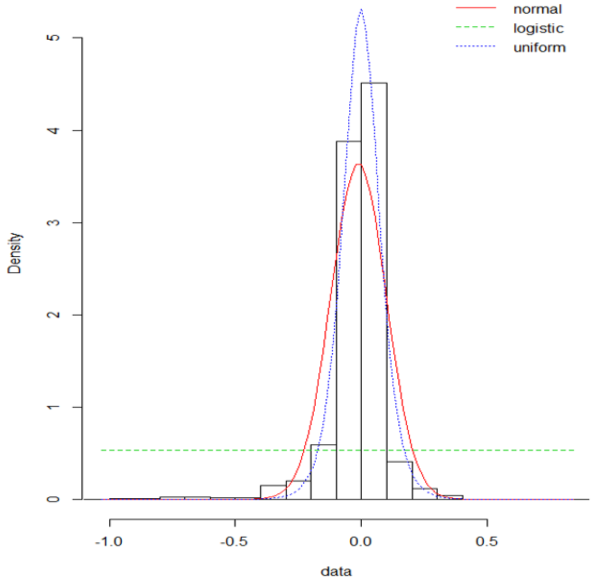
(a) Testing data (b) Training data

Figure 5.1. DJIA Histogram and Density Plots: December 2007-June 2009

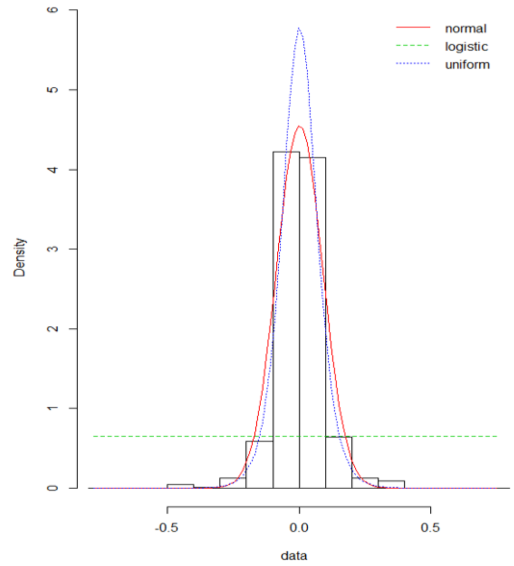


(a) Testing data (b) Training data

Figure 5.2. DJIA Histogram and Density Plots: July 2009-June 2016

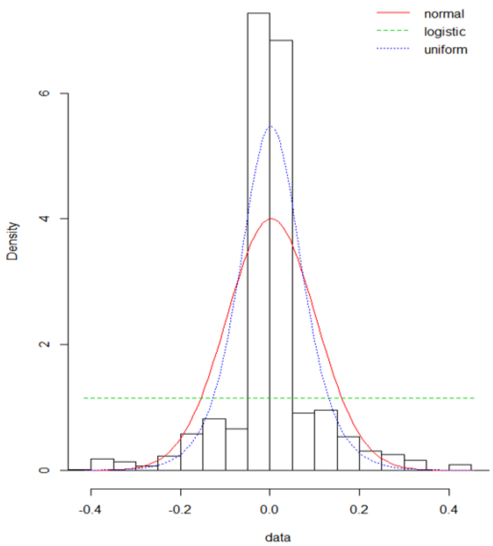


(a) Testing data

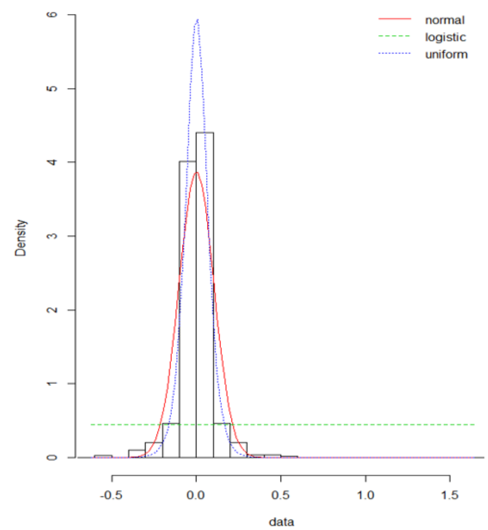


(b) Training data

Figure 5.3. S&P500 Histogram and Density Plots: December 2007-June 2009



(a) Testing data



(b) Training data

Figure 5.4. S&P500 Histogram and Density Plots: July 2009-June 2016

5.2. CV-CAPM Beta Estimation of Each Stock

Using the daily excess returns, equations (3.13) and (3.15) are used to regress the daily excess return of each stock on the daily excess return on the market index for the training and testing data over the periods of December 2007-June 2009 and July 2009-June 2016. Concerning the period of December 2007-June 2009, Tables A.1 and A.2 provide the systematic risk coefficient for the individual stocks of S&P500 and DJIA over the training and the testing data respectively. From Table A.1 of S&P500, the estimated beta coefficients range from 0.7587 to 0.9974 over the training data, and from 0.1963 to 1.2719 over the testing data. Additionally Table A.2 reports the betas coefficients of DJIA which range from 0.9113 to 1.1258 over the training data and from 0.9621 to 1.1138 over the testing.

For the period of July 2009- June 2016, Table A.3 provides the estimated beta coefficients for S&P500 over the training and testing data. These estimates range from 0.9047 to 1.0724 for the training data and from 0.9602 to 1.0139 over the testing data. Concerning DJIA, Table A.4 provides the estimated betas ranging from 0.9043 to 1.0476 over the training data and from 0.9672 to 1.0422 over the testing. Tables A.1-A.4 also report the individual alpha value associated with each stock. A negative (positive) alpha coefficient implies that there is a constant damage (a gain) for holding that sotck. Table 5.3 reports the summary of the betas estimation in three groups: (β_i <0.5 (group 1); 0.5 < $\beta_i \leq 1$ (group 2), and β_i >1 (group 3). These betas are compared to the market risk of β_{market} =1. The results in Table 5.3 are subdivided across S&P500 and DJIA. Across each time period, the number of stocks are presented with the minimum and maximum risk. For example, the results in Table 5.3 shows over the period of December 2007-June 2009 in terms of DJIA 12 and 16 stocks of the training and testing components respectively are more riskier than the market risk. Following the success of generating β_i, Figures 5.5 and 5.6 shows the linear trend of the estimated betas of DJIA and S&P500 in relation to the number of stocks n. Literature has concluded that as n increases, the risk of the portfolio decreases due to diversification.

Table 5.3. Summary of CV-CAPM Beta Estimation

partition	Paramters	S&P500		DJIA	
		December 2007-June 2009	July 2009-June 2016	December 2007-June 2009	July 2009-June 2016
		CV-CAPM			
Training	β_i <0.5	0	0	0	0
	0.5 < β_i ≤1	142	98	16	12
	β_i >1	0	44	12	16
	minimum β_i	0.7587	0.9047	0.9113	0.9043
	maximum β_i	0.9974	1.0724	1.1258	1.0476
Testing	β_i <0.5	4	0	0	0
	0.5 < β_i ≤1	78	139	12	14
	β_i >1	60	3	16	14
	minimum β_i	0.1963	0.9602	0.9621	0.9672
	maximum β_i	1.2719	1.0139	1.1138	1.0422

Figure 5.5. Distribution of DJIA Betas

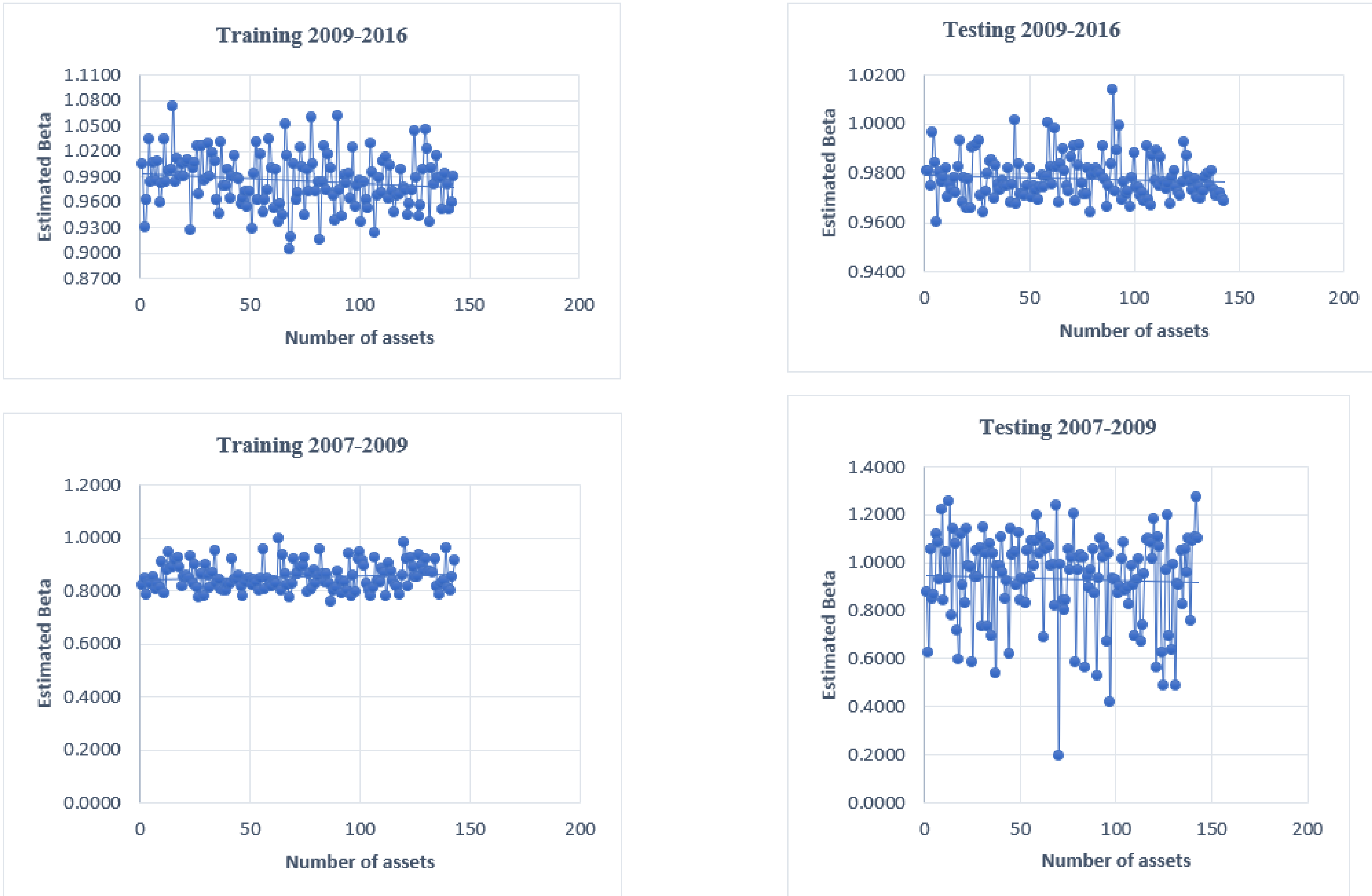


Figure 5.6. Distribution of S&P500 Betas

5.3. CV-CAPM Portfolio Betas and Statistical Tests

In theory, CAPM is a regression model that assumes that the joint intercepts are zero. Hence, to estimate the portfolio betas of the training and testing data over the period of December 2007-June 2009 and July 2009-June 2016, equations (3.14) and (3.16) are used by regressing the daily average excess return of the portfolio on the daily excess return of the market index. Table 5.4 reports the estimated portfolio betas and the joint alphas value over the period of December 2007-June 2009 and July 2009-June 2016.

From Table 5.4, concerning S&P500 during December 2007-June 2009, the joint alpha coefficient of the training data is 0.0028 (p-value of 0.22) and -0.0047 (p-value of 0.26) for the testing data. During the period of July 2009-June 2016, the joint alpha coefficient of the training data is 0.0009 (p-value of 0.16) and 0.0001 (p-value of 0.70) over the testing data. Concerning DJIA, during the period of December 2007-June 2009, the joint alpha coefficient of the training data is -0.0000 (p-value of 0.60) and for 0.0007 (p-value of 0.37) over the testing data. During the period of July 2009-June 2016, the joint alpha coefficient of the training data is 0.0028 (p-value 0.099) and 0.0000 (p-value of 0.70) for the testing data. Hence, the results suggest that the joint alphas value are statistically zero at 1% and 5% level. Hence, we can conclude that the CV- CAPM is robust and and the key assumption of CAPM in terms of the joint alphas for all stocks are jointly zero hold.

Additionally, the theory of CAPM predicts that a higher systematic risk is correlated with a higher return. Hence, we expect all the beta coefficients to be positive. Concerning S&P500, the portfolio beta for the period of December 2007- June 2009 are 0.8527 (p-value <0.001) for the training data and 0.9334 (p-value <0.001) for the testing data. For the period of July 2009-June 2016, the portfolio beta coefficients are 0.9847 (p-value <0.001) for the training and 0.9779 (p-value <0.001) for the testing data. Concerning DJIA, the portfolio beta coefficients for the period of December 2007-June 2009 are 1.0000 (p-value <0.001) for the training data and 1.0210 (p-value <0.001) for the testing data. For the period of July 2009-June 2016, the portfolio beta coefficients are 0.9959 (p-value <0.001) for the training data and 1.0000 (p-value <0.001) for the testing data. The significant portfolio betas validate the CAPM prediction that a higher risk is directly associated with a higher return.

Table 5.4. Estimation of CV-CAPM Portfolio Betas

partition	Paramters	S&P500		DJIA	
		December 2007-June 2009	July 2009-June 2016	December 2007-June 2009	July 2009-June 2016
Training	Portfolio (β)	0.8527	0.9847	1.0000	0.9959
	p-value (β)	<0.001	<0.001	<0.001	<0.001
	S.E (β)	0.0263	0.0061	0.0005	0.0016
	joint (α)	0.0028	0.0009	-0.0000	0.0028
	p value (α)	0.22	0.16	0.60	0.099
	S.E (α)	0.0023	0.0006	0.0004	0.0002
Testing	Portfolio (β)	0.9334	0.9779	1.0121	1.0000
	p-value (β)	<0.001	<0.001	<0.001	<0.001
	S.E (β)	0.0425	0.0082	0.0073	0.0002
	joint (α)	-0.0047	0.0001	0.0007	0.0000
	p value (α)	0.26	0.70	0.37	0.70
	S.E (α)	0.0042	0.0008	0.0007	0.0002

5.4. Test for Systematic Risk with CV-CAPM

A major step in this analysis is to test whether the estimated portfolio beta for both the training and testing data are statistically the same across December 2007-June 2009, and July 2009-June 2016. Is it true for example that the estimated portfolio beta over the training data for December 2007-June 2009 is the same as the estimated portfolio beta over the training data for July 2009-June 2016 and so on? Table 5.5 provides the empirical result of the two-sided hypothesis testing. Table 5.5 lists the p-values when testing for the equality of the estimated portfolio beta over each time period. The results are consistent across the board. For example, in Table 5.5, the estimated portfolio beta of the training data for December 2007-June 2009 period is statistically different from the estimated portfolio of the training data for July 2009-June 2016 period in term of DJIA and S&P500. Furthermore, these results are consistent with the literature that suggest systematic risks are non-diversifiable risks.

