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RECREATING THE THREE FACTOR MODEL WITH MODERN DATA

by

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Abstract

This paper is intended to test the widely accepted Three Factor Model developed by EuegneFama and Kenneth French in 1992. Modern data is used in order to test the hypothesis that the Three Factor Model is still indeedaccurate and relevant. A statistical observation was done using OLS estimators during the time period 1951 to 2016.The data set used is monthly data with a specific measure on cash flow to price taken from the Center for Research in Security Prices. Evidence suggest the three factor model may not fully explain portfolio returns but does fairly explain most portfolios.

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1. Introduction

1.1 The CAPM

The Capital Asset Pricing Model is a way of describing the relationship between systematic risk and expected return for assets. It is was developed in the 1960's and is still widely used as an estimator for returns of assets, mainly stocks and portfolios. The main idea this model emphasizes on is the market risk associated with a potential investment; which is deemed the "beta." There are several assumptions behind the formula that have been shown not to necessarily hold in reality. However, the CAPM seems to still be used due to its simplicity and ease of comparisons for investment alternatives.

By using beta, the formula assumes that risk is able to be measured by the asset's volatility, however, price movements in both directions are not necessarily of equal risk. The CAPM also does not take into the account the fact that the risk-free rate does not remain constant over a discounting period. This means that an increase in the risk-free rate could make the stock being analyzed seemed overvalued for investors. The CAPM unrealistically makes the assumption that investors are able to borrow and lend at a risk-free rate. Yet, actual investors are unable to borrow at the same rate as the government. This means that the minimum return may actually provide less of a return than the model calculates.

Still, the CAPM has multiple practical uses, namely its simplicity and application as a tool to gauge the reasonableness of future expectations. The model itself has been widely stress tested and has been proven to better estimate returns than the Dividend Discount Model as well as the Weighted Average Cost of Capital model in multiple scenarios.

1.2: The Three Factor Model

The Three Factor Model is an asset pricing model first developed in 1992 that essentially expands the Capital Asset Pricing Model. The two researchers who established this model are Eugene Fama and Kenneth French, two researchers at the University of Chicago Booth School of Business at the time. Theyin essence take the already established CAPM and add two more factors to the model to further explain the expected returns of the portfolios. The two factors they add are used to account for size risk as well as value risk. They define these in their regression equation using the terms, "small minus big" and "high minus low." Small minus big refers to the fact that small-cap stocks tend to outperform the larger-cap stocks. The high minus low refers to the phenomenon of value stocks outperforming growth stocks. The term, "value stock" refers to a stock that trades at a lower price relative to its earnings or sales. With the inclusion of these extra factors, the model is thought to be a better tool for evaluating portfolio performance. Fama and French conducted studies to test their model and found that when they include the two extra factors, the model can explain as much as 95% of the return of a diversified portfolio.

1.3: The Issue

The Three Factor Model was created in the early 1990's, when the size of real GDP was nearly half of what it is today. Since 1992, there have been three different recessions, all forcing the federal reserve to change policies in order to offset economic downturn. During this time, the federal reserve was known to use mainly conventional monetary policies to either increase or decrease the money supply. However, since the 2008 recession the federal reserve has taken to unconventional monetary policy, such as quantitative easing. These policy implications have changed the way the markets act and have had a major effect on the stock market. It is known that expansionary quantitative easing

causes the markets to become bullish and stock prices tend to rise. However, it makes sense that quantitative easing when used as a way to shrink would cause stock prices to fall in value. The real issue is whether or not the three factor model still applies to today's markets or whether it needs to be revised using other factors.

