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The Federal Funds Rate's Effect in the Equity Market in the context of the Fama-French Three-Factor Model

Introduction

This paper looks at how interest rates affect the equities market while in the framework of the Fama-French three factor model. All else equal, lowering interest rates tends increase the returns of companies and raise stock prices. It is found throughout the regressions of this paper that the federal funds rate has a weak-to-essentially no predictive power for changes in prices in the equity market. I believe reasons for this are the low variation in the federal funds rate and the many announcements of a rate change by the fed without any actual real rate changes for years.

Researched Work on the Topic

In regards to other researchers who have looked into this topic, Fed Chairman Ben Bernanke and Economist Kenneth Kuttner in *What Explains the Stock Market's Reaction to Federal Reserve Policy?* observed how changes in the federal funds rate affect the equities markets. Using Fama-French's three factor model they find that industries have different responses to unexpected changes in the federal funds rate depending on the

industry being observed. They find that high tech and telecommunications industries respond the most reactively to new changes in interest rates. Energy and utility companies respond less to new changes (Bernanke, Kuttner, pp. 1242).

Research has also been done on the federal funds rate's effect on companies based off of size. Research done by Economist Guo Hui in *Stock prices, firm size, and changes in the federal funds rate target* show that changes in interest rates affect small companies differently depending on business conditions. He finds that "the estimated impact of monetary shocks is significantly larger for small stocks than for big stocks in the 1970s, when business conditions were typically bad."(Hui, pp. 487). He also adds that this effect is not present later on in the 1990s when market conditions were generally better. It is important to point out that the interest rates used in the data were only those that were unexpected. If a change in the interest rate was expected, then in theory, that change should have already been incorporated into the markets.

Guo Hui in *Stock prices, firm size, and changes in the federal funds rate target* also examines the affects of policy changes on firms with different book-to-market ratios, a critical component of the Fama-French three-factor model. He notes that companies with high book-to-market ratios often tend to be companies that were in long periods of financial stress, thus in general these companies were credit-constrained. It is this credit-constraint factor that causes firms with high book-to-market ratios to react more dramatically to monetary response changes. Higher interest rates, in general, will cause more strain to companies that already had trouble receiving credit.

Economists Gabriel Perez-Quiros and Allan Timmermann in *Firm Size and Cyclical Variations in Stock Returns* expand on Guo Hui's point that federal reserve policy

decisions affect smaller firms more dramatically than big ones, but add an additional explanation to why by including the problem of asymmetric information. There tends to be more asymmetric information problems with small firms, as data about the company may not be as readily available as it is for a much larger firm, making it harder, in general, for small firms to receive loans. In addition, small firms do not have as much collateral as big firms, affecting the quality of loans they can receive. For these reasons, "small firms will be more adversely affected by lower liquidity and higher short-term interest rates."(Perez-Quiros, Timmermann, pp. 1229).

Description of the Data used for Analysis

All my data was retrieved from the wrds Wharton data website. At its simple core, I have mutual fund, Fama-French three-factor model, and federal funds rate data from 2010 to 2018. This data will be sufficient in studying how changes in the federal funds rate affect stock returns while holding the overall market, size, and value constant. This data is also sufficient in studying how changes in interest rates affect the market in general. This is done by excluding the Fama-French factors from the equation; the regression will simply include portfolio returns and the Fed's interest rates. It will be interesting to see how the results vary depending on which variables are omitted and which are included.

An important distinction between the data used in this paper and the data used in many other research papers is that the analysis in this paper includes all federal fund rates. Many papers only included changes in the interest rates that were unexpected, as markets generally don't react to expected changes in the rate. Including all the rates, both

expected and unexpected, may give a general overview to how rates affect the equity markets by not hand selecting which rates we wish to observe. Including both expected and unexpected rates may also give insights into whether the market believes interest rate hikes or decreases will also occur. If the Fed continually says that they will raise interest rates, but fail to actually do so for an extended period of time, does this affect the way the market reacts to changes in interest rates? The data used in this analysis is from 2010 to 2018, a period of time which saw very interesting developments happen with the Federal Reserve Bank. Janet Yellen and the reserve board, during a large section of this time, promised that interest rates would be hiked, but after a good deal of time, they stayed at their low levels; quantitative easing, the introduction of money into the economy, was used for a very long period of time. Does this distort the way the market reacts to new fed policy if the market not longer believes in the Fed's word?