This thesis proposed a method of partitioning S&P500 and DJIA into training data and test data before applying the theory of CAPM to minimize the errors in its estimation. To validate our methodology, we compare the accuracy of the traditional CAPM to the CV-CAPM using the daily excess returns of December 2007-June 2009, and July 2009-June 2016. Consequently, for the traditional CAPM and CV-CAPM, we divide the period into training and testing data. Furthermore, for consistent comparison, the number of the observations in the training of the CV-CAPM is the same as in the traditional CAPM. The results of RMSE and MAD are in Table 5.6. From Table 5.6, the results suggest CV-CAPM provides better accuracy in terms of MAD and RMSE across both data sets.

Table 5.5. Statistical Comparison of Portfolio Betas

Data	Null hypothesis	P-value
S&P500	$\beta_{train_{period1}} = \beta_{train_{period2}}$	0.003
	$\beta_{train_{period1}} = \beta_{aggregate_1}$	$3X\ 10^{-11}$
	$\beta_{test_{period1}} = \beta_{aggregate1_{period}}$	<0.001
	$\beta_{test_{period1}} = \beta_{test_{period2}}$	<0.001
	$\beta_{test_{period2}} = \beta_{aggregate2}$	0.8
	$\beta_{train_{period2}} = \beta_{aggregate2}$	0.7
	$\beta_{aggregate1} = \beta_{aggregate2}$	$3X\ 10^{-7}$
DJIA	$\beta_{train_{period1}} = \beta_{train_{period2}}$	0.004
	$\beta_{train_{period1}} = \beta_{aggregate_1}$	0.003
	$\beta_{test_{period1}} = \beta_{aggregate1_{period}}$	<0.001
	$\beta_{test_{period1}} = \beta_{test_{period2}}$	<0.001
	$\beta_{test_{period2}} = \beta_{aggregate2}$	0.7
	$\beta_{train_{period2}} = \beta_{aggregate2}$	0.5
	$\beta_{aggregate1} = \beta_{aggregate2}$	0.8

Period 1: December 2007-June 2009. Period 2: July 2009-June 2016. Train: training data. Test: Testing data. Two sided statistical tests.

Table 5.6. Comparing CV-CAPM and Traditional CAPM

	S&P500		DJIA	
Criteria	December 2007- June 2009	July 2009-June 2016	December 2007- June 2009	July 2009-June 2016
		CV CAPM		
MAD	0.0023	0.0012	0.0027	0.0006
RMSE	0.0032	0.0014	0.0034	0.0007
		Traditional CAPM		
MAD	0.0035	0.0011	0.0028	0.0010
RMSE	0.0050	0.0016	0.0036	0.0012

5.5. Test for Unsystematic or Diversifiable Risk with CV-CAPM

In financial economics, diversification is a tool for reducing risk. Portfolio diversification, a concept developed by Markowitz (1959), based on the mean-variance analysis, can be measured using correlation coefficient. In the absence of impactful correlation coefficients, the theory suggests that a portfolio constructed with optimal levels of assets coupled with economies of scale could result in risk reduction from diversification. In a portfolio of linear relationship, the theory of well-diversification for assets leads us to the theory of optimality by determining the optimal number of assets that should be included in the portfolio. Following (Robinson and Barry, 1987), to find the optimal level of diversification, we assume the following properties:

1. A firm must only choose between two assets: safe asset $k_{(n+1)}$ and n risky assets $k_1, \ldots . k_n$.
2. Based on the assumption that the distributions are identically distributed then the expected return on the asset i^{th}.
3. σ_{ii}=σ_l^2 $\forall$ i=1,...,n is the variance of return on the i^{th}.
4. σ_{ij}=$\rho\sigma_l^2$ $\forall$ $i \neq j$ =1,...,n is the covariance of return on the i^{th} and j^{th} assets.
5. β is the portfolio beta.

The certainty equivalent model in addition to transaction cost is:

$$maxy_{CE} = \left[(r - r_{n+1})(W_o - q_{n+1}) + r_{n+1}W_o - cn - \frac{\beta}{2}(W_o - k_{n+1})^2 \left[\frac{1 + (n-1)\rho}{n}\right] \sigma_l^2\right], \quad (5.1)$$

where the optimal where the optimal amount of investment in the safe asset, k_{n+1} is:

$$k_{n+1} = \frac{(r - r_{n+1}) + \beta W_o[1 + (n-1)\rho]\sigma_l^2}{\beta[1 + (n-1)\rho]\sigma_l^2}. \quad (5.2)$$

From equation (5.2), the first order condition for n is:

$$\frac{dy_{CE}}{dn} = -c + \left[\frac{\beta}{2} \frac{(W_o - k_{n+1})^2[1-\rho]\sigma_l^2}{n^2}\right]. \quad (5.3)$$

Setting equation (5.3) to 0 and solving it for n yields the following results

$$n = \left[\frac{\beta}{2c}(1-\rho)\right]^{1/2}\left[(W_o - k_{n+1})\sigma_l\right]. \tag{5.4}$$

Subtituting equation (5.2) into equation (5.4) yields he finite number of assets that is defined as

$$n = \left[\frac{r_i - r_{i+1}}{\beta^{1/2}\sigma_{ij}}\right] \times \left[(\frac{1-\rho}{2c})^{1/2}\right] + \frac{\rho - 1}{\rho}. \tag{5.5}$$

For a fixed transaction cost, the number of stocks in DJIA and S&P500 should be optimal. A test for optimality suggests the DJIA and S&P500 are well-diversified. Further testing is done by performing a quantitative financial shock analysis on the banking sector of DJIA and S&P500.

This evaluation is done in two stages. In the first stage, the returns of the banking sectors of DJIA and S&P500 are increased by 25% (positive shock) and in the second stage, the same returns are decreased by 25% (negative shock). In each stage, we consider four stocks: American Express Co (AXP), Goldman Sachs Group Inc (GS), JPMorgan Chase & Co (JPM) and the Travelers Companies Inc (TRV) and estimate the individual beta coefficients, the portfolio betas over the training and testing data of December 2007-June 2009, and July 2009-June 2016.

Concerning S&P500, Tables A.5 and A.6 present the results of the positive shock of December 2007-June 2009 and July 2009-June 2016 respectively. Tables A.7 and A.8 respectively show the results of the negative shocks from December 2007-June 2009 and July 2009-June 2016. These tables contain the analysis of the 142 stocks with their respective alpha value and beta values for CV-CAPM. These are relevant for a manager who will use an asset pricing model to calculate the cost of capital. The beta valuations differ quite a bit for the average portfolio beta in Table 5.7.

Concerning DJIA, Tables A.9 and A.10 present the results of the positive shock for the respective periods of December 2007-June 2009 and July 2009 -June 2016 whereas Tables A.11 and A.12 present the results of the negative shock for the respective periods of December 2007-June 2009 and July 2009 -June 2016 The beta valuations differ quite a bit across S&P500 and DJIA. For example, the mimimum beta value for the positive shock of S&P500 from December 2007-June 2009 is 0.0572. The estimated beta coefficient suggest that the stocks have changed due to the shock with positive beta estimates.

Table 5.7. Estimation of the Shocks Analysis

partition	Paramters	S&P500		DJIA	
		December 2007-June 2009	July 2009-June 2016	December 2007-June 2009	July 2009-June 2016
		25% Increase of AXP, GS, JPM and TRV			
Training	β_i <0.5	0	0	0	0
	0.5 < β_i ≤1	138	141	13	13
	β_i >1	4	1	15	15
Testing	β_i <0.5	8	0	0	0
	0.5 < β_i ≤1	86	64	11	13
	β_i >1	48	78	17	15
		25% Decrease of AXP, GS, JPM and TRV			
Training	β_i <0.5	0	0	0	0
	0.5 < β_i ≤1	142	142	16	17
	β_i >1	0	0	12	11
Testing	β_i <0.5	5	0	0	0
	0.5 < β_i ≤1	75	72	19	13
	β_i >1	62	70	9	15

Table 5.8 reports the the unsystematic risk of the training and testing data over December 2007- June 2009 and July 2009-June 2016 for DJIA and S&P500. The estimated portfolio betas over the training and testing of each period are positive. These estimates are statistically significant and are different from zero at 1% level. We expect all the beta coefficients for these different portfolios to be positive. The theory of CAPM predicts that a higher systematic risk is correlated with a higher return. The systematic risk of the portfolio is smaller than the majority of systematic risk of the individual stock beta listed in Tables A.5-A.12. This is expected if DJIA and S&P500 are diversified.

Table 5.8. Estimation of the Unsystematic Risks

partition	Paramters	S&P500		DJIA	
		December 2007- June 2009	July 2009-June 2016	December 2007- June 2009	July 2009-June 2016
		25% increase of AXP, GS, JPM and TRV			
Training	Portfolio (β)	0.8769	0.9709	1.0079	1.0000
	p-value (β)	<0.001	<0.001	<0.001	<0.001
	joint (α)	0.0026	0.0007	0.0002	$8.17X\ 10^{-5}$
	p-value (α)	0.26	0.22	0.62	0.27
Testing	Portfolio (β)	0.8789	1.0056	1.0295	0.9871
	p-value (β)	<0.001	<0.001	<0.001	<0.001
	joint (α)	0.0044	0.0009	-0.0003	0.0008
	p-value (α)	0.28	0.38	0.64	0.2
		25% Decrease of AXP, GS, JPM and TRV			
Training	Portfolio (β)	0.8561	0.9733	1.002	0.9934
	p-value (β)	<0.001	<0.001	<0.001	<0.001
	joint (α)	-0.0005	0.0007	0.0002	0.0001
	p-value (α)	0.83	0.23	0.5	0.36
Testing	Portfolio (β)	0.9333	1.0004	0.9904	1.0066
	p-value (β)	<0.001	<0.001	<0.001	<0.001
	joint (α)	0.0050	0.0004	0.0005	0.0003
	p-value (α)	0.22	0.75	0.46	0.068

6. CONCLUSIONS

This study applies the ML-CAPM to test the theory of risk efficiency in a well-diversified portfolio using the S&P500 and DJIA indexes from December 2007 to June 2009 (during financial crisis) and July 2009 to June 2016 (post financial crisis) for empirical analysis. The paper contributes to the literature in several ways. First, we used the CV technique to partition each period into a training and a testing data in a way that minimizes noise or error in the estimation. We applied a ML approach to estimate the betas while accounting for bias or error in the estimation. Second, we provided a framework to test the normality assumption of CAPM. Finally, we built a predictive ML-CAPM and then used the model to test whether the S&P500 and DJIA are lower risk in a well-diversified market indexes by estimating their unsystematic risks. Finally, to evaluate the unsystematic risks, we conducted a sensitivity analysis by analyzing a 25% shock to the banking sector, to evaluate whether that change is captured by the other stocks.

Other strengths of our paper include addressing the mean-variance assumption of the CAPM model and robustness of our results. Moreover, we conclude that CV-CAPM is more robust and efficient compared to the traditional CAPM in terms of RMSE and MAD. Additionally, the findings of our study are supportive of the theory that a higher beta value is directly associated with a higher return. Our study consists of few limitations. First, we did not account for transaction costs while estimating the optimal level of diversification because of insufficient data. Further studies could concentrate on predicting the trained betas on the test data for testing the performance of various CAPM models in order to choose the best performing model for forecasting the stock values.

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APPENDIX

Table A.1. S&P500 Beta Estimation: (December 2007-June 2009)

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
A	0.0019	0.7414	0.8220	-0.0024	-0.5435	0.8794
AAPL	0.0033	1.1454	0.8484	-0.0030	-0.3678	0.6270
ABT	0.0035	1.2410	0.7861	-0.0032	-0.3969	1.0538
ADBE	0.0021	0.8341	0.8301	-0.0028	-0.6548	0.8520
ADI	0.0035	1.1932	0.8245	-0.0044	-0.9412	0.8643
ADM	0.0033	1.1430	0.8497	-0.0039	-0.5522	1.1168
ADP	0.0045	1.8464	0.8063	-0.0067	-0.8501	1.0861
ADSK	0.0001	0.0244	0.8244	-0.0025	-0.5475	0.9298
AEE	0.0014	0.5712	0.8127	-0.0052	-0.4762	1.2246
AES	0.0001	0.0313	0.9070	-0.0007	-0.1277	0.8414
AET	0.0032	0.9908	0.7923	-0.0113	-1.5615	1.0457
AFL	0.0045	1.5012	0.8780	-0.0097	-1.8302	0.9340
AIG	-0.0073	-1.2280	0.9466	-0.0245	-1.4241	1.2592
AKAM	0.0026	0.8072	0.8899	-0.0073	-1.2817	0.7794
ALK	0.0066	1.4490	0.8864	-0.0052	-0.6629	1.1395
ALL	0.0037	1.1179	0.9151	-0.0103	-1.4165	1.0779
AMG	0.0021	0.5581	0.9265	-0.0094	-1.6299	0.7187
AMZN	0.0032	1.0597	0.8871	0.0002	0.0225	0.5963
AON	0.0049	1.7123	0.8158	-0.0106	-1.0077	1.1189
APC	0.0026	0.8520	0.8504	0.0008	0.1689	0.9079
APH	0.0026	0.8937	0.8558	-0.0013	-0.3218	0.8298
ATVI	0.0040	1.3582	0.8479	-0.0057	-0.8932	1.1405
AVB	0.0028	0.8810	0.9324	-0.0040	-0.7591	0.9841
AVY	0.0032	1.2443	0.8280	-0.0066	-1.2081	0.9837
AXP	0.0006	0.2102	0.8992	-0.0024	-0.3064	0.5859
BA	0.0004	0.1466	0.8101	-0.0005	-0.0891	0.9426
BAX	0.0046	1.8503	0.7759	-0.0061	-0.7375	1.0479
BBY	0.0034	1.0979	0.8651	-0.0074	-1.3139	0.9423
BDX	0.0045	1.6470	0.7810	-0.0065	-0.7856	1.0589
BEN	0.0029	1.0167	0.8991	-0.0043	-0.7810	0.7341
BIIB	0.0043	1.3621	0.8582	-0.0093	-1.1046	1.1480
BMY	0.0016	0.5740	0.8132	0.0004	0.0556	1.0414
BWA	0.0011	0.3548	0.8673	-0.0024	-0.4564	0.7373
C	-0.0022	-0.4378	0.9520	-0.0192	-2.0750	1.0763
CCI	0.0010	0.3489	0.8246	0.0003	0.0482	0.6923
CHRW	0.0039	1.3282	0.8430	-0.0023	-0.3628	1.0400
CI	0.0002	0.0392	0.8048	-0.0027	-0.3527	0.5384

