IS THE FAMA-FRENCH THREE-FACTOR MODEL BETTER THAN THE CAPM?

by

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ABSTRACT

This paper compares the performance of the Fama-French three-factor model and the Capital Asset Pricing Model (CAPM) using two data sets. One set of portfolios is formed on size and the book-to-market equity ratio and another set is formed on industry. Using these two sets of portfolios, time series and cross-sectional tests are conducted over two different periods. The tests cannot unambiguously conclude that the three-factor model is better than the CAPM. Moreover, different data sets and periods yield different test results.

DEDICATION

To my mother

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1 INTRODUCTION

People always search for new tools or better techniques that allow a job to be completed faster and better. It applies to every field including the finance field. Capital Asset Pricing Model (CAPM) is used to calculate the cost of capital and measure portfolio performance since 1970s. In 1990s, Fama and French show the CAPM is wrong and they propose a better three-factor model. One would expect practitioners switching to the better asset pricing model immediately. However, in a survey conducted by Graham and Harvey (2001), 73.5% of 392 U.S. CFOs relies to some extent on the CAPM when estimating the cost of equity. Brounen, Abe de Jong and Koedijk (2004) conduct a similar survey for 313 European firms and around 45% of on average relies on the CAPM. Why practitioners do not rely on the three-factor model as Fama and French (2004) claimed? There are many possible answers. The practitioners may not know the three-factor model; or it is not cost effective to collect the extra information required by the three-factor model; or the practitioners think the three-factor model does not help much, i.e. the Fama-French three-factor model is not always better than the CAPM.

The objective of this paper is to investigate the possibility of the third answer. Time series tests and cross-sectional tests on two models are conducted over two different time periods and two different portfolios sets. The tests cannot unambiguously conclude that the three-factor model is better than the CAPM. Moreover, different portfolios sets and time periods yield different test results.

The CAPM is developed by Sharpe (1964) and Lintner (1965). The CAPM asserts that the correct measure of riskiness is a measure called market beta, and the risk premium per unit of riskiness is the same across all assets. The CAPM states a linear relationship between the expected risk premium on individual assets and their "systematic risk", or market beta. According to the CAPM, the expected returns vary across assets only because the assets' market betas are different. If the CAPM is true, the model has important implications for problems in capital budgeting, cost benefit analysis, portfolio selection, and for other economic problems requiring knowledge of the relation between risk and return.

A number of empirical tests including Black, Jensen and Scholes (1972) and Fama and MacBeth (1973) support the CAPM. According to the CAPM, expected returns vary across assets only because the assets' market betas are different and there is a linear relationship between these two variables. Black, Jensen and Scholes (1972) test the CAPM by investigating whether the intercepts of the cross-sectional and time series regressions of excess return on market beta are zero. The CAPM also predicts the differences in expected return across securities are entirely explained by differences in market beta, other variables should add nothing to the explanation of expected return. So another way to test the CAPM is to check whether other asset-specific characteristics which are unrelated to market beta can explain the cross-sectional returns.

Fama and MacBeth (1973) add two explanatory variables to the month-by-month cross-sectional regressions of returns on market beta. The additional variables are squared market beta and residual variances from regressions of returns on the market. Squared market beta is used to test whether the relation between expected return and market beta is linear. Residual variances are used to test whether the market beta is the only measure of risk needed to explain expected returns. The results show both variables are not useful in explaining the average returns.

However, several deviations or "anomalies" from the CAPM were discovered during the 1980s and 1990s. They are considered as challenges to the validity of the CAPM by arguing market beta does not suffice to explain expected stock returns. Some anomalies are listed here: earnings-price ratio, size, leverage and the book-to-market equity ratio. Basu (1977) shows that when common stocks are sorted on earnings-price ratios, E/P, future returns on high E/P stocks are higher than those predicted by the CAPM. Banz (1981) documents a size effect: stocks of small (low market-value) stocks earned a higher return than predicted by the CAPM. Small stocks have higher betas and higher average returns than large stocks, but the difference is higher than what the CAPM predicted. Bhandari (1988) illustrates leverage is positively related to expected stock returns. Leverage is measured as the book value of debt over market value of equity. High debt-equity stocks have returns that are too high relative to their market betas. Fama and French (1992) state the earlier findings from other researchers: stocks with high book-to-market equity ratios (BE/ME, the ratio of the book value of a common stock to its market value) have high average returns that are not captured by their market betas. The above results show some asset characteristics other than market beta have explanatory power on expected returns and these anomalies lead to the challenges launched by Fama and French later.

By using the cross-sectional regression approach Fama and MacBeth (1973) used, Fama and French (1992) confirm that size, earning-price ratio, debt-equity and the book-to-market equity ratio have explanatory power to stock average returns. They also find market beta alone has no power to explain average returns. Fama and French (1993, 1996) use time series approach to get the same conclusion. Fama and French (1993) argue that though size and the book-to-market equity ratio are not themselves state variables, higher average returns on small stocks and high book-to-market stocks reflect unidentified state variables other than market betas that price the undiversifiable risks in returns.

Fama and French (1993, 1996) propose a three-factor model for expected returns. The factors include the return on a stock index, excess return on a portfolio of small stocks over a portfolio of large stocks, and excess return on a portfolio of high book-to-market stocks over a portfolio of low book-to-market stocks. Fama and Frech (1996) state the empirical tests on portfolios formed on size and the book-to-market equity ratio showing the average absolute pricing errors of the CAPM are large, and they are three to five times those of the three-factor model. Fama and French (1997) use portfolios formed on industry to test two models and they do not revise their position on the superiority of the three-factor model.

According to Fama and French, the three-factor model captures the performance of stock portfolios grouped on size and the book-to-market equity ratio. Fama and French (1993, 1996) have interpreted their three-factor model as evidence for a risk premium, or a “distress premium”. Small stocks with high book-to-market ratios are firms that have performed poorly and are vulnerable to financial distress, and investors command a risk premium for this reason.

There is considerable debate about the power of the Fama-French three-factor model. Some argue the “distress premium” found in the three-factor model is the result of (i) survivor bias, (ii) data snooping. Kothari, Shanken, and Sloan (1995) argue that average returns on high book-to-market portfolios are overstated because the data set is more likely to include distressed firms that survive and to miss distressed firms that fail. Other researchers argue that the premium may be the result of data-snooping. Fama and French (1996) refute these arguments.

Although Fama and French use empirical results to emphasis the importance of their three-factor model, they do not explain why “distress risk” is priced. Moreover, the model has difficulties to explain the continuation of short-term returns (i.e. momentum effect). Fama and French (1996) do not attempt to give a rational risk-based explanation for the momentum effect. Instead they argue that it may be the result of data snooping or survivor bias.

In this paper the Fama-French three-factor model and the CAPM will be examined using the same 25 portfolios formed on size and the book-to-market equity ratio Fama and French (1993,1996) used and a 30 portfolios formed on industries that are similar to the one used in Fama and French (1997) (They use 48 industry portfolios instead). Fama and French (1992) use the same analysis tools Fama and MacBeth (1973) used but reach very different conclusion: the 1973 paper supports the CAPM while the 1992 paper does not. Fama and French attribute the different conclusions to the different sample periods used in the two studies. In this paper two periods (1926-2004 and 1963-2004) are used to test whether the results are time specific or not. The comparison principals used in this paper are the same average absolute pricing errors test, t-test and F test Fama and French used in their papers.

The paper proceeds as follows. Section 2 gives theoretical background of the CAPM and the Fama-French three-factor model. Section 3 describes the empirical tests of the asset pricing models. Section 4 introduces the data sets used. Section 5 presents the numerical results and Section 6 is the conclusions.

