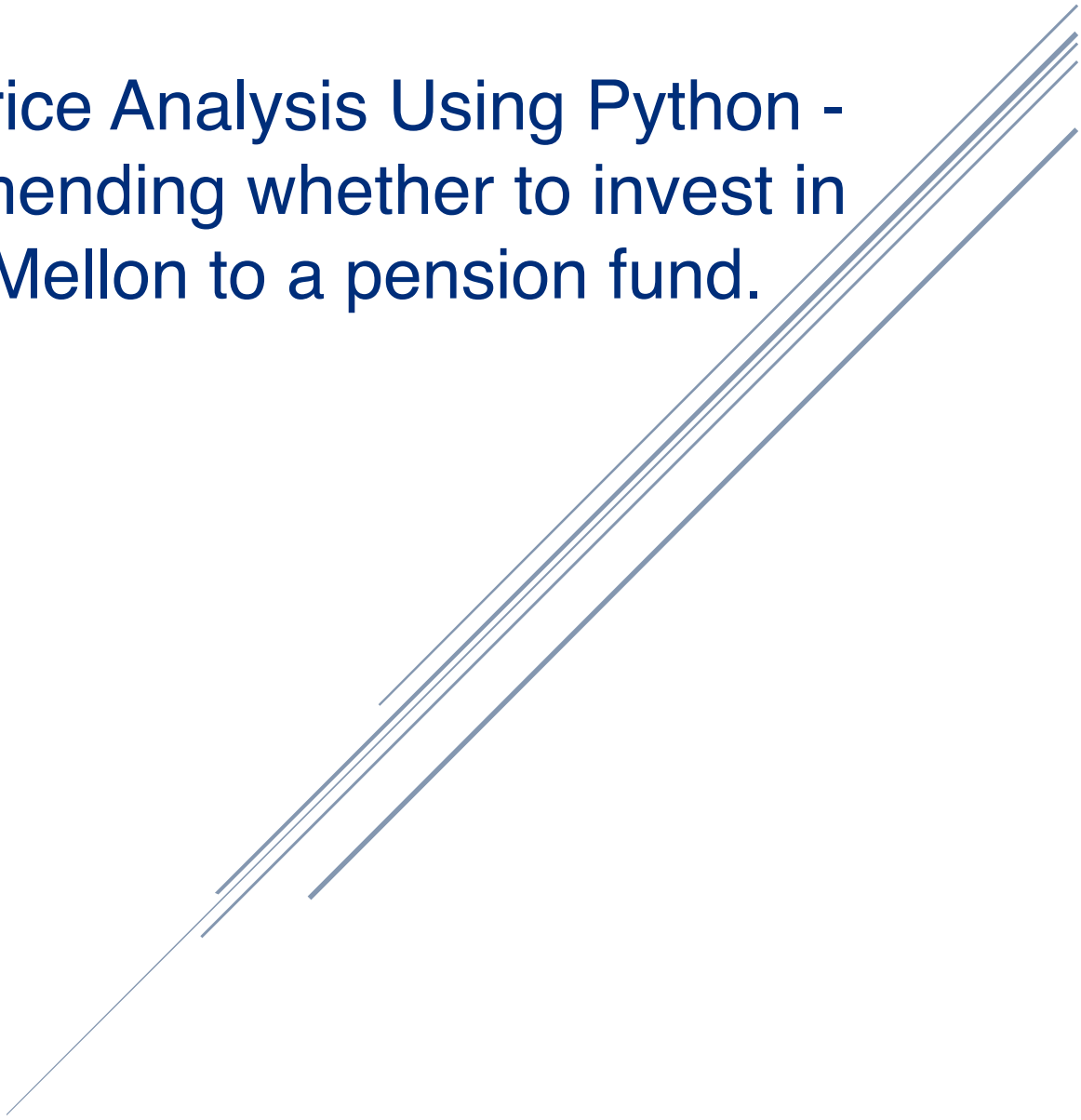
Stock Price Analysis Using Python - Recommending whether to invest in BNY Mellon to a pension fund.