All my data is in the daily format. This was to incorporate a higher frequency analysis of the federal funds rate on portfolio returns. Markets tend to react immediately to new federal funds rate changes. Having monthly or yearly portfolio returns would not be a sufficient dataset to examine because there would be too much time in between return statements, considering the fast reacting nature of the market to interest rate changes. Perhaps there would be too much time for other variables to affects market conditions in between changes in the federal funds rate. I believe daily returns is a suitable timeframe for analysis.

The mutual fund I decided to study was the SPDR S&P 500, otherwise known as SPY. It is an exchange-traded fund meant to follow the S&P 500. This mutual fund was a suitable choice because it is well diversified, a good representation of the stock market as

a whole, and all of the companies in the fund are based in the United States. As mentioned in Bernankes and Kuttner's paper *What Explains the Stock Market's Reaction to Federal Reserve Policy,* different industries seem to have different responses to Federal Reserve policy. By including a portfolio that is well diversified, the regression should reveal overall effects of policy changes, regardless of industry. It is important that the mutual fund is an American based one, as American monetary policy would have the biggest effect to American companies, obviously. Although many of the companies in the fund have operations in foreign countries that are affected by their monetary policy, I believe that this will not distort the results of the regression because the fund is an American based one. In addition, I extracted daily returns from the fund. As mentioned before, the daily timeframe of the data is an important component for the regression used. Markets react the-day-of for new changes in the federal funds rate. I extracted this data from the same website I retrieved the interest rates data, the wrds Wharton data website.

The federal funds rate is an important tool for the Federal Reserve Bank and a vital component of this paper. It is the rate at which banks loan to each other. Often, when there is financial crisis, the Federal Reserve Bank may decide to lower interest rates, as it did after the financial crisis of 08'. The idea behind this decision is that by lowering the interest rate, banks and firms will be more willing to give out loans. This encourages investment and stimulates the economy. One would expect a negative correlation between interest rates and portfolio returns. The point of including the Fama-French three factor model into the regression is to examine the intersection of interest rates, over market, size, and value.

The last component of data I extracted from the wrds website is the Fama-French three factor model data, again in daily format to match the time format of the portfolio returns and federal funds rate data. The Fama-French three-factor model was an important evolution to the analysis on the pricing of stocks. Whereas before many regressions only included the market-risk factor, the Fama-French model includes variables to explain market size and value components of companies. This has been shown to be better predictor of returns as opposed to only including the market-risk factor. The size and value component of the regression will be important in examining effects of Federal Reserve policy in the equity market.

