Group Project 3:

Estimation of CAPM and the FAMA-FRENCH Three-Factor Model

-Prof: Natalia Gershun

Group 8

Krutarth Kothekar

Rutuja Kunkulol

Adil Natalkar

Akshika Yadav

Jinpeng Zhang

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Introduction

The chosen two companies:

- *Ford Motor Company (F),*
  - *Large-capitalization stock*
  - *High book-to-market (BM) ratio*
- *ATRC (AtriCure Inc),*
  - *Small capitalization stock*
  - *Low BM ratio.*

Reasoning:

After the group discussion, we would prefer to pick up two featured companies that are out of the wide industry range and considerations. The selected two stocks, Ford and AtriCure Inc, significantly represent the expected construction throughout our project this time.

In applying the Capital Asset Pricing Model (CAPM), the choice of Ford and AtriCure Inc offer an insightful contrast in investment characteristics. Ford, as a major player in the automotive sector, is characterized by its large capitalization and high Book-to-Market (BM) ratio (noticing that the definition of large-cap is a company with more than $10 billion market cap value, and comparably the small-cap refers a company's total market value in between $250 million to $2 million). This positions Ford as a stable and low-risk entity within the market, consistent with CAPM's prediction of lower volatility and, hence, lower expected returns for such stocks. The high BM ratio further suggests that Ford may be undervalued, positioning it as a value stock attractive for investors prioritizing steady performance and lower risk.

On the other hand, AtriCure Inc., representing the smaller-cap segment in the medical device industry, showcases a different investment profile with its low BM ratio. This implies a higher potential for growth, albeit with increased risk, a typical characteristic of small-cap stocks. According to CAPM, the higher risk associated with AtriCure, indicated by a potentially higher beta, is expected to be compensated by higher returns. Therefore, AtriCure is an ideal example for those seeking growth opportunities and willing to embrace the associated market volatility.

The strategic selection of these two companies for a portfolio well clarifies the importance of diversification, resonating with both CAPM and modern portfolio theory principles. This blend of a lower-risk, stable-return stock like Ford with a higher-risk, high-growth potential stock like AtriCure exemplifies a balanced approach to managing risk and return. This well-considered combination effectively demonstrates the practical implications of the CAPM in constructing a diversified investment portfolio.

Part 1: CAPM

Deliverables for the CAPM estimation

Estimate of Beta and Standard Error (σβ) from (R1) Regressions.

In conducting the regression analyses for FORD and ATRC using the Capital Asset Pricing Model (CAPM), we obtained estimates for beta (β) along with their corresponding standard errors (σ).

FORD:

*The estimated beta for Ford is **1.0132**. It suggests that the stock's returns are slightly more volatile than the overall market.*

*The standard error for Ford's beta is **0.0118** which indicates high level of accuracy for beta estimates.*

As Ford's beta is slightly greater than 1, it implies that the stock is marginally more volatile than the market. In a bullish market, Ford might perform slightly better than the market, but in a bearish market, it could underperform to a similar degree.

ATRICURE:

*The estimated beta for AtriCure is **0.9979**. This value is very close to 1, implying that AtriCure's stock returns tend to move in line with the market.*

*The standard error for AtriCure's beta is **0.011**. Similar to Ford, this low standard error suggests a high level of accuracy for beta estimate.*

The beta being just slightly less than 1 indicates that AtriCure may be marginally less volatile compared to the overall market. This suggests that its returns could slightly underperform in a rising market but also potentially lose less in a declining market.

Both the stocks exhibit a risk profile similar to the overall market, given their beta values are close to 1 the closeness of these beta suggests that both stocks are suitable for a portfolio that aims to mimic the broader market's performance.

Significance of Coefficients at 5% Confidence Level

- ***FORD:***

Constant (Intercept)

Coefficient: 0.0190	*Standard Error: 0.019*	*T-Statistic: 0.996*	*P-Value: 0.324*

Significance: The p-value is greater than 0.05, so the constant is not statistically significant at the 5% level.

Market Beta (rm)

Coefficient: 1.0132	*Standard Error: 0.011*	*T-Statistic: 91.271*	*P-Value:0.000 (or less than 0.05)*

Significance: The market beta is statistically significant at the 5% level, as the p-value is effectively zero.

- ***ATRICURE***

Constant (Intercept)

Coefficient: 0.0118.	*T Statistic: 0.599*	*P Value: 0.551*	*Standard Error: 0.020.*

Significance: The p-value is greater than 0.05, indicating that the constant is not statistically significant at the 5% level.