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
CLX	0.0039	1.3850	0.7996	-0.0052	-0.7147	0.9844
CMCSA	0.0040	1.3051	0.8238	-0.0075	-1.1134	1.1077
CMS	0.0020	0.8038	0.8263	-0.0003	-0.0549	0.9603
COF	0.0043	1.1717	0.9189	-0.0095	-1.8893	0.8470
COG	0.0016	0.4930	0.8395	0.0057	1.0817	0.9233
COO	0.0018	0.5340	0.8417	-0.0031	-0.4907	0.6178
COP	0.0017	0.6529	0.8586	-0.0028	-0.4091	1.1413
COST	0.0039	1.3282	0.8167	-0.0058	-0.8877	1.0348
CPB	0.0036	1.3215	0.7803	-0.0047	-0.5738	1.0450
CSCO	0.0022	0.8589	0.8332	-0.0016	-0.4281	0.9076
CVX	0.0030	1.2322	0.8466	-0.0020	-0.3067	1.1219
CXO	0.0037	1.0541	0.8482	0.0087	1.1983	0.8418
DGX	0.0054	2.0185	0.8187	-0.0083	-1.1779	0.9369
DIS	0.0025	1.0243	0.8420	-0.0017	-0.3711	0.9270
DISH	-0.0008	-0.2382	0.8321	-0.0026	-0.5425	0.8321
DLTR	0.0087	2.4887	0.8018	-0.0105	-1.3704	1.0526
DOV	0.0035	1.3737	0.8458	-0.0034	-0.7302	0.9411
DRE	0.0021	0.4880	0.9562	-0.0088	-1.1306	1.0907
DTE	0.0027	1.0855	0.8051	-0.0027	-0.4264	0.9883
DVN	0.0017	0.5933	0.8479	0.0015	0.2871	1.0884
EA	0.0023	0.7853	0.8214	-0.0161	-1.8408	1.1979
EFX	0.0034	1.3689	0.8170	-0.0050	-0.8540	1.0358
EIX	0.0013	0.5475	0.8375	-0.0027	-0.3421	1.1052
EMN	0.0023	0.8529	0.8269	-0.0027	-0.4788	0.6898
EQR	0.0046	1.3223	0.9974	-0.0074	-1.0381	1.0580
ES	0.0029	1.1722	0.8025	-0.0039	-0.5004	1.0759
ESS	0.0048	1.5543	0.9359	-0.0094	-1.4102	1.0663
ETFC	0.0000	0.0043	0.8616	-0.0057	-0.6788	0.9893
ETN	0.0015	0.5551	0.8226	-0.0009	-0.1738	0.9917
EW	0.0051	1.8999	0.7723	0.0003	0.0578	0.8220
EXC	0.0015	0.5684	0.8259	-0.0030	-0.3260	1.2373
F	0.0037	0.9220	0.9190	-0.0019	-0.1043	0.1964
FAST	0.0058	2.0246	0.8633	-0.0079	-1.4998	0.9933
FL	0.0053	1.3170	0.8635	-0.0106	-1.7742	0.8458
FLS	0.0013	0.4089	0.8862	0.0042	0.5772	0.8023

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
FOXA	0.0003	0.1092	0.8912	-0.0010	-0.2149	0.8439
FRT	0.0038	1.1622	0.9235	-0.0065	-1.1101	1.0559
GD	0.0022	0.8354	0.7975	-0.0030	-0.4857	0.9685
GE	0.0013	0.4479	0.8613	-0.0082	-1.2881	1.0187
GILD	0.0048	1.6728	0.8067	-0.0057	-0.5998	1.2030
GS	-0.0007	-0.1846	0.8801	0.0020	0.2320	0.5846
GWW	0.0046	1.6680	0.8268	-0.0045	-0.8540	0.9690
HAS	0.0063	2.1141	0.8572	-0.0091	-1.2468	1.0208
HCP	0.0041	1.1964	0.9539	-0.0053	-0.8916	1.0333
HD	0.0052	1.7847	0.8620	-0.0082	-1.3591	1.0216
HIG	-0.0021	-0.2545	0.8319	-0.0088	-0.8573	0.5626
HOLX	0.0023	0.7520	0.8607	-0.0118	-1.5840	0.9403
HPQ	0.0046	1.7277	0.8262	-0.0068	-1.4531	0.8955
HRL	0.0035	1.1650	0.7587	-0.0040	-0.5595	0.9675
HSY	0.0055	2.0308	0.8019	-0.0094	-1.1328	1.0573
IBM	0.0045	1.7490	0.8108	-0.0039	-0.8158	0.8702
INCY	0.0000	0.0136	0.8705	0.0061	0.5252	0.5293
INTC	0.0020	0.7842	0.8358	-0.0026	-0.6074	0.9377
IRM	0.0026	0.9184	0.7905	-0.0060	-0.7259	1.1028
IT	0.0046	1.5143	0.8296	-0.0044	-0.9116	1.0230
JNJ	0.0042	1.5872	0.7979	-0.0057	-0.7398	1.0647
JPM	0.0038	0.9883	0.9395	-0.0067	-0.9160	0.6695
K	0.0042	1.6500	0.7791	-0.0052	-0.7205	1.0363
KMX	0.0009	0.2560	0.8574	0.0007	0.0720	0.4196
KO	0.0036	1.3426	0.7962	-0.0054	-0.8763	0.9378
LUK	0.0023	0.7821	0.9211	-0.0088	-1.2729	0.9316
M	0.0025	0.6671	0.9473	-0.0094	-1.5058	0.9297
MAA	0.0036	1.0524	0.9136	-0.0036	-0.7374	0.8705
MAR	0.0033	1.0531	0.8921	-0.0072	-1.5891	0.9035
MAT	0.0054	1.7139	0.8270	-0.0091	-1.3895	1.0150
MCD	0.0048	1.8170	0.8023	-0.0057	-0.7077	1.0835
MCK	0.0023	0.8212	0.7775	-0.0012	-0.2340	0.8831
MMM	0.0030	1.1477	0.8103	-0.0020	-0.3895	0.8935
MOS	0.0012	0.2480	0.9263	0.0009	0.1314	0.8271
MRK	0.0016	0.5663	0.8361	-0.0041	-0.6387	0.9875
MSFT	0.0027	1.0650	0.8313	-0.0026	-0.5658	0.9038

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
MTB	0.0029	0.7908	0.8810	-0.0069	-1.2459	0.6952
NKE	0.0040	1.4956	0.8682	-0.0056	-0.9551	0.9277
NOC	0.0021	0.8094	0.7787	-0.0041	-0.6030	1.0140
NTAP	0.0037	1.2445	0.9017	-0.0015	-0.2300	0.6737
NVDA	-0.0014	-0.3684	0.8730	0.0009	0.1233	0.7417
ORCL	0.0042	1.7600	0.8362	-0.0027	-0.5955	0.9509
PEG	0.0012	0.4850	0.8234	-0.0014	-0.1786	1.0939
PFE	0.0038	1.5299	0.8141	-0.0067	-0.8704	1.1037
PG	0.0037	1.4443	0.7848	-0.0060	-0.7031	1.0847
PH	0.0018	0.7171	0.8575	-0.0025	-0.5296	1.0156
PHM	0.0079	1.8214	0.9818	-0.0132	-1.3740	1.1823
PNC	0.0008	0.1818	0.9177	-0.0017	-0.2372	0.5638
PPL	0.0019	0.7709	0.8180	-0.0047	-0.5278	1.1073
PSA	0.0055	1.7286	0.9232	-0.0078	-1.2608	1.0680
PVH	0.0010	0.2922	0.8862	0.0019	0.2597	0.6273
PXD	-0.0008	-0.2570	0.8498	0.0084	0.7490	0.4868
RE	0.0022	0.7275	0.8546	-0.0026	-0.3662	0.9708
REG	0.0032	0.9456	0.9360	-0.0101	-1.1487	1.2014
RL	0.0033	1.0190	0.8939	-0.0015	-0.2347	0.6953
SBUX	0.0015	0.5269	0.8740	0.0004	0.0593	0.6393
SCHW	0.0043	1.3627	0.9222	-0.0087	-1.7395	0.9932
SIG	0.0004	0.1128	0.8746	0.0039	0.3246	0.4883
TGT	0.0041	1.3036	0.8723	-0.0083	-1.5434	0.9118
TMK	0.0036	1.1828	0.8683	-0.0083	-1.3918	0.9044
TRV	0.0049	1.6233	0.9178	-0.0078	-1.1712	1.0478
TXN	0.0021	0.7696	0.8156	-0.0039	-0.8503	0.8271
UNH	0.0040	1.1955	0.7830	-0.0124	-2.0081	1.0568
UTX	0.0026	1.0656	0.8263	-0.0013	-0.2676	0.9596
VZ	0.0038	1.4960	0.8372	-0.0078	-0.9546	1.0989
WFC	0.0030	0.7349	0.9599	-0.0049	-0.9152	0.7600
WM	0.0038	1.4792	0.8087	-0.0032	-0.4169	1.0912
WMT	0.0059	2.1998	0.8024	-0.0075	-0.9073	1.1051
XOM	0.0030	1.1980	0.8514	-0.0030	-0.3092	1.2719
ZION	0.0017	0.3530	0.9123	-0.0153	-1.8959	1.1014

Table A.2. DJIA Beta Estimation: (December 2007-June 2009)

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
AAPL	-0.0013	-0.5426	1.0087	0.0021	0.4746	1.0084
AXP	-0.0016	-0.6392	1.0669	-0.0068	-1.3217	0.9901
BA	-0.0010	-0.5970	0.9812	-0.0008	-0.2889	1.0011
CSCO	-0.0006	-0.4459	0.9985	0.0005	0.1946	0.9874
CVX	-0.0003	-0.1536	1.0050	0.0056	1.6608	1.0360
DIS	0.0002	0.1480	1.0066	-0.0009	-0.4293	1.0112
GE	-0.0019	-0.9710	1.0596	-0.0066	-1.3414	0.9788
GS	-0.0070	-2.2133	1.0719	0.0084	1.1471	1.0015
HD	0.0004	0.1941	1.0032	0.0034	1.0257	1.0360
IBM	0.0017	1.6550	0.9899	-0.0037	-1.6211	0.9621
INTC	0.0006	0.3470	0.9992	-0.0033	-1.1422	0.9872
JNJ	0.0011	0.9648	0.9757	0.0028	1.1101	0.9868
JPM	-0.0050	-1.4293	1.1258	0.0061	0.8521	1.0619
KO	0.0015	0.9921	0.9405	-0.0029	-0.9015	0.9849
MCD	0.0028	2.3107	0.9684	0.0016	0.5866	0.9684
MMM	-0.0003	-0.2015	0.9861	0.0014	0.7470	1.0038
MRK	0.0021	1.1996	0.9976	-0.0065	-1.2657	1.0236
MSFT	-0.0003	-0.1709	0.9853	0.0004	0.1578	1.0161
NKE	0.0025	1.4201	1.0198	-0.0061	-1.6327	1.0808
PFE	0.0012	1.1425	0.9772	0.0012	0.5894	0.9954
PG	0.0018	1.4546	0.9561	0.0000	0.0166	0.9658
TRV	-0.0005	-0.1998	1.0804	0.0060	1.0592	1.0746
UNH	-0.0027	-0.9688	0.9113	0.0081	1.2877	1.1138
UTX	-0.0003	-0.2984	0.9949	0.0028	1.3598	1.0077
V	-0.0011	-0.4560	1.0291	0.0061	1.5770	1.0027
VZ	0.0031	2.0355	0.9938	-0.0039	-1.8047	0.9958
WMT	0.0029	2.1800	0.9705	0.0000	-0.0162	0.9949
XOM	0.0010	0.6163	1.0048	0.0034	1.0404	1.0632

Table A.3. S&P500 Beta Estimation: (July 2009-June 2016)

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
A	0.0007	0.7229	1.0042	0.0004	0.2709	0.9811
AAPL	0.0019	1.9273	0.9304	0.0005	0.4164	0.9807
ABT	0.0007	0.9904	0.9625	-0.0001	-0.1271	0.9749
ADBE	0.0010	0.9594	1.0335	-0.0002	-0.1640	0.9965
ADI	0.0009	1.1182	0.9842	0.0001	0.0707	0.9845
ADM	0.0005	0.5208	1.0063	0.0001	0.0619	0.9602
ADP	0.0011	1.5140	0.9849	0.0002	0.1715	0.9803
ADSK	0.0016	1.6278	1.0086	-0.0014	-0.8645	0.9765
AEE	0.0005	0.7152	0.9602	-0.0002	-0.1804	0.9782
AES	-0.0002	-0.1928	0.9824	-0.0006	-0.4641	0.9819
AET	0.0016	1.6251	1.0343	0.0007	0.5243	0.9701
AFL	0.0004	0.4452	0.9843	-0.0007	-0.6290	0.9752
AIG	0.0014	1.2546	0.9975	-0.0018	-1.0995	0.9731
AKAM	0.0019	1.6930	0.9977	-0.0015	-0.7633	0.9780
ALK	0.0030	2.2684	1.0724	-0.0002	-0.1293	0.9720
ALL	0.0010	1.3792	0.9845	0.0002	0.1886	0.9825
AMG	0.0017	1.6842	1.0117	-0.0003	-0.2132	0.9933
AMZN	0.0008	0.7504	0.9904	0.0021	1.3983	0.9679
AON	0.0009	1.0930	1.0046	0.0011	1.0688	0.9779
APC	0.0004	0.4095	0.9906	-0.0007	-0.3931	0.9659
APH	0.0013	1.6300	1.0068	0.0001	0.0558	0.9775
ATVI	0.0010	1.1298	1.0102	0.0000	0.0313	0.9660
AVB	0.0011	1.2980	0.9279	-0.0001	-0.0575	0.9906
AVY	0.0004	0.4095	1.0003	-0.0003	-0.2846	0.9912
AXP	0.0010	1.1973	1.0066	-0.0006	-0.5415	0.9915
BA	0.0014	1.2075	1.0264	-0.0004	-0.3438	0.9935
BAX	0.0003	0.4180	0.9693	-0.0010	-0.8546	0.9710
BBY	0.0001	0.0726	1.0251	-0.0008	-0.5191	0.9644
BDX	0.0010	1.2702	0.9847	-0.0005	-0.5016	0.9724
BEN	0.0005	0.6650	0.9876	-0.0005	-0.3927	0.9798
BIIB	0.0027	2.4911	1.0293	0.0014	0.9969	0.9847
BMY	0.0009	0.9998	0.9902	0.0013	1.0675	0.9853
BWA	0.0012	1.2670	1.0182	0.0016	1.0192	0.9695
C	0.0009	0.8468	1.0087	-0.0015	-1.1157	0.9832
CCI	0.0007	0.9094	0.9626	0.0011	1.0454	0.9754
CHRW	0.0002	0.1868	0.9459	0.0002	0.1554	0.9732
CI	0.0016	1.5665	1.0303	0.0007	0.5547	0.9769

