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# **Explaining Stock Returns: the CAPM, Fama-French Three Factor Model and Carhart's Four Factor Model**

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## **Abstract**

This paper provides a literature review from the last 60 years of asset pricing models. In Chapter 2 the EMH and the CAPM will be discussed followed by the Three Factor Model from Fama and French and Carhart's Four Factor Model in Chapter 3. In Chapter 4 the most important papers, which is subjective, will be reviewed and discussed. The literature study does not give enough empirical evidence to strongly support that the Three Factor model is better than the CAPM.

## Table of Contents

Abstract.....	2
1. Introduction and Problem formulation .....	4
1.1 Introduction.....	4
1.2 Problem formulation.....	4
2. EMH and the CAPM .....	5
2.1 Efficient Market Hypothesis.....	5
2.2 Capital Asset Pricing Model .....	6
3. Fama, French and Carhart.....	8
3.1 Fama-French Three Factor Model .....	8
3.2 Carhart's Four Factor Model.....	9
4. Literature review .....	11
5. Conclusions .....	16
5.1 Conclusions & limitations .....	16
5.2 Recommendations for further research.....	16
References.....	17

# 1. Introduction and Problem formulation

## 1.1 Introduction

Since the existence of the stock market people have wanted to be able to explain the stock market returns. Being able to explain the returns might give you a better idea about how the stock will perform in the future. One of the only things we can do to predict the future is trying to explain the past. In the last 50 years asset pricing models have become increasingly popular. One model that has been especially popular is the Capital Asset Pricing Model, known better as the CAPM. In about every financial textbook this model is explained in much detail. This raises the question why we would need all these models in the first place. The answer is pretty simple; because they can help with many different things like valuating investments and to help with capital budgeting. The CAPM has been a great model for a long time that explains the cross-sectional differences of stock returns with only a single factor, beta. Any stock return behavior that cannot be explained by the CAPM is called an anomaly. During the years, many anomalies have been spotted. In the last 50 years, the CAPM and all models trying to explain stock returns have been a hot issue. Numerous studies have tested the CAPM for empirical validity. A major breakthrough came in 1992 when Fama and French found proof that beta alone was not good enough to explain variance in stock returns. The financial world would never be the same again. This paper will mainly focus on three models, the CAPM, Fama-French Three Factor Model and Carhart's Four Factor model.

## 1.2 Problem formulation

With this paper I will investigate three different types of financial models. I will first of all explain the three models and their origin. Furthermore there will be a discussion about the usefulness of the models and in the end there will be a discussion which model proves to be the best in modern finance. Is the Fama-French Three Factor Model more useful than the CAPM?

## 1.3 Data and structure

There has been a lot of research about the stock market. As stated earlier I will mainly focus on three different models; Capital Asset Pricing Model, Fama-French Three Factor Model and Carhart Four Factor Model. The data I will use are numerous papers about these subjects. All of these three models are explained and criticized in many papers. I will make a selection of the most useful papers, which I will use to discuss the models. In Chapter 2 I will explain the Efficient Market Hypothesis and the (origin) of the CAPM. In Chapter 3 the Three Factor Model will be discussed together with Carhart's model. Chapter 4 will provide a literature review and Chapter 5 gives a conclusion.

## 2. EMH and the CAPM

In this chapter, I will give an outline of some very important financial theories. First of all, I will start with explaining the Efficient Market Hypothesis (EMH), including the random walk. After that, the origin of the Capital Asset Pricing Model (CAPM) will be discussed, followed by an explanation of the CAPM, Fama-French Three Factor Model and Carhart's Four Factor Model.

### 2.1 *Efficient Market Hypothesis*

The Efficient Market Hypothesis (EMH) has been the main starting point for many financial papers. This hypothesis was founded by Eugene Fama, but not before many other people had been doing research in the same area. In 1863, Jules Regnault already modelled the random character of the stock market price. This later became the Random Walk Theory. The main point of the EMH is that it will be impossible to 'beat the market', gaining a higher return on their stock than other people. This hypothesis is based on the idea that all available information is directly reflected in the stock price, therefore making it impossible to make a profit by having more information than other traders. When new information arises, the news spreads very quickly and the stock price will be adjusted to the news instantly. If this hypothesis is true, then it will be useless to study past stock returns or search for undervalued companies, because you will not be able to gain a higher return. As said earlier, a very important factor of the EMH is the Random Walk Theory. This theory roughly says that stock prices seem to wander randomly over time (Kendall (1953)). The main idea and logic behind this theory is that if the EMH holds, then tomorrow's prices will only be affected by the news and information of tomorrow and that it will be independent of the price changes today. However, nobody knows what will happen tomorrow, so news is unpredictable. If the news is unpredictable, then the stock returns of tomorrow will be random. When Fama came up with the EMH, he thought of three types of efficiency; strong-form, semi-strong form and weak form. The difference between the three forms is what kind of information is factored in the price. In the weak form, the only information available are the historical prices. Semi-strong form means that all publicly known information is reflected in the price. At last, strong form efficiency says that all information, including inside or private information is reflected in the price.

