Airline Stocks' Return Prediction with Modified Fama-French 3-Factor Model

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Abstract: Will the industry factor perform better than the market factor in the Fama-French 3-factor Model for airline stocks in the pandemic? The covid-19 pandemic has brought about the extreme downside of the airline industry. This paper reconstructs the Fama-French 3-factor model by replacing the market risk premium with the industry ETF risk premium to investigate whether the industry factor improves the Fama-French 3-factor model. The JETS ETF is chosen because it is the only airline industry ETF. Three sample airline stocks with different scales of capital size are selected to test the performance of FFM and the modified FFM. Besides directly comparing the two factor models, we combine time series models and factor models to test the future stock price prediction ability of the two models without future factor data. The comparison result has been analyzed from several quantitative levels: correlation and covariance, adjusted R squared, F-statistics' p value, root mean square errors (RMSEs), and correct ratio. The result shows that the industry factor performs much better than the market factor in a pure factor model. However, when combining FFM or the modified FFM with time series models, the performance of FFM and the modified FFM is quite similar and hard to compare.

1. Introduction

The covid-19 pandemic poses serious implications on the financial livelihood of industries. Along with the spread of covid from epidemic to pandemic, its impact is exacerbating the financial market globally [1]. However, within such a global impact, some industries are benefitted such as healthcare, some industries are barely impacted such as logistics, and others have taken a hit such as airline transportation [6,10,14]. Note that there have been studies regarding the boosting of certain industries, we however wanted to shift the attention to the other side.

Because of the uneven impacts of covid pandemic on different industries, this research would need new factor models to apply to the prediction of stock returns of different sectors to accord with the current pandemic trend. Also, this paper is going to study the industry factors' influence on extremely downside industry stocks with different capital size during the Covid-19 outbreak. For example, the airline industry during the pandemic is largely negatively impacted, and such industry can be applied to this study [13].

There have been many factor models when it comes to returning predictions such as multi-factor model of Rosenberg and Dynamic Factor Model, and the one this research chose to include in this study is Fama-French 3-factor model [3,7,8,12]. The reason this research chose Fama-French 3-factor model is that it can efficiently catch stock variations as well as statically significant [11]. The Fama-French 3-factor model consists of small minus big (SMB), high minus low (HML), and Market minus risk-free rate (Market-Premium) [4]. However, the uneven impact on different industries brings the

wondering that if the Market-Premium factor in Fama-French 3-factor model can effectively represent individual sectors such as the airline sector this paper studied. One possible way is to adjust Market-Premium's factor's parameter to target a specific sector. Therefore, this research modified Market-Premium to ETF (Exchange Traded Fund) minus risk-free rate (ETF-Premium) and keep SMB and HML unchanged. This paper chose to replace Market-Premium with ETF-Premium because ETF of one sector is comprised of different components of stocks from the sector, and ETF price is the same as the stock price resulting from biding and asking prices, therefore ETF can as well show the overall trend of this sector, which the market value in Market-Premium plays the same role as ETF [5]. Consequently, while facing such an incongruity impacted industry, ETF-Premium would be a better factor than the Market-Premium in the Fama-French 3-factor model. In this research, this research chooses three airline stocks: Mesa Airline (MESA), Spirit Airlines (SAVE), and Delta Airlines (DAL) each with small, medium, and large capital sizes respectively. Such a choice can legibly demonstrate to what extent the pandemic negatively impacts the airline sector, and different capital sizes would manifest a more comprehensive explanation of the effect on the entire sector. According to the research's selection of stocks, "jets- ETF" (JETS) is the only ETF in the airline industry and, SAVE and DAL are held by JETS.

This paper has two goals in this study: to explore whether the research's modified Fama-French Model is better than the original Fama-French Model through general correlation analysis and to see which model fits better in terms of prediction of the three airline stock returns using Time Series Analysis. This research used Time Series Analysis as an approach to return prediction because Time Series Analysis allows this research to check on the out-of-sample behaviors of the dataset, meaning that time series analysis will produce future forecasts of the dataset and can check the accuracy of the forecasting method using the observed data [2]. Also, Time Series can predict more accurately and robust than other statistical forecasting methods [9].