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
CLX	0.0009	1.0848	0.9795	-0.0005	-0.4866	0.9748
CMCSA	0.0013	1.7331	0.9977	0.0012	1.1707	0.9822
CMS	0.0009	1.2859	0.9647	0.0004	0.4333	0.9683
COF	0.0013	1.4815	0.9901	-0.0013	-1.0012	0.9756
COG	0.0015	1.2515	1.0138	-0.0005	-0.2811	1.0014
COO	0.0019	2.1137	0.9885	0.0012	0.8565	0.9676
COP	0.0004	0.5686	0.9875	0.0003	0.2281	0.9837
COST	0.0008	1.0260	0.9573	0.0015	1.4900	0.9716
CPB	0.0001	0.1411	0.9651	0.0005	0.5078	0.9714
CSCO	0.0003	0.2825	0.9732	-0.0007	-0.6999	0.9707
CVX	-0.0001	-0.1133	0.9554	0.0008	0.7771	0.9749
CXO	0.0006	0.6001	0.9725	0.0015	0.9453	0.9820
DGX	-0.0002	-0.2226	0.9295	0.0012	0.8677	0.9702
DIS	0.0014	1.8318	0.9942	0.0010	0.9464	0.9748
DISH	0.0014	1.2490	1.0313	0.0013	0.9866	0.9729
DLTR	0.0022	2.5230	0.9630	0.0005	0.3739	0.9693
DOV	0.0010	1.1442	1.0160	-0.0006	-0.5265	0.9740
DRE	0.0005	0.5352	0.9487	0.0005	0.4101	0.9793
DTE	0.0005	0.7093	0.9629	0.0008	0.7710	0.9743
DVN	-0.0003	-0.3290	0.9743	-0.0010	-0.7733	0.9785
EA	0.0018	1.4822	1.0336	-0.0003	-0.1794	1.0005
EFX	0.0013	1.6260	1.0001	0.0006	0.6068	0.9824
EIX	0.0006	0.8399	0.9531	0.0002	0.1676	0.9753
EMN	0.0009	1.1351	0.9983	0.0004	0.3933	0.9984
EQR	0.0010	1.2567	0.9366	0.0005	0.4363	0.9828
ES	0.0008	1.1357	0.9580	0.0001	0.0710	0.9681
ESS	0.0013	1.5822	0.9449	0.0006	0.5250	0.9837
ETFC	0.0008	0.5951	1.0520	-0.0008	-0.5380	0.9896
ETN	0.0009	1.0187	1.0146	0.0000	-0.0170	0.9810
EW	0.0010	0.6899	0.9047	0.0018	1.2478	0.9749
EXC	-0.0007	-0.7439	0.9190	-0.0004	-0.3261	0.9725
F	0.0000	-0.0135	1.0056	0.0010	0.7358	0.9866
FAST	0.0007	0.8099	0.9621	0.0002	0.1850	0.9912
FL	0.0018	2.0130	0.9707	0.0016	1.0256	0.9686
FLS	0.0007	0.7182	1.0241	-0.0005	-0.3055	0.9834

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
FOXA	0.0012	1.3596	1.0017	0.0008	0.6833	0.9916
FRT	0.0011	1.4121	0.9449	0.0000	0.0033	0.9762
GD	0.0007	0.8272	0.9979	0.0005	0.4845	0.9716
GE	0.0002	0.2807	0.9726	0.0007	0.6749	0.9713
GILD	0.0022	1.7934	1.0602	-0.0002	-0.0954	0.9820
GS	0.0000	-0.0231	1.0041	0.0001	0.0776	0.9642
GWW	0.0010	1.3147	0.9727	0.0003	0.2623	0.9794
HAS	0.0012	1.4109	0.9837	-0.0010	-0.7731	0.9800
HCP	0.0003	0.2896	0.9160	0.0001	0.1175	0.9819
HD	0.0016	1.9398	0.9834	0.0014	1.3628	0.9802
HIG	0.0011	0.9823	1.0251	-0.0019	-1.4433	0.9798
HOLX	0.0012	1.4277	0.9736	-0.0007	-0.5230	0.9911
HPQ	-0.0003	-0.3051	1.0157	-0.0018	-1.4180	0.9777
HRL	0.0012	1.3634	1.0007	0.0010	0.9398	0.9664
HSY	0.0010	1.1360	0.9684	0.0011	1.0212	0.9749
IBM	0.0002	0.1860	0.9382	-0.0001	-0.1113	0.9837
INCY	0.0029	1.6848	1.0611	0.0011	0.5175	1.0139
INTC	0.0004	0.4287	0.9739	0.0002	0.1756	0.9725
IRM	0.0009	0.9766	0.9435	-0.0009	-0.6375	0.9894
IT	0.0020	2.3230	0.9912	0.0000	-0.0122	0.9994
JNJ	0.0005	0.7001	0.9827	0.0000	-0.0231	0.9691
JPM	0.0005	0.5346	0.9931	-0.0005	-0.4213	0.9763
K	-0.0001	-0.1491	0.9641	0.0005	0.4051	0.9716
KMX	0.0011	0.9729	1.0235	0.0012	0.7758	0.9728
KO	0.0005	0.6095	0.9550	-0.0003	-0.3079	0.9664
LUK	-0.0001	-0.0889	0.9794	-0.0008	-0.6601	0.9782
M	0.0015	1.6473	0.9850	0.0014	0.9993	0.9884
MAA	0.0005	0.6094	0.9373	0.0002	0.1545	0.9742
MAR	0.0013	1.5263	0.9837	0.0009	0.8375	0.9742
MAT	0.0001	0.1274	0.9636	-0.0001	-0.0431	0.9711
MCD	0.0004	0.5119	0.9528	0.0004	0.3609	0.9721
MCK	0.0019	1.8847	1.0283	-0.0002	-0.2297	0.9687
MMM	0.0010	1.4110	0.9952	-0.0005	-0.5216	0.9910
MOS	-0.0008	-0.6512	0.9247	0.0002	0.1544	0.9690
MRK	0.0005	0.6656	0.9670	0.0000	-0.0079	0.9668
MSFT	0.0001	0.0995	0.9880	0.0008	0.7679	0.9870

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
MTB	0.0004	0.5585	0.9708	0.0007	0.6385	0.9772
NKE	0.0013	1.3450	1.0084	0.0009	0.7740	0.9895
NOC	0.0015	1.6231	1.0130	0.0003	0.2749	0.9750
NTAP	0.0003	0.2646	0.9652	-0.0010	-0.7359	0.9863
NVDA	0.0004	0.3995	1.0027	-0.0008	-0.4550	0.9767
ORCL	0.0007	0.8050	0.9719	0.0001	0.1064	0.9735
PEG	0.0004	0.5607	0.9488	-0.0008	-0.7485	0.9757
PFE	0.0005	0.6154	0.9679	0.0009	0.8075	0.9677
PG	0.0003	0.4280	0.9686	-0.0001	-0.0927	0.9779
PH	0.0010	1.1675	0.9991	-0.0001	-0.0793	0.9809
PHM	0.0011	0.8948	0.9781	-0.0006	-0.3167	0.9743
PNC	0.0007	0.8246	0.9746	-0.0002	-0.1717	0.9720
PPL	-0.0003	-0.3968	0.9453	0.0005	0.4496	0.9709
PSA	0.0011	1.6454	0.9582	0.0004	0.4121	0.9763
PVH	0.0009	0.8262	0.9746	0.0008	0.4611	0.9928
PXD	0.0009	0.8153	1.0442	0.0020	1.3191	0.9871
RE	0.0010	1.3368	0.9884	-0.0003	-0.2769	0.9789
REG	0.0008	0.9880	0.9440	0.0001	0.1271	0.9763
RL	0.0005	0.5722	0.9557	0.0000	-0.0260	0.9730
SBUX	0.0021	2.3096	0.9982	0.0001	0.0618	0.9773
SCHW	0.0008	0.7159	1.0447	-0.0009	-0.7458	0.9705
SIG	0.0023	2.2533	1.0231	-0.0003	-0.2519	0.9745
TGT	0.0002	0.2599	0.9368	0.0011	0.9332	0.9698
TMK	0.0012	1.5669	1.0007	0.0004	0.4168	0.9727
TRV	0.0012	1.6412	0.9806	-0.0004	-0.3540	0.9781
TXN	0.0011	1.3024	1.0143	0.0001	0.1208	0.9798
UNH	0.0011	1.3918	0.9881	0.0022	1.6710	0.9749
UTX	0.0007	1.0084	0.9883	-0.0005	-0.5096	0.9807
VZ	0.0004	0.4790	0.9521	0.0007	0.6658	0.9730
WFC	0.0008	1.0119	0.9935	0.0001	0.1282	0.9708
WM	0.0007	0.9272	0.9806	-0.0006	-0.6062	0.9709
WMT	0.0003	0.4263	0.9512	0.0003	0.3154	0.9718
XOM	0.0000	-0.0139	0.9593	0.0003	0.2947	0.9696
ZION	0.0004	0.4153	0.9899	0.0006	0.3951	0.9687

Table A.4. DJIA Beta Estimation: (July 2009-June 2016)

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
AAPL	0.0017	1.2944	0.9043	0.0029	2.9668	1.0261
AXP	0.0008	0.6184	0.9739	0.0017	2.2140	1.0222
BA	0.0010	1.1569	1.0476	-0.0008	-0.9787	0.9730
CSCO	-0.0002	-0.3349	0.9765	-0.0002	-0.1396	1.0403
CVX	-0.0006	-1.4133	0.9918	0.0001	0.1486	1.0000
DIS	0.0008	1.7434	1.0027	0.0015	1.7923	1.0252
GE	-0.0004	-1.1843	1.0064	0.0006	0.7618	0.9672
GS	0.0010	0.7144	0.9639	-0.0012	-1.1511	0.9952
HD	0.0013	2.8397	1.0179	0.0001	0.1625	0.9791
IBM	-0.0001	-0.0994	0.9575	-0.0003	-0.7240	1.0031
INTC	-0.0004	-0.7746	0.9770	0.0017	1.5353	1.0422
JNJ	-0.0003	-0.6390	1.0174	-0.0003	-0.5137	1.0113
JPM	0.0007	0.6775	0.9693	-0.0003	-0.2969	0.9957
KO	-0.0002	-0.6122	0.9820	-0.0001	-0.2306	1.0040
MCD	-0.0002	-0.4793	0.9988	-0.0005	-0.9193	0.9906
MMM	0.0003	0.6719	1.0078	0.0006	0.9625	1.0178
MRK	-0.0002	-0.5167	0.9875	0.0003	0.3671	1.0145
MSFT	-0.0001	-0.2294	0.9968	0.0005	0.6523	1.0196
NKE	0.0009	1.2167	1.0297	0.0007	0.7451	0.9811
PFE	-0.0001	-0.1761	1.0150	-0.0004	-0.5473	0.9710
PG	-0.0001	-0.2823	1.0209	-0.0018	-2.6257	0.9692
TRV	0.0007	1.9681	1.0078	-0.0011	-2.0647	1.0141
UNH	0.0011	1.9590	1.0067	0.0004	0.4884	1.0327
UTX	0.0001	0.2581	1.0083	0.0000	-0.0704	0.9959
V	0.0015	1.5322	1.0015	0.0002	0.2911	1.0009
VZ	0.0001	0.1475	1.0008	-0.0014	-2.2404	0.9852
WMT	0.0000	-0.0676	1.0003	-0.0014	-2.0170	0.9776
XOM	-0.0010	-1.4642	1.0139	-0.0004	-0.9261	0.9997

Table A.5. Twenty percent increase S&P500 (December 2007-June 2009)