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1. Introduction

In this paper, we will analyse a stock over a given period, as the purpose of this report is to give a verdict of whether to invest or not. This is done in accordance with the benchmark of the S&P500. The verdict will be given in consideration to the client whose priorities and preferences are outlined below. It is assumed that the readers of this report will be of professional experience and will have an understanding of financial concepts.

1.1 Client

The client we are advising is STR pension fund. Pension funds cannot be based on risky assets, as the fund value would need to be paid back to the employees who have paid into the fund, at a given date – they are relatively risk-averse. They are subsequently seeking stocks that are providing abnormal or high returns, for a lower level of risk. We have spoken to a representative from STR pension fund and they have identified that to reduce their risk for a given amount of returns, they must diversify their portfolio. To achieve this diversification, they are looking to enter the financial industry.

1.2 Company Overview

The stock that has been selected to be analysed is the Bank of New York Mellon Company. The Bank of New York Mellon Company, BK, is a banking and financial services firm from New York, America that was founded on 1st July 2007. It is the culmination of a $16.5billion merger deal between The Bank of New York and Mellon Financial Corporation. (MELLON, 2019)The Bank of New York was founded in 1781, whilst Mellon Financial Corporation was founded by the Mellon family in 1869 and they formed the merger in an attempt to form a securities-processing powerhouse. The merger improved international presence as they looked to become stronger in their endowments, mutual funds, and pensions. The company is involved in Investment management, Investment Services and wealth management for the highest net-value clients. It is the largest custodian bank in the world, with reserved values reported to be approximately $35.5 trillion as assets under custody and a further $1.8trillion as assets under management. It is for this reason as to why it has been selected for the STR pension fund. It is currently included in both the S&P100 and S&P500 indexes, and it is one of the oldest assets to exist on the New York Stock Exchange, NYSE.

1.3 Data Collection

Our data consists of monthly prices of The Bank of New York Mellon's monthly prices from June 1990 to August 2019. This information was devised to include a series of historical events including the merger, the financial crisis of 2008 and important personnel changes. The data was taken from Yahoo Finance, whose original source was the New York Stock Exchange. A summary of the data is shown in Table 1.

Table 1: BK Data	
Year Range	1990-2019
Frequency	Monthly
Number of Observations	348*
Source	Yahoo

2. Explanatory Data Analysis

To see if BK would outperform the market, we produced some graphs and performed some tests to understand the data to a better degree. The first graph that was produced was to plot the stock price of BK to grasp how it has changed over time, this is illustrated in figure 1.

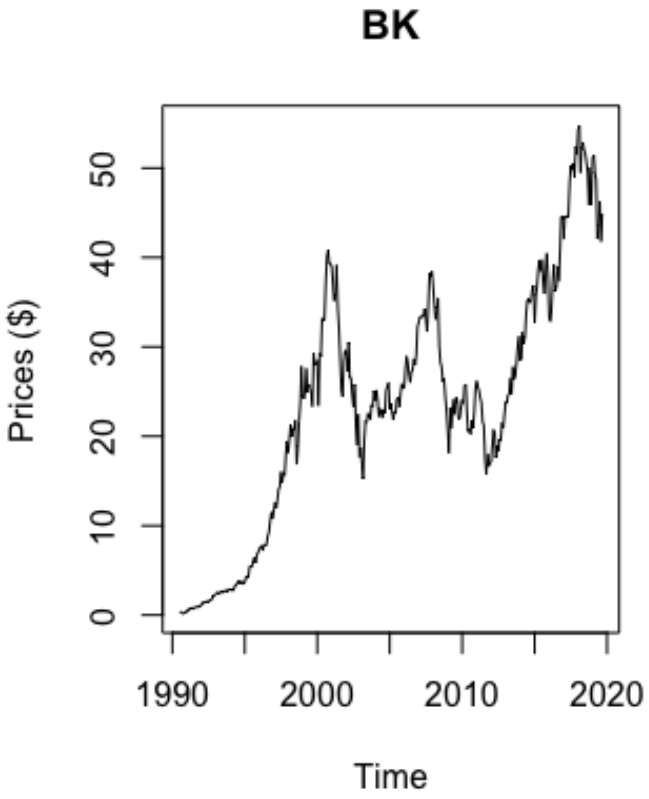

Figure 1 – BK Stock Price.