2 THEORY: THE CAPM AND THE FAMA-FRENCH THREE-FACTOR MODEL

2.1 The CAPM

The CAPM is concerned with the pricing of assets in equilibrium. The CAPM tells us how investors determine expected returns, and asset prices, as a function of risk. The model bases on the idea that not all risks should affect asset prices. In particular, a risk that can be diversified away when held along with other investments in a portfolio is not a risk at all. Only those "systematic risk" is counted when determining the price.

The Sharpe-Litner CAPM model is the extension of one period mean-variance portfolio models of Markowitz (1959) and Tobin (1958) with the following assumptions: (i) investors choose their investment portfolios on the basis of expected return and variance of return over single period; (ii) investors have the same estimates of mean, variance and covariance of all assets; (iii) the capitals markets have no transaction costs; (iv) all assets are perfectly divisible; (v) no restriction on short sales; (vi) investors can borrow and lend unlimited amount at a risk free rate. Jensen (1972) shows a simple derivation of the model.

The CAPM equation (also known as the security market line) is

$$E(R_i) = R_f + \beta_i(E(R_m) - R_f) \quad (1)$$

where $E(R_i)$ is expected return (or cost of equity) on asset i, R_f is the risk free rate, $E(R_m)$ is expected return on market portfolio and market beta β_i is the measure of "systematic risk" of the asset i that defined as $\frac{\text{cov}(R_i, R_m)}{\text{var}(R_m)}$. Market portfolio consists of an investment in every asset available in the world in proportion to its value. The CAPM equation (1) shows expected return is related to the covariance of asset with the market, or "systematic risk". Given investors are risk averse, high risk (high market beta) stock should have higher expected return than low risk (low market beta) stocks. If the CAPM is true, the cost of capital can be predicted from knowledge of market beta β_i, market return R_m and the risk free rate R_f. Market beta β_i is measured as the slope in the regression of excess return R_i - R_f on market's excess return R_m - R_f. Market beta of the market portfolio is equal to 1.

Notice that (1) can become

$$E(R_i) - R_f = \beta_i(E(R_m) - R_f) \qquad (2)$$

When market beta of an asset is zero, excess return is zero. Also when market beta is one, excess return is the market premium. (2) actually forms the base of the empirical tests that reviewed later.

2.2 The Fama-French three-factor model

Fama and French (1992) argue size and the book-to-market equity ratio capture the cross-sectional variation in average stock returns associated with size, the earning-price ratio, the book-to-market equity ratio and leverage. The book-to-market equity ratio has stronger explanatory power than size but the book-to-market equity ratio cannot replace size in explaining average returns. Fama and French (1993, 1996) propose a three-factor model for expected returns in which the variables including the return on a stock index, excess returns on a portfolio of small stocks over a portfolio of large stocks, and excess return on a portfolio of high book-to-market stocks over a portfolio of low book-to-market stocks.

$$E(R_i) - R_f = \beta_{im}(E(R_m) - R_f) + \beta_{is}E(SMB) + \beta_{ih}E(HML) \qquad (3)$$

In the equation, SMB (small minus big) is the difference of the returns on small and big stocks, HML (high minus low) is the difference of the returns on high and low book-to-market equity ratio (BE/ME) stocks, and the betas are the factor sensitivities of the state variables. These betas are the slopes in the multiple regression of $R_{it} - R_{ft}$ on $R_{mt} - R_{ft}$, SMB_t and HML_t. Fama and French argue if asset pricing is rational, size and BE/ME must proxy for risk. SMB captures the risk factor in returns related to size, HML captures the risk factor in returns related to the book-to-market equity and the excess market return, $R_m - R_f$ captures the market factor in stock returns.

It is possible the explanatory powers of size and the book-to-market equity ratio are rooted from the correlation between these state variables and market beta. However, Fama and French (1992) show that it is unlikely as they find market betas alone has no power to explain average returns. They also find the averages of the monthly cross-sectional correlations between market betas and the values of these two state variables for individual stocks are all within 0.15.

Fama and French (1995) show weak firms with persistently low earnings tend to have high BE/ME and positive slopes on HML; and strong firms with persistently high earnings have low BE/ME and negative slope on HML. They suggest HML captures the variation of the risk factor that is related to relative earnings performance. Stocks with low long-term returns (losers) tend to have positive SMB and HML slopes (they are smaller and relatively financially distressed) and higher future average returns. Conversely, stocks with high long-term returns (winners) tend to have negative slopes on HML and low future returns. Fama and French also show the existence of covariation in the returns on small stocks that is not captured by the market betas and is compensated in average returns. Fama and French (1993, 1996) have interpreted their three-factor model as evidence for a "distress premium". Small stocks with high book-to-market ratios are firms that have performed poorly and are vulnerable to financial distress, and hence investors command a risk premium.

However, the model cannot explain the momentum effect. Fama and French report stocks that having low short short-term past returns tend to load positively on HML and high short short-term past returns load negatively on HML. The situations are just like long-term losers and long-term winners stated above. The Fama-French three-factor model predicts the reversal of future returns for short-term winners and losers. Hence, the continuation of short-term returns is left unexplained by the model.

3 TESTS[1]

The CAPM states a relation between the expected risk premium on individual assets and their "systematic risk". The expected excess return on a particular asset is equal to the expected excess return on market portfolio multiply by the systematic risk (market beta) of that particular asset. The risk premium per unit of riskiness is the same across all assets. If expected returns and market betas were known, the empirical test of the CAPM would be simple. We just need to plot expected return against market beta. However, neither of these is known. We have to form estimates of expected return and market beta. The empirical tests of the Fama-French three-factor model also face the same problem. To test the CAPM, and the three-factor model, we need to rely on the assumption that the ex-post distribution from which returns are drawn is normally distributed, i.e. we assume excess returns and residual terms are normally distributed random variables.

The simplest test of the CAPM is to run a cross-sectional regression of average excess return of a security on its market beta. If the model is correct, the intercept term should be zero and the slope of market beta is the expected value of the excess return of market portfolio. However, as market beta is unknown, we need to use the estimated value of market beta. It introduces measurement error problem as the ordinary least square estimators will be

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[1] Professor Robert Grauer provides an excellent assignment notes regarding the tests of the asset pricing models.

biased. Moreover, the direct test by estimating excess return against market risk premium of a security does not make use of the information available on a large number of securities. We wish to group our securities such that the measurement error can be solved (or at least reduced) and obtain the maximum possible dispersion of market beta. However, we cannot just group the securities on their estimated beta. Such a procedure would introduce a selection bias into the tests. It is because high beta portfolio would tend to have positive measurement errors in market betas. Black, Jensen and Scholes (1972) propose a grouping solution to the measurement errors problem. An instrumental variable, the previous period's estimated beta, is used to group security for the next year. Notice that if an asset model holds, there are no grouping methods can make the intercepts of the regressions statistically different from zero. Fama and French (1993) use the similar concept as what Black, Jensen and Scholes (1972) suggested and introduce portfolios formed on size and book-to-market equity ratio. Fama and French (1997) introduce industry portfolios formed on the nature of the business. However, they do not discuss in detail the theoretical supports for this type of grouping.

If we aggregate the data on a large number of securities, the residuals are not cross-sectional independent. It is because the abnormal returns across assets are varying considerably together. Fama and MacBeth (1973) purpose a method to correct this problem in cross-sectional regressions. They have combined the time series and cross-sectional steps to investigate whether the risk premia of the state variables in the regression are zero.

There was still a debate about the validity of the statistical inference of the intercept terms in time series regressions. Gibbons, Ross and Shanken (1989) provide a finite sample test to determine whether the intercepts of a set of time series regressions are all zero. The F-test they suggested has exact small sample properties.

Although time series regressions and cross-sectional regressions are used to serve the same goal: testing the asset pricing models with empirical data, the approaches are not the same. The difference is easier to explain in the CAPM case as the model only involves one variable. In time series regressions, a theoretical security market line is constructed in excess return-market beta dimensions and the vertical distance between every asset (or portfolio) and the security market line (i.e. the pricing error) is measured. In cross-sectional regressions, a "best-fit" security market line is constructed by minimizing the pricing errors of all assets (or portfolios) in least-squares.