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
A	0.0005	0.1940	0.8399	0.0016	0.3777	0.8377
AAPL	0.0020	0.7009	0.8780	0.0022	0.2844	0.5669
ABT	0.0038	1.3603	0.7960	-0.0057	-0.7134	1.0262
ADBE	0.0005	0.2046	0.8548	0.0021	0.4713	0.7955
ADI	0.0031	1.0764	0.8449	-0.0032	-0.6407	0.8191
ADM	0.0031	1.0646	0.8868	-0.0048	-0.6864	1.0255
ADP	0.0042	1.5789	0.8208	-0.0069	-0.9330	1.0496
ADSK	0.0012	0.4173	0.8723	-0.0063	-0.9125	0.8154
AEE	0.0014	0.5589	0.8140	-0.0076	-0.7166	1.2128
AES	0.0018	0.5472	0.9243	-0.0053	-1.2566	0.8030
AET	0.0029	0.9396	0.8225	-0.0117	-1.4627	0.9747
AFL	0.0010	0.3421	0.8992	0.0005	0.1020	0.8892
AIG	-0.0112	-1.8919	1.0288	-0.0140	-0.7925	1.0650
AKAM	0.0021	0.6775	0.9405	-0.0051	-0.9137	0.6685
ALK	0.0058	1.2932	0.9267	-0.0041	-0.5029	1.0430
ALL	0.0012	0.3428	0.9137	-0.0035	-0.4948	1.0833
AMG	0.0022	0.6196	0.9768	-0.0083	-1.2964	0.6122
AMZN	0.0027	0.8631	0.8980	0.0031	0.4113	0.5804
AON	0.0044	1.4803	0.8069	-0.0108	-1.0685	1.1389
APC	0.0032	1.0429	0.8764	-0.0011	-0.2269	0.8461
APH	0.0025	0.9396	0.8813	-0.0009	-0.1728	0.7724
ATVI	0.0044	1.5016	0.8607	-0.0085	-1.3188	1.1069
AVB	0.0032	0.9955	0.9568	-0.0055	-1.0955	0.9288
AVY	0.0023	0.8681	0.8497	-0.0047	-0.9074	0.9331
AXP	-0.0024	-0.7338	0.9933	0.0075	0.6837	0.3628
BA	0.0009	0.3432	0.8443	-0.0026	-0.4904	0.8588
BAX	0.0042	1.5655	0.7873	-0.0063	-0.8112	1.0186
BBY	0.0030	0.9507	0.8819	-0.0064	-1.1644	0.9060
BDX	0.0047	1.6857	0.7881	-0.0088	-1.0894	1.0401
BEN	0.0027	1.0085	0.9385	-0.0028	-0.5033	0.6499
BIIB	0.0051	1.7045	0.8810	-0.0132	-1.4667	1.0930
BMY	0.0042	1.5344	0.8247	-0.0088	-1.1586	1.0086
BWA	0.0019	0.6556	0.8985	-0.0042	-0.7292	0.6696
C	-0.0036	-0.7298	1.0453	-0.0153	-1.6060	0.8614
CCI	0.0026	0.8604	0.8637	-0.0035	-0.6294	0.6047
CHRW	0.0043	1.5053	0.8684	-0.0044	-0.6554	0.9778
CI	0.0018	0.5186	0.8694	-0.0061	-0.7089	0.3956
CLX	0.0027	0.9124	0.7849	-0.0026	-0.3970	1.0183

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
CMCSA	0.0031	1.0012	0.8592	-0.0060	-0.8426	1.0218
CMS	0.0020	0.7917	0.8220	-0.0011	-0.2095	0.9677
COF	0.0005	0.1346	0.9491	0.0028	0.5091	0.7848
COG	0.0041	1.2775	0.8869	-0.0022	-0.3946	0.8073
COO	0.0012	0.3218	0.8116	0.0000	0.0050	0.6976
COP	0.0022	0.8440	0.8801	-0.0059	-0.8661	1.0847
COST	0.0046	1.5916	0.8329	-0.0092	-1.3606	0.9955
CPB	0.0032	1.1015	0.7857	-0.0049	-0.6385	1.0288
CSCO	0.0026	1.0522	0.8573	-0.0033	-0.7842	0.8506
CVX	0.0037	1.4714	0.8642	-0.0052	-0.7816	1.0751
CXO	0.0045	1.2836	0.9063	0.0065	0.9265	0.7025
DGX	0.0044	1.5392	0.8218	-0.0056	-0.8409	0.9333
DIS	0.0025	0.9836	0.8596	-0.0020	-0.4796	0.8853
DISH	-0.0004	-0.1164	0.8788	-0.0037	-0.9082	0.7231
DLTR	0.0075	2.0945	0.8005	-0.0081	-1.0890	1.0581
DOV	0.0033	1.2886	0.8852	-0.0034	-0.7581	0.8492
DRE	0.0004	0.0764	0.9879	-0.0041	-0.8551	1.0178
DTE	0.0033	1.2574	0.8168	-0.0054	-0.9088	0.9583
DVN	0.0032	1.1340	0.8807	-0.0044	-0.7994	1.0046
EA	-0.0001	-0.0432	0.8373	-0.0106	-1.2029	1.1590
EFX	0.0037	1.4323	0.8468	-0.0067	-1.1469	0.9636
EIX	0.0019	0.7447	0.8433	-0.0059	-0.8141	1.0859
EMN	0.0013	0.4710	0.8362	0.0011	0.2103	0.6743
EQR	0.0033	0.8988	1.0055	-0.0036	-0.5779	1.0432
ES	0.0023	0.8583	0.7935	-0.0034	-0.4870	1.0928
ESS	0.0047	1.5292	0.9505	-0.0097	-1.4276	1.0356
ETFC	-0.0013	-0.2557	0.9383	-0.0021	-0.2655	0.8077
ETN	0.0012	0.4272	0.8480	-0.0009	-0.1765	0.9282
EW	0.0053	1.9363	0.7904	-0.0007	-0.1422	0.7806
EXC	0.0025	0.9814	0.8455	-0.0083	-0.8756	1.1817
F	0.0022	0.5247	0.9881	0.0065	0.3941	0.0572
FAST	0.0041	1.3856	0.8637	-0.0032	-0.6155	0.9956
FL	0.0062	1.7918	0.8956	-0.0132	-1.5486	0.7792
FLS	0.0044	1.4382	0.9425	-0.0046	-0.6285	0.6710
FOXA	0.0001	0.0477	0.9145	-0.0003	-0.0622	0.7911
FRT	0.0045	1.3284	0.9577	-0.0092	-1.7097	0.9770

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
GD	0.0025	0.8950	0.8261	-0.0048	-0.8534	0.8990
GE	0.0011	0.3708	0.8889	-0.0084	-1.3897	0.9541
GILD	0.0050	1.7960	0.8238	-0.0086	-0.8696	1.1567
GS	0.0003	0.0639	0.9902	-0.0002	-0.0190	0.3084
GWW	0.0057	2.0813	0.8544	-0.0085	-1.5796	0.9046
HAS	0.0052	1.6754	0.8522	-0.0066	-0.9868	1.0357
HCP	0.0037	1.0961	0.9616	-0.0046	-0.7583	1.0176
HD	0.0040	1.3460	0.8666	-0.0054	-0.9026	1.0130
HIG	0.0006	0.0959	0.9346	-0.0151	-0.8488	0.3322
HOLX	0.0020	0.6491	0.8529	-0.0112	-1.4810	0.9636
HPQ	0.0039	1.4188	0.8600	-0.0050	-1.1960	0.8197
HRL	0.0028	0.9091	0.7669	-0.0031	-0.4566	0.9459
HSY	0.0030	1.0596	0.8015	-0.0033	-0.4183	1.0583
IBM	0.0045	1.6924	0.8227	-0.0042	-0.9765	0.8448
INCY	0.0008	0.2228	0.8835	0.0056	0.5024	0.5054
INTC	0.0016	0.6177	0.8805	-0.0018	-0.4272	0.8317
IRM	0.0022	0.7233	0.8085	-0.0063	-0.7781	1.0557
IT	0.0049	1.6331	0.8508	-0.0063	-1.2162	0.9722
JNJ	0.0040	1.4395	0.8067	-0.0061	-0.8165	1.0413
JPM	0.0007	0.1483	1.0248	0.0045	0.4359	0.5151
K	0.0035	1.2955	0.7989	-0.0043	-0.6266	0.9869
KMX	0.0016	0.4310	0.8502	0.0009	0.0943	0.4494
KO	0.0036	1.2793	0.8009	-0.0059	-1.0219	0.9273
LUK	0.0029	0.9405	0.9546	-0.0105	-1.6483	0.8581
M	0.0002	0.0505	0.9926	-0.0020	-0.3175	0.8294
MAA	0.0048	1.4076	0.9413	-0.0069	-1.4280	0.8103
MAR	0.0017	0.5373	0.9231	-0.0022	-0.4549	0.8354
MAT	0.0040	1.2192	0.8536	-0.0056	-0.8828	0.9543
MCD	0.0043	1.5509	0.8079	-0.0057	-0.7337	1.0677
MCK	0.0034	1.1878	0.8107	-0.0052	-1.1913	0.8037
MMM	0.0030	1.1166	0.8242	-0.0025	-0.5485	0.8610
MOS	0.0046	1.2139	0.9701	-0.0090	-0.8639	0.7274
MRK	0.0026	0.8829	0.8459	-0.0079	-1.3425	0.9631
MSFT	0.0017	0.6835	0.8620	-0.0001	-0.0255	0.8321
MTB	0.0012	0.3292	0.8998	-0.0007	-0.1312	0.6611
NKE	0.0024	0.8101	0.8534	-0.0010	-0.2300	0.9659

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
NOC	0.0019	0.6725	0.7912	-0.0046	-0.7214	0.9809
NTAP	0.0026	0.9174	0.9088	0.0028	0.4034	0.6662
NVDA	-0.0003	-0.0818	0.9161	-0.0018	-0.1905	0.6428
ORCL	0.0032	1.2747	0.8701	0.0001	0.0184	0.8713
PEG	0.0016	0.6395	0.8367	-0.0040	-0.5121	1.0562
PFE	0.0028	1.0945	0.8307	-0.0052	-0.6831	1.0616
PG	0.0034	1.2263	0.7907	-0.0066	-0.8142	1.0670
PH	0.0020	0.7588	0.8817	-0.0038	-0.8818	0.9564
PHM	0.0075	1.7742	0.9842	-0.0131	-1.3089	1.1817
PNC	0.0001	0.0141	0.9413	0.0024	0.3394	0.5197
PPL	0.0031	1.1979	0.8150	-0.0097	-1.1310	1.1097
PSA	0.0043	1.3165	0.9449	-0.0050	-0.8539	1.0196
PVH	0.0030	0.8653	0.9015	-0.0027	-0.3833	0.5985
PXD	-0.0006	-0.2002	0.8793	0.0098	0.9093	0.4230
RE	0.0047	1.6110	0.8624	-0.0107	-1.4166	0.9519
REG	0.0045	1.2850	0.9560	-0.0153	-1.7971	1.1537
RL	0.0035	1.0100	0.9040	-0.0010	-0.1733	0.6798
SBUX	0.0021	0.7399	0.8973	-0.0003	-0.0367	0.5919
SCHW	0.0032	1.0290	0.9272	-0.0058	-1.1084	0.9859
SIG	0.0028	0.7275	0.9268	-0.0013	-0.1160	0.3750
TGT	0.0029	0.9178	0.8831	-0.0046	-0.8000	0.8915
TMK	0.0021	0.6967	0.9038	-0.0039	-0.6480	0.8258
TRV	0.0017	0.5042	0.9731	0.0012	0.1794	1.0327
TXN	0.0010	0.3570	0.8488	-0.0005	-0.1101	0.7516
UNH	0.0027	0.7847	0.8176	-0.0100	-1.7449	0.9757
UTX	0.0027	1.0479	0.8434	-0.0021	-0.4663	0.9175
VZ	0.0030	1.1142	0.8444	-0.0066	-0.8353	1.0800
WFC	0.0034	0.8754	0.9972	-0.0050	-0.8112	0.6822
WM	0.0044	1.6694	0.8255	-0.0063	-0.8410	1.0471
WMT	0.0050	1.8069	0.8134	-0.0065	-0.8109	1.0773
XOM	0.0041	1.6088	0.8659	-0.0084	-0.8552	1.2287
ZION	-0.0007	-0.1432	0.9538	-0.0089	-0.9310	1.0066

Table A.6. Twenty percent increase S&P500 (July 2009-June 2016)

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
A	0.0001	0.1594	0.9714	0.0026	1.8046	1.0489
AAPL	0.0024	2.9892	0.9818	-0.0021	-1.0672	0.8690
ABT	0.0008	1.0602	0.9711	-0.0003	-0.3047	0.9547
ADBE	0.0002	0.2778	0.9859	0.0031	1.4602	1.0955
ADI	0.0008	1.0293	0.9825	0.0004	0.3306	0.9870
ADM	0.0002	0.2352	0.9693	0.0015	0.9279	1.0423
ADP	0.0010	1.4516	0.9665	0.0009	0.8094	1.0147
ADSK	0.0006	0.6655	0.9803	0.0020	1.1364	1.0380
AEE	0.0004	0.5215	0.9703	0.0002	0.1343	0.9540
AES	-0.0001	-0.0980	0.9707	-0.0005	-0.3851	1.0026
AET	0.0007	0.8886	0.9893	0.0038	1.9668	1.0733
AFL	0.0000	0.0093	0.9542	0.0012	0.8432	1.0329
AIG	0.0007	0.6780	0.9606	0.0012	0.5440	1.0470
AKAM	0.0020	1.7058	0.9933	-0.0018	-0.9306	0.9893
ALK	0.0019	1.9210	0.9879	0.0046	1.5354	1.1571
ALL	0.0006	0.8594	0.9655	0.0020	1.5333	1.0182
AMG	0.0010	1.2006	0.9709	0.0026	1.3945	1.0734
AMZN	0.0013	1.3238	0.9444	0.0017	0.8519	1.0581
AON	0.0010	1.4110	0.9674	0.0017	0.9795	1.0539
APC	0.0006	0.5721	0.9833	-0.0012	-0.6450	0.9856
APH	0.0008	1.0453	0.9767	0.0021	1.4811	1.0418
ATVI	0.0008	0.9358	0.9870	0.0009	0.6163	1.0217
AVB	0.0013	1.7343	0.9724	-0.0012	-0.7406	0.8888
AVY	0.0003	0.3451	0.9679	0.0008	0.4093	1.0526
AXP	0.0008	0.9012	0.9855	0.0016	0.8602	1.0750
BA	0.0004	0.5400	0.9730	0.0036	1.4268	1.1019
BAX	0.0003	0.3439	0.9717	-0.0008	-0.7164	0.9653
BBY	0.0003	0.2342	0.9271	0.0008	0.2209	1.1605
BDX	0.0004	0.5980	0.9652	0.0015	1.1764	1.0118
BEN	0.0000	0.0106	0.9677	0.0015	1.2779	1.0189
BIIB	0.0019	2.1365	0.9780	0.0048	2.1445	1.0929
BMY	0.0007	0.9631	0.9632	0.0024	1.3732	1.0366
BWA	0.0008	0.9336	0.9768	0.0034	1.8900	1.0611
C	0.0000	-0.0275	0.9663	0.0022	1.1959	1.0687
CCI	0.0013	1.7481	0.9641	-0.0006	-0.5238	0.9677
CHRW	0.0004	0.4639	0.9652	-0.0007	-0.5045	0.9292
CI	0.0010	1.2947	0.9763	0.0034	1.5436	1.0925
CLX	0.0005	0.6360	0.9666	0.0010	0.7741	0.9996