This research first compared the Fama-French model and this research's modified model fundamentally using adjusted R squared, p-values and test mean squared errors (MSEs). Yanqing Wu has previously used such correlation analysis to compare their modified Fama-French Model and the original Fama-French 3-factor model who replace SMB and HML with ETFs, and their result shows the original Fama-French 3-factor model is better [15]. This research adopted a similar approach to the dataset, however, paper found that this research's obtained model indices and correct ratios confirm that the industry factor has a much better performance than the market factor in factor models. A further application of 10-day time-series prediction is to evaluate the prediction performance of this research's model and the Fama-French model. The criteria are the MSEs between the real future values and predicted values, and the correct ratio, which is a ratio of correct forecasts about prices' ups and downs. However, with different capital sizes, the effect of the industry factors fluctuates when applying time series models to conduct prediction.

The rest of paper is structured as follows. Section 2 introduces the framework for the modified Fama-French factor model and the application of time-series prediction. Section 3 presents and discusses the results of model performance, model prediction and model comparison. Section 4 concludes the paper.

2. Methods

2.1 Data and stochastic properties

The dataset of stocks we apply in our modeling consists of log returns for three airline stocks spanning from August 1, 2019 to October 10, 2021, where log returns are calculated using daily adjusted closing price. The three airline stocks are Mesa Airline (MESA), Spirit Airlines (SAVE), and Delta Airlines (DAL) each with small, medium, and large capital sizes respectively. The dataset of factors we select in the Fama-French model and our modified Fama-French model consists of Fama-French 3-factors and the log return of "jets-ETF" (JETS), which is the only ETF in the airline industry. The span of the factor data is from August 1, 2019, to September 30, 2021, which is the latest updated

date of Fama-French 3-factors data. The data have been downloaded from Yahoo Finance [17] and Kenneth R. French data library [18].

When conducting data processing, we converted the stock log returns and ETF log return into risk premiums as the outputs and the input respectively in the models, which equals to returns minus the risk-free rate (R_f). Since the R_f from April 1, 2020, to September 30, 2021 is zero, we assume that the future R_f from October 1, 2021 to October 10, 2021remains zero. After converting the original data into outputs and inputs in the models, we conducted the mean normalization and handled the outliers on the outputs and all the inputs. Mean normalization is to greatly improve the accuracy of models by limiting the massive variance in the scale of data dimensions and making the features have numerical comparability. The outliers are detected using IQR (interquartile range) outlier detection and assigned to the IQR upper bound or lower bound.

We conducted a statistical analysis on the processed data. The correlation analysis on outputs and inputs is to confirm the feasibility of the two factor models. The statistical features of data are calculated to present the distribution of both outputs and inputs. The white noise test using lb-value (statistics) and the stationary ADF test are implemented to test fundamental times-series properties. We used PYTHON language to implement the empirical research process.

2.2 Modeling

2.2.1 Factor model selection

1) Fama-French 3-Factor Model

In 1993, Fama and French pointed out that a 3-factor model could be established to explain stock returns [16]. The Fama-French 3-factor model is defined as follows:

$$E(Rit) - Rft = \beta i[E(Rmt - Rft)] + siE(SMBt) + hiE(HMIt) \quad (1)$$

The regression model is expressed as follows:

$$Rit - Rft = ai + \beta i(Rmt - Rft) + siSMBt + hiHMIt \quad (2)$$

The Fama-French factors data are selected from Kenneth R. French data library U.S. Research Returns Daily Data [18]. The factor data are constructed using the 6 value-weight portfolios formed on size and book-to-market. The definition of factors are as follows:

SMB (Small Minus Big) is the average return on the three small portfolios minus the average return on the three big portfolios,

$$SMB = 1/3\ (Small\ Value + Small\ Neutral + Small\ Growth) - 1/3\ (Big\ Value + Big\ Neutral + Big\ Growth) \quad (3)$$

HML (High Minus Low) is the average return on the two value portfolios minus the average return on the two growth portfolios,

$$HML = 1/2\ (Small\ Value + Big\ Value) - 1/2\ (Small\ Growth + Big\ Growth) \quad (4)$$

Rm-Rf, the excess return on the market, value-weight return of all CRSP firms incorporated in the US and listed on the NYSE, AMEX, or NASDAQ that have a CRSP share code of 10 or 11 at the beginning of month t, good shares and price data at the beginning of t, and good return data for t minus the one-month Treasury bill rate (from Ibbotson Associates). [16,18]