Figure 1, illustrates the stock price of BK from 1990 to 2019, a series of 29 years. From visually analysing the data, it appears that there is a trend. From the start, there is a large increase in the stock price, climbing from $0 in 1990, to approximately $40 in the early 2000. Following this period there is a drop around 2002, which evidence would suggest that it in part due to the dot com bubble crisis of this same period. This behaviour was almost identically replicated over the next years, with a rise and then a similar drop around 2008, due to the subprime mortgage financial crisis. Since 2012, the stock price has been on a steady incline, reaching the company's highest stock price in 2016. There has since been a decline where the stock price dropped to approximately $40. Generally, there is an increase in the stock price from 1990 to the present day and as a result it is a stock that can be of interest to STR Pension Fund. As the fund holder is looking to make some returns from the fund that is being deposited, there has been possibility to make these returns from investing in the BK stock for this time period.

3. Test for Stationarity

To understand whether or not STR Pension Fund should invest in the BK stock, we will use the S&P500 as the benchmark for the stock to outperform. By assessing the overall trend from figure 1, it appears that the data is non-stationary. This describes the series follows a stochastic process, which means the data is difficult to model and unpredictable. There is also a chance that if we were to run statistical models on this data, in its non-stationary form, it could yield a relationship that is non-existent or dispel a relationship that should appear. This is not ideal as we attempt to provide the most accurate and precise decision for STR Pension Fund, based on our asymptotic inference.

To confirm this analysis, we used a unit root test, for stationarity, called the Augmented Dickey-Fuller Test. Here, the null hypothesis is that there is a unit root in our data and we looked for results that reject the null. We ran an Augmented Dickey-Fuller Test, with the results displayed below, we had to choose a lag period to ensure our residuals are not serially correlated. By following Akaike's Information Criterion(AIC), we have decided to choose a lag period of 1. The results below detail that we cannot reject our null hypothesis as our P-Value is too high, subsequently, we need to transform our data to the stationary form.

```
        Augmented Dickey-Fuller Test

data:  BKSR_V2$BK.Adjusted
Dickey-Fuller = -2.2701, Lag order = 22, p-value = 0.4639
alternative hypothesis: stationary
```

4. Modelling

We will look to apply a model to our data series. However, from our ADF test, we have seen that our data needs to be transformed. We will transform our data by calculating the monthly returns instead of the stock price. This is useful as it firstly, should remove the trends of the data and it also allows for greater scope for manoeuvrability. Below is the plot where the Monthly Returns are plotted, instead of the stock price, still over the same period.