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
CMCSA	0.0012	1.6429	0.9788	0.0020	1.6277	1.0216
CMS	0.0008	1.2029	0.9683	0.0006	0.5482	0.9605
COF	0.0011	1.3081	0.9780	-0.0007	-0.5016	1.0004
COG	0.0009	0.8483	0.9633	0.0025	1.1451	1.0968
COO	0.0014	1.5837	0.9728	0.0028	2.1135	1.0032
COP	0.0005	0.6825	0.9807	0.0002	0.1434	0.9969
COST	0.0008	1.0574	0.9587	0.0016	1.3950	0.9654
CPB	0.0003	0.3757	0.9618	0.0002	0.1446	0.9752
CSCO	0.0003	0.3035	0.9741	-0.0008	-0.6026	0.9690
CVX	0.0005	0.7505	0.9671	-0.0011	-0.9150	0.9468
CXO	0.0012	1.1600	0.9829	-0.0004	-0.1997	0.9593
DGX	0.0005	0.6515	0.9625	-0.0014	-0.8603	0.8968
DIS	0.0014	1.8557	0.9754	0.0015	1.1708	1.0147
DISH	0.0014	1.5271	0.9796	0.0020	0.9508	1.0850
DLTR	0.0018	2.0173	0.9650	0.0017	1.3984	0.9633
DOV	0.0004	0.4868	0.9748	0.0020	1.2012	1.0623
DRE	0.0008	0.9962	0.9713	-0.0009	-0.5850	0.9278
DTE	0.0007	1.0173	0.9703	0.0001	0.0680	0.9570
DVN	-0.0002	-0.1978	0.9824	-0.0016	-1.0423	0.9617
EA	0.0003	0.3080	1.0077	0.0046	2.0093	1.0599
EFX	0.0006	0.8692	0.9699	0.0033	2.3160	1.0439
EIX	0.0007	0.9200	0.9730	-0.0002	-0.1759	0.9318
EMN	0.0008	1.0866	0.9833	0.0011	0.8128	1.0254
EQR	0.0016	2.1901	0.9692	-0.0018	-1.1738	0.9072
ES	0.0009	1.3452	0.9648	-0.0004	-0.3477	0.9517
ESS	0.0013	1.7810	0.9747	-0.0001	-0.0402	0.9167
ETFC	-0.0005	-0.4569	0.9776	0.0045	1.6092	1.1463
ETN	0.0006	0.8362	0.9752	0.0015	0.9055	1.0630
EW	0.0023	2.2564	0.9848	-0.0038	-1.2019	0.8047
EXC	0.0001	0.1796	0.9696	-0.0038	-1.8663	0.8619
F	0.0000	-0.0090	0.9635	0.0019	0.9380	1.0696
FAST	0.0007	0.8054	0.9722	0.0002	0.1731	0.9634
FL	0.0025	2.7499	0.9778	-0.0007	-0.4874	0.9545
FLS	0.0003	0.4212	0.9695	0.0018	0.8044	1.0954
FOXA	0.0006	0.7399	0.9747	0.0034	1.9198	1.0452
FRT	0.0013	1.8547	0.9705	-0.0011	-0.8638	0.9184

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
GD	0.0005	0.7078	0.9738	0.0013	1.0141	1.0238
GE	0.0008	1.0221	0.9610	-0.0007	-0.6344	0.9917
GILD	0.0008	0.9425	0.9781	0.0056	1.8304	1.1572
GS	0.0001	0.0674	0.9715	0.0008	0.3773	1.0706
GWW	0.0007	0.8758	0.9623	0.0017	1.4304	0.9965
HAS	0.0007	0.8331	0.9719	0.0008	0.5579	1.0020
HCP	0.0010	1.4420	0.9676	-0.0030	-1.6310	0.8656
HD	0.0017	2.1735	0.9646	0.0016	1.2664	1.0150
HIG	-0.0003	-0.3318	0.9664	0.0036	1.5246	1.1019
HOLX	0.0010	1.1587	0.9835	-0.0001	-0.0489	0.9666
HPQ	-0.0012	-1.2639	0.9748	0.0016	0.9009	1.0649
HRL	0.0008	1.1436	0.9639	0.0026	1.6353	1.0446
HSY	0.0011	1.4418	0.9522	0.0010	0.7701	1.0020
IBM	0.0005	0.7594	0.9760	-0.0019	-1.1524	0.8997
INCY	0.0023	2.1261	0.9639	0.0050	1.1791	1.2055
INTC	0.0005	0.6442	0.9829	-0.0005	-0.3945	0.9560
IRM	0.0007	0.9158	0.9819	-0.0010	-0.5668	0.9044
IT	0.0014	1.7196	0.9718	0.0024	1.5840	1.0321
JNJ	0.0004	0.5567	0.9650	0.0007	0.5902	1.0053
JPM	0.0005	0.5094	0.9701	0.0006	0.3377	1.0537
K	0.0000	0.0257	0.9649	0.0001	0.1033	0.9680
KMX	0.0008	0.9284	0.9658	0.0030	1.2772	1.0941
KO	0.0005	0.7461	0.9690	-0.0008	-0.6989	0.9366
LUK	-0.0004	-0.4791	0.9644	0.0006	0.4988	1.0061
M	0.0014	1.6607	0.9693	0.0020	1.2570	1.0160
MAA	0.0008	1.1451	0.9663	-0.0013	-0.8711	0.9090
MAR	0.0016	1.9236	0.9767	0.0000	-0.0050	0.9888
MAT	0.0002	0.2240	0.9569	-0.0001	-0.0477	0.9806
MCD	0.0006	0.7934	0.9687	-0.0004	-0.3742	0.9367
MCK	0.0010	1.3505	0.9732	0.0035	1.5422	1.0882
MMM	0.0006	0.9393	0.9766	0.0011	0.8763	1.0259
MOS	0.0002	0.2062	0.9740	-0.0035	-1.4151	0.8640
MRK	0.0005	0.7477	0.9737	-0.0003	-0.2207	0.9542
MSFT	0.0004	0.5991	0.9800	-0.0001	-0.0846	1.0015
MTB	0.0007	0.8389	0.9629	0.0003	0.2913	0.9892
NKE	0.0009	1.1604	0.9711	0.0028	1.5121	1.0637

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
NOC	0.0011	1.4909	0.9670	0.0024	1.2707	1.0705
NTAP	0.0002	0.2062	0.9634	-0.0006	-0.4037	0.9820
NVDA	-0.0002	-0.2131	0.9993	0.0010	0.5524	0.9915
ORCL	0.0005	0.6836	0.9811	0.0002	0.1810	0.9561
PEG	0.0005	0.7350	0.9642	-0.0013	-1.0190	0.9381
PFE	0.0006	0.7566	0.9575	0.0009	0.7257	0.9868
PG	0.0003	0.4009	0.9673	0.0001	0.0853	0.9771
PH	0.0008	1.0790	0.9680	0.0009	0.6424	1.0426
PHM	0.0014	1.1668	0.9775	-0.0016	-0.7966	0.9745
PNC	0.0009	1.1315	0.9703	-0.0008	-0.6591	0.9794
PPL	0.0004	0.4966	0.9620	-0.0017	-1.3146	0.9316
PSA	0.0013	1.9131	0.9681	-0.0002	-0.1492	0.9517
PVH	0.0010	0.9162	0.9585	0.0011	0.6446	1.0160
PXD	0.0012	1.2857	0.9839	0.0022	1.0081	1.1148
RE	0.0001	0.0959	0.9625	0.0032	2.4055	1.0304
REG	0.0011	1.4916	0.9670	-0.0011	-0.8003	0.9231
RL	0.0002	0.2366	0.9589	0.0010	0.6095	0.9621
SBUX	0.0018	2.1567	0.9668	0.0016	0.9578	1.0400
SCHW	-0.0001	-0.0763	0.9727	0.0030	1.3019	1.1254
SIG	0.0012	1.2813	0.9898	0.0034	1.9247	1.0508
TGT	0.0010	1.1847	0.9597	-0.0015	-1.0547	0.9166
TMK	0.0007	0.9758	0.9665	0.0028	1.9348	1.0445
TRV	0.0007	0.9642	0.9680	0.0025	1.9182	1.0270
TXN	0.0008	1.0738	0.9832	0.0016	0.9968	1.0472
UNH	0.0012	1.4668	0.9751	0.0022	1.7247	1.0033
UTX	0.0002	0.3266	0.9646	0.0016	1.3595	1.0265
VZ	0.0007	0.9322	0.9626	-0.0004	-0.3022	0.9467
WFC	0.0010	1.3077	0.9752	-0.0002	-0.1839	1.0100
WM	0.0002	0.2931	0.9575	0.0014	1.1269	1.0160
WMT	0.0002	0.3257	0.9620	0.0005	0.4003	0.9460
XOM	0.0005	0.7254	0.9621	-0.0011	-1.1336	0.9604
ZION	0.0009	0.9266	0.9596	-0.0002	-0.1164	1.0293

Table A.7. Twenty percent decrease S&P500 (December 2007-Dec 2009)

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
A	-0.0001	-0.0427	0.8394	0.0034	0.7847	0.8380
AAPL	-0.0019	-0.6436	0.8638	0.0147	2.0369	0.5630
ABT	0.0014	0.4851	0.7834	0.0012	0.1595	1.0900
ADBE	-0.0018	-0.7202	0.8415	0.0091	1.9875	0.8224
ADI	-0.0005	-0.1899	0.8183	0.0075	1.4839	0.8874
ADM	0.0007	0.2268	0.9032	0.0025	0.3646	0.9967
ADP	0.0008	0.2945	0.8126	0.0029	0.3865	1.1003
ADSK	-0.0035	-1.0475	0.8343	0.0078	1.9478	0.9107
AEE	0.0006	0.2610	0.8130	-0.0059	-0.5528	1.2673
AES	-0.0027	-0.9025	0.9192	0.0084	1.5302	0.7989
AET	-0.0015	-0.4751	0.8145	0.0014	0.1877	1.0148
AFL	-0.0001	-0.0344	0.8673	0.0038	0.7175	0.9757
AIG	-0.0146	-2.1212	0.9352	-0.0046	-0.3468	1.3268
AKAM	-0.0047	-1.4813	0.9097	0.0161	2.9959	0.7142
ALK	0.0067	1.4469	0.9162	-0.0070	-0.9110	1.0901
ALL	0.0011	0.3412	0.9121	-0.0037	-0.4856	1.1102
AMG	-0.0041	-1.1176	0.8900	0.0108	1.7213	0.8030
AMZN	-0.0007	-0.2306	0.8715	0.0140	1.8373	0.6104
AON	0.0010	0.3521	0.7918	-0.0012	-0.1153	1.2226
APC	-0.0001	-0.0402	0.9073	0.0092	1.9480	0.7538
APH	0.0010	0.3630	0.8713	0.0039	0.8524	0.7857
ATVI	-0.0010	-0.3878	0.8615	0.0077	1.0036	1.1329
AVB	-0.0005	-0.1561	0.9321	0.0056	1.1758	0.9920
AVY	0.0010	0.3646	0.8346	-0.0010	-0.1846	0.9858
AXP	-0.0034	-1.2105	0.8362	0.0128	2.6476	0.7421
BA	-0.0022	-0.8381	0.8225	0.0064	1.3022	0.9188
BAX	0.0016	0.6052	0.7734	0.0012	0.1508	1.0861
BBY	0.0003	0.0931	0.8491	0.0015	0.2816	0.9996
BDX	0.0006	0.2047	0.7730	0.0033	0.4137	1.1125
BEN	-0.0009	-0.3346	0.9027	0.0086	1.5597	0.7104
BIIB	-0.0002	-0.0587	0.8481	0.0023	0.2720	1.2098
BMY	0.0010	0.3405	0.8042	0.0006	0.0773	1.0884
BWA	-0.0028	-0.8893	0.8750	0.0103	2.1727	0.7025
C	-0.0100	-1.8681	0.9214	0.0035	0.5472	1.1786
CCI	-0.0025	-0.8589	0.8459	0.0122	2.0000	0.6176
CHRW	0.0026	0.9321	0.8458	0.0003	0.0472	1.0545
CI	-0.0043	-1.0786	0.7902	0.0125	1.6878	0.5514
CLX	0.0017	0.5893	0.7954	0.0000	0.0064	1.0187
CMCSA	0.0001	0.0179	0.8391	0.0026	0.3825	1.0971

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
CMS	0.0012	0.5088	0.8403	0.0011	0.1979	0.9351
COF	-0.0011	-0.2924	0.9108	0.0075	1.3682	0.8682
COG	0.0008	0.2323	0.8931	0.0082	1.6778	0.7780
COO	-0.0015	-0.4108	0.8030	0.0082	1.4932	0.7048
COP	-0.0004	-0.1467	0.8820	0.0016	0.2306	1.1043
COST	0.0023	0.7968	0.8325	-0.0024	-0.3529	1.0177
CPB	0.0010	0.3302	0.7806	0.0015	0.1943	1.0732
CSCO	-0.0009	-0.3580	0.8474	0.0073	2.0999	0.8750
CVX	0.0011	0.4588	0.8695	0.0021	0.3026	1.0864
CXO	0.0014	0.3940	0.9265	0.0166	2.6607	0.6169
DGX	0.0011	0.4071	0.8032	0.0038	0.5804	0.9978
DIS	0.0001	0.0207	0.8593	0.0054	1.1603	0.8876
DISH	-0.0062	-1.9575	0.8587	0.0142	2.9736	0.7541
DLTR	0.0044	1.2695	0.7974	0.0007	0.0927	1.0996
DOV	-0.0001	-0.0268	0.8749	0.0070	1.5074	0.8712
DRE	-0.0033	-0.7043	0.9669	0.0068	1.2072	1.0771
DTE	0.0015	0.5665	0.8114	-0.0002	-0.0328	0.9912
DVN	0.0005	0.1620	0.8867	0.0039	0.6646	1.0021
EA	-0.0032	-1.0756	0.8563	-0.0017	-0.1900	1.1457
EFX	0.0001	0.0270	0.8222	0.0037	0.6157	1.0453
EIX	0.0006	0.2606	0.8403	-0.0025	-0.3288	1.1251
EMN	-0.0013	-0.4850	0.8280	0.0095	1.7941	0.6738
EQR	-0.0003	-0.0937	0.9755	0.0072	1.1986	1.1290
ES	0.0016	0.6243	0.8058	-0.0018	-0.2347	1.0969
ESS	-0.0004	-0.1334	0.9270	0.0056	0.8956	1.1095
ETFC	-0.0047	-0.9179	0.8985	0.0081	1.0265	0.8985
ETN	0.0000	-0.0147	0.8438	0.0027	0.5051	0.9492
EW	0.0020	0.7607	0.7813	0.0092	1.8778	0.8025
EXC	0.0010	0.4062	0.8427	-0.0044	-0.4687	1.2326
F	-0.0023	-0.5494	0.9420	0.0218	1.2976	0.0622
FAST	0.0022	0.7604	0.8736	0.0023	0.4226	0.9844
FL	-0.0037	-0.9195	0.8608	0.0170	2.9033	0.8550
FLS	-0.0010	-0.3305	0.9288	0.0124	1.8173	0.6712
FOXA	-0.0022	-0.8792	0.9031	0.0069	1.5088	0.8049
FRT	-0.0009	-0.2791	0.9306	0.0070	1.3259	1.0521
GD	-0.0007	-0.2582	0.8028	0.0045	0.7481	0.9711