The data spanning from August 1, 2019, to September 30, 2021, are randomly divided into training set and test set with a ratio of 7:3. The ordinary least-squares (OLS) model can show only linear relationships between stock risk premiums and factors. However, the true relationship between the

outputs and inputs remains to explore. To fit a model with the best performance and predictions, we compare the 10-cross-validation RMSEs of seven machine-learning models. The OLS model is the simplest linear model and enables us to judge the significance and goodness of the factors. The ridge, lasso and elastic net models are regularized linear regressions, which add penalties to the regression function to avoid overfitting. Random Forest and Extra Tree models are decision tree models, where the minimum sample spilts are set to 7 and 6 respectively. The neural network model we implemented is a nonlinear machine-learning model with Keras deep learning library. The neural network model we built has 3 layers in total, where the numbers of neurons are 32, 20 and 1. We compiled the neural network using cross-entropy, root mean square propagation and accuracy performance metric. The Keras model is wrapped with epochs of 150, batch size of 50. The arguments settings in the neural network models were adjusted according to the model average cross-validation RMSE.
The final Fama-French model was selected comparing the cross-validation RMSEs of the seven models. Then we fitted the model with test set data to evaluate the performance of the model. Both test RMSE and Correct Ratio are calculated. The Correct Ratio is defined as a ratio of correct forecasts about prices' ups and downs:

$$Correct\ Ratio\ =\ the\ number\ of\ the\ same\ plus-or-minus\ signs\ of\ predicted\ values\ and\ real\ values \quad (5)$$

2) Our modified Fama-French Factor Model

We perceive that the industry factor is much more significant than the market factor especially for the airline industry during the COVID-19 epidemic time. Thus, we modified the Fama-French Factor model by replacing the market return with the JETS (ETF) log returns:

$$E(Rit)\ -Rft\ =\ \beta i[E(RJETSt-Rft)]\ +\ siE(SMBt)\ +\ hiE(HMIt) \quad (6)$$

The regression model is expressed as follows:

$$Rit\ -Rft\ =\ ai\ +\ \beta i(RJETSt-Rft)\ +siSMBt\ +hiHMIt \quad (7)$$

The factor model selection process for our modified model is completely same as the above Fama-French 3-Factor Model selection. Then we compared the test RMSE and correct ratio of two models to evaluate the goodness of the market factor and the industry factor.

2.2.2 Time Series Prediction of Factors

1) Future input value prediction

The Time series model is applied for factor prediction to forecast future factor values so that the future inputs can fit into the factor models and predict the future stock risk premiums. Since the future Rf from October 1, 2021, to October 10, 2021, is assumed to be zero, the stock risk premiums equal to the stock log returns.

There are four factors in total, which are market risk premium (excess return on the market), JETS risk premium, SMB and HML. For each factor, we fitted four time series models to predict future input values from October 1, 2021, to October 10, 2021. The four models are AR(p) autoregressive model, MA(q) moving average model, ARMA (p, q) autoregressive moving average model and ARIMA (p, d, q) Autoregressive Integrated Moving Average model.

With the whole data set, we used the order select function of ARMA in stats model package to directly generate the optimal parameters in the four time series models. The maximum p and q are set to control the calculation time. Therefore, the orders of the models are local optimizers. The ARMA(p,q) model was separated into AR model and MA model to enable us to observe high order performance. Using methods of AIC, BIC, and HQIC, different optimal orders are generated. We picked the best order which has the smallest test MSE.

After finding best orders for the four time series models, we divided the sets into training set and test sets, then we train the model to predict test set. We selected the model with the smallest test MSE among the four time series models.

2) Future input volatility prediction

Based on the best models we have selected, we tested whether the stock is of heteroskedasticity to apply ARCH or GARCH models. If the stock is heteroskedastic, the ARCH or GARCH model is applied to predict the volatility of future inputs. The orders of ARCH or GARCH model are generated according to both the PACF plot of residual squared and the significance of model parameters.

2.2.3 Stock Return Prediction and Model Comparison

The stock risk premium can be predicted using the predicted factor values and the selected factor model. Since the risk-free rate is assumed to be zero, the normalized stock log return equals to the normalized stock risk premium value. We compared the correct ratios and RMSEs for the Fama-French 3-factor model and our modified Fama-French model to assess the model performance.

3. ResultS

The airline industry is one of the most affected industries during the epidemic. In order to compare the effectiveness of the modified model and the original Fama-French model during the epidemic, we chose to analyze the airline industry. The sample data selected also allows for comparison of predicted values for different capital sizes. We chose Delta, Spirit, and Mesa as representatives of large, medium, and small capital sizes respectively. The dataset we select to implement our modeling framework from 2019-08-01 to 2021-09-31, and the test data are from 2021-09-01 to 2021-09-10. Finally, at the practical level, we used time series analysis to predict the return of Fama-French and Modified and compare it with the real return, so as to compare which model is more effective. The entire dataset was downloaded from Yahoo Finance.