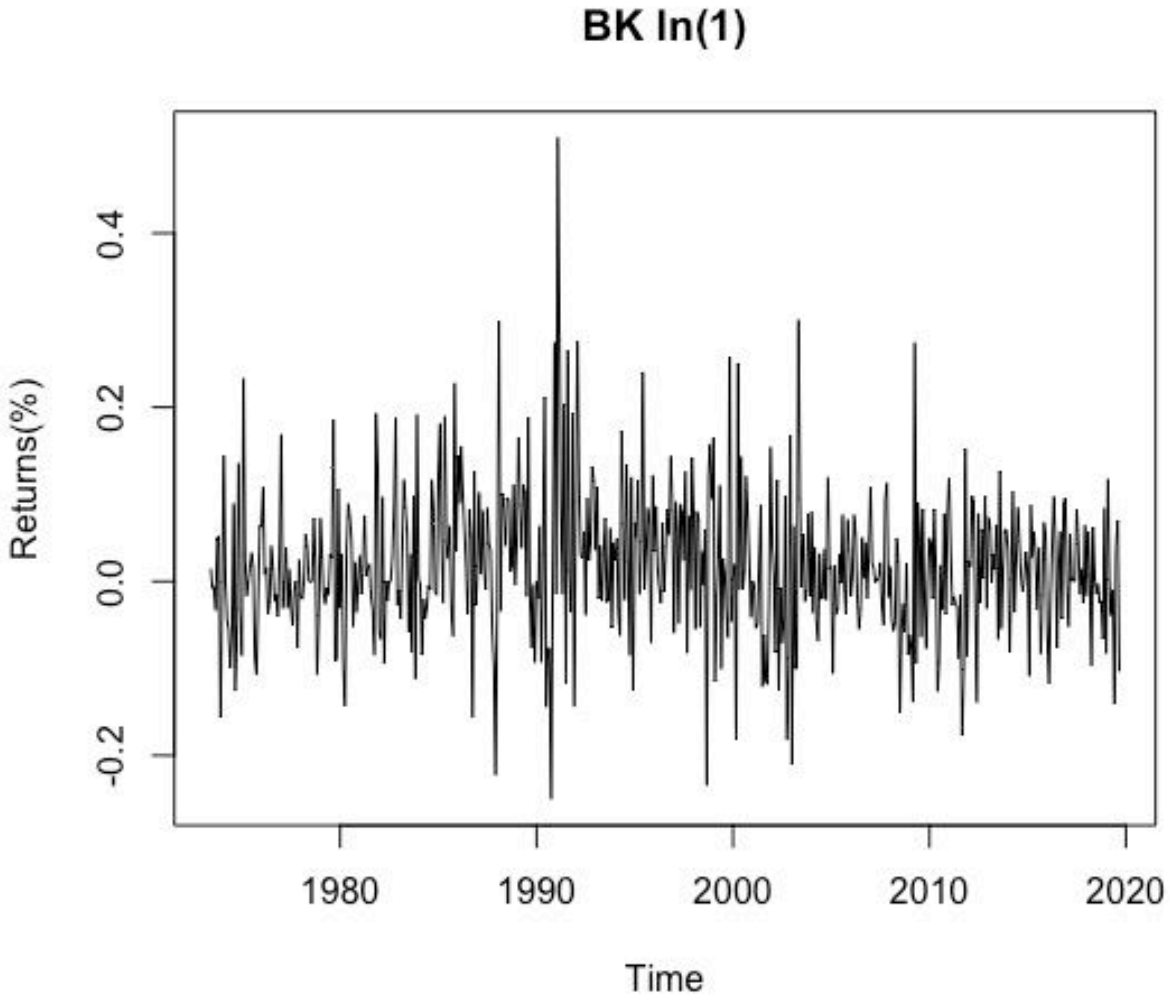

Figure 2 – Graph of the monthly returns plotted across time.

