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EXAMINING THE IMPACT OF THE MARKET RISK PREMIUM BIAS ON THE CAPM AND THE FAMA FRENCH MODEL

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ABSTRACT

The Capital Asset Pricing Model and the Fama French Three Factor Model are widely considered two of the premier financial asset pricing models. The Fama French Model uses three factors, SMB, HML, and Market Premium, to predict stock returns. It was created as an extension to the Capital Asset Pricing Model, which only considers one factor, the Market Premium. Glenn Pettengill, Sridhar Sundaram, and Ike Mathur observed that the Capital Asset Pricing Model has a flaw in that it relies on the positive relationship between risk and return but does not consider that an inverse relationship exists when the market premium is negative. Pettengill et al. note that this flaw creates a market risk premium bias within the model. This paper utilizes a similar method as Pettengill et al. to determine that the same flaw exists for the Fama French Model. It then determines that the Fama French Model is better that the Capital Asset Pricing Model at reducing the impact of the market risk premium bias.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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Chapter 1

Introduction

Capital Asset Pricing Model

The Capital Asset Pricing Model (CAPM) was designed by William Sharpe (1964) and John Lintner (1965) to predict stock returns. The underlying principle of the CAPM is that a stock's return is dependent on its sensitivity to non-diversifiable risk. The formula for the CAPM is:

(1) $$E\ (R_a) = R_f + ß * (E\ (R_m) - R_f) + \alpha$$

Figure 1: The Capital Asset Pricing Model

Where

$E\ (R_a)$ = the expected return of the stock,

R_f = the risk free rate

$E\ (R_m)$ = the expected return of the market

$(E\ (R_m) - R_f)$ = the market risk premium

ß = the coefficient of the market risk premium, referred to as "the beta factor" or "beta"

α = the error term

While there are flaws in the Capital Asset Pricing Model which will be addressed later, it is a very popular model to use for predicting expected stock returns due to its simplicity and the intuitive nature of a positive linear relationship between non-diversifiable risk and stock returns.

Fama French Model

The Fama French three-factor model was created by Eugene Fama and Kenneth French (1992) to predict stock returns. Fama and French observed that the Capital Asset Pricing Model (CAPM) was accurate but did not account for two types of stocks that tend to outperform the market: small cap stocks and stocks with a high book-to-market ratio. To account for these observations, they created two variables and added them to the CAPM.

When creating these variables, Fama and French first constructed six portfolios named S/L, S/M, S/H, B/L, B/M, and B/H. These were created from the intersection of two size groups and three book-to-market groups. For instance, the S/L portfolio includes all of the small market cap stocks that also have a low book-to-market ratio. Once these portfolios were constructed, Fama and French were able to create their variables.

The first variable that Fama and French designed accounts for the risk factor associated with the size of a stock. They named this variable SMB (small minus big). SMB is the difference between the returns of small stocks and big stocks within the same book-to-market group. For instance, the difference between the returns of the S/L portfolio and the B/L portfolio would be calculated. Essentially, this variable accounts for the difference between returns on small and big stocks with similar book-to-market ratios. It is affected by the difference in returns associated with the size of the stock without being swayed by the book-to-market ratio.

The second variable that Fama and French designed accounts for the risk factor associated with the book to market ratio of a stock. They named this variable HML (high minus low). HML is the difference between the returns of high book-to-market stocks and low book-to-market stocks within the same size group. For instance, the difference between the returns of the S/H portfolio and the S/L portfolio would be calculated. Essentially, this variable accounts for the difference between returns on stocks with high and low book-to-market ratios with similar sizes.

It is affected by the difference in returns associated with the book-to-market ratio of the stock without being swayed by the size of the stock.

By utilizing these variables, Fama and French created the Fama French three-factor model:

(2) $$E\ (R_a) = R_f + ß_1 * (E\ (R_m) - R_f) + ß_2 * (SMB) + ß_3 * (HML) + \alpha$$

Figure 2: The Fama French Model

Where

$E\ (R_a)$ = the expected return of the stock

R_f = the risk free rate

$E\ (R_m)$ = the expected return of the market

$(E\ (R_m) - R_f)$ = the market risk premium

SMB = small minus big factor

HML = high minus low factor

$ß_1$, $ß_2$, and $ß_3$ = the coefficients associated with each factor

α = the error term.

Market Risk Premium Bias

Glenn Pettengill, Sridhar Sundaram, and Ike Mathur (1995) point out that the CAPM relies on the notion that there is a positive relationship between risk and return. However, when the realized market return is below the risk free rate, there will actually be an inverse relationship between the beta factor and portfolio return. Amazingly, the market risk premium is negative in approximately 40 percent of the 1047 months between July 1926 and September 2013. This impressive number of instances in which the market risk premium is negative suggests that there may be a flaw within any model that does not account for this. Pettengill et al. create a dummy variable (δ) to account for whether excess returns are positive or negative and apply this to the CAPM. They discover that a market risk premium bias exists within the CAPM because it does not account for the instances in which the market risk premium is negative.

The Fama-French model also relies on the notion that there is a positive relationship between risk and return. The goal of this paper is to determine if a similar market risk premium bias exists within the Fama French Model. In order to test for market risk premium bias, this paper utilizes techniques similar to those used by Pettingill et al. and applies them to both the CAPM and the Fama French Model. The results of this paper support the existence of market risk premium bias within both the CAPM and the Fama French Model.

After determining that market risk premium bias exists within both models, this paper will also determine which model between the CAPM and Fama French Model is more effective at mitigating the market risk premium bias. The results illustrate that both models underestimate the value of the beta coefficient associated with market risk premium. The results also indicate that the Fama French Model underestimates the beta value to a lesser degree, thus it is the superior model at reducing the impact of market risk premium bias.

Chapter 2

Literature Review

The Capital Asset Pricing Model (CAPM) designed by William Sharpe (1964) and John Lintner (1965) has been one of the premium asset pricing models ever since it was created. The underlying principle of the CAPM is that there is a positive linear relationship between a stock's expected return and non-diversifiable risk. The model was widely accepted at first due to its sound logic. Investors who are both rational and risk averse only need to be rewarded for non-diversifiable risk because they will diversify away all other types of risk. The model's measure of a stock's sensitivity to non-diversifiable risk is the beta factor in equation (1).