3.1 Statistical Analysis

3.1.1 Correlation Analysis Colinear

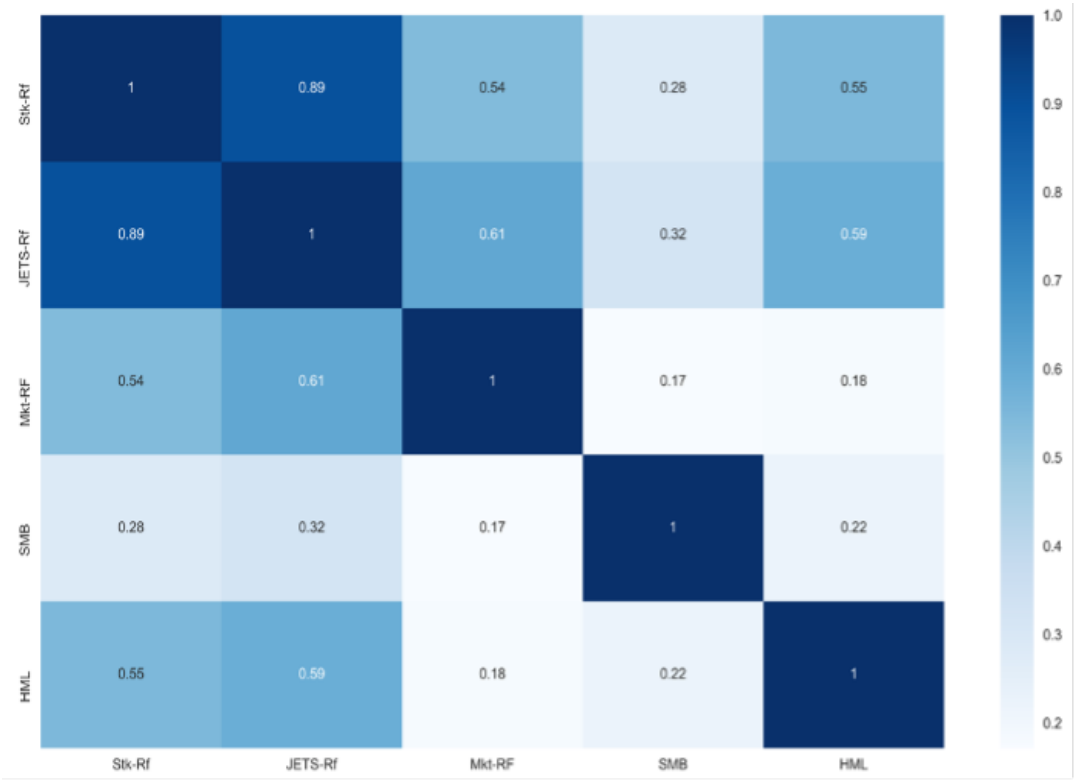

Figure 1. Delta Correlation Analysis

To ensure the validity of the experiment, we need to confirm that the factors we choose have a strong correlation with the model we are studying. As shown in Fig.1, Fig.2 and Fig.3, no matter for Delta, Spirit, or Mesa, ETF Premium factors have a stronger correlation with stock Premium than market Premium factors. At the same time, in order to avoid too much commonality among factors, which may affect the data results, we need to ensure the independence between factors. According to Fig.1, Fig.2 and Fig.3, we can see that the independent correlation of ETF Premium factors is not as small as that of market Premium factors.