The EMH has been a very good tool for many financial studies. However, economists have always tried to criticize the model and to come up with a better model. The financial crisis

from 2007 till 2010 did not do much good for the model. People tend to react differently in a crisis than they would normally do, adjusting their courses of action. Grantham even states that the financial crisis is caused by hypotheses like the EHM, because having too much faith in such a hypotheses makes financial leaders weak and let's them underestimate the dangers and risks of the financial market. Also well known financial journalists and reporters were not that happy anymore with the EMH. At the annual International Organization of Securities Commissions conference from June 2009 the EMH was the hot topic for the financial people. The hypothesis was heavily criticized. People discarded the theory as a useless with no real information about how markets function in real life. Fama, the inventor of the EMH model, has not lost faith in the model by saying stating that the markets were a victim of the crisis and not the cause. Further research might be needed, but it is unlikely that a trusted hypothesis like the EMH will be discarded so easily.

## *2.2 Capital Asset Pricing Model*

In 1952, Harry Markowitz came up with the Modern Portfolio Theory (MPT). This MPT was the framework on which the CAPM was built. The model Markowitz created was a single-period model, where an investor creates a portfolio at the beginning of the period. The objective for the investor is to maximize his expected return, taking into account the maximum amount of risk he or she wants to bear. The risk is measured by the standard deviation. As more and more stocks or securities are added to the portfolio, a line is created that is called the 'efficient frontier'. Depending on the amount of risk the investors wants to face, he or she can move along this line.

In modern finance the CAPM belongs to the most widely used models that try to measure the required rate of return of an asset. Jack Treynor (1961), William Sharpe (1964), John Lintner (1965) and Jan Mossin (1966) independently built on the MPT, resulting in the Capital Asset Pricing Model. According to the CAPM, investors will only invest in an asset if they get compensated for the time value of money and for the risk they take. Starting with the time value of money, the CAPM uses a risk-free rate. This risk-free rate compensates the portfolio holder for the return he or she would have normally gained if he or she had invested the same amount of money in a project that is absolutely risk free, like borrowing money to the government. In the CAPM this is reflected by  $R_f$ . Beside the risk free rate, portfolio holders also experience other kinds of risk. In the CAPM, we can see two types of risk: systematic risk and non-systematic risk. Systematic risk cannot be avoided and the holder of the portfolio

should be compensated for this. Systematic risk is often macro-economic and has their effect on all stocks. On the other hand, investors should not be granted a higher return for bearing non-systematic risk, also called the specific risk, because this kind of risk can be mineralized and in most cases even eliminated by diversification. Specific risk is usually related with factors that only affect a single asset. Still, one of the risks remains, systematic risk, and the CAPM uses a beta to compensate investors for the risk they take. A high beta means that the asset is greatly affected by macro-economic changes, so the variance will be high. A low beta means that the asset is not heavily affected by market changes, so the expected return can also be lower. With these things taken into account, the formula will be as follows:

$$E(R_a) = R_f + \beta_a \times E(R_m - R_f)$$

Where:

$E(R_a)$	=	Expected return on assets
$R_f$	=	Risk-free rate
$\beta_a$	=	Beta of the asset
$ER_m$	=	Expected return on market

In recent years, the CAPM has taken quite some blows by many different researches. One of the heard shortcomings of the model is Roll's critique (1977). The problem Roll's has with the CAPM is that it is only testable if the composition of the entire market portfolio is available. Because it is pretty much impossible to get all the information that is required, the CAPM would not be testable and unusable. His critique was noted, but in modern finance there are not many people that really pay much attention to his critique. One other often heard complain about the CAPM is that it is a fairly simple and short model that only uses one beta to explain the stock return, but this is at the same time of one the reasons that many people like the CAPM so much. In the following pages two respected models will be explained that try to improve the CAPM by adding more betas.

The CAPM might not be perfect, but it is still a globally used and accepted model. The model is fairly simple to use compared with other way more complex formula's and that is one of the main reasons for it ongoing usage.