Early tests of the CAPM agreed with the model's use of beta as a measure of risk and the concept of a positive linear relationship between a stock's expected returns and beta. Fischer Black, Michael C. Jensen, and Myron Scholes (1972) use time series tests instead of cross-sectional tests to assess the validity of the CAPM. They conclude that the beta factor is useful in explaining asset returns and that there is a positive linear relationship between beta and expected returns. Fama and MacBeth (1973) similarly conclude that they cannot reject the existence of a positive linear relationship between expected returns and beta.

Many recent tests, however, have critiqued the CAPM. Merton H. Miller and Myron Scholes (1972) find that stocks with high beta values tend to have lower expected returns than their beta value would suggest and that stocks with low beta values tend to have higher expected returns than their beta value would suggest. In other words, the relationship between beta and returns is flatter than the CAPM would suggest. Later, Richard Roll (1977) challenges the assumption of the CAPM that a linear relationship exists between beta and expected returns. More recently, Glenn Pettengill, Sridhar Sundaram, and Ike Mathur (1995) test the relationship between beta and expected returns and discover that the market premium bias exists within the CAPM.

Pettengill et al. first observed the market risk premium bias in their paper entitled *The Conditional Relationship between Beta and Returns* in 1995. In their paper, they explore the usefulness of the Capital Asset Pricing Model (CAPM) in predicting stock returns. They claim that a major shortcoming of the CAPM is that it is biased because it does not account for the possibility of a negative market risk premium. They argue that when the realized market return is greater than the risk-free rate there is a positive relationship between beta and returns. Conversely, when the realized market return is less than the risk free rate there is an inverse relationship between beta and returns. In order to prove that this systematic relationship between returns and risk exists, they run the following regression:

$$R_{it} = Y_{0t} + Y_{1t} * \delta * ß_i + Y_{2t} * (1- \delta) * ß_i + \varepsilon_t \quad (3)$$

Figure 3: Pettengill et al. Regression

Where

R_{it} = realized portfolio returns

Y_{0t} = constant value

Y_{1t} = estimated coefficient of beta when market risk premium is positive

Y_{2t} = estimated coefficient of beta when market risk premium is negative

$ß_i$ = the beta factor

ε_t = the error term

$\delta = 1$ if $(Rm – Rf) > 0$ and

$\delta = 0$ if $(Rm – Rf) < 0$

The key values in this regression are y_{1t} and y_{2t}. They expect Y_{1t} to be positive because it is estimated when the realized market excess returns are positive. They expect Y_{2t} to be negative because it is estimated when the realized market excess returns are negative. They test two different hypotheses to confirm their expectations. The first hypothesis that they test is:

H_0: $y_1 = 0$

H_a: $y_1 > 0$

The null hypothesis is that the y_1 coefficient is equal to 0. If they can reject this null hypothesis in favor of the alternate hypothesis that y_1 is positive, then they can prove that there is a positive relationship between beta and returns when the realized market excess returns are positive.

The second hypothesis that they test is:

H_0: $y_2 = 0$

H_a: $y_2 < 0$

The null hypothesis is that the y_2 coefficient is equal to 0. If they can reject this null hypothesis in favor of the alternate hypothesis that y_2 is negative, then they can prove that there is an inverse relationship between beta and returns when the realized market excess returns are negative.

In their conclusion, Pettengill et al. reject both null hypotheses. Thus, they conclude that the positive relationship between beta and expected returns is conditional on realized returns. This discovery leads to the conclusion that the CAPM has market risk premium bias.

Chapter 3

Methodology

Data Used

The data range for this paper is from July 1926 to September 2013. The returns used were monthly returns for 25 different portfolios formed on size and book-to-market obtained from Kenneth French's website. Four different types of portfolio returns were used: equal weighted excess returns, equal weighted nominal returns, value weighted excess returns, and value weighted nominal returns. Data on the risk-free rate, the SMB factor, and the HML factor were also obtained from Kenneth French's website.

Determining if a Market Risk Premium Bias Exists

In addition to this data, a dummy variable (DELTA or δ) was created to account for whether the market risk premium was positive or negative. Every data point has a δ value where

$\delta = 1$ if $(R_m - R_f) < 0$ and

$\delta = 0$ if $(R_m - R_f) > 0$

A summary of the data can be observed in Table 1, while a more detailed summary of the data can be viewed in Appendix A.

Table 1: Summary Statistics of Factors

Statistic	**R_m-R_f**	**SMB**	**HML**	**RF**	**MKT**	**DELTA**
Mean	0.640	0.236	0.396	0.288	0.928	0.401
Standard Error	0.167	0.101	0.109	0.008	0.167	0.015
Standard Deviation	5.413	3.264	3.543	0.254	5.402	0.490
Sample Variance	29.299	10.651	12.552	0.064	29.185	0.240
Minimum	-29.000	-16.390	-12.680	-0.060	-28.970	0
Maximum	37.740	38.490	37.310	1.350	37.840	1
Count	1047	1047	1047	1047	1047	1047

Because the data set consists of returns for 25 different portfolios over the same time period, it is a panel data set with the portfolio number (1 through 25) acting as the panel variable. To test for the market risk premium bias, several different panel regressions were run. Fixed effects are assumed. All regressions were run using Stata Data Analysis and Statistical Software.

To test for the market risk premium bias within the Fama French Model, the following regression was run:

(4) $$R_a = \alpha + ß_1 * (R_m\text{-}R_f) + ß_2 * (SMB) + ß_3 * (HML) + ß_4 * (\delta) + \varepsilon$$

Figure 4: Fama French Model Regression

Where

α = constant value

(R_m-R_f) = realized market risk premium

SMB = small minus big factor

HML = high minus low factor

δ = dummy variable accounting for direction of market risk premium

$ß_1$, $ß_2$, $ß_3$, and $ß_4$ = the coefficients associated with each factor

ε = the error term

The coefficient $ß_4$ is estimated to determine if the market risk premium bias exists. The following hypothesis is tested:

H_0: $ß_4 = 0$

H_a: $ß_4 \neq 0$

The null hypothesis is that the beta coefficient of the dummy variable is equal to 0. If the null hypothesis can be rejected, then the dummy variable is a significant factor and the market risk premium bias exists within the Fama French Model.