Empirical Framework

Before I get into the meat of the regressions and their results, I will first provide some basic summary statistics of the variables to get a good sense of the data and how varied it is. First, here are the summary statistics for the daily returns from the mutual fund SPY (SPDR S&P 500).

```
. summarize dret
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Variable	Obs	Mean	Std. Dev.	Min	Max
dret	2074	.000541	.0096043	-.0663312	.0780189

The ‘dret’ variable reveals the daily returns of the mutual fund and it is represented by the percentage increase or decrease from returns as opposed to showing the dollar change

experienced by the mutual fund. Overall, from the time of 2010 to 2018, on average the fund was in positive return territory. This is reflective of the market as a whole, as the general economy has been growing with positive numbers since the most recent financial crisis. Some other points to mention about the data, the max increase percentage in returns is higher than the absolute value of the worst day performance. In addition, the standard deviation, the amount of variation/dispersion presented in the data, is higher than the mean; there is a decent amount of variation present in the daily returns variable. Most suspect that had the Federal Reserve Bank not lowered interest rates, the economy would not have seen this kind of growth in the equity market. Considering the huge losses experienced in the 08' financial crisis, it is remarkable that the equity market was able to make such a comeback, in my opinion.

Here are the summary statistics for the federal funds rate data, the rate at which banks make loans to one another.

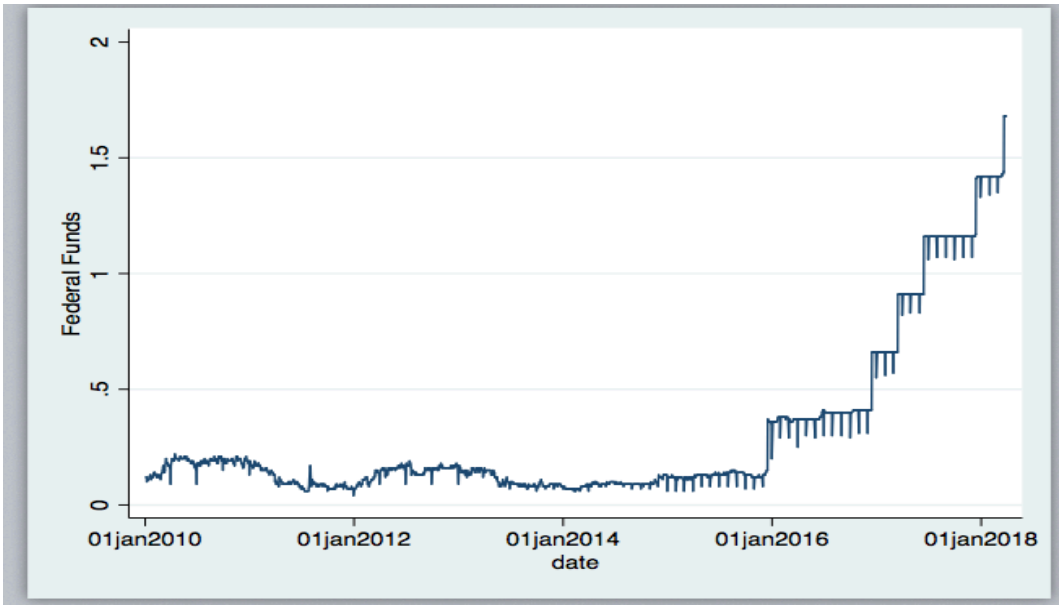
```
. summarize ff_o
```

Variable	Obs	Mean	Std. Dev.	Min	Max
ff_o	**2059**	**.3037882**	**.3603981**	**.04**	**1.68**

The .3037 mean of the federal funds rate is rather low considering that in the past this rate has been much higher. In response to the 08' financial crisis, interest rates were lowered considerably. Not only that but this low rate was sustained for many years, from 08' until 2016, although rates have only slowly risen since then. Such low interest for nearly a decade is a rather unprecedented move/strategy implemented by the Federal

Reserve Bank. This makes it an interesting time period to study how the market responds to changes in the federal funds rate in the context of the Fama-French three-factor model. The standard deviation is a little higher than the mean presented in the data. There appears to be less variation in the federal funds rate as there is for the daily returns of the mutual fund SPY. This should be expected, as the daily returns change every day for a mutual fund, whereas the federal funds rate may be slower to change, as it is in part a monetary policy decision that takes time to make. With less change in the interest rate, perhaps the affects of monetary policy will be less pronounced as it is for time periods with high degree of changes in the federal funds rate. All in all, this data shows that the federal funds rate was rather low for this time.

This graphs reveals the past federal funds rates throughout time. This helps give a visual representation of how interest rates have behaved in our dataset.



The graph confirms that there was relatively little variation for the first six years of the dataset. Then for the last two years there are consistent rate hikes, represented in a rigid upward pattern. Even at a maximum rate of 1.68%, this is still relatively low considering that the federal funds rate has been much higher in past decades.

The main component of my analysis is simply an ordinary least squares regression on the variables in question. I believe the ordinary least squares method is appropriate for the dataset, as it will show how the daily returns of the SPY index fund change in relation to changes in the federal funds rate while holding market risk, company size, and book-to-market ratios (the Fama-French three factor model variables) constant. First I reveal how changes in interest rates affect the equities market (the daily returns of the SPY index fund being the y variable and the federal funds rate being the x variable) with no other variables used as control variables. This is used to serve as a very broad/general regression and shows how fed policy affects the overall market, using the mutual fund as proxy. Here is the OLS regression.

Source	SS	df	MS	Number of obs =	2059
				F(1, 2057) =	0.00
Model	2.1592e-07	1	2.1592e-07	Prob > F =	0.9614
Residual	.189357997	2057	.000092055	R-squared =	0.0000
				Adj R-squared =	-0.0005
Total	.189358212	2058	.000092011	Root MSE =	.00959

dret	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ff_o	-.0000284	.0005868	-0.05	0.961	-.0011793	.0011224
_cons	.0005368	.0002766	1.94	0.052	-5.56e-06	.0010792

Although the coefficient of the federal funds rate variable 'ff_o' is negative as expected (lowering the interest rate in general tends to boost the economy), the variable does a horrible job at explaining the variation experienced in the daily returns variable 'dret'. The federal funds rate variable is statistically insignificant with a t-value of -.05 and a p value of .961. I believe there a couple of reasons for this result. First, it's important to keep in mind that for the first six years of the federal funds rate data, there is essentially no variation in rate change (as shown in the line graph showing the interest rates banks lent to each other for the last eight years). So while the daily returns of the SPY index funds were constantly changing, the federal funds rate essentially stayed stagnant throughout this period of six years. It is hard for variation in one variable to explain changes in another if one variable is essentially at a constant value. Both variables would have needed to stay constant for there to be a significant correlation. In addition, there are so many other factors and variables that cause changes in the equities market aside from just the interest rate set by the Federal Reserve Bank. There are other explanations for the patterns experienced in the equity market that are not present in the regression. CAPM and the Fama-French three factor model will be used to address this issue.

The next regression used for the analysis of the fed's policy effect in the market is one of the early forms of CAPM, which uses Beta (market risk) to help explain the pricing of assets, with the added twist of incorporating the federal funds rate into the analysis to hopefully explain some of the variation experienced in the daily returns. Here is the regression.