From the above figure, we can orally assess the graph. We find that our data now satisfies our requirements for stationarity. To be sure however, we applied a second ADF test to the transformed data to statistically verify our findings.

```
        Augmented Dickey-Fuller Test

data:  y
Dickey-Fuller = -6.5081, Lag order = 7, p-value = 0.01
alternative hypothesis: stationary
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As our P-Value is less than 0.01, our results are highly statistically significant, and we can reject the null hypothesis, meaning that the transformed data is stationary. This is beneficial as we can now be confident that the relationships that our model details are likely to be true.

4.1 Discuss the Model

Now we have transformed this data, we can apply our model. The model we will be specifying is the Capital Asset Pricing Model, this will be referred to as 'CAPM' interchangeably throughout the rest of this report. The CAPM is a formula that considers systematic risk, risk that experienced by the whole market, and the individual stocks expected returns. (Fahad, 2018) The model claims that no stock can outperform the market in the long run, and any additional returns from the model are as a result of taking additional risk, which would be represented by Beta. The Beta term is a coefficient which accounts for the additional risk that the stock is exposed to, which is the reason why the returns on the stock differ from the returns of the market. It is simply a sensitivity term, which suggests how the expected returns change in accordance to the market.

It must be noted that there are a series of assumptions for CAPM to be satisfied, and further explanation can be found within the literature.

$$Ri=Rf+\beta i(Rm-Rf)$$

In accordance to the CAPM model, the BK stock cannot outperform the market without absorbing additional risk. Any additional returns would be as a result of additional risk. So, we decided to run a linear regression analysis to investigate this claim. The linear regression model we will be using would be through the Ordinary Least Squares Model, and we will be running the Market Returns against the Log Returns for the same period, from 1990 to 2019.

From the model, we expect that the Beta to be a specific value that accounts for the risk associated with the firm, but there should be no alpha. Alpha would be the y intercept, which signifies the y value, when x is 0. Specifically, if x is 0 and y is greater than 0, it would mean the stock is achieving greater returns than the market, without taking in any additional risk. According to the model, this would be impossible and it should not be achieved, so our null hypothesis for this regression is that alpha would be 0 and beta should be a value that represents the stocks sensitivity to changes in the market.

5.1 Speak about the calculations

We conducted our asymptotic inference using the R statistical software. The results we have achieved from our data is detailed in figure 3, and we calculated our estimated alpha to be 0.008, and Beta to be 1.083335. For CAPM, it is important to analyse these two variables profusely. Our value for Beta represents the slope of the regression line, and it corresponds to how BK returns change in response to changes in market returns. The beta describes that the BK stock will be sensitive to the market by 1.083. If the market experiences growth the stock of BK will achieve greater returns as a more proportional rate. Our value is also statistically highly significant, as our p value was less than 0.01. This means that we can reject our null hypothesis of our beta being 0.

The positive alpha value we achieved of 0.008 represents the amount of excess returns BK achieves without taking in additional risk, as per the CAPM model. We did achieve a p value which was less than 0.05, meaning we are able to reject our null hypothesis. According to CAPM, our alpha and error should be 0 as the formula strictly calculates the returns of the stock based on Beta. Statistically, we have achieved an alpha that is different from 0. This information will contribute to the advice we provide. Another statistical value that could be analysed from our data is the R^Squared of our results. R squared indicates how much our model explains the data. For our CAPM model we achieved 0.333 which suggests that approximately a third BK's monthly returns can be explained by the market return. Ideally, we would bid to achieve as high of an R squared value as possible.

We graphically plotted this regression in Figure 3 below, whilst the results have been collated into a table also.

Figure 3 – Regression Between BK Returns and Market Returns

	Dependent variable:
	BKrf
MktRf	1.083^{***}
	(0.065)
Constant	0.008^{**}
	(0.003)
Observations	556
R^2	0.334
Adjusted R^2	0.333
Residual Std. Error	0.069 (df = 554)
F Statistic	277.788^{***} (df = 1; 554)
Note:	*p<0.1; **p<0.05; ***p<0.01

Figure 4 - Table of regression results between stock returns and market returns

5.2 Speak about the error terms

The method we have chosen to estimate our relationship is the OLS method. Here, there are a series of assumptions that must be applied which increase the confidence we have in our predictions. These assumptions are tests of the residuals, checking if the model has accurately captured the information in the data. These are referred to as the Gauss Markov assumptions, and further explanation can be found in the relevant literature. The four assumptions are

1. The residuals are uncorrelated
2. The mean of the residuals is zero
3. There is a constant variance between the residuals