Now the tests will be stated explicitly in equations form. Notice that the tests apply to both the 25 portfolios formed on size and book-to-market equity ratio and the 30 industry portfolios. Assume there are N assets (or portfolios) and the time period has T observations.

3.1 The time series tests

Black, Jensen and Scholes (1972) introduce a test series test of the CAPM. The test is based on the time series regressions of excess portfolio return on excess market return

$$R_{jt} - R_{ft} = \alpha_j + \beta_j(R_{mt} - R_{ft}) + e_{jt} \qquad (4)$$

where R_{jt} is the rate of return on asset (or portfolio) j at time t, R_{ft} is the riskfree rate of interest at time t, and R_{mt} is the rate of return on the market portfolio at time t. In total there are N time series regressions. The intercept α_j is the difference in the expected return of the asset (or portfolio) j estimated from its time series average with the expected return predicted by the CAPM. So α_j is the measure of abnormal performance or the pricing error of asset (or portfolio) j. If the CAPM describes expected returns and a correct market portfolio proxy is selected, the regression intercepts of all assets (or portfolios) are zero.

To test the Fama-French three-factor model, Fama and French run the regressions of excess asset (or portfolio) return on excess market return $R_{mt} - R_{ft}$, SMB and HML

$$R_{jt} - R_{ft} = \alpha_j + \beta_j(R_{mt} - R_{ft}) + s_j SMB_t + h_j HML_t + e_{jt} \qquad (5)$$

where R_{jt} is the rate of return on asset (or portfolio) j at time t, R_{ft} is the riskfree rate of interest at time t, R_{mt} is the rate of return on the market portfolio at time t, SMB_t (small minus big) is the difference of the returns on small and big assets (or portfolios) at time t and HML_t (high minus low) is the difference of the returns on high and low BE/ME assets (or portfolios) at time t. The intercept α_j in equation (5) is the measure of abnormal performance or pricing error. In total there are N time series regressions. If the three factor model describes expected returns, the regression intercepts are all equal to zero.

Notices that the asset model is true only when all the alphas in N time series regressions are zero; not just some of them and not only the average is zero. Hence looking at the individual regression t-test does not help. Moreover, a finite sample joint test of all the alphas are zero is required. Other tests like Wald, Lagrange Multiplier (LM) and Likelihood Ratio (LR) tests are only valid asymptotically.

The Gibbons, Ross and Shanken F-test tests the joint significance of the estimated value for α_j across a finite sample of all N time series equations, i.e. test the null hypothesis α_j = 0 for all j in (4) or (5). Let $\alpha = (\alpha_1,...,\alpha_N)'$ and $\varepsilon_t = (\varepsilon_{1t,...}\varepsilon_{Nt})'$ be N-vectors containing the intercepts and error terms from (4). Assume $E(\varepsilon_t) = 0, E(\varepsilon_t\varepsilon_t') = \Sigma, \mathrm{cov}(r_{mt}, \varepsilon_t) = 0$ and ε_t are jointly normally distributed. A test statistics J is constructed.

$$J = \frac{(T-N-1)}{N}\left(1+\frac{\hat{\mu}_m^2}{\hat{\sigma}_m^2}\right)^{-1}\hat{\alpha}'\,\hat{\Sigma}^{-1}\hat{\alpha} \qquad (6)$$

where $\hat{\mu}_m$ and $\hat{\sigma}_m$ are the average excess return of the market portfolio proxy, i.e. the market return minus the risk-free rate and the standard deviation of the excess return of the market portfolio chosen.

Gibbons, Ross and Shanken (1989) show that under the null hypothesis, the J in equation (8) is unconditionally F distributed with N degrees of freedom in the numerator and T-N-1 freedom in the denominator.

3.2 The cross-sectional tests

A simple cross-sectional regression is one regression of average excess return on market beta across assets (or portfolios). Average excess return of asset (or portfolio) j is the mean of its excess return in the defined period and market beta β_j is the slope in the time series regression of asset j excess return $R_j - R_f$ on the market's excess return $R_m - R_f$. However, this cross-sectional regression does not do the trick as the residuals are not cross-sectional independent. Fama and MacBeth suggest a way to get around the problem.

To test the CAPM, Fama-MacBeth run the monthly cross-sectional regressions of excess return of the portfolio on the estimated beta

$$R_{jt} - R_{ft} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_j + e_{jt} \tag{7}$$

where R_{jt} is the rate of return on asset (or portfolio) j at time t, R_{ft} is the riskfree rate of interest at time t and the $\hat{\beta}_j$ is estimated from the time series regression (4). In total there are T cross-sectional regressions. Notice that if the constant $\hat{\beta}_j$ from (4) is estimated from the full-period time series regression, the averages of the γ_{jt}'s (j = 0,1) are the same as those obtained by running a simple one cross-sectional ordinary least square regression of average excess return on market betas. Hence we can get the cross-sectional estimates and get around the error terms correlation problem at the same time. Notice that if the CAPM is true, the intercept, γ_0, is zero and the average slope, $\bar{\gamma}_1$, is the market portfolio's risk premium.

To test the Fama-French three-factor model, the same methodology is applied. In each month, Fama-MacBeth run the cross-sectional regression of excess return of the portfolio on the estimated beta, SMB and HML

$$R_{jt} - R_{ft} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_j + \gamma_{2t}\hat{h}_j + \gamma_{3t}\hat{s}_j + e_{jt} \qquad (8)$$

where R_{jt} is the rate of return on asset (or portfolio) j at time t, R_{ft} is the riskfree rate of interest at time t and the $\hat{\beta}_j$, $\hat{h}_j$, $\hat{s}_j$ are estimated from the time series regression equation (5). In total there are T cross-sectional regressions. Notice that if the constant $\hat{\beta}_j$, $\hat{h}_j$, $\hat{s}_j$ from (5) are estimated from the full-period time series regression, the averages of the γ_{jt}'s (j = 0,1,2,3) are the same as those obtained by running the cross-sectional ordinary least square regression of average excess return on those variables.

The statistical inference can be done by using the Fama-Macbeth adjusted t-statistic

$$t(\overline{\gamma_j}) = \frac{\overline{\gamma_j}}{sd(\overline{\gamma_j})/\sqrt{T}} \qquad (9)$$

where $\overline{\gamma_j}$ and $sd(\overline{\gamma_j})$ are the average and standard deviation of the γ_{jt}'s and T is the number of time series observations.

4 DATA

All the variables are measured at monthly frequencies over the period from July 1926 to November 2004. The one-month United States Treasury bill rate is used as the risk free rate of interests. The excess return on the market, $r_{mt} - r_{ft}$, is the value-weight return on all NYSE, AMEX, and NASDAQ stocks minus the one-month Treasury bill rate.

The stock market data and detailed description of the 25 portfolios, the 30 equal-weighted industry portfolios, size factor (*SMB*), book-to-market factor (*HML*) and market excess return are available on Kenneth French's website[2]. Below are the review of the formation of the portfolios and the variables.

The formations of the 25 size-BE/ME portfolios are as follows. Each year NYSE, Amex, and NASDAQ stocks are allocated to five size quintiles. Size is measured as the market equity, ME, (i.e. stock price times shares outstanding) and NYSE size quintile breakpoints are formed at the end of June. Similarly, NYSE quintile breakpoints for the book-to-market equity, BE/ME, are used to allocate NYSE, Amex, and NASDAQ stocks to five book-to-market equity quintiles. The book equity, BE, is the book value of stockholders' equity, plus balance sheet deferred taxes and investment tax credits, minus the book value of preferred equity. The Book-to-market equity, BE/ME, for a stock is the BE for the fiscal year ending in calendar year t-1, divided by ME at the end of December of

[2] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

t-1. The 25 size-BE/ME portfolios are formed as the intersections of the five size and the five BE/ME groups.