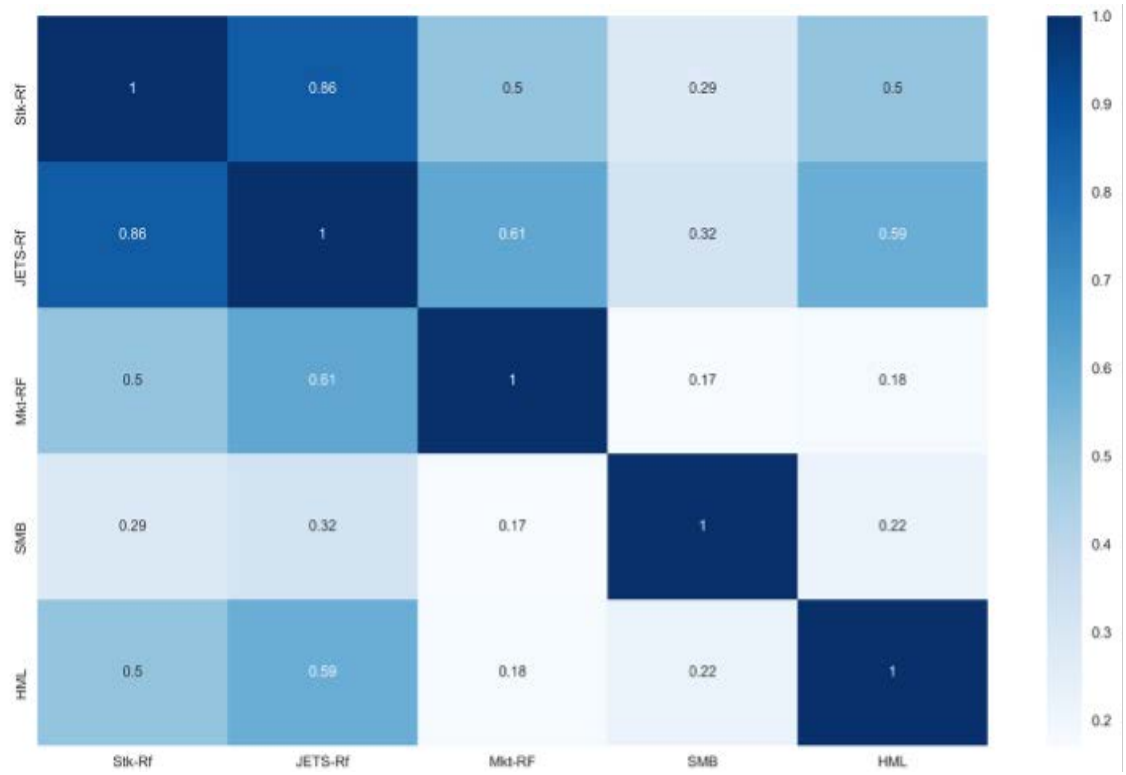

Figure 2. Spirit Correlation Analysis

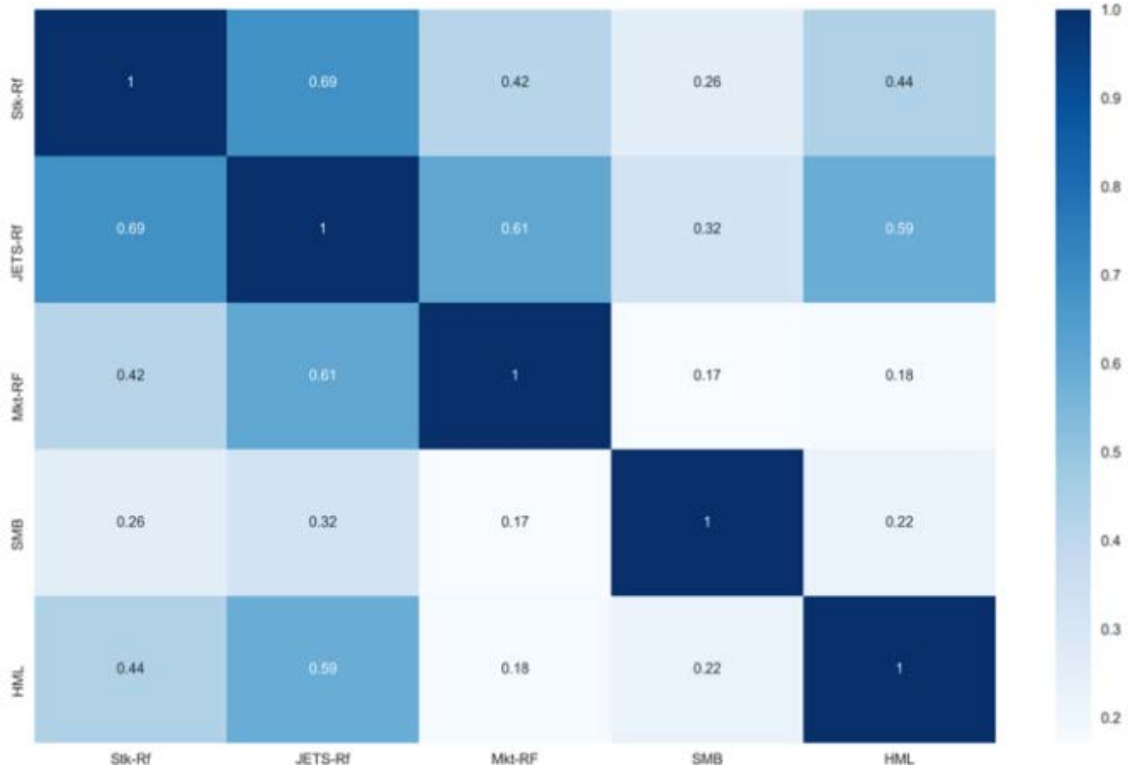

Figure 3. Mesa Correlation Analysis

We can see that the independent correlation of ETF Premium factors is not as small as that of market Premium factors. Comparatively, the factors in the modified model have a higher correlation than the factors in Fama-French 3-Factor Model. The reason is that the ETF we choose is Jets which is an ETF that has holdings on many airline companies. Even if ETF, Jets, has more holdings on Delta, relatively small number of holdings on Spirit and no holdings on Mesa, using this factor can help us to predict the future stock returns better in the airline industry. Unlike market premium, which is the rate of return on a risky investment. This factor cannot narrow down the return on a risky asset into the return on only investing in airline stocks.
Another possible explanation is the investment preferences. Most people would like to invest stocks that have relatively higher return, lower volatility or less risky. The stocks that have higher market value might have l. With ETFs

3.1.2 Statistical Properties(market/etf)

Table 1 shows that except for market risk premium and SMB, the remaining Daily average returns are all negative, and except for market risk premium, the rest are close to 0. JETS risk premium exhibits the lowest volatility in terms of standard deviation. Market risk premium has the strongest volatility. But all the return distributions are skewed to the left, except for the SMB and HML. Except HML, all kurtosis values are greater than 3, so except HML, the dataset has heavier tails than a normal distribution. All values are Stationary. Only SMB is white noise.

Table 1. Statistical Properties

	Mean	Std. dev.	Max	Min	Skewness	Kurtosis	Stationary test	White noise test
Delta risk premium	-0.002911	0.038367	0.184762	-0.307003	-0.908791	13.407791	stationary	not a white noise