Market Beta (rm)

Coefficient: 0.9979	*Standard Error: 0.011*	*T-Statistic: 87.362*	*P-Value: 0.000 (or less than 0.05)*

Significance: The market beta is statistically significant at the 5% level, as indicated by its very low p-value.

In both regressions, the coefficients for the market beta (rm) are statistically significant at the 5% level, as evidenced by their very low p-values. This significance is inferred from the very large t-statistics which would only occur if the p-values were much lower than the standard significance level of 0.05. This statistical significance indicates that the relationship between the excess returns of these stocks and the market excess returns is not due to random chance.

Confidence Intervals for Beta Estimates

- **FORD**

95% Confidence Interval : [0.991, 1.035]

This interval suggests that with 95% confidence, the true beta value for Ford lies between 0.991 and 1.035.

The interval around 1 reinforces this, suggesting that Ford's stock is neither significantly riskier nor safer than the overall market.

The narrow range of this interval indicates a high degree of accuracy in the beta estimate, providing confidence in its accuracy.

- **ATRICURE**

95% Confidence Interval: [0.975, 1.021]

The 95% confidence interval for beta also indicates that the true beta value lies between 0.975 and 1.021 with 95% confidence.

Similar to Ford, this interval around 1 suggests that stock performance closely tracks the market. It is neither much more volatile nor much more stable than the market.

The accuracy of this estimate is also high, as indicated by the narrowness of the confidence interval.

Comparison of Confidence Intervals

Similarity in Interval Ranges:

Both stocks have confidence intervals that are centered around 1. This similarity suggests that both stocks have a market-level risk profile. The interval for FORD is slightly shifted upwards compared to ATRC's, suggesting a potential difference in the estimated beta values.

Implications for Investment:

These confidence intervals suggest that both Ford and AtriCure are likely to respond similarly to overall market changes. The stocks are expected to provide returns that are closely aligned with the broader market's performance.

Diversification Consideration:

Since both stocks have betas close to 1, including both in a portfolio might not offer significant diversification benefits in terms of risk exposure. They are both subject to similar levels of market risk.

Comparison of Bloomberg Betas with Estimated Betas

As we downloaded the betas for both Ford and Atricure InC from Bloomberg, there is a bit of a gap between the Bloomberg-provided betas and our estimation. Specifically, the betas retrieved from Bloomberg: F (Ford Motor Company): 1.497 and ATRC (AtriCure Inc): 1.295. Based on the original data that we estimated, F: 1.011 and ATRC: 0.997, the betas closing to 1 indicates that both companies' stock returns would tend to have variability similar to the market return. In general, the market performance of these two companies could be assessed as, on average, that there is no significance of either a higher volatility or lower volatility than the market. Differently comparing the betas with the Bloomberg's ones, both companies' stocks are higher than 1 which means more violate than the market. As we learned before, if the market goes up by 1%, followingly these stocks would be expected to increase by more than 1%.

However, after discussing and re-determined the known and same conditions, the difference in betas between our results and Bloomberg is acceptable and reasonable. Similarly, we tried to figure out and generate those potential uncertainties that caused the different results, whether technically or mathematically. As a consequence, we summed up the following assumptions based on our working foundation and the Bloomberg system: data quality, changes in the market environment, frequency of data updates, liquidity factors, and different calculation systems. For instance, there might be a tiny difference between the databases, and Bloomberg's data might be updated more frequently and specifically. Furthermore, the factor of the market environment would not be able to refresh up to the date as long as it always varies. Therefore, they are still reasonable that such a difference should be considered as part of the broader complexity and nuances inherent in financial modeling and investment analysis. More importantly, instead of focusing on a single factor, it massively requires us to think comprehensively in wide aspects among a variety of factors. (data retrieved from Bloomberg attached on the appendix)

Coefficient of Determination (R-squared) from Both Regressions

How well the models fit the data?

*For FORD, R^2 is **0.9931**, indicating that 99.31% of the variability in FORD's excess returns can be explained by the market's excess returns.*

*For ATRC, R^2 is **0.9925**, meaning that 99.25% of the variability in ATRC's excess returns can be accounted for by the market's excess returns.*

Comparison of R^2 Values

Similarity in High R^2 Values:

Both stocks exhibit very high R^2 values , indicating that the CAPM model explains a significant portion of the return variability for both stocks.

Implication:

These high R^2 values suggest that external factors specific to stocks (such as company-specific news, operational changes, etc.) have less influence on their stock returns compared to market-wide factors. This is indicative of the stocks' strong integration with and responsiveness to market dynamics.

