Fama–French Factor Model Analysis

Daily Data: 2021–01–04 to 2024–12–31

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Abstract

This report presents an empirical analysis of four stocks (TSM, OXY, MRVI, SJW) using the Fama–French one-, three-, and five-factor models on daily data from January 4, 2021 to December 31, 2024. We document data preparation, model estimation, factor importance, and draw conclusions about factor contributions. The R script used for analysis is provided in the Appendix.

1 Introduction

The Fama–French factor models extend the CAPM by incorporating size, value, profitability, and investment factors. This study examines how each factor explains excess returns for four stocks over a five-year period. The objective is to compare model fit and factor significance across one-, three-, and five-factor specifications.

2 Data and Methodology

2.1 Data

Daily return data for TSM, OXY, MRVI, and SJW were obtained from Yahoo Finance. Fama–French daily 5-factor data were downloaded from Ken French's library and trimmed to the period 2021-01-04 through 2024-12-31.

2.2 Methodology

Excess returns are computed as daily returns minus the risk-free rate (RF). We estimate:

- **CAPM (1-factor):** $R_{i,t} - R_{f,t} = \alpha + \beta_M(R_{M,t} - R_{f,t}) + \epsilon_t$

- **FF3 (3-factor):** Add SMB and HML
- **FF5 (5-factor):** Further add RMW and CMA

Estimation is by OLS regression.

3 Results

3.1 Model Fit

Table 1 shows the Adjusted R-squared for each model and ticker.

Table 1: Adjusted R^2 for One-, Three-, and Five-Factor Models

Ticker	CAPM	FF3	FF5
TSM	0.3668	0.3792	0.3783
OXY	0.1066	0.2697	0.3229
MRVI	0.0551	0.0866	0.0864
SJW	0.0856	0.1333	0.1515

3.2 Factor Significance

Table 2 summarizes p-values for factor loadings in the FF5 model.

Table 2: FF5 Model Factor Loading p-values

Ticker	Mkt.RF	SMB	HML	RMW	CMA
TSM	¡2e-16***	0.7227	0.0004***	0.7696	0.4789
OXY	¡2e-16***	0.204	¡2e-16***	1.07e-14***	1.52e-05***
MRVI	5.95e-05***	3.15e-05***	0.0342*	0.2356	0.5900
SJW	¡2e-16***	1.07e-10***	0.9740	5.98e-05***	0.0073**

Signif. codes: *** p¡0.001; ** p¡0.01; * p¡0.05

4 Analysis and Discussion

4.1 Market Factor

The market factor is highly significant for all four stocks (p¡2e-16), confirming its primary explanatory power.

4.2 Size and Value

SMB is significant only for small-cap stocks (MRVI, SJW), while HML is significant positive for value stock OXY and negative for growth stocks (TSM, MRVI).

4.3 Profitability and Investment

RMW and CMA factors contribute mainly for value stocks (OXY, SJW), indicating profitability and conservative investment patterns were relevant.

4.4 Marginal Benefit of Additional Factors

The jump from FF3 to FF5 yields modest R^2 improvements except for OXY, suggesting three factors capture most of the cross-sectional variation.

5 Conclusion

Over the 2021–2024 period, the market, size, and value factors explain the bulk of daily excess returns. Profitability and investment factors add value for certain value-oriented firms but have limited general applicability. The classic three-factor model remains robust for broad application.

A R Script

The following R script was used to conduct the analysis.

Listing 1: Fama–French Model Estimation Script

```
# Fama–French Factor Model Estimation Script
# ------------------------------------------------------------
# 1. Clear workspace and load required libraries
rm(list = ls())
library(quantmod)
```

```r
library(xts)
library(tseries)

# 2. Read the cleaned Fama French 5-factor data (last 4 years)
ff_file <- "/Users/charlie/Desktop/NYU-2025-Spring/spring-       /7831/HW/HW
ff <- read.csv(ff_file, header = TRUE, stringsAsFactors = FALSE)

# 3. Convert Date column: first to character, then parse as Date (YYYYMMDD)
ff$Date <- as.character(ff$Date)
ff$Date <- as.Date(ff$Date, format = "%Y%m%d")

# 4. Create an xts object and extract factor series
ff_xts <- xts(ff[, -1], order.by = ff$Date)
rmrf <- ff_xts$Mkt.RF
smb  <- ff_xts$SMB
hml  <- ff_xts$HML
rmw  <- ff_xts$RMW
cma  <- ff_xts$CMA
rf   <- ff_xts$RF

# 5. Define function to estimate factor models for a given ticker
estimate_models <- function(ticker, start_date, end_date) {
  # Download daily adjusted close prices and compute daily returns (%)
  stock_data <- tryCatch(
    getSymbols(ticker, src = "yahoo", from = start_date, to = end_date, aut
    error = function(e) stop(paste("Error downloading data for", ticker, ":
  )
  returns <- dailyReturn(Ad(stock_data)) * 100
```

```
  # Align with risk-free rate and compute excess returns
  df <- merge(returns, rf, join = "inner")
  colnames(df) <- c("Return", "RF")
  df$ExcessReturn <- df$Return - df$RF

  # Merge excess returns with factor series (inner joins)
  data_all <- merge(df$ExcessReturn, rmrf, join = "inner")
  data_all <- merge(data_all, smb,  join = "inner")
  data_all <- merge(data_all, hml,  join = "inner")
  data_all <- merge(data_all, rmw,  join = "inner")
  data_all <- merge(data_all, cma,  join = "inner")
  colnames(data_all) <- c("ExcessReturn", "Mkt.RF", "SMB", "HML", "RMW", "C
  data_all <- na.omit(data_all)

  # Estimate models: CAPM, FF3, FF5
  capm <- lm(ExcessReturn ~ Mkt.RF,                    data = data_all)
  ff3  <- lm(ExcessReturn ~ Mkt.RF + SMB + HML,        data = data_all)
  ff5  <- lm(ExcessReturn ~ Mkt.RF + SMB + HML + RMW + CMA, data = data_all

  # Print summaries
  cat("\n==============================\n")
  cat("Ticker:", ticker, "--Period:", start_date, "to", end_date, "\n")
  cat("---CAPM-(1-factor)-Summary---\n"); print(summary(capm))
  cat("\n---FF3-(3-factor)-Summary---\n");    print(summary(ff3))
  cat("\n---FF5-(5-factor)-Summary---\n");    print(summary(ff5))
}

# 6. Specify tickers and date range
tickers    <- c("TSM", "OXY", "MRVI", "SJW")
```

```r
start_date <- first(index(ff_xts))
end_date   <- last(index(ff_xts))

# 7. Run estimation for each ticker
for (tkr in tickers) {
  estimate_models(tkr, start_date, end_date)
}
```