Spirit risk premium	-0.003198	0.053759	0.313470	-0.403850	-0.494246	11.777705	stationary	not a white noise
Mesa risk premium	-0.002630	0.058517	0.253850	-0.396221	-0.471686	7.059575	stationary	not a white noise
market risk premium	0.100932	1.626136	9.340000	-12.000000	-0.818604	13.644723	stationary	not a white noise
JETS risk premium	-0.002668	0.032252	0.167940	-0.231023	-0.544824	10.498208	stationary	not a white noise
SMB	0.023042	0.826678	5.540000	-3.600000	0.362130	4.368919	stationary	White noise
HML	-0.036673	1.341945	6.750000	-4.950000	0.294842	2.379594	stationary	not a white noise

3.2 Factor Model Selection

3.2.1 Cross-Validation RMSE

The average prediction error generated by the RMSE measurement model in predicting observations. The average difference between the observed known result value and the predicted value of the model. The lower the RMSE, the better the model. Therefore, according to Table 2, cross-validation RMSE for Fama-French 3-factor model, we selected Ridge model for all three stocks. For

Table 3. Cross-validation RMSE for our modified Fama-French Factor Model, we select Ridge for Delta. ExtraTree for Spirit, OLS for Mesa.

Table 2. Cross-Validation RMSE for Fama-French 3-factor model

Model	Delta (Big cap)	Spirit (Median cap)	Mesa (Small cap)
OLS	0.024488	0.037338	0.047206
Ridge	0.024482	0.037331	0.047202
Lasso	0.033649	0.046463	0.056766
ElasticNet	0.033649	0.046463	0.056766
RandomForest	0.026441	0.039880	0.052166
ExtraTree	0.025401	0.039221	0.053735
NeuralNetwork	0.035117	0.053543	0.059227

Delta: Ridge; Spirit: Ridge; Mesa: Ridge

Table 3. Cross-Validation RMSE for our modified Fama-French Factor Model:etf

Model	Delta (Big cap)	Spirit (Median cap)	Mesa (Small cap)
OLS	0.014259	0.024031	0.040532
Ridge	0.014241	0.024019	0.040533
Lasso	0.033649	0.046463	0.056766
ElasticNet	0.033649	0.046463	0.056766
RandomForest	0.015008	0.023690	0.043344
ExtraTree	0.014802	0.023404	0.043934
NeuralNetwork	0.036835	0.052182	0.057521