```
. reg dret ff_o mktrf
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Source	SS	df	MS	Number of obs =	2059
Model	.181670364	2	.090835182	F(2, 2056) =	24292.51
Residual	.007687849	2056	3.7392e-06	Prob > F =	0.0000
				R-squared =	0.9594
				Adj R-squared =	0.9594
Total	.189358212	2058	.000092011	Root MSE =	.00193

dret	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ff_o	-.0000134	.0001183	-0.11	0.910	-.0002453	.0002186
mktrf	.9737526	.0044177	220.42	0.000	.965089	.9824163
_cons	.0000131	.0000558	0.24	0.814	-.0000963	.0001225

Again the federal funds rate variable fails to be statistically significant and cannot explain the variation experienced in the returns of the mutual fund. At this point in my analysis, I was beginning to believe that perhaps fed policy in general did not have as big of an impact on the overall economy than I had previously thought. I was under the impression that when the interest rate changed, there were massive movements in the economy. One reason why I believe I got this result for the regression is that the data used for the federal funds rate includes all rate figures, both anticipated *and* unanticipated rate changes, whereas usually in analysis the only rate changes that are included in the regression are those that are unexpected by the market. If a rate hike or decrease was already anticipated, by the time the change actually happened, the market in theory would have already moved in price to reflect that sentiment. Maybe because I included both anticipated and unanticipated rate changes, perhaps the majority of rate changes were anticipated, thus explaining why the market doesn't seem to move with the movement of the federal funds rate.