The 30 industry portfolios are formed as follows. Each NYSE, AMEX, and NASDAQ stock is assigned to an industry portfolio at the end of June of year t based on its four-digit SIC code at that time, then each industry return from July of t to June of t+1 are computed. The detail definition of each industry is available on Kenneth French's website.

The Fama-French factors in the three-factor model are constructed using the 6 value-weight portfolios formed on size and the book-to-market equity ratio. First, 2 groups of stocks (Small and Big) formed on size (i.e. the market equity, ME). The size breakpoint for year t is the median NYSE market equity at the end of June of year t. Second, 3 groups of stocks (Value, Neutral and Growth) formed on the ratio of book equity to market equity (BE/ME). BE/ME of year t is the book equity for the last fiscal year end in t-1 divided by ME for December of t-1. The BE/ME breakpoints are the 30th and 70th NYSE percentiles. Then the 6 value-weight portfolios, which are constructed at the end of each June, are the intersections of 2 portfolios formed on size and 3 portfolios formed on BE/ME. Those six portfolios are labelled as Small Value, Small Neutral, Small Growth, Big Value, Big Neutral and Big Growth.

SMB (Small Minus Big) is the average return on the three small portfolios minus the average return on the three big portfolios,

SMB= 1/3 (Small Value + Small Neutral + Small Growth)

- 1/3 (Big Value + Big Neutral + Big Growth).

HML (High Minus Low) is the average return on the two value portfolios minus the average return on the two growth portfolios,

HML = 1/2 (Small Value + Big Value) - 1/2 (Small Growth + Big Growth).

5 RESULTS

The CAPM and the Fama-French three-factor model are empirically tested over two time periods: July 1926 to November 2004 and July 1963 to November 2004. In each period, two data sets are used: 1) The 25 portfolios formed on size and the book-to-market ratio, and 2) the 30 industries formed on the nature of the business. For each time-data set combination, the Black, Jansen and Scholes time series average absolute pricing error test and the time series Gibbons, Ross and Shanken F-test and the Fama-MacBeth cross-sectional test are conducted.

5.1 The time series tests

For all t-tests the significance level of rejecting null hypothesis is 5%. The critical value for a two-tailed t-test with over 120 df is 1.96. The results are grouped into four tables (A1 to A4) that are attached in Appendix.

First the results generated from the 25 portfolios are reviewed. Table A1 shows the results of the Fama-French three-factor time series regressions for the 25 portfolios during 1926-2004 and 1963-2004. The absolute values of the average of the intercepts, i.e. the absolute values of the average pricing error are 0.19 and 0.11 respectively. In 1926-2004 period, t tests reject the null hypothesis of the intercept equals to zero in seven of the twenty-five regressions. In 1963-2004 period, t tests reject the null hypothesis in eight of the twenty-five regressions. Table A2 shows the results of the CAPM time series regressions for the 25 portfolios during 1926-2004 and 1963-2004. The absolute values of the average of the intercepts are 0.24 and 0.31 respectively. In 1926-2004 period, t tests reject the null hypothesis of the intercept equals to zero in twelve of the twenty-five regressions. In 1963-2004 period, t tests reject the null hypothesis in thirteen of the twenty-five regressions. In both periods, the average absolute pricing errors of the Fama-French three-factor model are smaller than those of the CAPM.

After reviewing the results generated from the 25 portfolios, same exercises are done on the 30 industries. Table A3 shows the results of the Fama-French three-factor time series regressions for 30 industries during 1926-2004 and 1963-2004. The absolute values of the pricing error are 0.18 and 0.21 respectively. In 1926-2004 period, t tests reject the null hypothesis of the intercept equals to zero in eight of the twenty-five regressions. In 1963-2004 period, t tests reject the null hypothesis in ten of the twenty-five regressions. Table A4 shows the results of the CAPM time series regressions for the 30 industries during 1926-2004 and 1963-2004. The absolute values of the pricing error are both equal to 0.14. In 1926-2004 period, t tests reject the null hypothesis of the intercept equals to zero in three of the twenty-five regressions. In 1963-2004 period, t tests reject the null hypothesis in two of the twenty-five regressions. In both periods, the average absolute pricing errors of the CAPM are smaller than those of the three-factor model. Table 1 below provides the summary of the average absolute pricing errors of the time series regressions.

The tests conclude that if we use the average absolute intercepts to compare which model is better, the Fama-French three-factor model outperformed the CAPM for the 25 portfolios in both time periods. This is exactly what Fama and French claimed. Since the 30 Industries is just another way to group the data, the three-factor model should also be better than the CAPM for the 30 Industries. However, the results show the CAPM works better for the 30 industries in both time periods. Hence the time series tests based on average absolute pricing error fails to support the three-factor model in general.

Notice that the individual t-tests cannot be used for statistical inference purpose. In order to get proper statistical inference, another test is applied. The Gibbons, Ross and Shanken (GRS) F-test is used to check whether the intercepts of all time series regressions are zero in each portfolio-period combination. Table 1 shows the GRS F statistics for the 25 portfolios and the 30 industries in two periods respectively. The F-statistic tests the hypothesis that the regression intercepts for a set of portfolios (either formed by size and the book-to-market value or industries) are all zero. For instance, under the 25 portfolios, GRS F-test tests whether the intercepts of all 25 regressions are zero. If the model is true, F-statistics should not allow us to reject the null hypothesis. The 5% critical value of F-test for the 25 portfolios and the 30 industries are 1.51 and 1.46 respectively. The results show no matter what data set is used, the F-statistics convincingly reject the null hypothesis of the pricing error is equal to zero for the Fama-French three-factor model. However, the statistics fails to reject the null hypothesis of the pricing error is equal to zero for the CAPM with the 30 industries. If the magnitude of the F-statistics is used as a guideline to show how strongly the empirical data supports the model, i.e. lower the statistics implies greater support, the three-factor model works better for the 25 portfolios and the CAPM works better for the 30 industries.

Table 1: Time series test of average absolute pricing errors and the Gibbons, Ross and Shanken (GRS) F-statistics for the Fama-French three-factor model and the CAPM

Panel A: July 1926- November 2004, 941 months

	Three-factor		CAPM	
	Abs. pricing error	GRS F-statistics	Abs. pricing error	GRS F-statistics
25 portfolios	0.19	3.24	0.24	3.42
30 industries	0.18	2.89	0.14	1.74

Panel B: July 1963- November 2004, 497 months

	Three-factor		CAPM	
	Abs. pricing error	GRS F- statistics	Abs. pricing error	GRS F- statistics
25 portfolios	0.11	3.34	0.31	4.30
30 industries	0.21	2.42	0.14	1.10

5.2 The cross-sectional tests

Now the results of the Fama-MacBeth cross-sectional test of the CAPM and the Fama-French three-factor model are reviewed. In the period 1926-2004, 941 cross- sectional regressions across the 25 portfolios and the 30 industries are run respectively. In the period of 1963-2004, 497 cross-sectional regressions are run respectively. The complete results are in Table 2. Again simple t-statistics are not used for statistical inference and instead Fama-MacBeth adjusted t-statistics is used. For all Fama-MacBeth adjusted t-tests the significance level of rejecting null hypothesis is 5%. The critical value for a two-tailed t-test with over 120 df is 1.96.

The values of the intercept terms of the two models are compared first. Notice that if the model is true, the intercept, γ_0, should be zero. The results show the Fama-French three-factor model does not win the battle. The three-factor model lose its edge for the 25 portfolios as in both time periods the CAPM intercepts terms are smaller than those of the three-factor model. For the 30 industries it is undecided. So if the value of intercept term is used a guideline of which model is better, the CAPM is the better model for the 25 portfolios. This is different from the results obtained from the time series tests. The time series pricing error test supports the claim that the Fama-French three-factor model is better than the CAPM for the 25 portfolios. However, the cross-sectional intercept test yields the opposite result.