Delta: Ridge; Spirit: ExtraTree; Mesa: OLS

3.2.2 Comparing model goodness

When we compare the model goodness, we use the adjusted R squared value and P value of F-test of OLS to verify the validity of the factors. According to Table 4, for Delta, Spirit or Mesa, the Modified model has a larger adjusted R squared value. Meanwhile, as Table 5 shows, Modified model has higher P value for different capital sizes, so modified model is better for P value and adjusted R squared value than Fama-French model.

Table 4. Statistics of two model's adjusted R-squared value

Stock	Capital Size	Fama-French Model	Modified model	larger adjusted R squared value
Delta	Big	0.526	0.810	Modified model
Spirit	Median	0.002	0.762	Modified model
Mesa	Small	0.002	0.494	Modified model

Table 5. Statistics of two models' p-value Prob

Stock	Capital Size	Fama-French Model	Modified model	Larger p-value
Delta	Big	2.20e-59	2.05e-131	Modified model
Spirit	Median	2.69e-41	7.37e-114	Modified model
Mesa	Small	3.13e-32	3.14e-54	Modified model

Based on Table 6 and Table 7, Modified Model is a better choice for The TEST RMSE and the test Correct ratio than Fama-French model.

Table 6. The test RMSE of two models

Stock	Capital Size	Fama-French Model	Modified model	Smaller test RMSE
Delta	Big	0.03170375232043345	0.020496201704258414	Modified model
Spirit	Median	0.045924806817630795	0.03177050477282258	Modified model
Mesa	Small	0.05238303425057348	0.04683625408750358	Modified model

Table 7. The test Correct ratio of two models

Stock	Capital Size	Fama-French Model	Modified model	larger correct ratio
Delta	Big	0.7721518987341772	0.9177215189873418	Modified model
Spirit	Median	0.759493670886076	0.8544303797468354	Modified model
Mesa	Small	0.759493670886076	0.7974683544303798	Modified model

ETFs depend most on the index and decide whether to reduce, to increase, or keep the same holdings on that stock. If there are a lot of people choose to invest on a stock, then the index of that stock might increase greatly. Other than this situation, it may help the index of a stock to increase if the policy supports the industry. As some of countries decide to lift travel bans gradually, demand for traveling to other countries may increase and the demand for buying airline tickets will rise too. If this trend of increasing index maintains for a while, it is possible that ETF choose to increase the holdings on that stock, and vice versa. Under the background of this thesis, higher proportion of the holdings of an airline company, the better results will be reflected to us on the modified model. And the related industry factor will be better than the entire market premium.

Based on the proportion of holdings of Jets, Delta has higher proportion than Spirit. Jets does not have any holdings on MESA. The proportion of Jets' holdings on airline companies may impact the effects on modified models. Based on the data and the results of modified model, Delta, which Jets has most holdings on, has largest adjusted R Squared Value and correct ratio and smallest p-value and Root Mean Square Error. The second best is Spirit which Jets holdings on this airline company is lower than Delta.

3.3 Time Series Prediction of factors

Figure 4, Figure 6, Figure 8 and Figure 10 show the original value in blue, the conditional volatility in green, the fitted value in light green, predicted value in red lines and the volatility of predicted value in red dots for Market Premium, ETF Premium, HML and SMB. And we magnify the predicted value and the volatility of predicted value between 2021-09-01 and 2021-09-10 for Market Premium, ETF Premium, HML and SMB in Figure 5, Figure 7, Figure 9 and Figure 11. Figure 4 shows the Time Series Prediction of Market Premium. As can be seen from the figure, conditional Volatility is very close to original market premium. But the return of market premium is not very close to the original market premium. In Figure 5, we can confirm that the predicted Market Premium Volatility ranges from 0.3 to 0.6. In Figure 7, we can see that the predicted ETF Premium Volatility is around 0.6. In Figure 9, we can realize that the predicted HML Volatility ranges from 0.6 to 0.7. In Figure 11, we can observe that the predicted SMB Volatility ranges from 0.8 to 0.9. Compared with market premium, CONDITIONAL volatility and return of ETF premium, HML and SMB are not close to the true value. SMB returns deviate the most from origin SMB. However, the predicted volatility of SMB, HML, and ETF Premium is more stable than that of Market Premium. Market Premium.