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
GE	-0.0027	-0.8937	0.8592	0.0028	0.4770	1.0429
GILD	0.0021	0.7420	0.8348	-0.0002	-0.0159	1.1679
GS	-0.0024	-0.7688	0.8479	0.0104	2.0085	0.6688
GWW	0.0022	0.8091	0.8401	0.0020	0.3508	0.9501
HAS	0.0006	0.1926	0.8538	0.0071	0.9833	1.0521
HCP	-0.0001	-0.0179	0.9486	0.0066	1.2360	1.0587
HD	0.0018	0.6075	0.8570	0.0010	0.1686	1.0578
HIG	-0.0103	-1.3880	0.8100	0.0182	1.3114	0.5948
HOLX	-0.0032	-0.9581	0.8435	0.0045	0.7076	1.0012
HPQ	-0.0003	-0.0990	0.8320	0.0076	1.6987	0.8899
HRL	0.0009	0.2740	0.7559	0.0025	0.3858	0.9983
HSY	0.0005	0.1866	0.8006	0.0039	0.4808	1.0921
IBM	0.0006	0.2316	0.8124	0.0075	1.7258	0.8742
INCY	-0.0016	-0.4311	0.8980	0.0137	1.2489	0.4137
INTC	0.0003	0.0993	0.8546	0.0021	0.4981	0.8970
IRM	-0.0004	-0.1335	0.8069	0.0010	0.1147	1.0906
IT	0.0033	1.1045	0.8594	-0.0017	-0.3204	0.9645
JNJ	0.0014	0.5104	0.7946	0.0011	0.1453	1.1044
JPM	-0.0016	-0.4914	0.8598	0.0111	2.1602	0.8303
K	0.0014	0.5240	0.7831	0.0015	0.2231	1.0542
KMX	-0.0021	-0.5794	0.8488	0.0131	1.4012	0.3991
KO	0.0011	0.4068	0.7893	0.0012	0.1943	0.9751
LUK	-0.0019	-0.5709	0.9191	0.0037	0.6763	0.9429
M	-0.0023	-0.5910	0.9739	0.0058	1.1263	0.8586
MAA	0.0004	0.1179	0.9160	0.0066	1.3415	0.8622
MAR	-0.0003	-0.1041	0.8989	0.0038	0.8381	0.8903
MAT	-0.0002	-0.0513	0.8368	0.0067	0.9796	1.0115
MCD	0.0023	0.8480	0.8081	-0.0001	-0.0186	1.1001
MCK	0.0000	0.0147	0.7907	0.0050	0.9277	0.8569
MMM	0.0008	0.2882	0.8214	0.0042	0.8624	0.8722
MOS	0.0002	0.0493	0.9418	0.0046	0.6730	0.7742
MRK	-0.0006	-0.1998	0.8359	0.0013	0.2046	1.0047
MSFT	-0.0001	-0.0578	0.8398	0.0055	1.0764	0.8883
MTB	-0.0023	-0.6226	0.8445	0.0097	1.7789	0.7815
NKE	0.0002	0.0751	0.8854	0.0058	1.0900	0.8894
NOC	0.0000	0.0111	0.7864	0.0006	0.0830	1.0176

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
NTAP	0.0000	0.0093	0.9129	0.0112	1.6203	0.6216
NVDA	-0.0054	-1.4171	0.8994	0.0141	2.1349	0.6500
ORCL	0.0007	0.2829	0.8487	0.0074	1.8217	0.9290
PEG	0.0012	0.5061	0.8300	-0.0033	-0.4112	1.1034
PFE	0.0015	0.6007	0.8123	-0.0019	-0.2558	1.1424
PG	0.0014	0.5332	0.7819	-0.0013	-0.1563	1.1267
PH	0.0001	0.0472	0.8772	0.0018	0.3628	0.9778
PHM	0.0045	1.0141	0.9700	-0.0043	-0.4639	1.2478
PNC	-0.0041	-0.9292	0.8801	0.0153	2.0338	0.6317
PPL	-0.0003	-0.1032	0.8209	-0.0001	-0.0093	1.1299
PSA	0.0022	0.6733	0.9157	0.0010	0.1763	1.1099
PVH	-0.0037	-1.0899	0.8812	0.0179	2.4697	0.6110
PXD	-0.0027	-0.8392	0.8801	0.0169	1.6006	0.3589
RE	-0.0009	-0.2756	0.8180	0.0056	0.8612	1.0841
REG	-0.0010	-0.2697	0.9226	0.0007	0.0901	1.2703
RL	-0.0008	-0.2453	0.9079	0.0126	2.1671	0.6373
SBUX	-0.0012	-0.4355	0.8802	0.0105	1.4784	0.5979
SCHW	0.0000	-0.0058	0.9030	0.0037	0.6807	1.0592
SIG	-0.0030	-0.7361	0.8745	0.0170	1.5892	0.4456
TGT	-0.0007	-0.2062	0.8656	0.0059	1.2860	0.9394
TMK	0.0004	0.1364	0.8264	0.0008	0.1306	1.0306
TRV	0.0001	0.0255	0.8514	0.0054	0.7734	1.1227
TXN	-0.0013	-0.4539	0.8191	0.0065	1.5645	0.8196
UNH	-0.0016	-0.4865	0.8234	0.0030	0.4493	0.9778
UTX	0.0013	0.5223	0.8287	0.0018	0.3674	0.9672
VZ	0.0011	0.4217	0.8309	-0.0015	-0.1863	1.1475
WFC	-0.0013	-0.3277	0.9206	0.0095	1.6345	0.8523
WM	0.0019	0.7392	0.8227	0.0007	0.0943	1.0828
WMT	0.0031	1.1128	0.8059	-0.0011	-0.1312	1.1319
XOM	0.0015	0.5846	0.8758	-0.0012	-0.1221	1.2473
ZION	-0.0029	-0.5915	0.8761	-0.0029	-0.3857	1.2288

Table A.8. Twenty percent decrease S&P500 (July 2009-June 2016)

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
A	0.0004	0.4696	0.9779	0.0005	0.2506	1.0371
AAPL	0.0018	2.3551	0.9730	0.0019	0.8813	0.8853
ABT	0.0003	0.3997	0.9666	0.0013	0.9931	0.9625
ADBE	0.0004	0.4031	0.9776	0.0001	0.0595	1.1124
ADI	0.0008	1.1917	0.9798	0.0000	-0.0228	0.9931
ADM	-0.0002	-0.2445	0.9650	0.0009	0.5179	1.0506
ADP	0.0009	1.4174	0.9738	0.0004	0.2816	1.0028
ADSK	0.0007	0.8404	0.9777	0.0004	0.1767	1.0437
AEE	0.0005	0.7705	0.9699	0.0000	-0.0019	0.9549
AES	0.0000	0.0561	0.9777	-0.0013	-0.9220	0.9919
AET	0.0006	0.7829	0.9729	0.0019	0.9243	1.1032
AFL	0.0005	0.6376	0.9712	-0.0014	-0.7862	1.0038
AIG	0.0012	1.1179	0.9670	-0.0019	-0.8941	1.0397
AKAM	0.0010	0.9628	0.9845	0.0010	0.3810	1.0080
ALK	0.0012	1.3538	0.9770	0.0026	0.8283	1.1792
ALL	0.0010	1.5315	0.9726	-0.0003	-0.1873	1.0064
AMG	0.0010	1.2670	0.9818	0.0008	0.3857	1.0548
AMZN	0.0014	1.4566	0.9648	-0.0004	-0.1974	1.0242
AON	0.0005	0.7760	0.9691	0.0013	0.6955	1.0520
APC	0.0001	0.1418	0.9864	0.0001	0.0615	0.9809
APH	0.0010	1.3022	0.9776	0.0003	0.1803	1.0415
ATVI	0.0008	1.0822	0.9637	-0.0008	-0.4911	1.0676
AVB	0.0016	2.2758	0.9690	-0.0006	-0.3393	0.8963
AVY	-0.0001	-0.1265	0.9655	0.0000	0.0134	1.0589
AXP	0.0006	0.8768	0.9784	-0.0004	-0.3164	1.0080
BA	0.0010	1.4232	0.9671	-0.0012	-0.4607	1.1162
BAX	0.0000	-0.0236	0.9730	0.0002	0.1362	0.9632
BBY	-0.0008	-0.7754	0.9527	-0.0001	-0.0148	1.1177
BDX	0.0004	0.6506	0.9695	0.0005	0.3935	1.0042
BEN	0.0001	0.0730	0.9776	0.0006	0.4275	1.0003
BIIB	0.0017	1.9514	0.9788	0.0031	1.2959	1.0913
BMY	0.0005	0.7015	0.9708	0.0018	0.9202	1.0222
BWA	0.0006	0.7106	0.9770	0.0023	1.1517	1.0599
C	0.0002	0.2603	0.9851	-0.0002	-0.0723	1.0350
CCI	0.0009	1.2411	0.9696	0.0007	0.5017	0.9588
CHRW	0.0002	0.3023	0.9714	0.0007	0.4461	0.9168
CI	0.0007	0.9771	0.9767	0.0017	0.7519	1.0925
CLX	0.0005	0.6336	0.9686	0.0004	0.2786	0.9965
CMCSA	0.0014	2.1084	0.9829	0.0006	0.3707	1.0151

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
CMS	0.0010	1.5279	0.9660	0.0001	0.0655	0.9655
COF	0.0007	0.9077	0.9836	0.0001	0.0889	0.9920
COG	0.0006	0.5469	0.9921	0.0017	0.6524	1.0444
COO	0.0013	1.5612	0.9663	0.0024	1.3918	1.0143
COP	0.0004	0.6274	0.9832	0.0001	0.0593	0.9932
COST	0.0012	1.7819	0.9639	0.0003	0.2128	0.9560
CPB	0.0003	0.4426	0.9660	-0.0001	-0.0819	0.9681
CSCO	-0.0002	-0.2919	0.9716	0.0007	0.4166	0.9735
CVX	0.0006	1.0206	0.9781	-0.0007	-0.5958	0.9279
CXO	0.0009	0.9596	0.9741	0.0007	0.3098	0.9765
DGX	0.0007	0.9671	0.9681	-0.0005	-0.3001	0.8868
DIS	0.0011	1.5931	0.9687	0.0012	0.8163	1.0283
DISH	0.0008	0.8606	0.9783	0.0017	0.7349	1.0891
DLTR	0.0018	2.1816	0.9719	0.0020	1.2590	0.9501
DOV	0.0004	0.5072	0.9778	0.0002	0.0941	1.0581
DRE	0.0010	1.3876	0.9692	-0.0007	-0.3825	0.9330
DTE	0.0007	1.0218	0.9687	0.0003	0.2840	0.9604
DVN	-0.0006	-0.7933	0.9885	0.0004	0.2315	0.9497
EA	0.0005	0.5584	0.9674	0.0017	0.5829	1.1333
EFX	0.0011	1.6297	0.9740	0.0004	0.2676	1.0369
EIX	0.0007	0.9683	0.9662	0.0004	0.2952	0.9441
EMN	0.0012	1.5673	0.9910	-0.0005	-0.3501	1.0135
EQR	0.0017	2.4536	0.9696	-0.0008	-0.4789	0.9091
ES	0.0009	1.3851	0.9644	-0.0001	-0.0991	0.9539
ESS	0.0017	2.4431	0.9675	-0.0002	-0.1486	0.9312
ETFC	-0.0007	-0.7451	0.9818	0.0017	0.5560	1.1377
ETN	0.0004	0.5548	0.9790	0.0004	0.2274	1.0575
EW	0.0013	1.4825	0.9729	0.0028	0.7756	0.8249
EXC	-0.0001	-0.1363	0.9652	-0.0010	-0.4470	0.8705
F	0.0003	0.3607	0.9741	-0.0010	-0.4523	1.0524
FAST	0.0010	1.2729	0.9797	-0.0003	-0.1697	0.9505
FL	0.0016	1.8032	0.9712	0.0024	1.3763	0.9675
FLS	0.0004	0.4678	0.9832	-0.0006	-0.2882	1.0731
FOXA	0.0012	1.6453	0.9709	-0.0002	-0.1330	1.0536
FRT	0.0015	2.2592	0.9650	-0.0009	-0.6064	0.9309
GD	0.0004	0.5267	0.9714	0.0007	0.4123	1.0289