To test for the market risk premium bias within the CAPM, the following regression was run:

(5) $$R_a = \alpha + ß_1 * (R_m\text{-}R_f) + + ß_2 * (\delta) + \varepsilon$$

Figure 5: CAPM Regression

Where

α = constant value

$(R_m\text{-}R_f)$ = realized market risk premium

δ = dummy variable accounting for direction of market risk premium

$ß_1$ and $ß_2$ = the coefficients associated with each factor

ε = the error term

The coefficient $ß_2$ is estimated to determine if the market risk premium bias exists. The following hypothesis is tested:

H_0: $ß_2 = 0$

H_a: $ß_2 \neq 0$

The null hypothesis is that the beta coefficient of the dummy variable is equal to 0. If the null hypothesis can be rejected, then the dummy variable is a significant factor and the market risk premium bias exists within the CAPM.

Testing the Effect of the Bias on Beta

After discovering that the market risk premium bias existed within both the Fama French Model and the CAPM, regressions were run without the dummy variable. This was done to test the effect that the market risk premium bias has on beta in each model. Whichever model's beta value is more affected by the addition of the dummy variable is more biased due to the direction of the market risk premium.

Chapter 4

Empirical Results

Determining if Market Risk Premium Bias Exists

The results of the regressions can be viewed in Table 2, Table 3, Table 4, and Table 5, while more detailed regression results can be viewed in Appendix B. Each table shows the same four regressions run with different types of returns used. In each table, underlined numbers are statistically insignificant using a 95% confidence interval. The numbers in the R_m-R_f, SMB, HML, and DELTA columns are the coefficients of each of variable. The numbers in the Constant column are the constants in each regression. The numbers in the t column are the t-statistic for the coefficient of the dummy variable. The numbers in the P>|t| column are the probability that the coefficient of the dummy variable is equal to 0.

Table 2: Equal Weighted Excess Returns

Regression	**Constant**	**R_m-R_f**	**SMB**	**HML**	**DELTA**	**t**	**P >|t|**
Fama French (with Delta)	-0.206	1.099	0.664	0.405	0.408	5.75	0.000
Fama French (without delta)	-0.028	1.072	0.664	0.412	N/A	N/A	N/A
CAPM (with delta)	-0.338	1.338	N/A	N/A	1.147	13.84	0.000
CAPM (without delta)	0.169	1.264	N/A	N/A	N/A	N/A	N/A

Table 3: Equal Weighted Nominal Returns

Regression	Constant	R_m-R_f	SMB	HML	DELTA	t	P >|t|
Fama French (with Delta)	-0.066	1.099	0.661	0.406	0.449	6.32	0.000
Fama French (without delta)	0.262	1.069	0.661	0.412	N/A	N/A	N/A
CAPM (with delta)	-0.067	1.337	N/A	N/A	1.191	14.37	0.000
CAPM (without delta)	0.460	1.261	N/A	N/A	N/A	N/A	N/A

Table 4: Value Weighted Excess Returns

Regression	Constant	R_m-R_f	SMB	HML	DELTA	t	P >|t|
Fama French (with Delta)	-0.149	1.061	0.604	0.366	0.193	2.82	0.005
Fama French (without delta)	-0.064	1.049	0.604	0.370	N/A	N/A	N/A
CAPM (with delta)	-0.268	1.278	N/A	N/A	0.862	10.98	0.000
CAPM (without delta)	0.113	1.223	N/A	N/A	N/A	N/A	N/A

Table 5: Value Weighted Nominal Returns

Regression	Constant	R_m-R_f	SMB	HML	DELTA	t	P >|t|
Fama French (with Delta)	-0.123	1.061	0.601	0.368	0.234	3.41	0.001
Fama French (without delta)	0.225	1.046	0.600	0.372	N/A	N/A	N/A
CAPM (with delta)	0.003	1.278	N/A	N/A	0.906	11.53	0.000
CAPM (without delta)	0.403	1.219	N/A	N/A	N/A	N/A	N/A

The results in Table 2, Table 3, Table 4, and Table 5 support the notion that market risk premium bias exists within each model. In all 16 regressions, the coefficient for the dummy variable is statistically significant even at a 99% confidence interval. Thus, both null hypotheses are rejected and the dummy variable proves significant. The t-values for the coefficient of the dummy variable are much greater in the CAPM than in the Fama French Model. This suggests that the addition of the dummy variable has a much greater impact on the CAPM model than the Fama French Model.

Testing the Effect of the Bias on Beta

The tables show that a market risk premium bias exists within both models. The next question to answer is which model is better at mitigating this bias. This question can be answered by examining how each model is affected by the addition of the dummy variable.

In all 8 regressions, the beta value increases with the addition of the dummy variable. This suggests that both models underestimate the value of beta due to market risk premium bias. Table 6 displays the extent to which beta is underestimated in each regression.

Table 6: Underestimations of Beta

Regression	**Model**	**Underestimation of Beta**
Equal Weighted Excess Returns	Fama French	2.55%
Equal Weighted Excess Returns	CAPM	5.85%
Equal Weighted Nominal Returns	Fama French	2.81%
Equal Weighted Nominal Returns	CAPM	6.09%
Value Weighted Excess Returns	Fama French	1.23%
Value Weighted Excess Returns	CAPM	4.54%
Value Weighted Nominal Returns	Fama French	1.50%
Value Weighted Nominal Returns	CAPM	4.79%

In all four cases using different types of returns, the CAPM underestimates beta by a higher percentage than the Fama French Model does. The CAPM on average underestimates beta by 4.54% - 6.09% while the Fama French Model only underestimates beta by 1.23% - 2.81%.

Chapter 5

Conclusion

The Capital Asset Pricing Model and the Fama French Model are widely regarded as the two most popular models for predicting asset returns. Some regard the CAPM as the most useful model due to its simplicity. Others appreciate that the Fama French Model accounts for two anomalies that are not accounted for by the CAPM: that small cap stocks and stocks with a high book-to-market ratio tend to outperform other types of stocks.