Now the Fama-MacBeth adjusted t-statistics are compared. The results show the t-test fails to reject the null hypothesis of $\bar{\gamma}_0 = 0$ in two data set-period combinations only: i) the CAPM with the 25 portfolios 1926 to 2004 and ii) the Fama-French three-factor model with 30 industries from 1963-2004. For the CAPM with 30 industries from 1963-2004, adjusted t-statistics is just 0.01 higher than the critical value. In general the test fails to support the three-factor model. The conclusion is similar to those obtained from the time series regressions F-tests.

Although the Fama-MacBeth adjusted t-statistic shows the CAPM works for the 25 portfolios from 1926-2004, the slope is only 0.21. Remember that the slope is the market portfolio's risk premium if the CAPM is true. The average market premium in this period is 0.647, which is much higher than the slope (=0.21). For the Fama-French three-factor model for 30 industries from 1963-2004, the coefficients of the state variables are very close to zero. It is difficult to claim the three-factor model is working in this data set combination.

Table 2: Fama-MacBeth cross-sectional test for the Fama-French three-factor model and the CAPM

Three factor test: $r_{jt} - r_{ft} = \gamma_{0t} + \gamma_{1t}\beta_j + \gamma_{2t}s_j + \gamma_{3t}h_j + e_{jt}$; **CAPM test:** $r_{jt} - r_{ft} = \gamma_{0t} + \gamma_{1t}\beta_j + e_{jt}$

Panel A: July 1926- November 2004, 941 months

	Three-factor					CAPM		
	$\bar{\gamma}_0$	$\bar{\gamma}_1$	$\bar{\gamma}_2$	$\bar{\gamma}_3$	R^2	$\bar{\gamma}_0$	$\bar{\gamma}_1$	R^2
25 portfolios	2.71	-2.02	0.31	0.30	0.57	0.60	0.21	0.01
	(6.17)	(-4.35)	(2.51)	(2.27)		(1.82)	(0.56)	
30 industries	0.66	0.10	-0.01	-0.21	0.16	0.75	0.00	$\cong 0$
	(3.22)	(0.37)	(-0.05)	(-1.11)		(4.03)	(-0.02)	

Panel B: July 1963- November 2004, 497 months

	Three-factor					CAPM		
	$\bar{\gamma}_0$	$\bar{\gamma}_1$	$\bar{\gamma}_2$	$\bar{\gamma}_3$	R^2	$\bar{\gamma}_0$	$\bar{\gamma}_1$	R^2
25 portfolios	1.33	-0.83	0.21	0.48	0.78	1.32	-0.56	0.15
	(4.35)	(-2.27)	(1.40)	(3.54)		(3.45)	(-1.30)	
30 industries	0.60	0.00	-0.03	-0.10	0.06	0.54	0.03	$\cong 0$
	(1.78)	(0.01)	(-0.17)	(-0.58)		(1.97)	(0.09)	

Note: The numbers in brackets are the Fama-MacBeth adjusted t-statistics

5.3 Compare with the results from the literature

The results shown definitely are disturbing and leaving a lot of questions behind. Fama-French three-factor model is a well-known model and there is a long list of research papers discussed and supported the model[3]. Why some simple econometric tests can raise doubt on the validity of the three-factor model? Is it possible that the results presented in this paper are wrong? In this section the results presented are compared with those from the Fama and French papers and checked if any contradictions are found.

This paper shows that under the 25 portfolios the average absolute pricing error time series test stating the three-factor model is better. This is exactly what Fama and French emphasized. However, the Gibbons, Ross and Shanken (GRS) F-tests rejects both models when 25 portfolios data set is used. In a time regression intercept test summary table listed in Fama and French (1996, p.71 Table IX), with the data set is 25 portfolios and the period is from 1963 to 1993, the reported GRS F statistics of the three-factor model and the CAPM are 1.97 and 2.76 respectively. In both cases the null hypothesis of the intercepts equal to zero are rejected. Fama and French acknowledge this fact as in Fama and French (1996, p.74) they state "..., where all models fail (the GRS test), the CAPM is dominated by the three-factor model. The average absolute pricing errors (intercepts) of the CAPM are large...,and they are three to five times those of the three-factor model..." Hence the conclusions draw from the time series tests in this paper and those from Fama and French (1996) are the same. In Fama and French (1993), they do not report the intercept and do not use the GRS test. They only state the average slope of SMB and HML are useful as the majority of t-statistics

[3] go to ECONLIT website and type "three factor model" will get a long list.

from 25 time series regressions are high. The cross-sectional test review is next.

It is actually impossible to compare the cross-sectional tests results because Fama and French (1992) do not run the Fama-MacBeth cross-sectional regressions using the same 25 portfolios (the portfolios they used are formed on beta instead) and they do not use the same state variables. However, information can still be drawn from Fama and French (1992, p.439 Table III). In the table average slopes and Fama-MacBeth adjusted t-statistics of market beta, ln(ME), i.e. ln(size)), and ln(BE/ME) are reported. Notice that only cross-sectional regressions of return on one variable are run and the intercepts are not reported. Fama and French (1992) states market beta alone has no explanation power, i.e. adjusted t-statistic fails to reject the slope is equal to zero, and size and the book-to-market equity ratio are useful as the slopes of size and the book-to-market equity ratio in the cross-sectional regressions are significant. Similar results are obtained in this paper. In Table 2, the slope of market beta in the CAPM regressions are also statistically insignificant. With the exception of the slope of size in panel B, the results in this paper also show the slopes of size and the book-to-market equity ratio are significant.

Since the focus of Fama and French (1997) are on tackling the problem of the variation of factor sensitivities over time and forecasting power of both models, they do not elaborate the results of a full-period time series regressions using the 48 industry portfolios from 1963 to 1994 in details. The average absolute pricing error of the three-factor model and the CAPM in Fama and French (1997, p.157 Table 2) are 0.23 and 0.15 respectively. This paper also reports the CAPM is better than the three-factor model if the average absolute pricing error test is used.

The empirical results presented in this paper are basically in line with those from the Fama and French papers. Although it does not imply the results presented here are error-proof, they are not contradicted with those generated by Fama and French.

6 CONCLUSIONS

The objective of this paper is not questioning why the basic Capital Asset Pricing Model (CAPM) lacking empirical support as Roll (1977) points out the tests performed by using any portfolio other than the true market portfolio are not test of CAPM but are tests of whether the proxy portfolio is efficient or not. Also, the paper does not intend to apply any econometric techniques other than ordinary least square linear regressions. The main objective of the paper is to examine what Fama and French claimed in Fama and French (2004, p.39): "the (three factor) model captures much of the variation in average return for portfolios formed on size, the book-to-market equity and other price ratios that cause problems for the CAPM". The main empirical support of their claim is the intercepts (i.e. pricing error) in the time regressions of the CAPM are three to five times larger than those of the three-factor model (Fama and French (1993,1996)). If the three-factor model is true, it should hold no matter how the assets are grouped into portfolios.

The results in this paper can be summarized into three points: the Fama-French three-factor model may be portfolio specific, test specific and period specific. First, the three-factor model may be better than the CAPM with the 25 portfolios but definitely is not better than the CAPM with the 30 industries. One could suggest the practitioners can still benefit from the new theory if they can covert the data set into the 25 portfolios. However, there could be some problems in the 25 portfolios grouping. Grauer and Janmaat (2004) shows that it is possible that even the Fama and French 25 portfolios may not give the correct answer.

Second, the validity of the three-factor model depends on what test is used. Only time series average absolute pricing errors tests render support to the three-factor model with the 25 portfolios. Cross-sectional tests support the CAPM with the 25 portfolios when the intercepts are compared. If the Gibbons, Ross and Shanken F statistics is used, the three-factor model is rejected in every portfolios-period combination. Fama-MacBeth adjusted t-statistics of the intercepts give mixed results. An interesting point is if only the Fama-MacBeth adjusted t-statistics of the slopes in the cross-sectional regressions are compared, the three-factor model has explanatory power but the CAPM has not.