Differences:

The difference in R^2 values between these stocks, though minimal (0.993 vs. 0.992), is negligible in practical terms.

1. Testing Hypothesis

Null Hypothesis (H0): *$\alpha=0$*

(alpha intercept is zero)

Alternative Hypothesis (H1): *$\alpha\neq0$*

(alpha intercept is not zero)

- **FORD**

Alpha Intercept (α) *0.0190*	***T-Statistic:*** *0.996*	***P-Value:*** *0.324*

The alpha intercept is 0.0190, and its associated p-value is 0.324. Since the p-value is greater than the significance level of 0.05, we do not reject the null hypothesis. This suggests that the alpha for Ford is not statistically different from zero, implying that the CAPM model adequately explains its returns, with no significant abnormal returns.

- ***ATRICURE***

Alpha Intercept (α) *0.0118*	***T-Statistic:*** *0.599*	***P-Value:*** *0.551*

The alpha intercept for AtriCure is 0.0118, with a p-value of 0.551. This p-value, being greater than 0.05, leads to not rejecting the null hypothesis. Therefore, alpha is not statistically different from zero, indicating that the CAPM model also sufficiently explains its returns without significant abnormal returns.

These finding aligns with the CAPM theory that the market's excess returns should account for the stock's excess returns, without any persistent abnormal returns that cannot be explained by the market. In practical terms, there aren't consistent, significant extra returns (either positive or negative) for these stocks beyond what the CAPM would predict.

Fama-French estimation:

Results and Statistical Significance of Fama-French Estimation

In the multifactor model, a comprehensive multiple regression analysis has been conducted for Ford, employing the excess return of Ford as the dependent variable.

Ford Fund (FORD) Fama-French Model

Market Beta (rm):

Coefficient: 1.0111	*T-Statistic: 97.735*	*P-Value: 0.000*

Analysis: *The market beta is highly statistically significant at the 5% confidence level, indicated by a p-value of effectively zero. This suggests a very strong relationship between stocks returns and the market's excess returns.*

HML Coefficient:

Coefficient: 0.0069	*T-Statistic: 2.464*	*P-Value: 0.017*

Analysis: *The HML factor, representing the value premium, is statistically significant. This implies that Ford's returns are influenced by the value factor, with value stocks likely offering higher returns.*

SMB Coefficient:

Coefficient: 0.0103	*T-Statistic: 2.331*	*P-Value: 0.023*

Analysis: *The SMB coefficient is significant, indicating that Ford's returns are somewhat influenced by the size premium – small stocks versus big stocks.*

AtriCure Fund (ATRC) Fama-French Model

Market Beta (rm):

Coefficient: 0.9971	*T-Statistic: 94.512*	*P-Value: 0.000*

Analysis: *The market beta for stocks is also highly significant, affirming a strong correlation with the market's excess returns.*

HML Coefficient:

Coefficient: -0.0049	*T-Statistic: -1.707*	*P-Value: 0.093*

Analysis: *The HML factor is not statistically significant for stocks. This suggests that the value premium does not have a significant impact on stocks returns.*

SMB Coefficient:

Coefficient: 0.0135	*T-Statistic: 2.983*	*P-Value: 0.004*

Analysis: *The SMB factor is significant, indicating that the size of the company plays a significant role in stocks returns.*

Interpretation of R^2 Values

Ford Fund (FORD)

R^2 Value: *0.994*

Analysis: *This high R^2 value indicates that the Fama-French model explains approximately 99.4% of the variance in Ford's returns. This level is exceptional, suggesting that the combination of market, size, and value factors provides a comprehensive explanation of Ford's stock performance.*

AtriCure Fund (ATRC)

R^2 Value: *0.994*

Analysis: *R^2 value of 0.994 for AtriCure indicates that 99.4% of the variability in its returns is explained by the model. This suggests a strong fit and that the Fama-French model, including the market, size, and (to a lesser extent) value factors, effectively captures the dynamics of AtriCure's stock returns.*

Further analysis

- *The beta coefficients' significance in both models highlights the importance of market movements in explaining the returns of both stocks.*
- *The significant SMB coefficients in both regressions suggest that company size is a relevant factor for both stocks.*
- *The difference in the significance of the HML coefficient between both stocks underscores the diverse impacts of the value factor across different companies.*
- *The identical and high R^2 values for both companies indicate that the Fama-French three-factor model is highly effective in explaining the stock returns of both a large-cap/value company (Ford) and a company that could be categorized differently (AtriCure).*

The results underscore the relevance of not only market risk but also size and value factors in explaining stock returns. For Ford, all three factors are significant, while for AtriCure, the market

and size factors play key roles. The high R^2 values in both cases reflect the robustness of the Fama-French model in capturing the complexities of stock performance in different market segments.