### **3. Fama, French and Carhart**

After the world has had its first contract with the CAPM it did not take much time before the first reactions arrived. The CAPM is a fairly simple model that was found by logic and reason, but some of the underlying assumptions are not that realistic. For example the assumption that all information is free of charge and that there are no transaction costs. In 1976, Ross choose not to simple extend on a existing theory but to create a new one now known as the Arbitrage Pricing Theory (APT). An important premise of the APT is that arbitrage opportunities should not exist in efficient financial markets. The main idea of the APT is that there are an X amount of factors that make assets systematically deviate from their expected values. X will be able to take any number and the theory says nothing about what the X can be. Note that this theory only looks at systematic deviations and not at firm-specific abnormal returns. Because of firm-specific deviations are not related to each other they can be diversified away. The most important difference from the CAPM model is that the CAPM uses only one source for systematic risk and the APT uses X sources. I will now explain the Fama-French Three Factor Model and Carhart's Four Factor model. A further look at what happened after the realization of the CAPM will be given in Chapter 4.

#### ***3.1 Fama-French Three Factor Model***

This model is basically an expansion on the CAPM. As can be seen in the CAPM formula, there is a market risk factor. The problem with the CAPM was that it seemed that two classes of stock did better than the market as a whole; small caps and value stocks. Because of this, Fama and French decided to add two more factors to the model; size and value. Because the first part of the formula is nearly the same, I will mainly explain the SMB and the HML in this paragraph. The beta in the Three Factor Model is analogous to the beta used in the CAPM, but they are not the same. Because there are two more factors explaining the return on the portfolio. SMB is short for Small market capitalization Minus Big. The SMB measures the (historical) excess returns of small caps over big caps. The HML stands for High book-to-market ratio Minus Low. The HML measures the (historical) excess returns of value stocks over growth stocks. Value stocks are stocks with a high book-value-to-price ratio. Consequently, growth stocks are stocks with a low book-value-to-price ratio. This results in the following formula:



$$E(R) = R_f + \beta_3(K_m - R_f) + b_{smb} * SMB + b_{hml} * HML$$

Where:

E(R)	=	Expected return on assets
R <sub>f</sub>	=	Risk-free rate
β <sub>3</sub>	=	Beta of the assets
K <sub>m</sub>	=	Return of the stock market
b <sub>smb</sub>	=	Coefficient SMB
SMB	=	Small(cap) Minus Big
b <sub>hml</sub>	=	Coefficient HML
HML	=	High(book/price) Minus Low

### *3.2 Carhart's Four Factor Model*

This model is not so common as the other two above mentioned models. This model expands on Fama-French Three Factor Model by adding one additional factor; momentum. This factor was added, because many studies, like Jegadeesh and Titman (1993), Fama and French (1996) and again Jegadeesh and Titman (2001) found that it was possible to increase your earnings by buying stock that was doing well over the last 1-6 months and selling stocks that were doing badly over the last 1-6 months. This strategy is often used in cases when you have to decide in a couple of minutes which stocks you wish to buy. Buying stocks that just lost a lot of value and selling stocks that increased in value tends to give good results. The reason behind this is that the market always corrects itself. After a large gain in value, there are always people that wish to cash out their profit and sell their stock for the high price, decreasing the value of the stock in the process. Another theory says that after a (large) increase in value, the stock may be overpriced and will quickly return to its real value. UMD is short for Up Minus Down. The UMD measures the (historical) excess returns of the „winners’ that went up minus the „losers’ that lost value. This resulted in the following formula:

$$E(R) = R_f + \beta_4(K_m - R_f) + b_{smb} * SMB + b_{hml} * HML + b_{umd} * UMD$$

Where:

E(R)	=	Expected return on assets
R <sub>f</sub>	=	Risk-free rate

$\beta_a$	=	Beta of the assets
$K_m$	=	Return of the stock market
$b_{smb}$	=	Coefficient SMB
SMB	=	Small(cap) Minus Big
$b_{hml}$	=	Coefficient HML
HML	=	High(book/price) Minus Low
$b_{umd}$	=	Coefficient UMD
UMD	=	Up Minus Down

#### **4. Literature review**

In this literature review the most important papers about explaining stock returns from 1952, when Markowitz came up with Modern Portfolio Theory, till around 2011 will be discussed. As stated in Chapter 2, Jack Treynor was one of the first economists that started to work on the CAPM model. When he developed the CAPM in 1961, there was no way yet to fully test it. Because there were no samples large enough or of sufficient quality, the real testing of the CAPM started in 1970. In 1973, the world was shown the famous Black and Scholes options pricing model. One of the first studies that gave a different answer than the CAPM was the research by Basu (1977). While he agrees with the Efficient Market Hypothesis, Basu reaches another conclusion than the CAPM. In his findings, stocks with high earnings/price ratio earned significantly higher returns than stocks with low earnings/price ratio. In a later research, Basu (1983) expands on his earlier research and now he concludes that these earnings/price ratio's are not only evident in small caps. This research was a huge blow to the CAPM, because in the CAPM model the beta should explain everything.