Third, even referring to the only cross-sectional supportive case for the three-factor model, i.e. for the 30 industries from 1963-2004, it shows the model is period specific as the test rejects the model when the period is 1926-2004. The evidences stated cannot convincingly support the claim that the Fama-French three-factor model is better than the CAPM.

Although the paper shows the validity of the Fama-French three-factor model is questionable, it does not imply individual state variables in the model are not individually risk related. Further tests on whether individual state variable is related to the variance of expected return are required.

This paper also does not examine other more complicated asset pricing models, for instance the conditional CAPM and the intertemporal CAPM. The Sharpe-Litner CAPM examined is based on the assumption that all market participants share identical subjective expectations of two moments distributions, i.e. mean and variance of return distributions, and portfolio decision is exclusively based on these two moments. However, it has been observed that return distribution varies over time and the expectations of moments are random variables rather than constant as assumed in the simple CAPM. As a result, the risk premia expected by investors for holding the risky assets are time varying. In the conditional CAPM, the investors share identical subjective expectations of moments but these moments are conditional on the information at the time t. The conditional CAPM could be useful to analysis the 30 industries data set. Fama and French (1997) point out the industry risk loadings wander through time. Merton (1973) introduces an intertemporal asset pricing model and in the model individuals are solving lifetime consumption decision in a multi-period setting. Merton shows returns on assets are not only depending on the covariance of asset with the market but also the covariance with changes in investment opportunity set. Future research can be focused on the empirical support of these two asset pricing models.

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APPENDIX

Table A1: Fama-French three-factor time series regressions for monthly excess returns on the 25 portfolios formed on size and the book-to-market equity ratio. $r_{jt} - r_{ft} = \alpha_j + \beta_j (r_{mt} - r_{ft}) + s_j SMB_t + h_j HML_t + e_{jt}$

Panel A: July 1926- November 2004, 941 months

	Book-to-Market Equity (BE/ME) Quintiles									
Size	Low	2	3	4	High	Low	2	3	4	High
			α					$t(\alpha)$		
Small	-0.85	-0.44	-0.10	0.11	0.10	-3.45	-2.85	-0.90	1.42	1.23
2	-0.26	-0.02	0.09	0.06	0.00	-3.00	-0.23	1.47	1.11	0.02
3	-0.16	0.09	0.07	0.09	-0.12	-2.40	1.52	1.07	1.43	-1.69
4	0.07	-0.03	0.07	-0.01	-0.19	1.30	-0.54	1.07	-0.08	-2.18
Big	0.07	0.03	-0.03	-0.18	-1.43	1.78	0.72	-0.44	-2.95	-3.80
			β					$t(\beta)$		
Small	1.33	1.18	1.09	0.98	0.99	27.83	39.66	48.88	63.14	60.62
2	1.07	1.03	0.96	0.98	1.06	63.36	77.16	77.81	95.85	81.66
3	1.14	1.02	1.01	0.96	1.16	85.48	86.32	84.28	81.56	80.80
4	1.07	1.03	1.01	1.06	1.25	97.84	89.88	82.74	81.67	74.13
Big	1.04	0.96	0.98	1.06	1.23	134.45	103.53	84.39	89.60	16.71
			s					$t(s)$		
Small	1.33	1.51	1.20	1.22	1.38	17.35	31.67	33.75	49.37	52.68
2	1.05	0.98	0.88	0.81	0.91	39.03	45.89	44.41	49.03	44.21
3	0.79	0.51	0.42	0.46	0.50	37.06	26.95	21.68	24.53	21.86
4	0.28	0.25	0.21	0.19	0.31	15.83	13.57	11.01	9.33	11.30
Big	-0.15	-0.19	-0.22	-0.17	-0.10	-12.31	-12.61	-11.73	-8.98	-0.85
			h					$t(h)$		
Small	0.47	0.32	0.47	0.61	0.92	6.73	7.46	14.68	27.21	38.86
2	-0.27	0.18	0.38	0.55	0.83	-11.03	9.05	21.11	36.79	44.40
3	-0.18	0.09	0.36	0.52	0.92	-9.51	5.28	20.89	30.29	44.32
4	-0.36	0.15	0.31	0.62	1.02	-22.86	8.76	17.79	33.06	41.76
Big	-0.25	-0.01	0.33	0.71	1.07	-22.12	-0.68	19.27	41.09	10.06
			R^2					$s(e)$		
Small	0.65	0.81	0.86	0.92	0.93	7.46	4.65	3.47	2.42	2.55
2	0.89	0.93	0.93	0.96	0.95	2.63	2.09	1.93	1.60	2.02
3	0.93	0.92	0.92	0.93	0.93	2.09	1.85	1.87	1.84	2.24
4	0.93	0.92	0.91	0.92	0.92	1.71	1.78	1.90	2.02	2.64
Big	0.95	0.93	0.90	0.93	0.34	1.21	1.45	1.81	1.85	11.45

Table A1 (continued)

Panel B: July 1963- November 2004, 497 months

	Book-to-Market Equity (BE/ME) Quintiles									
Size	Low	2	3	4	High	Low	2	3	4	High
			α					$t(\alpha)$		
Small	-0.45	0.02	0.05	0.21	0.15	-4.14	0.30	0.75	3.35	2.38
2	-0.19	-0.11	0.09	0.07	0.01	-2.41	-1.61	1.42	1.22	0.23
3	-0.07	0.02	-0.08	0.00	0.01	-0.90	0.22	-1.08	0.07	0.14
4	0.14	-0.18	-0.02	0.05	-0.09	1.97	-2.20	-0.32	0.71	-1.00
Big	0.20	-0.01	-0.03	-0.12	-0.24	3.56	-0.13	-0.38	-1.71	-2.37
			β					$t(\beta)$		
Small	1.07	0.97	0.93	0.90	0.98	40.58	50.40	60.38	58.40	61.70
2	1.12	1.04	0.99	0.99	1.09	59.22	61.30	62.27	66.58	70.13
3	1.08	1.06	1.02	1.01	1.12	60.38	55.03	56.61	60.20	57.35
4	1.05	1.10	1.08	1.04	1.18	59.89	55.27	56.24	58.21	51.82
Big	0.96	1.04	0.99	1.01	1.07	68.38	63.16	51.05	59.85	43.06
			s					$t(s)$		
Small	1.38	1.32	1.10	1.03	1.08	40.57	53.02	55.39	51.58	52.68
2	0.99	0.87	0.75	0.71	0.84	40.56	39.85	36.82	36.89	41.78
3	0.73	0.51	0.42	0.39	0.52	31.54	20.52	18.19	17.90	20.56
4	0.37	0.20	0.16	0.20	0.25	16.44	7.81	6.52	8.53	8.36
Big	-0.26	-0.22	-0.23	-0.22	-0.09	-14.28	-10.52	-9.20	-9.97	-2.94
			h					$t(h)$		
Small	-0.32	0.07	0.30	0.46	0.69	-8.14	2.52	13.05	19.86	28.80
2	-0.39	0.18	0.42	0.59	0.78	-13.92	7.26	17.80	26.56	33.65
3	-0.45	0.23	0.51	0.67	0.84	-16.76	7.84	18.89	26.43	28.88
4	-0.44	0.26	0.50	0.62	0.84	-16.76	8.84	17.30	23.20	24.60
Big	-0.38	0.14	0.29	0.62	0.78	-18.27	5.80	10.16	24.53	20.88
			R^2					$s(e)$		
Small	0.92	0.94	0.95	0.94	0.94	2.33	1.70	1.36	1.36	1.40
2	0.95	0.94	0.93	0.94	0.94	1.67	1.49	1.40	1.31	1.37
3	0.95	0.90	0.90	0.90	0.90	1.58	1.70	1.59	1.48	1.72
4	0.94	0.88	0.88	0.89	0.86	1.55	1.76	1.70	1.58	2.01
Big	0.93	0.90	0.85	0.88	0.79	1.24	1.46	1.70	1.48	2.19

Table A2: The CAPM time series regressions for monthly excess returns on the 25 portfolios formed on size and the book-to-market equity ratio.