While the CAPM and the Fama French Model are the two most popular models, neither is perfect. Both are flawed in the sense that they neglect to consider that an inverse relationship between returns and beta will exist when the market returns fall below the risk-free rate. This flaw creates what Pettengill et al. coined as the market risk premium bias.

This paper does not claim that either model is more useful. Both models are useful at predicting asset returns; however the results of this study suggest Fama French Model is superior to the CAPM when considering market risk premium bias. Each model contains market risk premium bias, but the addition of two variables, SMB and HML, in the Fama French Model lessens the impact of this bias. The Fama French Model only underestimates beta by 1.23% - 2.81% while the CAPM underestimates beta by 4.54% - 6.09%.

There is opportunity for further research about the phenomenon of market risk premium bias. It would be valuable to continue to look at the relationship between beta and returns, particularly when the market risk premium is negative. This would be useful in understanding exactly what causes market risk premium bias and could potentially lead to the creation of a model that completely eliminates this bias.

Appendix A

Summary of Data

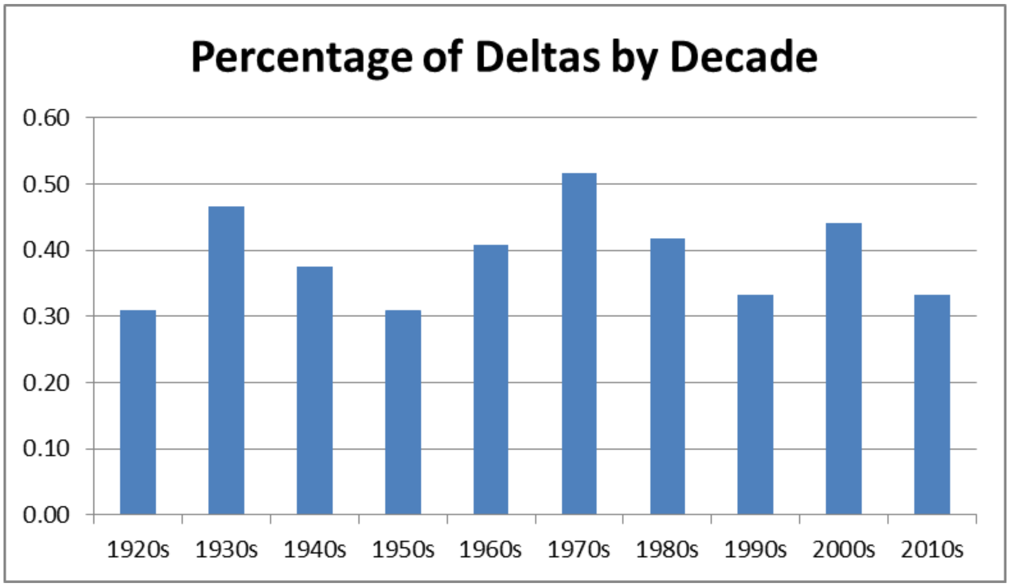
Summary of R_m-R_f, SMB, and HML

R_m-R_f		*SMB*		*HML*	
Mean	0.640	Mean	0.236	Mean	0.396
Standard Error	0.167	Standard Error	0.101	Standard Error	0.109
Median	1.020	Median	0.050	Median	0.240
Mode	1.410	Mode	0.050	Mode	0.480
Standard Deviation	5.413	Standard Deviation	3.264	Standard Deviation	3.543
Sample Variance	29.299	Sample Variance	10.651	Sample Variance	12.552
Kurtosis	7.377	Kurtosis	21.973	Kurtosis	17.701
Skewness	0.159	Skewness	2.152	Skewness	2.012
Range	66.740	Range	54.880	Range	49.990
Minimum	-29.000	Minimum	-16.390	Minimum	-12.680
Maximum	37.740	Maximum	38.490	Maximum	37.310
Sum	669.770	Sum	246.910	Sum	415.040
Count	1047	Count	1047	Count	1047

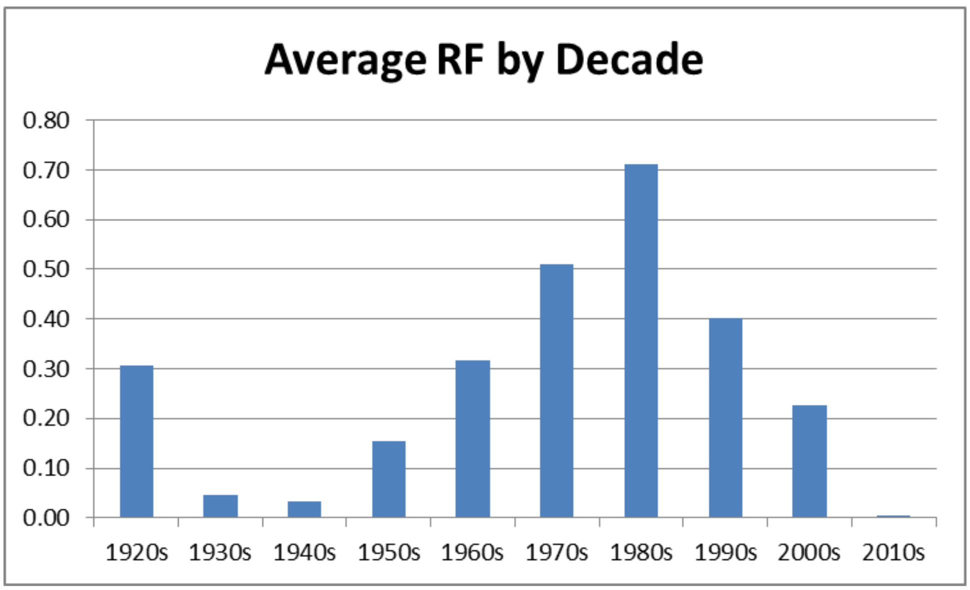
Summary of R_f, R_m, and DELTA

R_f		R_m		*DELTA*	
Mean	0.288	Mean	0.928	Mean	0.599
Standard Error	0.008	Standard Error	0.167	Standard Error	0.015
Median	0.250	Median	1.280	Median	1
Mode	0.030	Mode	-1.750	Mode	1
Standard Deviation	0.254	Standard Deviation	5.402	Standard Deviation	0.490
Sample Variance	0.064	Sample Variance	29.185	Sample Variance	0.240
Kurtosis	1.259	Kurtosis	7.355	Kurtosis	-1.840
Skewness	1.043	Skewness	0.126	Skewness	-0.404
Range	1.410	Range	66.810	Range	1
Minimum	-0.060	Minimum	-28.970	Minimum	0
Maximum	1.350	Maximum	37.840	Maximum	1
Sum	301.630	Sum	971.400	Sum	627
Count	1047	Count	1047	Count	1047