Comparing and contrasting results from the CAMP model and FF models for the large cap/value stock

R^2 Values:

CAPM Model's *R^2 value is 0.993, indicating that 99.3% of the variability in Ford's stock returns is explained by market movements.* ***For Fama-French*** *R^2 value increases slightly to 0.994, suggesting that 99.4% of the stock return variability is explained when size and value factors are included. The increment, although marginal, indicates a slightly better fit.*

Market Beta:

CAPM Model's *calculated market beta is 1.0132, suggesting a near-perfect correlation with the market, but slightly more volatile.* ***FF Model's*** *Market beta is 1.0111, which is very close to the CAPM model.*

Additional Factors in FF Model:

HML (Value Factor) *coefficient is 0.0069 with a p-value of 0.017, indicating a statistically significant impact from the value factor.* ***SMB (Size Factor)*** *coefficient is 0.0103 with a p-value of 0.023, also showing significant influence from the size factor.*

Statistical Significance of the models:

FF Model: *The significant coefficients for SMB (0.0103, p-value: 0.023) and HML (0.0069, p-value: 0.017) in the FF model underscore the importance of considering both size and value factors alongside market risk in analyzing Ford's stock performance which contrasts with the CAPM model.*

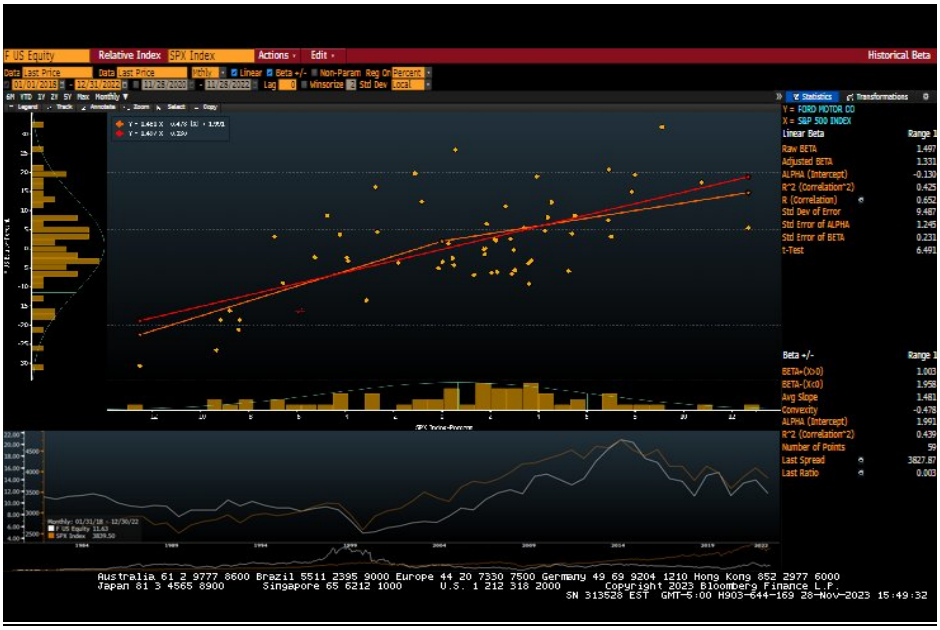
Does FF model outperform CAPM in explaining returns on the small cap/growth stock?

Based on the provided regression results, the Fama-French (FF) model appears to outperform the CAPM in explaining returns for a small cap/growth stock like AtriCure (ATRC). The FF model, with its inclusion of the size (SMB) and value (HML) factors, offers a more comprehensive explanation than the CAPM, which only accounts for market risk. This is evident in the significant SMB coefficient in the FF model for AtriCure, highlighting the importance of company size in influencing its stock performance. While both models exhibit high R^2 values, indicating a strong fit, the FF model's additional factors provide insights into return dynamics that the CAPM model overlooks. Specifically, the FF model's ability to capture the nuances of size and growth characteristics makes it more suitable for explaining the returns of small cap/growth stocks like AtriCure.