I believe there can be another reason for the lack of explanatory power in the federal funds rate variable. During the term of fed chairwoman Janet Yellen, The Federal

Reserve bank made numerous announcements of a rate hike in the future, prompting the expected response in the market. But after numerous claims of a rate hike, it never came (until years later in 2016), thus some believe that the market stopped believing the word of the fed and the reserve bank lost credibility. It may be possible that announcements changed the price of the market significantly, but because an interest rate change never happened, the federal funds rate variable never had a chance to explain the variation in the returns in the equity market.

One additional regression, which includes the entire Fama-French three-factor model variables, is used to reveal how the federal funds rate interacts with the equity market while holding, overall market risk, firm size, and value constant as control variables. Here is the regression.

```
. reg dret ff_o mktrf smb hml
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Source	SS	df	MS		
Model	.182604451	4	.045651113	Number of obs	= 2059
Residual	.006753761	2054	3.2881e-06	F(4, 2054)	= 13883.73
				Prob > F	= 0.0000
Total	.189358212	2058	.000092011	R-squared	= 0.9643
				Adj R-squared	= 0.9643
				Root MSE	= .00181

dret	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ff_o	-6.53e-06	.0001109	-0.06	0.953	-.0002241	.000211
mktrf	.9994903	.0045675	218.83	0.000	.990533	1.008448
smb	-.1378302	.0083018	-16.60	0.000	-.1541111	-.1215494
hml	.0069767	.008619	0.81	0.418	-.0099262	.0238797
_cons	-3.52e-07	.0000523	-0.01	0.995	-.000103	.0001023

Again, the federal funds rate variable is not statistically significant and doesn't explain the variation observed in the pricing in the equity market. Not only that but the coefficient on the federal funds rate variable is microscopic. I suspected that the close-to-

no variation period in the federal funds rate from 2010 to 2016 was causing the low explanatory power in the variable so I reran the regression, this time only including the years 2016 to 2018, where the federal funds rate continually goes up. The downside of doing this, however, is a smaller sample size. The result is still basically the same as before.

Source	SS	df	MS	Number of obs =	561
				F(4, 556) =	58497.82
Model	.030717039	4	.00767926	Prob > F =	0.0000
Residual	.000072989	556	1.3127e-07	R-squared =	0.9976
				Adj R-squared =	0.9976
Total	.030790028	560	.000054982	Root MSE =	.00036

dret	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ff_o	-2.66e-06	.0000384	-0.07	0.945	-.0000782	.0000729
mktrf	.9814394	.0020591	476.64	0.000	.9773949	.9854839
smb	-.1287601	.0032075	-40.14	0.000	-.1350604	-.1224597
hml	-.0212421	.0029508	-7.20	0.000	-.0270382	-.015446
_cons	-1.43e-06	.0000337	-0.04	0.966	-.0000677	.0000648

The federal funds rate variable is still microscopic and does not explain variation observed in the SPY index fund daily return (p value is .945). I thought running a regression that included a time period with more variation in the interest rate would be able show more correlation with the overall equity market, but this is not the case.

Discussion of Results

Throughout all of the regressions, changes in interest rates failed to predict changes in the prices for the general equity market. Although I do know that monetary policy has an important role and impact on the general economy, I may have overemphasized its

impact, as I thought the recent increases from 2016 onwards certainly would have had predictive power in the regression (albeit they are small incremental increases in the interest rate). I do believe it is possible that other factors are affecting the economy so strongly that monetary policy might not be enough to overcome them, as the overall market variable throughout the regressions did a great job in predicting changes in the mutual fund data. It may be possible that there simply wasn't enough variation in the federal funds rate to have any predictive power in the first place. Additionally, I keep in mind that the Fed made so many announcements of a rate hike that would have had an impact on the economy. As mentioned in all of the research papers of other academics at the beginning of the paper, when examining unanticipated rate changes, the equity market has a noticeable response. So many announcements without an actual change in monetary policy may have distorted results, as the federal funds rate stays constant while the market continually reacts. The federal funds rate would have to actually move along with prices in the equity market for it to have any form of predictive power.

Citations

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