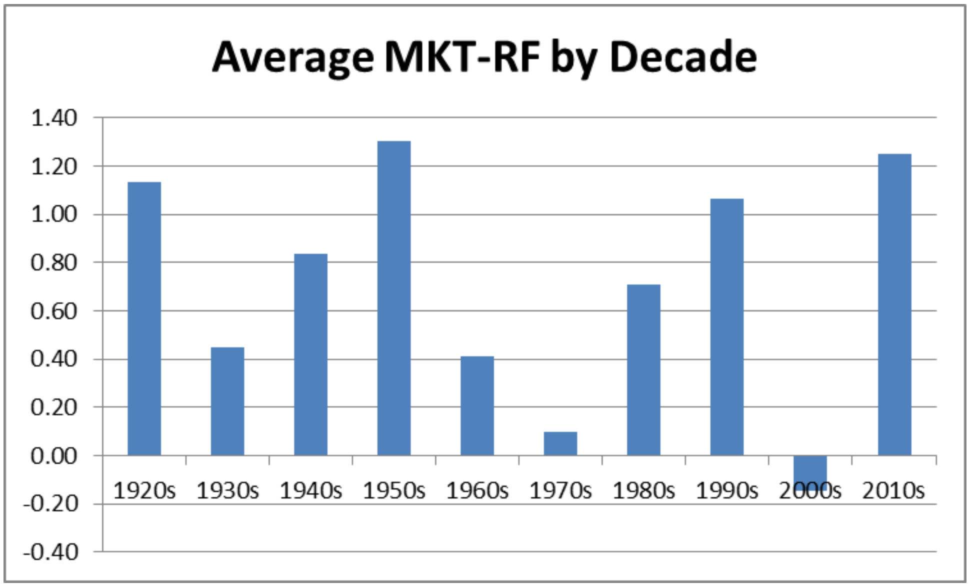
Percentage of Deltas by Decade



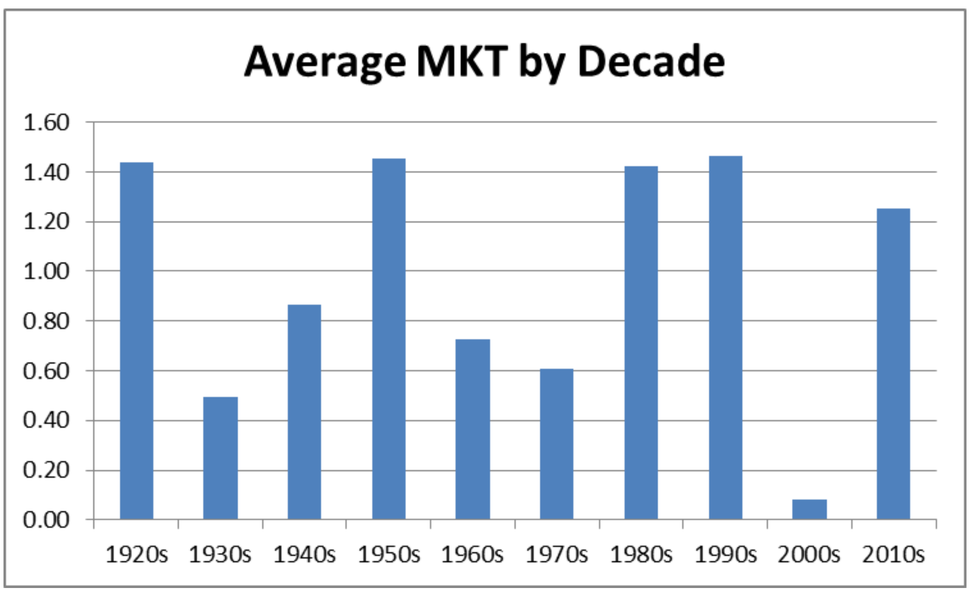
Average Rf by Decade



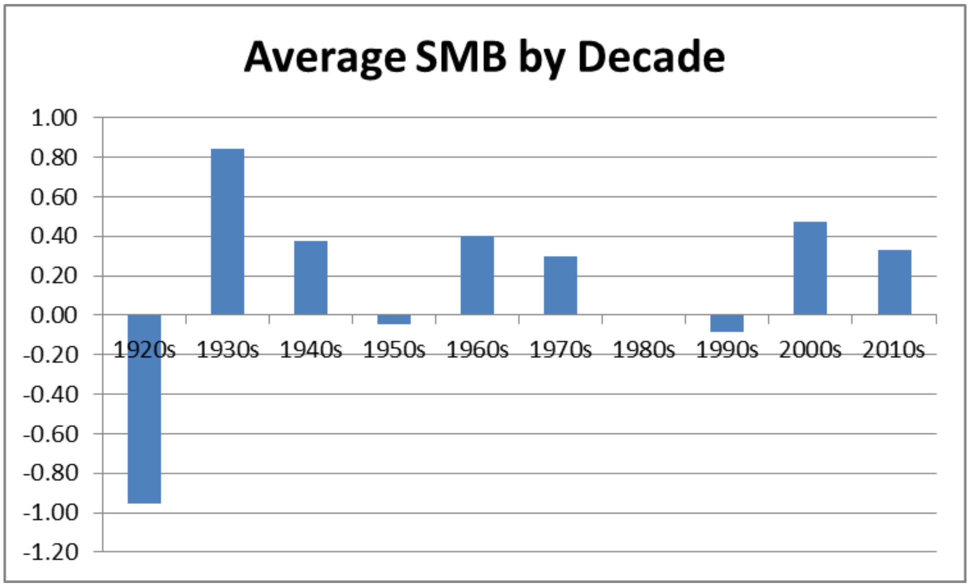
Average Rm-Rf by Decade



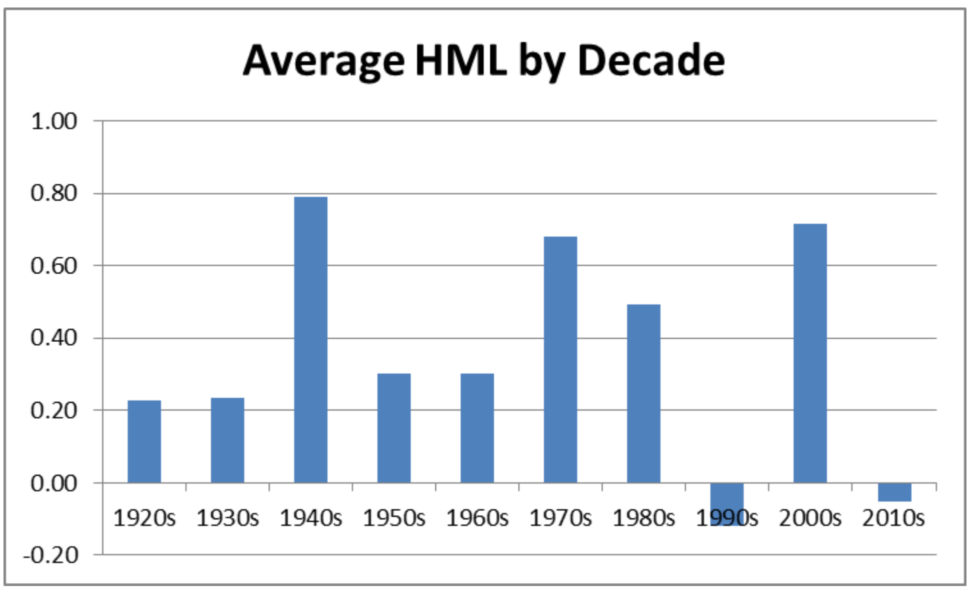
Average Rm by Decade



Average SMB by Decade



Average HML by Decade



Appendix B

Detailed Regression Results

Equal Weighted Excess Returns - Fama French With Delta

```
Fixed-effects (within) regression               Number of obs      =     26175
Group variable: Portfolio                       Number of groups   =        25

R-sq:  within  = 0.7791                         Obs per group: min =      1047
       between =      .                                        avg =    1047.0
       overall = 0.7782                                        max =      1047

                                                F(4,26146)         =  23049.44
corr(u_i, Xb)  = -0.0000                        Prob > F           =    0.0000
```

ExcessRetu~s	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
MKTRF	1.098836	.0067527	162.72	0.000	1.085601	1.112072
SMB	.6644308	.0078097	85.08	0.000	.6491234	.6797382
HML	.4045081	.0070835	57.11	0.000	.3906241	.4183921
DELTA	.4081155	.0710186	5.75	0.000	.2689153	.5473158
_cons	-.2058089	.0393848	-5.23	0.000	-.2830052	-.1286125
sigma_u	.28340762					
sigma_e	3.88422					
rho	.00529553	(fraction of variance due to u_i)				

F test that all u_i=0:   F(24, 26146) =   5.57   Prob > F = 0.0000

Equal Weighted Excess Returns - Fama French Without Delta

```
Fixed-effects (within) regression               Number of obs      =     26175
Group variable:  Portfolio                      Number of groups   =        25

R-sq:  within  =  0.7788                        Obs per group: min =      1047
       between =       .                                       avg =    1047.0
       overall =  0.7779                                       max =      1047

                                                F(3,26147)         =  30684.00
corr(u_i, Xb)  =  0.0000                        Prob > F           =    0.0000
```

ExcessRetu~s	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
MKTRF	1.071541	.0048027	223.11	0.000	1.062127	1.080954
SMB	.6638254	.0078138	84.96	0.000	.6485101	.6791408
HML	.4123684	.0069544	59.30	0.000	.3987374	.4259995
_cons	-.0276069	.0242954	-1.14	0.256	-.0752272	.0200134
sigma_u	.28340762					
sigma_e	3.8865979					
rho	.00528909	(fraction of variance due to u_i)				