4. The residuals are normally distributed

It is important that these assumptions are met otherwise, our least squared estimators are no longer BLUE. There are tests to assess whether these conditions are met, and they have been outlined in various literature. We have chosen to bypass the individual tests for these assumptions, and will use the ACF. If we test for white noise on our residuals, we will be able to confirm that our assumptions are met. The test for ACF was carried out conducted and we achieved a p value of more than 0.01 for the Box Ljung test. This is statistically significant and as a result, we can reject our null hypothesis that we have white noise. As stated earlier, all of our assumptions have subsequently been satisfied.

6 Test for Robustness

CAPM is said to be the cornerstone of modern financial theory. It has been widely accepted for a number of years, and it is the model we were originally drawn to. Before we provide our conclusion, we need to test the robustness of our model.

It must be noted that our output is only true for the model we use, so we can only confirm our results and base our analysis from this model. If the model was different we may yield different interpretations from our results. We can use a different model to test the robustness of the results we produced, and make the comparison between our results of the different models. It is possible that the CAPM could be improved in order to better represent the different risk sources a company such as The Bank of New York Mellon is exposed to. There are 2 notable extensions of the CAPM formula called the Fama French Model and the Carhat Model, and we utilised both. We assumed the beneficiaries of this report have a good understanding of the models, so only brief mentioning of the theory of these models will be provided.

The Fama French Model, sometimes called the Three Factor Model(3FM), is one that looks to highlight more risk opportunities that a stock may be exposed to, that may not be considered in the CAPM. This is beneficial as theoretically it would provide a better insight into the returns of stocks as there are more explanatory variables. With CAPM, the only explanatory variable is the market whilst with Fama French's Model, there are 2 additional explanatory variables to CAPM. The first is the size of the firm, referred to as SMB(Small minus big), which looks to describe the idea that small firms are more likely to outperform large firms. (Kampman, 2011)The second variable is the book to market ratio, referred to as High Minus Low(HML). This accounts for value stocks that experience a high book-to-market ratio and are likely to generate large returns in comparison to the stock index. There are obvious benefits of capturing this additional risk, as it adequately accounts for the returns the stock is producing.

The Carhat Model is a further extension of the models we have highlighted. This is a less common model, but it would be interesting to see if improves our understanding of the relationship between the variables. The factor that is added with the Carhat Model is momentum. The theory is that the previous performance of the stock would affect the future stock performance as it was found that stock that have been performing well over the last 6 months should continue to do so (Carhart, 2012). The variable would be represented by UMD in the model, meaning up minus down.

We now find ourselves with a trident of models to provide us with an accurate and precise understanding. For the same periods, we have inputted the data into both the three-factor model and the four-factor model, and have stored the results in R.

Before we draw a conclusion on the financial performance of the stock, we will apply a further test to ensure the robustness of our model. It is possible for us to increase the range of data from 1990 to 1973, and in theory we would follow the idea that more data would be beneficial. We did however find this additional work to be time consuming and also, the stock price was stationary for a number of years until 1990. We also felt that the data does not represent the current position of the BK and the extra 17 years we have assessed does not provide any additional information for decision making. We do, however, appreciate the benefit of being able to reduce our range of values to strategically devised periods. We will continue to base our decisions based of the information from 1990-2019. In order to boost the robustness of our models, we have split our sample into subsamples, which will be inputted into both the three-factor model and the four-factor model. The reason for us splitting this period is to see if our alpha and beta values vary depending on the time period we are regressing. Specifically, we can analyse how the BK stock performed at different economic conditions as well as different stages in the company's

lifetime. We have selected the periods from 1990-2006 and 2006-2019. We have chosen this period to represent how the firm performed before and after the merger. The firm has seen different objectives since their merger, and it would be naïve to not recognise this separation in approach and conduct.

7 Comparing R Squared Values

	Pre - Merger		Post - Merger	
MODEL	**3FM**	**4FM**	**3FM**	**4FM**
R SQUARED	**0.404**	**0.411**	**0.406**	**0.413**