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
GE	0.0009	1.2703	0.9729	-0.0013	-0.9495	0.9730
GILD	0.0004	0.4550	0.9787	0.0030	1.0103	1.1557
GS	-0.0005	-0.8013	0.9744	0.0012	0.7390	0.9948
GWW	0.0007	1.0305	0.9693	0.0011	0.6776	0.9834
HAS	0.0000	0.0587	0.9669	0.0019	1.1334	1.0105
HCP	0.0014	2.0569	0.9640	-0.0022	-1.1477	0.8753
HD	0.0016	2.3190	0.9748	0.0009	0.5907	0.9978
HIG	-0.0001	-0.1413	0.9697	0.0003	0.1091	1.0966
HOLX	0.0008	0.9205	0.9870	0.0011	0.6702	0.9601
HPQ	-0.0015	-1.5810	0.9701	0.0003	0.1885	1.0728
HRL	0.0007	0.9864	0.9674	0.0015	0.8356	1.0385
HSY	0.0012	1.6805	0.9657	0.0002	0.1048	0.9790
IBM	0.0007	1.0641	0.9765	-0.0007	-0.3996	0.8995
INCY	0.0023	1.8947	0.9701	0.0001	0.0206	1.2003
INTC	0.0006	0.7982	0.9773	-0.0004	-0.2319	0.9674
IRM	0.0008	1.0037	0.9757	0.0003	0.1693	0.9154
IT	0.0013	1.7356	0.9729	0.0012	0.7491	1.0310
JNJ	0.0001	0.1539	0.9626	0.0006	0.4487	1.0102
JPM	0.0001	0.2242	0.9774	0.0001	0.0388	0.9791
K	0.0000	-0.0370	0.9641	0.0002	0.1338	0.9694
KMX	0.0005	0.6076	0.9693	0.0013	0.5172	1.0890
KO	0.0004	0.6255	0.9699	0.0002	0.1452	0.9351
LUK	0.0003	0.4189	0.9867	-0.0017	-1.0588	0.9665
M	0.0014	1.6257	0.9737	0.0012	0.7686	1.0088
MAA	0.0012	1.6881	0.9676	-0.0011	-0.7162	0.9082
MAR	0.0008	1.1216	0.9710	0.0020	1.1603	0.9997
MAT	0.0003	0.3680	0.9642	-0.0006	-0.3253	0.9684
MCD	0.0007	1.0136	0.9686	-0.0001	-0.0824	0.9375
MCK	0.0008	1.1022	0.9667	0.0014	0.6271	1.1012
MMM	0.0004	0.6318	0.9774	0.0008	0.5318	1.0250
MOS	0.0004	0.3909	0.9801	-0.0015	-0.6135	0.8536
MRK	0.0006	0.8730	0.9709	-0.0002	-0.1451	0.9601
MSFT	0.0004	0.5417	0.9846	-0.0003	-0.1970	0.9944
MTB	0.0010	1.3706	0.9706	-0.0009	-0.6256	0.9774
NKE	0.0009	1.1825	0.9791	0.0011	0.5468	1.0498
NOC	0.0007	1.0587	0.9703	0.0014	0.6656	1.0657

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
NTAP	-0.0002	-0.2614	0.9812	0.0010	0.4973	0.9487
NVDA	0.0003	0.2655	0.9911	-0.0006	-0.2886	1.0065
ORCL	0.0006	0.7530	0.9812	0.0007	0.4852	0.9552
PEG	0.0002	0.2950	0.9642	0.0002	0.1543	0.9385
PFE	0.0005	0.7543	0.9678	0.0007	0.4843	0.9678
PG	0.0003	0.4651	0.9737	0.0000	0.0253	0.9656
PH	0.0005	0.6932	0.9804	0.0007	0.4270	1.0210
PHM	0.0010	0.8500	0.9825	-0.0001	-0.0431	0.9678
PNC	0.0006	0.8502	0.9712	-0.0002	-0.1171	0.9797
PPL	0.0000	-0.0144	0.9631	0.0001	0.0483	0.9300
PSA	0.0015	2.2236	0.9701	-0.0003	-0.2978	0.9499
PVH	0.0011	1.0943	0.9696	0.0000	-0.0020	0.9974
PXD	0.0011	1.2197	0.9918	0.0000	-0.0152	1.1038
RE	0.0004	0.5629	0.9718	0.0011	0.7723	1.0120
REG	0.0014	1.9143	0.9704	-0.0009	-0.5541	0.9187
RL	0.0005	0.5932	0.9692	0.0003	0.1783	0.9426
SBUX	0.0012	1.5492	0.9685	0.0017	0.9489	1.0384
SCHW	-0.0007	-0.8649	0.9866	0.0020	0.7587	1.0992
SIG	0.0013	1.6285	0.9721	0.0012	0.5316	1.0843
TGT	0.0009	1.2203	0.9713	0.0001	0.0477	0.8961
TMK	0.0008	1.2751	0.9708	0.0007	0.4601	1.0373
TRV	0.0004	0.5912	0.9701	0.0011	0.8674	0.9726
TXN	0.0006	0.9272	0.9806	0.0005	0.3033	1.0534
UNH	0.0010	1.3473	0.9709	0.0020	1.2975	1.0105
UTX	0.0002	0.3458	0.9736	0.0006	0.4346	1.0100
VZ	0.0009	1.2724	0.9685	-0.0004	-0.3096	0.9371
WFC	0.0011	1.5487	0.9788	-0.0011	-0.7084	1.0068
WM	0.0006	0.8572	0.9666	-0.0006	-0.3934	1.0008
WMT	0.0006	0.8859	0.9741	0.0001	0.0822	0.9232
XOM	0.0005	0.8204	0.9751	-0.0008	-0.7064	0.9382
ZION	0.0012	1.2433	0.9722	-0.0021	-1.1091	1.0110

Table A.9. Twenty percent increase DJIA: (December 2007-June 2009)

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
AAPL	0.0016	0.6320	1.0064	-0.0068	-1.9474	0.9959
AXP	-0.0036	-0.9523	1.0513	-0.0046	-0.7903	1.1684
BA	-0.0012	-0.7017	0.9758	0.0009	0.3728	1.0417
CSCO	-0.0002	-0.1435	0.9862	0.0000	-0.0201	1.0304
CVX	0.0024	1.3103	1.0243	-0.0031	-1.1615	0.9665
DIS	-0.0003	-0.2239	1.0030	0.0011	0.5953	1.0320
GE	-0.0021	-0.9064	1.0306	-0.0061	-2.0460	1.0281
GS	-0.0052	-1.1327	1.0609	-0.0003	-0.0389	1.2050
HD	-0.0003	-0.1755	1.0001	0.0071	2.5852	1.0923
IBM	0.0001	0.0652	0.9746	0.0017	1.0180	1.0070
INTC	0.0000	-0.0088	0.9845	-0.0007	-0.2671	1.0339
JNJ	0.0011	0.8776	0.9887	0.0021	1.0690	0.9457
JPM	-0.0031	-0.6614	1.1431	-0.0035	-0.3652	1.2086
KO	-0.0004	-0.2723	0.9645	0.0025	0.8228	0.9239
MCD	0.0024	1.7287	0.9611	0.0037	1.7864	1.0008
MMM	0.0000	-0.0273	0.9929	0.0008	0.4581	0.9914
MRK	0.0012	0.6202	1.0110	-0.0047	-1.0528	0.9662
MSFT	0.0010	0.6279	0.9854	-0.0026	-0.9276	1.0262
NKE	-0.0006	-0.2828	1.0259	0.0046	1.5331	1.1064
PFE	0.0010	0.8517	0.9868	0.0019	0.9751	0.9718
PG	0.0023	1.7208	0.9591	-0.0016	-0.8037	0.9486
TRV	0.0017	0.4517	1.1254	-0.0020	-0.6979	1.1038
UNH	0.0019	0.5768	0.9640	-0.0040	-1.0321	1.0252
UTX	0.0000	-0.0278	1.0079	0.0013	0.7145	0.9693
V	0.0016	0.7241	1.0057	-0.0010	-0.2098	1.0758
VZ	0.0010	0.6552	1.0001	0.0019	0.9194	0.9707
WMT	0.0017	1.2049	0.9670	0.0047	1.8229	1.0319
XOM	0.0024	1.3370	1.0376	-0.0019	-0.7405	0.9596

Table A.10. Twenty percent increase DJIA: (July 2009-June 2016)

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
AAPL	0.0013	2.4008	1.0106	0.0031	0.9554	0.7255
AXP	0.0001	0.1231	1.0180	0.0054	1.1201	0.8912
BA	0.0000	-0.0096	1.0037	0.0026	1.1064	1.1109
CSCO	-0.0002	-0.3849	1.0063	-0.0003	-0.2546	0.9403
CVX	-0.0003	-0.9751	0.9913	-0.0009	-0.7946	0.9967
DIS	0.0009	1.9626	1.0024	0.0015	1.4118	1.0140
GE	-0.0004	-1.1620	0.9946	0.0007	0.9854	1.0143
GS	-0.0009	-1.1285	1.0021	0.0055	1.0752	0.8765
HD	0.0007	1.6527	0.9977	0.0021	2.3752	1.0451
IBM	-0.0001	-0.2264	1.0033	-0.0007	-0.4659	0.8771
INTC	0.0000	0.0709	1.0110	0.0000	-0.0343	0.9320
JNJ	0.0001	0.2257	0.9950	-0.0012	-1.1754	1.0640
JPM	-0.0005	-0.6595	1.0008	0.0045	1.0652	0.8982
KO	0.0000	0.1165	0.9961	-0.0011	-1.3739	0.9606
MCD	0.0000	-0.0710	0.9970	-0.0012	-0.8898	0.9985
MMM	0.0001	0.3822	1.0097	0.0011	0.9967	1.0084
MRK	0.0000	0.0598	1.0051	-0.0005	-0.6869	0.9610
MSFT	-0.0001	-0.3432	1.0113	0.0004	0.3602	0.9752
NKE	0.0006	1.1622	0.9964	0.0018	1.0538	1.0810
PFE	-0.0002	-0.5472	0.9855	0.0002	0.2070	1.0598
PG	-0.0003	-0.9770	0.9960	-0.0009	-0.8054	1.0520
TRV	0.0002	0.5579	1.0016	0.0017	1.7313	1.0393
UNH	0.0013	2.3561	1.0077	-0.0002	-0.1963	1.0165
UTX	-0.0003	-1.1450	0.9960	0.0014	1.4241	1.0302
V	0.0007	1.2888	1.0028	0.0027	1.0213	0.9989
VZ	0.0002	0.4817	0.9912	-0.0016	-1.1932	1.0146
WMT	-0.0001	-0.1564	0.9944	-0.0013	-0.9773	1.0025
XOM	-0.0003	-1.1993	0.9920	-0.0022	-1.1768	1.0555

Table A.11. Twenty percent decrease DJIA: (December 2007-June 2009)

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
AAPL	-0.0023	-1.0092	0.9918	0.0050	1.0959	1.1150
AXP	-0.0021	-1.1061	0.9997	-0.0005	-0.1952	1.0483
BA	0.0000	0.0193	0.9896	-0.0038	-1.4375	0.9772
CSCO	-0.0015	-0.9892	0.9989	0.0030	1.4499	0.9688
CVX	0.0009	0.5115	1.0178	0.0023	0.7156	1.0034
DIS	0.0000	-0.0337	1.0192	-0.0001	-0.0314	0.9379
GE	-0.0029	-1.4690	1.0295	-0.0038	-0.7793	1.0499
GS	-0.0025	-1.0816	1.0155	0.0001	0.0276	1.0000
HD	0.0028	1.5087	1.0119	-0.0039	-1.3587	1.0316
IBM	-0.0003	-0.2266	0.9807	0.0022	1.1239	0.9760
INTC	-0.0001	-0.0548	0.9944	-0.0013	-0.4894	0.9976
JNJ	0.0022	1.8698	0.9863	-0.0006	-0.2736	0.9378
JPM	-0.0018	-0.7086	1.0369	0.0005	0.0979	1.1690
KO	0.0009	0.5148	0.9528	-0.0008	-0.3113	0.9671
MCD	0.0031	2.4322	0.9755	0.0010	0.3844	0.9234
MMM	-0.0006	-0.4809	0.9954	0.0026	1.6298	0.9710
MRK	0.0000	-0.0011	1.0166	-0.0002	-0.0572	0.9346
MSFT	-0.0008	-0.4928	0.9997	0.0020	0.7346	0.9693
NKE	0.0008	0.4068	1.0460	-0.0006	-0.1666	0.9960
PFE	0.0014	1.2463	0.9934	0.0009	0.5057	0.9200
PG	0.0018	1.4811	0.9634	-0.0001	-0.0346	0.9331
TRV	0.0013	0.6254	1.0427	0.0020	0.7407	0.9878
UNH	-0.0019	-0.6390	0.9783	0.0065	1.1159	0.9852
UTX	-0.0007	-0.6202	0.9914	0.0039	2.0266	1.0489
V	0.0010	0.3954	1.0208	-0.0003	-0.0923	1.0238
VZ	0.0023	1.4683	1.0003	-0.0013	-0.5639	0.9537
WMT	0.0043	3.3145	0.9866	-0.0041	-1.4204	0.9285
XOM	0.0016	0.9205	1.0321	0.0019	0.6479	0.9761

Table A.12. Twenty percent decrease DJIA: (July 2009-June 2016)

Tickers	alpha(tr)	alpha t-value(tr)	beta(tr)	alpha(te)	alpha t-value(te)	beta(te)
AAPL	0.0020	1.6968	0.9432	0.0020	1.0990	0.8667
AXP	0.0004	0.5283	0.9594	0.0005	0.5884	1.0470
BA	0.0000	0.0957	0.9887	0.0015	0.7112	1.1628
CSCO	0.0000	0.0519	0.9910	-0.0009	-0.6784	0.9725
CVX	-0.0003	-0.6974	1.0062	-0.0008	-1.0567	0.9585
DIS	0.0010	2.1311	0.9940	0.0008	0.9571	1.0373
GE	-0.0004	-1.0328	0.9946	0.0004	0.4978	1.0163
GS	0.0000	-0.0117	0.9471	0.0000	-0.0230	1.0455
HD	0.0010	2.2530	0.9993	0.0009	1.1046	1.0464
IBM	0.0000	0.0541	0.9874	-0.0003	-0.2311	0.9032
INTC	0.0005	0.8119	0.9905	-0.0012	-1.3937	0.9765
JNJ	-0.0004	-0.8969	1.0124	-0.0001	-0.1294	1.0271
JPM	-0.0001	-0.1907	0.9582	0.0006	0.8254	1.0287
KO	-0.0001	-0.1930	0.9975	-0.0005	-0.6572	0.9529
MCD	0.0000	-0.0870	1.0180	-0.0008	-1.0548	0.9441
MMM	0.0002	0.5577	0.9926	0.0006	0.7717	1.0530
MRK	0.0000	0.0545	1.0035	-0.0002	-0.3527	0.9597
MSFT	0.0004	0.7772	0.9919	-0.0012	-1.5106	1.0222
NKE	0.0003	0.4947	0.9898	0.0020	1.3659	1.1082
PFE	-0.0003	-0.5318	1.0058	0.0002	0.2966	1.0156
PG	-0.0006	-1.1950	1.0200	-0.0002	-0.3927	0.9959
TRV	-0.0003	-0.9321	1.0066	0.0008	1.4451	0.9984
UNH	0.0007	1.3902	1.0010	0.0013	1.3358	1.0353
UTX	-0.0001	-0.2963	0.9911	0.0004	0.4659	1.0469
V	0.0006	0.6455	0.9674	0.0027	1.7044	1.0905
VZ	-0.0004	-0.7230	1.0144	0.0001	0.1666	0.9566
WMT	-0.0003	-0.6351	1.0148	-0.0002	-0.3354	0.9501
XOM	-0.0009	-1.3926	1.0288	-0.0004	-0.6803	0.9669