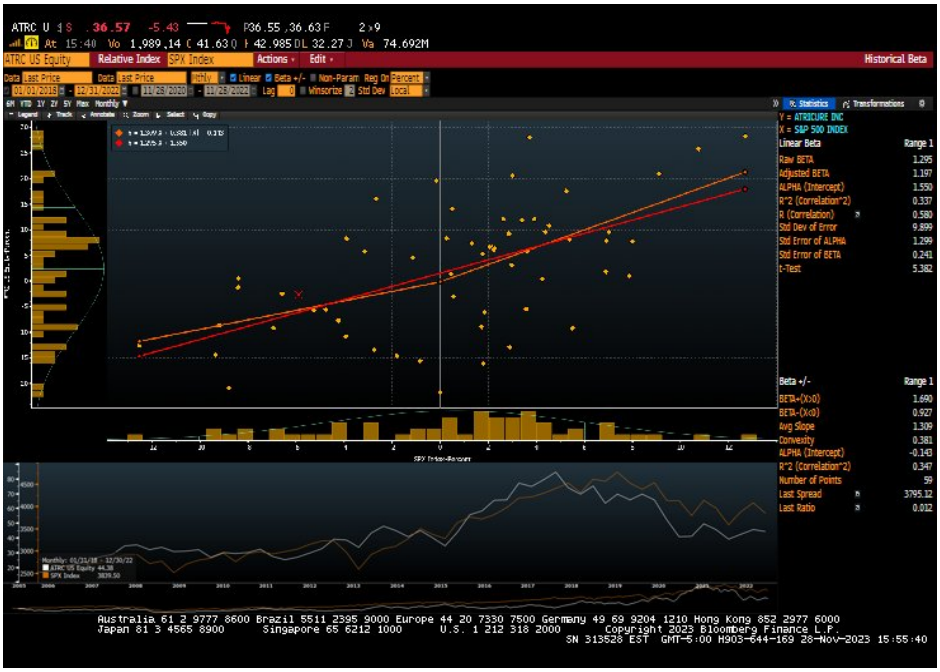
Appendix

Betas from Bloomberg:

F (Ford Motor Company):



ATRC (Atricure Inc):



Estimation ran by R and Python

R based:

```r
#CAPM and Multifactor models

### You should use your working directory to load data file from the case study ###
###Click: Session-->Set Working Directory-->To Source File Location

da = read.csv("Data.csv",header=T)  #<== Load data into R
head(da)  # <== Print out the first 6 rows of the data object "da".

market=da$Market
tbills=da$Tbills
hml=da$HML
smb=da$SMB
rm=market-tbills #excess return for the market
```

```r
#CAPM ANALYSIS:
# CAPM Analysis for FORD fund
r_FORD=da$RETURNS_FORD-tbills # excess return for FORD

#require(graphics)
capm_FORD=lm(r_FORD~rm)  # CAPM MODEL with one regressor
summary(capm_FORD)
```

```r
# CAPM Analysis for ATRC fund
r_ATRC=da$RETURNS_ATRC-tbills # excess return for ATRICURE

#require(graphics)
capm_ATRC=lm(r_ATRC~rm)  # CAPM MODEL with one regressor
summary(capm_ATRC)
```

```r
#CONFIDENCE INTERVALS:
#FORD
# Extracting the summary of the regression model for Ford
summary_ford <- summary(capm_FORD)

# Extracting the standard error for Ford's beta
se_ford <- summary_ford$coefficients["rm", "Std. Error"]

# Calculating the 95% confidence interval for Ford's beta
# The values come as 0.991 and 1.035 , which indicates that based on our regression analysis
# and with 95% confidence, beta value of Ford lies somewhere between 0.991 and 1.035.
# In Other words, if we were to conduct the same study many times, beta would fall within this range
ci_ford <- confint(capm_FORD, level = 0.95)["rm", ]
```

```r
#ATRC
# Extracting the summary of the regression model for ATRC
summary_atrc <- summary(capm_ATRC)

# Extracting the standard error for Ford's beta
se_atrc <- summary_atrc$coefficients["rm", "Std. Error"]

# Calculating the 95% confidence interval for ATRC's beta
# The values come as 0.975 and 1.021 , which indicates that based on our regression analysis
# and with 95% confidence, beta value of ATRC lies somewhere between 0.975 and 1.021.
# In Other words, if we were to conduct the same study many times, beta would fall within this range.
ci_atrc <- confint(capm_ATRC, level = 0.95)["rm", ]

#  the confidence interval for Ford's Beta and AtriCure's beta is centered around 1,
# indicating that its risk profile is similar to the overall market.

# FAMA FRENCH MULTI FACTOR MODEL:
# For FORD:

# #Multifactor model, This line runs a multiple regression for Ford, using the excess return of Ford
# and RM , HML , SMB factors as Independent variables.
Multi_FORD=lm(r_FORD~rm+hml+smb)
summary(Multi_FORD)

# For ATRC
Multi_ATRC=lm(r_ATRC~rm+hml+smb) #Multifactor model
summary(Multi_ATRC)
```