F test that all u i=0:   F(24, 26147) =   5.57   Prob > F = 0.0000

Equal Weighted Excess Returns - CAPM With Delta

```
Fixed-effects (within) regression               Number of obs      =     26175
Group variable: Portfolio                       Number of groups   =        25

R-sq:  within  = 0.6876                         Obs per group: min =      1047
       between =      .                                        avg =    1047.0
       overall = 0.6868                                        max =      1047

                                                F(2,26148)         =  28769.73
corr(u_i, Xb)  = -0.0000                        Prob > F           =    0.0000

------------------------------------------------------------------------------
ExcessRetu~s |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       MKTRF |   1.337595   .0075066   178.19   0.000     1.322882    1.352309
       DELTA |   1.147093   .0828612    13.84   0.000     .9846804    1.309505
       _cons |  -.3379411   .0465838    -7.25   0.000    -.4292479   -.2466342
-------------+----------------------------------------------------------------
     sigma_u |  .28340762
     sigma_e |  4.6189826
         rho |  .00375058   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(24, 26148) =     3.94           Prob > F = 0.0000
```

Equal Weighted Excess Returns - CAPM Without Delta

```
Fixed-effects (within) regression               Number of obs      =     26175
Group variable: Portfolio                       Number of groups   =        25

R-sq:  within  = 0.6853                         Obs per group: min =      1047
       between =      .                                        avg =    1047.0
       overall = 0.6845                                        max =      1047

                                                F(1,26149)         =  56932.73
corr(u_i, Xb)  = 0.0000                         Prob > F           =    0.0000

------------------------------------------------------------------------------
ExcessRetu~s |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       MKTRF |   1.263688   .0052961   238.61   0.000     1.253307    1.274069
       _cons |   .1694898   .0288533     5.87   0.000     .1129358    .2260438
-------------+----------------------------------------------------------------
     sigma_u |  .28340762
     sigma_e |  4.6357898
         rho |  .00372353   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(24, 26149) =     3.91           Prob > F = 0.0000
```