Beside the earnings/price ratio, the CAPM had to survive more critique. Banz (1981) and again Basu (1983) discovered that firms with low market capitalization have higher average returns than firms that have large market capitalization. If small firms give a higher return then the CAPM would be suffer another blow. Supporters of the CAPM quickly pointed out that the beta of small firms is usually higher than the beta of large firms. However, this difference in beta is not significant enough to fully explain the different return between small and large caps. A third problem with the CAPM was published by Rosenberg, Reid and Lanstein (1985). They created another piece of evidence against the CAPM by showing that stocks with high ratio's of book value of common equity to market value of common equity, also known as book to market equity, have noticeable higher returns than stocks with a low book to market equity. Another problem with the CAPM is founded by Bhandari (1988). Bhandari finds out that firms with high leverage have higher average returns than first with low leverage. A firm with a higher amount of debt should have a higher beta, but Bhandari shows that even after the beta is adjusted, firms still can get a higher return.

In 1992, Fama and French published their most important paper. This paper was especially important, because it took all the research that had been done in the last 30 years and

combined it into one formula, now known as the Fama-French Three Factor Model. What Fama and French did was using the old CAPM and then adding much of the critique explained in the above text. This gave some very interesting results. One of the first things they discovered was that the relation between the beta and the return was not quite true. Because of the (negative) correlation between company size and beta, beta and return only seemed to have a relation but when Fama and French adjusted for this correlation, the relation between beta and return pretty much vanishes. Because of this result, Fama and French decided to look for other variables that might explain the average returns. After some calculation, they tested whether size, E/P, leverage, Book to Market and beta, again following the findings that researchers had done before them. A few very important conclusions of their research are:

- 1) If variation in B that is unrelated to size is allowed, there is no reliable relation between B and average return.
- 2) The opposite roles of market leverage and book leverage in average returns are captured well by book to market equity.
- 3) The relation between E/P and average return seems to be absorbed by the combination of size and market to book equity.

The latter means that there is no need to include E/P in the model, because the effect of E/P is already reflected by Size and Book to Market equity. With these findings, Fama and French completed their new model. This new Fama-French Three Factor Model was a severe blow for everybody that still believed in the power of the CAPM and it is not surprising that many scientists wanted to prove them wrong. In 1993 Fama and French extended on their paper from 1992 in three ways; they expanded the set of asset returns to be explained. The assets that Fama and French worked with in 1992 only consisted of stocks and now they also wanted to test bonds. Because of these new bonds Fama and French also decided to expand the set of variables used to explain returns and to use a different approach to test asset pricing models. Results from this paper showed even more support for their findings in 1992.

Fama and French (1992) wrote a very interesting paper with a lot of new ideas and it is not more than logical that many people disagreed with them. One of the first scientists that tried to prove Fama and French wrong was Fischer Black. Black thought that Fama and French's paper was nothing less than a lucky shot. He said that there are many people that search for variables that explain stock returns every day. It makes sense that a few of them are bound to

show results. The biggest problem Black had was that Fama and French pretty much completely based their research on former research. There could be a chance that these former researchers just got very lucky with their results or that they influenced their data a little bit. The problem that Fama and French would have to deal with is data mining. Data mining is looking for mostly statistical relations in very large amounts of data. The problem with this is that researchers might think that there is a relationship between different variables, while in reality there is not. This can be tested by taking another set of data or another time span and then testing whether the same relation can be found.

Two years later, MacKinley (1995) also points out that data mining or data snooping might be a cause for the results Fama and French found. However, not everybody agrees with Black and MacKinley. Davis (1994) has done a huge research for 23 years using accounting data from Moody's and he concludes that a value premium is not that special in the period Fama and French did their research. Chan, Jegadeesh and Lakonishok (1995) came to the conclusion that the concern about the survivorship bias is exaggerated because only a very small amount of the firms will delay financial statements thus increasing Book to Market. Third, Kothari, Shanken and Sloan (1995) find that the use of value weighted portfolios to create the Fama-French factors greatly lowers the concern about survivorship bias. Another flaw found by some scientists of the Three Factor Model was the beta estimation. In 1977, Levhari and Levy explained why beta coefficients with monthly returns do not give the same answer as beta coefficients with yearly returns. Because of this, results of empirical research will differ whether you use the monthly or the yearly return. Fama and French used the monthly return. Kothari, Shanken and Sloan think that this is a mistake, because an average investor is more likely to invest in one year investments options than in one month investment options. In their paper they argue that the beta and the return are more related using a one year return instead of a monthly return. Because of all the critic that followed after Fama and French presented their paper in 1992, especially focusing on data mining and beta estimation, it was still unknown whether this new model would become the leading theory in finance or that the CAPM would keep his reign.