We are able to understand the benefits of using the 3FM and 4FM over the CAPM, as the R Squared values are higher. We then used the two subsamples we have devised, across both the 3FM and the 4FM. The results are again stored in R. We only aim to use the best model which describe the subsamples we are deploying. Above is a table which compares the R Squared for the models we have conducted across our individual subsamples. As stated earlier, we have selected the 2 subsamples with the greatest R Squared values, however the omitted tables have also been included below. The periods we will be addressing and the models we will be using are the 4 Factor Model, before the merger and after the merger as it produced the greatest R^Squared from all of the models we attempted. The selected periods are highlighted in the above table.

	Dependent variable:
	monthly.returns
MktRf	1.376***
	(0.085)
SMB	-0.199*
	(0.111)
HML	0.775***
	(0.133)
Constant	0.012***
	(0.004)
Observations	410
R^2	0.391
Adjusted R^2	0.387
Residual Std. Error	0.070 (df = 406)
F Statistic	86.918*** (df = 3; 406)
Note:	*p<0.1; **p<0.05; ***p<0.01

Pre-Merger – Three Factor Model

For the alpha value, we have achieved a value that was statistically significant, so we are able to reject the null hypothesis that our alpha value is 0. Our stock return based on the return of the market Beta is 1.376, which is also highly statistically significant. The coefficients within the linear regression model detail the extent to which excess stock return can be explained by the corresponding variables. This allows us to reject the null hypothesis that our Beta is 0, and if we were to believe our method, we expect the BK stock to be more sensitive to changes in the market.

	Dependent variable:
	monthly.returns
MktRf	0.931***
	(0.110)
SMB	-0.283
	(0.204)
HML	0.486***
	(0.172)
Constant	-0.001
	(0.005)
Observations	147
R^2	0.416
Adjusted R^2	0.404
Residual Std. Error	0.054 (df = 143)
F Statistic	33.925*** (df = 3; 143)
Note:	*p<0.1; **p<0.05; ***p<0.01

Post-Merger – Three Factor Model

For the alpha value, we have achieved a value that was not statistically significant, so we are unable to reject the null hypothesis. Our stock return based on the return of the market Beta is 0.931, which is also highly statistically significant. The coefficients within the linear regression model detail the extent to which excess stock return can be explained by the corresponding variables. This allows us to reject the null hypothesis that our Beta is 0, and if we were to believe our method, we expect the BK stock to be less sensitive to changes in the market.

7.1 Analysis

	Dependent variable:
	monthly.returns
MktRf	1.337^{***}
	(0.085)
SMB	-0.188^{*}
	(0.109)
HML	0.703^{***}
	(0.132)
UMD	-0.307^{***}
	(0.082)
Constant	0.015^{***}
	(0.004)
Observations	410
R^2	0.411
Adjusted R^2	0.406
Residual Std. Error	0.069 (df = 405)
F Statistic	70.768^{***} (df = 4; 405)
Note:	*p<0.1; **p<0.05; ***p<0.01

Pre-Merger – Four Factor Model

As stated earlier, based on our R squared, we have chosen to use the 4 factor/Carhat model to analyse the possible risk factors that can explain the monthly returns of BK stock before the merger. This model has the highest R^Squared. If we look at this subsample, before the merger between The Bank of New York and Mellon Company, we can see the results differ as opposed to the full sample. For the alpha value, we have achieved a value of 0.15, which was highly statistically significant. This means we can reject the null hypothesis that our alpha should be 0. Our stock could have outperformed the market for a given level of risk for a number of reasons including the skillset of employees, the technology available to the firm as well as many others, but we expect the opportunities to have been arbitraged away. Our stock return based on the return of the market Beta is 1.337, which is also highly statistically significant. The coefficients within the linear regression model detail the extent to which excess stock return can be explained by the corresponding variables. This allows us to reject the null hypothesis that our Beta is 0, and if we were to believe our method, we will see that the BK stock will return more than the market, when risk is acknowledged.

	Dependent variable:
	monthly.returns
MktRf	0.986^{***}
	(0.113)
SMB	-0.282
	(0.203)
HML	0.618^{***}
	(0.186)
UMD	0.192^{*}
	(0.108)
Constant	-0.001
	(0.005)
Observations	147
R^2	0.429
Adjusted R^2	0.413
Residual Std. Error	0.053 (df = 142)
F Statistic	26.631^{***} (df = 4; 142)
Note:	*p<0.1; **p<0.05; ***p<0.01

Post-Merger – Four Factor Model

The next subsample to consider would be post-merger, and, again, we will be using the 4FM as it gives us the biggest R^Squared value of all of our model calculations. For the alpha value, we have achieved a value that was not statistically significant, so we are unable to reject the null hypothesis. Our stock return based on the return of the market Beta is 0.986, which is also highly statistically significant. The coefficients within the linear regression model detail the extent to which excess stock return can be explained by the corresponding variables. This allows us to reject the null hypothesis that our Beta is 0, and if we were to believe our method, we expect the BK stock to be less sensitive to changes in the market.

8. Verdict

After conducting our regression analysis, we have reached a conclusion on whether BK stock should be invested in. Firstly, we have decided that the 4FM is the most appropriate reference in the model to use to forecast how we believe the stock will behave in the future. From conducting our analysis, we would advise STR pension fund to invest in BK stock. This decision is more than proportionally weighted towards the post-merger statistics. As our beta is lower than 1, and statistically, significant, we can believe that the Bk stock returns are less volatile than the market. For a fund such as STR who need to protect their investments in the long term, having a stock that is less volatile than the market would be ideal. They will be able to ensure returns regardless, but they will be hit less by any market crashes compared to the S&P index.