2. Literature Review

Eugene Fama and Kenneth French developed the three factor model in their 1993 paper "Common Risk Factors in the Returns on Stocks and Bonds." Within the paper, they identify five common risk factors in the returns of stocks as well as bonds. They split the five common factors into two categories, one dealing with stocks and the other in bonds. They identify three stock-market factors, those being an overall market factor and factors related to firm size and book-to-market equity. The first factor they are describing is known as the stock's beta, essentially a measure of volatility compared with that of the market. The next factor, firm size, can be seen as their small minus big or SMB. They outline that this is the historic excess of small cap companies over big cap companies. Their last factor can be seen as what they call high minus low or HML. This is identified as the value premium and it represents the spread in returns between companies with a high book-to-market ratio and companies with a low book-to-market ratio. This paper establishes the three factor model itself and is the basis to which a multitude of research is based on.

Fama and French (2006) go more in depth with their idea of the value premium, that is the idea that value stocks tend to return better than growth stocks on a risk-adjusted basis. They use this as the difference in returns between high book to market stocks and low book to market stocks, which they refer to as HML (high minus low). In this paper they are essentially defending their remarks made in their 1992 paper. They examine how value premiums vary with firm size, whether the capital asset pricing model explains value premiums and whether average returns compensate beta in the way predicted by the capital asset pricing model. They then go into a paper written by Loughran in 1997 and prove that evidence for a weak value premium among large firms is only the case in the period 1963 to 1995. They disprove another paper written by Ang and Chen in 2005 by showing that evidence that the capital asset pricing model can explain U.S. value premiums is only applicable to the period 1926 to 1963. They essentially disprove the capital asset pricing model throughout the period 1963 to 2004. The purpose of proving this is the CAPM was created using data from before 1963, mainly during the period 1926 to 1963. In this paper they do show that the capital asset pricing model can in fact explain the strong value premiums. However, when they used more modern data they reject the CAPM explanation of value premiums up to the year 2004. In this paper, I will be doing a very similar study to test not only the CAPM but also the three factor model when exposed to newer data during different time periods.

Clive Gaunt (2004) tests the three factor model and the capital asset pricing model using modern data in the Australian markets. This paper further expands on a topic introduced in Hallwell, Heaney and Sawicki in 1999 of whether the three factor model is able to play a role in asset pricing. Hallwell's paper establishes that the CAPM has significant explanatory power in the markets. However, Gaunt shows that the previous study was conducted during the years 1981-1991 and chooses to add a further 10 years of data. He then concludes that his study finds the three factor model to provide a significantly improved descriptive power over the capital asset pricing model and also finds that the book-to-market factor plays a role in asset pricing. In this study, data of 10 years makes a difference in proving the three factor model to be superior and relevant. Not only does it prove that older data can be sometimes be misleading but it also shows that the model performs not only in U.S. stock exchanges but also in the Australian Stock Exchange (ASX). Australia is an interesting area to study,

as it is considered a developed country due to its standard of living, however, its economic base is similar to that of developing countries. Australia's economy is heavily skewed to mining and agriculture as well as exporting low value-add products, which is something typically associated with developing nations. The ASX is fairly small in contrast to the New York Stock Exchange (NYSE) by both number of listings and market capitalization. While the ASX has a market cap of $1.982 trillion, the NYSE has a total cap of $30.01 trillion as of February 2018. This shows that the three factor model is still significant on a smaller exchange market and is not an anomaly only present in U.S. stocks exchange markets.

Daniel Chai (2019) is a very recent example of a paper concerning the Australian Stock Exchange with a comprehensive sample spanning a period 35 years. It is known that typical equity markets outside the United States are generally dominated by small-sized stocks that may be considered to be outside the investable universe of institutional investors. Chai in essence is comparing the performance of different factor models in pricing large Australian stocks. He then sheds some light on the findings in prior studies concerning both national and international pricing of assets. He concludes that the five factor model, from Fama and French in 2015 is superior to the competing models. As he expands the sample from the top 300 stocks to the top 500 stocks, this superiority becomes ever more apparent. This study demonstrates the need for more factors when evaluating portfolios.