Python based:

```
pip install pandas statsmodels scipy
```

```
Requirement already satisfied: pandas in /usr/local/lib/python3.10/dist-packages (1.5.3)
Requirement already satisfied: statsmodels in /usr/local/lib/python3.10/dist-packages (0.14.0)
Requirement already satisfied: scipy in /usr/local/lib/python3.10/dist-packages (1.11.3)
Requirement already satisfied: python-dateutil>=2.8.1 in /usr/local/lib/python3.10/dist-packages
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-packages (from pand
Requirement already satisfied: numpy>=1.21.0 in /usr/local/lib/python3.10/dist-packages (from pan
Requirement already satisfied: patsy>=0.5.2 in /usr/local/lib/python3.10/dist-packages (from stat
Requirement already satisfied: packaging>=21.3 in /usr/local/lib/python3.10/dist-packages (from s
Requirement already satisfied: six in /usr/local/lib/python3.10/dist-packages (from patsy>=0.5.2-
```

```
import pandas as pd
import statsmodels.api as sm
from scipy import stats
```

```
# Load the data
data = pd.read_csv('/content/Data.csv')
```

```
# Load the data
data = pd.read_csv('/content/Data.csv')
```

```
# CAPM Analysis for FORD
X = sm.add_constant(data['rm'])
model = sm.OLS(data['r_FORD'], X).fit()
print(model.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                 r_FORD   R-squared:                       0.993
Model:                            OLS   Adj. R-squared:                  0.993
Method:                 Least Squares   F-statistic:                     8330.
Date:                Mon, 27 Nov 2023   Prob (F-statistic):          2.36e-64
Time:                        16:21:11   Log-Likelihood:                 54.503
No. Observations:                  60   AIC:                            -105.0
Df Residuals:                      58   BIC:                            -100.8
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0190      0.019      0.996      0.324      -0.019       0.057
rm             1.0132      0.011     91.271      0.000       0.991       1.035
==============================================================================
Omnibus:                        2.786   Durbin-Watson:                   1.858
Prob(Omnibus):                  0.248   Jarque-Bera (JB):                2.606
Skew:                           0.500   Prob(JB):                        0.272
Kurtosis:                       2.796   Cond. No.                         3.12
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

```
[ ]  # CAPM Analysis for ATRC
     model = sm.OLS(data['r_ATRC'], X).fit()
     print(model.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                 r_ATRC   R-squared:                       0.992
Model:                            OLS   Adj. R-squared:                  0.992
Method:                 Least Squares   F-statistic:                     7632.
Date:                Mon, 27 Nov 2023   Prob (F-statistic):           2.93e-63
Time:                        16:21:39   Log-Likelihood:                 52.791
No. Observations:                  60   AIC:                            -101.6
Df Residuals:                      58   BIC:                            -97.39
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0118      0.020      0.599      0.551      -0.028       0.051
rm             0.9979      0.011     87.362      0.000       0.975       1.021
==============================================================================
Omnibus:                        0.395   Durbin-Watson:                   1.649
Prob(Omnibus):                  0.821   Jarque-Bera (JB):                0.551
Skew:                          -0.152   Prob(JB):                        0.759
Kurtosis:                       2.642   Cond. No.                         3.12
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

```
[ ]  # Confidence Intervals for Ford and ATRC
     ci_ford = model.conf_int(0.05).loc['rm']
     ci_atrc = model.conf_int(0.05).loc['rm']
     print(f"Confidence Interval for Ford's beta: {ci_ford}")
     print(f"Confidence Interval for ATRC's beta: {ci_atrc}")
```

```
Confidence Interval for Ford's beta: 0    0.975028
1    1.020757
Name: rm, dtype: float64
Confidence Interval for ATRC's beta: 0    0.975028
1    1.020757
Name: rm, dtype: float64
```

```
[ ]  # Fama French Multifactor Model
     X = sm.add_constant(data[['rm', 'HML', 'SMB']])
```

```
     # For FORD
     model = sm.OLS(data['r_FORD'], X).fit()
     print(model.summary())

     # For ATRC
     model = sm.OLS(data['r_ATRC'], X).fit()
     print(model.summary())
```