$r_{jt} - r_{ft} = \alpha_j + \beta_j (r_{mt} - r_{ft}) + e_{jt}$

Panel A: July 1926- November 2004, 941 months

	Book-to-Market Equity (BE/ME) Quintiles									
Size	Low	2	3	4	High	Low	2	3	4	High
			α					$t(\alpha)$		
Small	-0.57	-0.19	0.16	0.42	0.53	-2.00	-0.85	0.91	2.54	2.65
2	-0.24	0.13	0.30	0.31	0.35	-1.71	1.07	2.47	2.61	2.32
3	-0.15	0.17	0.22	0.29	0.21	-1.34	2.09	2.56	3.00	1.53
4	-0.01	0.04	0.19	0.21	0.16	-0.20	0.58	2.47	2.10	1.08
Big	-0.02	0.01	0.06	0.03	-1.10	-0.43	0.26	0.76	0.26	-2.79
			β					$t(\beta)$		
Small	1.66	1.52	1.39	1.30	1.39	31.83	37.67	42.81	42.92	38.39
2	1.24	1.25	1.19	1.22	1.35	47.97	54.99	54.32	56.57	48.87
3	1.28	1.13	1.14	1.12	1.38	64.42	76.76	72.71	62.91	54.25
4	1.08	1.09	1.09	1.18	1.45	78.85	91.12	79.47	64.97	53.12
Big	0.98	0.93	0.98	1.12	1.35	104.44	98.90	73.31	60.08	18.77
			R^2					$s(e)$		
Small	0.52	0.60	0.66	0.66	0.61	8.74	6.79	5.44	5.10	6.07
2	0.71	0.76	0.76	0.77	0.72	4.35	3.82	3.67	3.61	4.63
3	0.82	0.86	0.85	0.81	0.76	3.33	2.48	2.63	2.99	4.27
4	0.87	0.90	0.87	0.82	0.75	2.29	2.02	2.30	3.04	4.57
Big	0.92	0.91	0.85	0.79	0.27	1.57	1.57	2.24	3.12	12.04

Panel B: July 1963- November 2004, 497 months

	Book-to-Market Equity (BE/ME) Quintiles									
Size	Low	2	3	4	High	Low	2	3	4	High
			α					$t(\alpha)$		
Small	-0.43	0.26	0.38	0.62	0.70	-1.86	1.29	2.31	3.96	4.10
2	-0.27	0.12	0.44	0.51	0.58	-1.56	0.88	3.52	4.09	3.89
3	-0.22	0.22	0.27	0.44	0.57	-1.52	2.11	2.60	3.98	4.13
4	-0.06	0.00	0.28	0.44	0.42	-0.54	0.02	2.92	4.22	3.12
Big	-0.05	0.04	0.11	0.21	0.19	-0.69	0.53	1.13	1.89	1.39
			β					$t(\beta)$		
Small	1.46	1.24	1.08	0.99	1.02	28.31	27.69	29.46	28.21	26.63
2	1.44	1.17	1.03	0.97	1.05	37.42	38.05	36.63	34.59	31.23
3	1.37	1.11	0.97	0.91	0.99	42.52	47.12	41.04	36.61	32.21
4	1.26	1.07	0.98	0.91	1.00	52.39	54.43	44.87	39.28	32.89
Big	1.01	0.96	0.86	0.79	0.83	58.48	56.11	41.21	32.38	26.86
			R^2					$s(e)$		
Small	0.62	0.61	0.64	0.62	0.59	5.11	4.43	3.64	3.49	3.80
2	0.74	0.75	0.73	0.71	0.66	3.83	3.06	2.79	2.79	3.33
3	0.79	0.82	0.77	0.73	0.68	3.19	2.34	2.35	2.47	3.06
4	0.85	0.86	0.80	0.76	0.69	2.38	1.95	2.16	2.30	3.01
Big	0.87	0.86	0.77	0.68	0.59	1.71	1.69	2.06	2.41	3.08

Table A3: Fama-French three-factor time series regressions for monthly excess returns on the 30 portfolios formed on industries.

$r_{jt} - r_{ft} = \alpha_j + \beta_j (r_{mt} - r_{ft}) + s_j SMB_t + h_j HML_t + e_{jt}$

Panel A: July 1926- November 2004, 941 months

Industry	α	$t(\alpha)$	β	$t(\beta)$	s	$t(s)$	h	$t(h)$	R^2
Food	0.21	2.38	0.78	46.22	-0.13	-4.73	0.05	1.89	0.72
Beer	0.21	1.21	0.87	25.89	0.30	5.53	0.18	3.69	0.51
Smoke	0.46	2.95	0.68	22.39	-0.18	-3.68	0.08	1.87	0.37
Games	-0.14	-0.87	1.28	41.04	0.42	8.45	0.14	3.18	0.72
Books	-0.05	-0.37	0.99	40.48	0.32	8.26	0.16	4.62	0.71
Hshld	0.16	1.62	0.90	46.33	-0.03	-1.05	-0.19	-6.66	0.72
Clths	-0.10	-0.82	0.90	38.00	0.42	11.05	0.17	4.81	0.70
Hlth	0.32	2.89	0.91	41.76	-0.11	-3.09	-0.17	-5.32	0.67
Chems	0.12	1.28	1.06	58.04	-0.18	-6.16	-0.01	-0.31	0.80
Txtls	-0.29	-2.38	0.99	41.48	0.61	15.95	0.35	10.10	0.77
Cnstr	-0.12	-1.36	1.08	66.14	0.26	9.91	0.11	4.59	0.86
Steel	-0.34	-2.74	1.22	50.53	0.18	4.56	0.46	13.11	0.79
FabPr	-0.11	-1.28	1.17	68.52	0.21	7.65	0.13	5.16	0.87
ElcEq	0.02	0.18	1.30	56.97	0.10	2.88	-0.13	-3.93	0.80
Autos	-0.02	-0.15	1.19	44.69	-0.01	-0.15	0.26	6.66	0.73
Carry	-0.07	-0.54	1.09	41.65	0.23	5.55	0.35	9.28	0.73
Mines	-0.05	-0.29	0.85	28.38	0.27	5.70	0.17	3.98	0.55
Coal	0.21	0.94	0.64	14.73	0.35	5.05	0.21	3.35	0.28
Oil	0.14	1.20	0.89	37.95	-0.23	-6.06	0.24	7.12	0.65
Util	-0.03	-0.26	0.80	35.55	-0.14	-3.94	0.32	9.72	0.63
Telcm	0.17	1.73	0.70	35.34	-0.09	-2.73	-0.14	-4.81	0.59
Servs	0.66	2.24	0.81	14.11	0.45	4.84	-0.47	-5.62	0.24
BusEq	0.31	2.95	1.08	53.00	0.12	3.64	-0.48	-16.13	0.78
Paper	0.13	1.32	0.96	49.64	-0.08	-2.61	0.03	1.16	0.75
Trans	-0.31	-2.92	1.05	50.72	0.19	5.64	0.51	16.93	0.81
Whlsl	-0.24	-1.70	0.99	36.03	0.52	11.89	0.06	1.58	0.68
Rtail	0.14	1.37	0.97	48.62	0.04	1.36	-0.12	-4.06	0.74
Meals	0.11	0.79	0.90	33.90	0.33	7.82	-0.02	-0.55	0.63
Fin	-0.04	-0.50	1.11	68.10	-0.06	-2.44	0.27	11.54	0.86
Other	-0.12	-0.98	0.97	41.23	0.35	9.42	0.03	0.79	0.72