Equal Weighted Nominal Returns - Fama French With Delta

```
Fixed-effects (within) regression               Number of obs      =     26175
Group variable: Portfolio                       Number of groups   =        25

R-sq:  within  = 0.7779                         Obs per group: min =      1047
       between =      .                                        avg =    1047.0
       overall = 0.7770                                        max =      1047

                                                F(4,26146)         =  22895.25
corr(u_i, Xb)  = -0.0000                        Prob > F           =    0.0000
```

PortfolioR~n	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
MKTRF	1.098843	.0067602	162.54	0.000	1.085592	1.112093
SMB	.6613734	.0078184	84.59	0.000	.646049	.6766979
HML	.4059781	.0070914	57.25	0.000	.3920786	.4198775
DELTA	.4493016	.0710976	6.32	0.000	.3099465	.5886567
_cons	.0658935	.0394286	1.67	0.095	-.0113887	.1431757
sigma_u	.28340762					
sigma_e	3.8885401					
rho	.00528383	(fraction of variance due to u_i)				

```
F test that all u_i=0:     F(24, 26146) =     5.56         Prob > F = 0.0000
```

Equal Weighted Nominal Returns - Fama French Without Delta

```
Fixed-effects (within) regression               Number of obs      =     26175
Group variable: Portfolio                       Number of groups   =        25

R-sq:  within  = 0.7776                         Obs per group: min =      1047
       between =      .                                        avg =    1047.0
       overall = 0.7767                                        max =      1047

                                                F(3,26147)         =  30468.32
corr(u_i, Xb)  = -0.0000                        Prob > F           =    0.0000
```

PortfolioR~n	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
MKTRF	1.068793	.0048087	222.26	0.000	1.059367	1.078218
SMB	.660707	.0078235	84.45	0.000	.6453726	.6760415
HML	.4146317	.0069631	59.55	0.000	.4009837	.4282797
_cons	.2620792	.0243256	10.77	0.000	.2143996	.3097587
sigma_u	.28340762					
sigma_e	3.8914343					
rho	.00527602	(fraction of variance due to u_i)				

```
F test that all u_i=0:     F( 24, 26147) =     5.55        Prob > F =  0.0000
```

Equal Weighted Nominal Returns - CAPM With Delta

```
Fixed-effects (within) regression               Number of obs      =     26175
Group variable: Portfolio                       Number of groups   =        25

R-sq:  within  = 0.6865                         Obs per group: min =      1047
       between =      .                                        avg =    1047.0
       overall = 0.6857                                        max =      1047

                                                F(2,26148)         =  28627.25
corr(u_i, Xb)  = -0.0000                        Prob > F           =    0.0000

------------------------------------------------------------------------------
PortfolioR~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       MKTRF |   1.337394   .0075081   178.13   0.000     1.322677     1.35211
       DELTA |    1.19132   .0828781    14.37   0.000     1.028875    1.353766
       _cons |  -.0674639   .0465933    -1.45   0.148    -.1587894    .0238616
-------------+----------------------------------------------------------------
     sigma_u |  .28340762
     sigma_e |  4.6199267
         rho |  .00374905   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(24, 26148) =     3.94           Prob > F = 0.0000
```

Equal Weighted Nominal Returns - CAPM Without Delta

```
Fixed-effects (within) regression               Number of obs      =     26175
Group variable: Portfolio                       Number of groups   =        25

R-sq:  within  = 0.6840                         Obs per group: min =      1047
       between =      .                                        avg =    1047.0
       overall = 0.6832                                        max =      1047

                                                F(1,26149)         =  56602.78
corr(u_i, Xb)  = -0.0000                        Prob > F           =    0.0000

------------------------------------------------------------------------------
PortfolioR~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       MKTRF |   1.260637   .0052987   237.91   0.000     1.250251    1.271022
       _cons |   .4595315   .0288674    15.92   0.000     .4029498    .5161131
-------------+----------------------------------------------------------------
     sigma_u |  .28340762
     sigma_e |  4.6380555
         rho |  .00371991   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(24, 26149) =     3.91           Prob > F = 0.0000
```

Value Weighted Excess Returns – Fama French With Delta

Fixed-effects (within) regression — Number of obs = **26175**
Group variable: **Portfolio** — Number of groups = **25**

R-sq: within = **0.7779** — Obs per group: min = **1047**
between = **.** — avg = **1047.0**
overall = **0.7773** — max = **1047**

F(**4**,**26146**) = **22890.62**
corr(u_i, Xb) = **-0.0000** — Prob > F = **0.0000**

ExcessRetu~s	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
MKTRF	1.06139	.0065055	163.15	0.000	1.048639	1.074141
SMB	.6039011	.0075237	80.27	0.000	.5891542	.6186481
HML	.3663894	.0068241	53.69	0.000	.3530138	.3797651
DELTA	.1926542	.0684183	2.82	0.005	.0585507	.3267578
_cons	-.1485614	.0379427	-3.92	0.000	-.2229312	-.0741915
sigma_u	.22561031					
sigma_e	3.742001					
rho	.00362188	(fraction of variance due to u_i)				

F test that all u_i=0: F(24, 26146) = 3.81 — Prob > F = 0.0000

Value Weighted Excess Returns - Fama French Without Delta

Fixed-effects (within) regression — Number of obs = **26175**
Group variable: **Portfolio** — Number of groups = **25**

R-sq: within = **0.7778** — Obs per group: min = **1047**
between = **.** — avg = **1047.0**
overall = **0.7772** — max = **1047**

F(3,26147) = **30510.10**
corr(u_i, Xb) = **0.0000** — Prob > F = **0.0000**

ExcessRetu~s	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
MKTRF	1.048505	.0046247	226.72	0.000	1.03944	1.057569
SMB	.6036154	.007524	80.22	0.000	.5888678	.6183629
HML	.3701	.0066966	55.27	0.000	.3569743	.3832256
_cons	-.0644397	.0233946	-2.75	0.006	-.1102944	-.018585
sigma_u	.22561031					
sigma_e	3.7424968					
rho	.00362093	(fraction of variance due to u_i)				