Although this is our initial decision, we understand there are a series of factors that are important to the client we are advising. We have a specific client in STR pension fund who have their own risk preferences and priorities. It would be poor to not include the external variables that need to be considered by the STR Pension Fund, especially if this is an exchange that is going to continue in the future.

Firstly, we looked at the Balance Sheet of BK to diagnose the financial strength of the firm. The key variable that we considered within the Balance Sheet is the revenue. The revenues of BK have increased from 15,543 million to 16,392 million, which is a positive sign as it suggests that the firm is growing. (BNY Mellon, 2019) Specifically, it suggests that the firm's production or the number of services they are providing is increase. This expansion could suggest the stock could yield natural, internal growth that could steadily increase the returns of BK.

Another key factor that may influence the decision for whether STR Pension Fund should invest in the stock is with the personnel at the helm of the company, and any relevant changes. At the end of September, Charles W. Scharf stepped down as the CEO of the firm and he has since assumed a position at Wells Fargo. (BNY MELLON, 2019) Previously, Charles Scarf had mixed success at the firm and the firms returns stagnated post-merger. He has since been succeeded by Thomas Gibbons, who is now the interim CEO and he is hopeful for this to be made permanent. Thomas Gibbons has been in the firm for 30 years and there is a feeling of positivity regarding the future with him in this position. Gibbons was chief financial officer for 9 years and most recently was the vice chairman of clearing, markets and client management. His long, varied, tenure in the company has allowed him to be popular figure and it also entails that his ideas and beliefs are ones that align with the ambitions and targets of the business. In the long term, we can expect to see positive returns from this change as the business plan would be executed to a better degree.

Another matter to consider is the industry that Bank of New York Mellon is in. The financial industry has proven to be one that has experienced large crashes in the past and as a result, there is a lot of regulation, corporate governance and auditing. Banks received the "safety blanket" of being able to be bailed out in case of financial difficulty. Also, there are measures to ensure the banks conducts itself appropriately. This adds extra protection to the money invested by STR. In addition, we understand that the portfolio could benefit from the diversification of investing in the financial industry.

Finally, as stated earlier in this report, pension funds are funds that should maximise returns, but should have very little risk as the money will need to be repaid in the long term. The pension fund has a low risk appetite and they would like to reduce their industry exposure. A company like BK does align with the

objectives of STR Pension Fund as it is a custodian bank, meaning the funds deposited are not reinvested elsewhere like a commercial bank.

Taking all of these into account, we believe that BK stock is very good stock for the STR Pension Fund to invest in. We have analysed the financial performance against the market returns as well as the condition, objectives and plans of BK stock and we feel that the stock would be one that suits the portfolio of STR pension fund.

9.Conclusion

We have analysed The Bank of New York Mellon's stock prices from 1990-2019 to help us advise STR Pension Fund whether to invest or not. We identified the price to be non-stationary visually, and we confirmed this by performing the augmented Dickey-Fuller test. As a result, we transformed the data using monthly log returns to ensure the data is stationary and that we could be confident of the relationships we produced. Using the CAPM model we attempted to describe the relationship between BK stock returns and the market returns to see if there were any abnormal excess returns. From this, we found that there is little to no excess abnormal returns and all of the returns are accounted for by the Beta variable. We decided to extend the CAPM to the 3FM to better understand the risk the stock is exposed to. We, again, found that in some instances that the alpha returns were approximately 0, and the Bank of New York would not achieve abnormal returns and the only returns would be the normal expected returns. We finally analysed the financial health and the managerial conditions of the firm and we advised STR to invest. It must be noted that there are shortcomings of each model, and that should be acknowledged during the investment. We were limited by the resources available to us and offered the opportunity there would be some matters we would like to address firstly. The most notable being the time constraints we were given. Ideally, we would like to assess the corporation to see how data would make an effect, however this was not a luxury we were afforded, and we still believe we have produced a good report given what was available to us. Ultimately, we were still able to come to the decision that we would advise STR pension fund to invest in The Bank of New York Stock at this current moment.

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