3. **Methodology**

As this paper's overall goal is to test the Three Factor Model using more modern data, there will two different tests being conducted. The first will be the portfolio evaluation using the capital asset pricing model, with one regression variable. The next will be an OLS Regression using the three factors established by Fama and French in their 1993 paper. The data will be supplied from Kenneth French's website from Dartmouth, which is taken directly from the Center for Research in Security Prices. The data set being used consists of monthly returns ranging from the years 1951 to 2016 of portfolios that trade on stocks which have a specific measure on cash flow to price.

3.1: The Capital Asset Pricing Model

The purpose of using the CAPM first is to test if using the extra two factors are necessary at all. If given the same results while using the CAPM and the three factor model, it would be evident that the three factor model is irrelevant. The CAPM model historically has used a market risk factor solely to explain the excess returns investors seek. Therefore, there should only be one testable variable in the equation itself. The purpose of this study is to find the excess returns that are not accounted for by the capital asset pricing model. A variable will be added to the end fo the traditional model, which I will be using linear regression to find. For this reason, the formula being used in my regression will be:

$$Expected\ Return = r_f + \beta(r_m - r_f)$$

$r_f = risk\ free\ rate$

$\beta = Beta$

$r_m = return\ on\ the\ market$

However, it must be said that in order to find what the excess returns are given the variables I have, there needs to be some constant value added to the regression formula above. Throughout my

results I will referring to this constant value as "alpha" or α. For this reason, the regression equation I will be using to test the applicability of the capital asset pricing model will be:

$$Expected\ Return = r_f + \beta(r_m - r_f) + \alpha$$

r_f = *risk free rate*

β = *Beta*

r_m = *return on the market*

α = *unexplained returns by the model*

In order for the capital asset pricing model to hold reliable and true, a relatively small value of alpha should be observed. If the value of alpha is large and significant, then there will be questions asked about the CAPM itself. Even though it is not supposed to explain all of the returns a portfolio faces, it should explain most of the returns. For this reason, I am looking for a small value of alpha.

3.2: The Three Factor Model

Once I have established the value of alpha for the capital asset pricing model, I will then move to the same test using the two factors identified by Fama and French. The purpose of this is to test whether the capital asset pricing model outperforms the three factor model given the same data set. If after the study, I realize the three factor model does not outperform the capital asset pricing model, I will be forced to conclude that for this particular set of data, the three factor model is not relevant. I will be using a standard three variable regression equation typically associated with the Fama-French three factor model. The equation in mathematical form can be expressed as:

$$r = r_f + \beta_1(r_m - r_f) + \beta_2(SMB) + \beta_3(HML) + \varepsilon$$

r = *Expected Return*

r_f =*Risk free rate*

$(r_m - r_f)$= *Market risk premium*

β =*Factor's coefficient (sensitivity)*

SMB =*Historic excess returns of small-cap companies over large cap companies*

HML =*Historic excess returns of value stocks over growth stocks*

ε =*Risk*

In order to find the excess returns not measured by the three-factor model, I need to add in some constant value and solve for it. Similar to the capital asset pricing model, I will be using "alpha" which will be denominated by the symbol α. In order to find this alpha, I will be taking the regression equation and filling in all known variables and solving for the lone alpha as well as the multiple factor coefficients to test sensitivity. My revised regression equation will be expressed as:

$$r = r_f + \beta_1(r_m - r_f) + \beta_2(SMB) + \beta_3(HML) + \varepsilon + \alpha$$

r = *Expected Return*

r_f =*Risk free rate*

$(r_m - r_f)$= *Market risk premium*

β =*Factor's coefficient (sensitivity)*

SMB =*Historic excess returns of small-cap companies over large cap companies*

HML =*Historic excess returns of value stocks over growth stocks*

ε =*Risk*

α = Unexplained returns by the model

While testing the three factor model, I will be looking for a small, significant value of alpha. This will demonstrate the three factor model better explains the excess returns of the portfolios than that of the capital asset pricing model. If alpha if not small or significant, I will be forced to reject the connotation that the three factor model better explains stock returns than that of the capital asset pricing model.