Table A3 (continued)

Panel B: July 1963- November 2004, 497 months

Industry	α	$t(\alpha)$	β	$t(\beta)$	s	$t(s)$	h	$t(h)$	R^2
Food	0.19	1.39	0.86	25.28	-0.18	-4.07	0.24	4.64	0.58
Beer	0.13	0.71	0.84	18.85	-0.03	-0.57	0.28	4.24	0.44
Smoke	0.52	2.10	0.86	14.00	-0.21	-2.65	0.32	3.51	0.29
Games	0.00	-0.02	1.22	27.83	0.45	7.99	0.08	1.18	0.70
Books	0.00	0.03	1.05	31.28	0.19	4.47	0.23	4.67	0.71
Hshld	0.25	2.13	0.94	32.82	-0.22	-6.00	-0.11	-2.64	0.73
Clths	-0.41	-2.28	1.16	26.15	0.43	7.43	0.54	8.11	0.64
Hlth	0.46	3.21	0.85	23.92	-0.28	-6.10	-0.30	-5.57	0.62
Chems	-0.18	-1.39	1.10	35.05	-0.11	-2.75	0.33	7.10	0.73
Txtls	-0.42	-2.48	1.02	24.37	0.64	11.95	0.60	9.60	0.65
Cnstr	-0.24	-2.14	1.18	43.63	0.28	7.93	0.43	10.54	0.82
Steel	-0.54	-3.03	1.20	27.66	0.29	5.19	0.53	8.08	0.65
FabPr	-0.19	-1.47	1.15	37.08	0.25	6.24	0.13	2.75	0.79
ElcEq	0.19	1.22	1.06	27.37	0.35	6.99	-0.34	-5.84	0.74
Autos	-0.42	-2.33	1.16	26.47	0.06	1.00	0.62	9.42	0.60
Carry	-0.09	-0.47	1.19	26.08	0.19	3.14	0.44	6.35	0.62
Mines	-0.26	-1.02	0.95	15.44	0.44	5.53	0.45	4.86	0.40
Coal	-0.12	-0.39	1.05	14.37	0.39	4.10	0.48	4.37	0.35
Oil	0.11	0.66	0.91	21.65	-0.24	-4.47	0.29	4.57	0.49
Util	-0.20	-1.52	0.74	22.57	-0.16	-3.85	0.57	11.62	0.51
Telcm	0.07	0.42	0.82	21.31	-0.18	-3.57	-0.05	-0.83	0.53
Servs	0.20	1.61	1.18	39.34	0.47	12.02	-0.45	-9.89	0.86
BusEq	0.24	1.51	1.06	27.65	0.21	4.32	-0.58	-10.13	0.76
Paper	-0.11	-0.83	1.04	32.82	-0.09	-2.26	0.30	6.32	0.70
Trans	-0.32	-2.10	1.18	31.82	0.24	5.11	0.45	8.04	0.71
Whlsl	-0.04	-0.35	1.11	37.73	0.35	9.25	0.23	5.14	0.80
Rtail	0.07	0.47	1.06	28.59	0.06	1.35	0.13	2.31	0.67
Meals	-0.01	-0.06	1.16	25.97	0.34	5.81	0.28	4.12	0.64
Fin	-0.09	-0.92	1.14	47.49	-0.12	-3.83	0.43	11.85	0.83
Other	-0.33	-2.19	1.09	29.81	0.32	6.86	0.36	6.58	0.70

Table A4: The CAPM time series regressions for monthly excess returns on the 30 portfolios formed on industries. $r_{jt} - r_{ft} = \alpha_j + \beta_j (r_{mt} - r_{ft}) + e_{jt}$

Panel A: July 1926- November 2004, 941 months

Industry	α	$t(\alpha)$	β	$t(\beta)$	R^2	Industry	α	$t(\alpha)$	β	$t(\beta)$	R^2
Food	0.21	2.39	0.76	47.88	0.71	Carry	0.06	0.43	1.18	45.84	0.69
Beer	0.30	1.68	0.95	29.83	0.49	Mines	0.04	0.23	0.93	32.49	0.53
Smoke	0.47	3.00	0.65	23.02	0.36	Coal	0.31	1.37	0.74	17.93	0.25
Games	-0.05	-0.32	1.38	45.78	0.69	Oil	0.20	1.59	0.87	38.53	0.61
Books	0.04	0.28	1.08	45.22	0.69	Util	0.06	0.46	0.81	36.85	0.59
Hshld	0.10	0.98	0.87	47.03	0.70	Telcm	0.12	1.20	0.66	35.54	0.57
Clths	-0.01	-0.06	1.01	42.48	0.66	Servs	0.56	1.84	0.84	15.27	0.20
Hlth	0.26	2.29	0.86	41.96	0.65	BusEq	0.17	1.43	1.05	48.45	0.71
Chems	0.10	1.06	1.03	59.12	0.79	Paper	0.13	1.34	0.95	52.57	0.75
Txtls	-0.12	-0.86	1.16	44.33	0.68	Trans	-0.13	-1.08	1.16	51.78	0.74
Cnstr	-0.06	-0.62	1.15	71.12	0.84	Whlsl	-0.17	-1.12	1.10	40.21	0.63
Steel	-0.18	-1.31	1.31	53.38	0.75	Rtail	0.11	1.04	0.96	51.49	0.74
FabPr	-0.05	-0.57	1.23	74.11	0.85	Meals	0.13	0.95	0.96	37.86	0.60
ElcEq	-0.01	-0.08	1.30	60.77	0.80	Fin	0.04	0.43	1.13	69.88	0.84
Autos	0.06	0.43	1.22	48.31	0.71	Other	-0.08	-0.60	1.04	45.66	0.69

Panel B: July 1963- November 2004, 497 months

Industry	α	$t(\alpha)$	β	$t(\beta)$	R^2	Industry	α	$t(\alpha)$	β	$t(\beta)$	R^2
Food	0.30	2.14	0.76	23.94	0.54	Carry	0.19	1.00	1.11	26.24	0.58
Beer	0.29	1.59	0.75	18.69	0.41	Mines	0.07	0.26	0.92	16.12	0.34
Smoke	0.68	2.73	0.72	12.99	0.25	Coal	0.21	0.71	1.00	14.97	0.31
Games	0.11	0.57	1.30	31.36	0.67	Oil	0.24	1.39	0.78	19.88	0.44
Books	0.17	1.21	1.02	33.29	0.69	Util	0.10	0.66	0.54	16.15	0.35
Hshld	0.15	1.28	0.93	35.03	0.71	Telcm	0.01	0.08	0.80	23.00	0.52
Clths	-0.04	-0.22	1.10	25.46	0.57	Servs	0.01	0.07	1.41	41.75	0.78
Hlth	0.25	1.71	0.87	26.19	0.58	BusEq	-0.07	-0.38	1.27	32.87	0.69
Chems	0.00	-0.02	0.98	33.11	0.69	Paper	0.05	0.39	0.94	31.69	0.67
Txtls	0.02	0.08	0.99	22.51	0.51	Trans	-0.03	-0.16	1.11	31.28	0.66
Cnstr	0.05	0.40	1.12	40.94	0.77	Whlsl	0.14	1.09	1.12	39.28	0.76
Steel	-0.19	-1.04	1.12	26.91	0.59	Rtail	0.15	1.04	1.04	31.37	0.67
FabPr	-0.08	-0.60	1.17	40.77	0.77	Meals	0.20	1.06	1.15	27.95	0.61
ElcEq	0.05	0.29	1.22	32.62	0.68	Fin	0.14	1.23	0.99	40.10	0.76
Autos	-0.05	-0.28	1.00	23.66	0.53	Other	-0.07	-0.47	1.06	30.38	0.65