After Fama and French published their paper, a heated debate was created for many years. The model was quite new and in time a lot of scientists have thought of many ways to criticize the model or to improve the model even more. Two of the scientists that tried to

reject the critics were Barber and Lyon (1997). The problem, explained above, about data mining was still not solved and it had been lingering for quite some time now. Barber and Lyon came up with an interesting idea. Because data mining has only effect on one independent sample, Barber and Lyon created a sample of financial firms and they found a healthy Book to Market ratio among these firms. This research was quite important for the Three Factor model, because there now was an independent prove that the Book to Market ratio indeed worked. Also in 1997, Carhart wrote an article in the Journal of Finance. In his paper he states that there might be a possible fourth momentum. He is building on the research Daniel and Titman (1997) had been done. Daniel and Titman argue that firms' actual size and book to market equity contain more explanatory power for mean returns than do time series estimates of factor loadings.

An interesting survey by Graham and Harvey (2001) showed that 73.5% of 392 U.S. CFO's uses the CAPM when estimating the cost of equity. Another study by Brounen, Abe de Jong and Koedijk (2004) did the same study but then with 213 European CFO's and 43% of the CFO's said to relay on the CAPM. These are quite strange results considering the CAPM was a 50 year old model and in these 50 years many other, more complete and sophisticated models were introduced. Why would these people that would most likely have a superb understanding of finance still use the CAPM? A few answers come to mind. I think it is not very likely that these top CFO's only know the CAPM, so there must be a reason why the CAPM is picked over the Fama-French Three Factor model. A few more logical options come to mind. Because the Three Factor model is more complex it might not be profitable to collect all the data that is necessary while the CAPM is a lot easier to use. Another reason might be that CFO's simply don't believe that the model of Fama and French does a better job than the CAPM. Lam (2005) purposes a different solution by stating that over different times periods and different portfolio sets, the Fama-French Three Factor model just is not always a better choice than the CAPM. Malin and Veeraraghavan (2004) tested the Fama-French model on its robustness. They had data from three different countries; France, Germany and the United Kingdom. They wanted to see if the Three Factor Model could prove itself in the European market. The outcome was doubtful. Malin and Veeraraghavan found evidence for a small firm effect in France and Germany and a big firm effect in the United Kingdom, but not much else.

In 2008 Fama and French wrote yet another paper together this time focusing on some other anomalies than they usually do. According to their research they do get good results with the anomalies net stock issues, accruals and momentum, but asset growth and profitability are less robust. All in all a pretty good result considering that all anomalies got some kind of a positive result.

## 5. Conclusions

### *5.1 Conclusions & limitations*

This paper started with an introduction of the Efficient Market Hypothesis followed by Markowitz and the Modern Portfolio Theory. After that the CAPM, Fama-French Three Factor Model and Carhart's Four Factor Model were introduced and explained. In Chapter 4 the most important, subjectively of course, papers about the CAPM and Fama and French from the last 50 years were discussed. However, it is always possible that I may have missed an important paper. The question remains whether the CAPM is a viable theory or that Fama and French took the lead with their Three Factor Model. In the last 20 years the empirical evidence supporting Fama and French has been quite large. Many papers, as explained in this thesis, including work from Fama and French themselves support the fact that the model from Fama and French explains much and sometimes more than the CAPM does. Does this mean that the CAPM is useless now? I don't think this is the case. I think both models can exist alongside each other and that the beta is still useful. What the CAPM does is not necessarily wrong, but there is a chance that the outcome is not as accurate as you might think. The CAPM is still a quick, relatively easy way to obtain crucial information. There are enough researches and papers that do not agree, as shown in the above pages, that the Three Factor Model always gives a better answer than the CAPM. Further research is definitely necessary before we can even think of discarding a viable theory like the CAPM.

### *5.2 Recommendations for further research*

An interesting idea for future research is how the current economic crisis affects the stock market and by that the financial theories. As stated earlier in the paper the EMH model suffered some critique, so that might be something to watch out for. Fama and French, for example (1996), talk about other anomalies not yet fully researched that might give more answers, which might be interesting for the future. The last word has definitely not yet been said about this topic!



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