4. Results

4.1: The Capital Asset Pricing Model

Upon the running the regression for the capital asset pricing model, I was presented with a summary output of values for the tested coefficients as well as statistical values in order to test the significance. For this study, I will be using the P-value in order to verify whether the value is significant. I will also include the standard error as well as the t-statistic, however, I will be referencing the p-value mostly when describing significance. Table 1 below outlines the regression summary of the capital asset pricing model.

Table 1: Summary Output for CAPM

	Coefficients	**Standard Error**	**T Statistic**	**P-value**
Alpha	0.447426126	0.100166829	4.466809318	9.22E-06
β With Respect to Market Risk	1.027867247	0.022887738	44.90907996	7.9E-211

The results above indicate that the capital asset pricing model does work for estimating the excess returns for a stock portfolio. When looking through the coeifficents column, the Alpha is defined as nearly .45 and the beta is defined as nearly 1. This means that the excess returns not accounted for by the capital asset pricing model are nearly 45 basis points per month and the beta close to 1 signifies that the portfolio is just as volatile as the market. Those 45 basis points a month work out to be 528 basis points per year in returns that the model does not explain, on average. When working this out to percentage points, that is 5.28% returns that are not accounted for in a year. An investor may look to the capital asset pricing model and not realize that a possible investment may be more or less lucrative by nearly 5% a year. When looking to the P-value to test significance, both

values are essentially 0. The closer to 0 the P-value is, the less likely the results happened by chance. This shows the values given by the regression are significant.

4.2: The Three Factor Model

When running the regression for the three factor model, I was presented with a summary output that included a value for alpha as well as for the three beta coefficients used in the equation. Once again, in order to test significance, I will be observing the P-value of the data given and will accept the data if the P-value is close to 0. Table 2 shows the summary below.

Table 2: Summary Output for Three Factor Model

	Coefficients	**Standard Error**	**T Statistic**	**P-value**
Alpha	0.138530643	0.07881553	1.757656685	0.079233
β with respect to market risk	1.104806181	0.018841461	58.63696996	8.9E-276
β with respect to SMB	0.169216741	0.027624075	6.125698081	1.49E-09
β with respect to HML	0.642729896	0.029490771	21.79427231	3.41E-81

The results above demonstrate how the three-factor model is in fact more proficient at explaining excess returns in the portfolios. The alpha is nearly .14, which means that the model fails to explain nearly 14 basis points a month. When looked at from a yearly point of view, that is nearly 168 basis points annually. This would constitute 1.68% of returns that the model does not explain annually. The values are significant according to the P-value column, which shows the highest P-value to be almost .08, while the rest are essentially 0. A P-value of .08 means that there is an 8% chance that the results happened by chance. This means that it is not incredibly significant, but it is fairly significant and is not insignificant enough to reject.

Overall, it is clear that thethree-factor model better explains returns than does the CAPM. From an annual view, there is a difference of nearly 360 basis points that get explained by the three-factor model. In this case, the CAPM would be off by over three and half percent if an investor was to choose to apply it over the three-factor model. It must be said, however, that the three-factor model did not come out with an alpha of 0. This means that the three-factor model does not fully explain excess returns from portfolios. However, this was not claimed by Fama and French originally, who claimed the model fairly explains excess returns of stocks and bonds. Overall, the three-factor model, while it does not fully explain returns, does explain more than the capital asset pricing model.

Conclusion

The purpose of this paper was to test the three-factor model in explaining excess returns using modern data. The data set for this study comes from monthly returns ranging from the years 1951 to 2016 for portfolios that have a specific measure on cash flow to price. The data itself comes from the Center for Research in Security Prices, compiled by Kenneth French. Previous research shows the three-factor model better explains stock returns than does the capital asset pricing model. Studies considered were for both United States Stock Markets as well as the Australian Stock Exchange to validate the model does work for foreign exchanges as well, when presented alongside modern data. My regression does show that the three-factor model does better explain the excess returns of my portfolios than does the capital asset pricing model. There was shown to be a 3.6% annual difference between the two.

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