F test that all u_i=0: F(24, 26147) = 3.80 — Prob > F = 0.0000

Value Weighted Excess Returns - CAPM With Delta

```
Fixed-effects (within) regression               Number of obs      =     26175
Group variable: Portfolio                       Number of groups   =        25

R-sq:  within  = 0.6962                         Obs per group: min =      1047
       between =      .                                        avg =    1047.0
       overall = 0.6956                                        max =      1047

                                                F(2,26148)         =  29954.79
corr(u_i, Xb)  = 0.0000                         Prob > F           =    0.0000

------------------------------------------------------------------------------
ExcessRetu~s |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       MKTRF |   1.278059   .0071123   179.70   0.000     1.264118    1.291999
       DELTA |   .8618589   .0785087    10.98   0.000     .7079775     1.01574
       _cons |  -.2679586   .0441369    -6.07   0.000    -.3544693   -.1814478
-------------+----------------------------------------------------------------
     sigma_u |  .22561031
     sigma_e |  4.3763621
         rho |  .00265057   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(24, 26148) =     2.78           Prob > F = 0.0000
```

Value Weighted Excess Returns - CAPM Without Delta

```
Fixed-effects (within) regression               Number of obs      =     26175
Group variable: Portfolio                       Number of groups   =        25

R-sq:  within  = 0.6948                         Obs per group: min =      1047
       between =      .                                        avg =    1047.0
       overall = 0.6942                                        max =      1047

                                                F(1,26149)         =  59517.04
corr(u_i, Xb)  = 0.0000                         Prob > F           =    0.0000

------------------------------------------------------------------------------
ExcessRetu~s |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       MKTRF |   1.222529   .0050112   243.96   0.000     1.212707    1.232351
       _cons |   .1132955   .0273008     4.15   0.000     .0597845    .1668065
-------------+----------------------------------------------------------------
     sigma_u |  .22561031
     sigma_e |  4.3863518
         rho |  .00263854   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(24, 26149) =     2.77           Prob > F = 0.0000
```

Value Weighted Nominal Returns - Fama French With Delta

Fixed-effects (within) regression Number of obs = 26175
Group variable: **Portfolio** Number of groups = 25

R-sq: within = **0.7764** Obs per group: min = 1047
between = . avg = 1047.0
overall = **0.7758** max = 1047

F(4,26146) = 22691.27
corr(u_i, Xb) = -0.0000 Prob > F = 0.0000

MonthlyRet~n	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
MKTRF	1.061396	.0065185	162.83	0.000	1.048619	1.074173
SMB	.6008438	.0075388	79.70	0.000	.5860672	.6156203
HML	.3678594	.0068378	53.80	0.000	.3544569	.381262
DELTA	.2338403	.0685556	3.41	0.001	.0994676	.3682131
_cons	.123141	.0380189	3.24	0.001	.0486219	.1976601
sigma_u	.22561031					
sigma_e	3.7495136					
rho	.00360743	(fraction of variance due to u_i)				

F test that all u_i=0: F(24, 26146) = 3.79 Prob > F = 0.0000

Value Weighted Nominal Returns - Fama French Without Delta

Fixed-effects (within) regression Number of obs = 26175
Group variable: **Portfolio** Number of groups = 25

R-sq: within = **0.7763** Obs per group: min = 1047
between = . avg = 1047.0
overall = **0.7757** max = 1047

F(3,26147) = 30238.85
corr(u_i, Xb) = 0.0000 Prob > F = 0.0000

MonthlyRet~n	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
MKTRF	1.045756	.0046343	225.66	0.000	1.036673	1.05484
SMB	.6004969	.0075397	79.64	0.000	.5857187	.6152751
HML	.3723632	.0067105	55.49	0.000	.3592103	.3855162
_cons	.2252464	.0234432	9.61	0.000	.1792964	.2711964
sigma_u	.22561031					
sigma_e	3.750276					
rho	.00360597	(fraction of variance due to u_i)				

F test that all u_i=0: F(24, 26147) = 3.79 Prob > F = 0.0000

Value Weighted Nominal Returns - CAPM With Delta

```
Fixed-effects (within) regression               Number of obs      =     26175
Group variable: Portfolio                       Number of groups   =        25

R-sq:  within  = 0.6948                         Obs per group: min =      1047
       between =      .                                        avg =    1047.0
       overall = 0.6942                                        max =      1047

                                                F(2,26148)         =  29759.79
corr(u_i, Xb)  = 0.0000                         Prob > F           =    0.0000

------------------------------------------------------------------------------
MonthlyRet~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      MKTRF  |   1.277857   .0071185   179.51   0.000     1.263904     1.29181
      DELTA  |   .9060863   .0785777    11.53   0.000     .7520698    1.060103
      _cons  |   .0025186   .0441757     0.06   0.955    -.0840681    .0891053
-------------+----------------------------------------------------------------
    sigma_u  |  .22561031
    sigma_e  |  4.3802056
        rho  |  .00264593   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(24, 26148) =     2.78           Prob > F = 0.0000
```

Value Weighted Nominal Returns - CAPM Without Delta

```
Fixed-effects (within) regression               Number of obs      =     26175
Group variable: Portfolio                       Number of groups   =        25

R-sq:  within  = 0.6932                         Obs per group: min =      1047
       between =      .                                        avg =    1047.0
       overall = 0.6927                                        max =      1047

                                                F(1,26149)         =  59088.42
corr(u_i, Xb)  = 0.0000                         Prob > F           =    0.0000

------------------------------------------------------------------------------
MonthlyRet~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      MKTRF  |   1.219478   .0050168   243.08   0.000     1.209645    1.229311
      _cons  |   .4033372   .0273312    14.76   0.000     .3497665    .4569079
-------------+----------------------------------------------------------------
    sigma_u  |  .22561031
    sigma_e  |  4.3912445
        rho  |  .00263268   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u i=0:     F(24, 26149) =     2.76           Prob > F = 0.0000
```

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