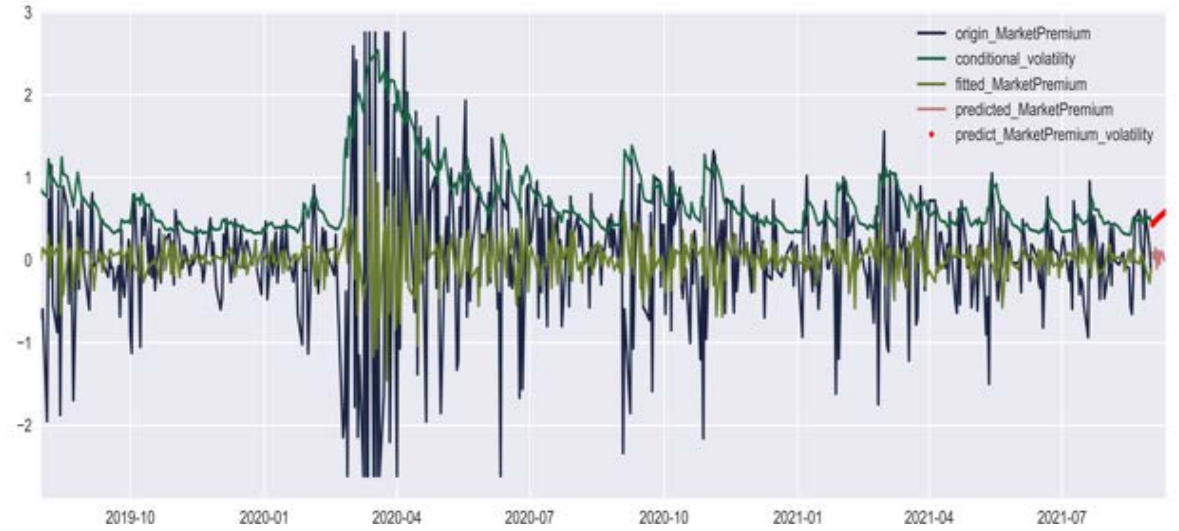

Figure 4. Time Series Prediction of factor: Market Premium

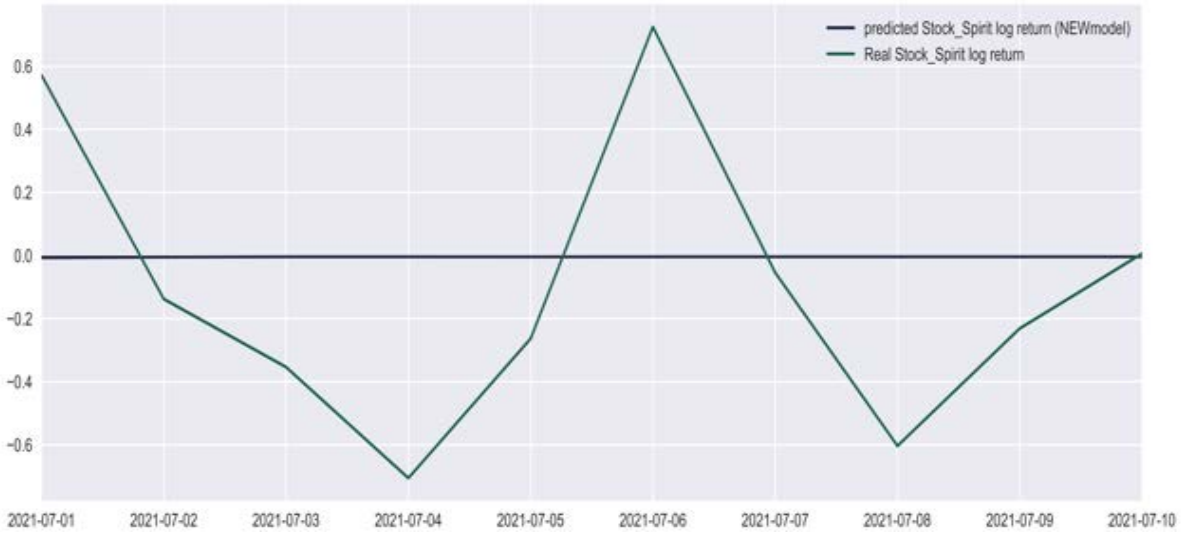

Figure 5. Time Series Prediction of factor: Market Premium (Zoomed in)

1) ETF Premium

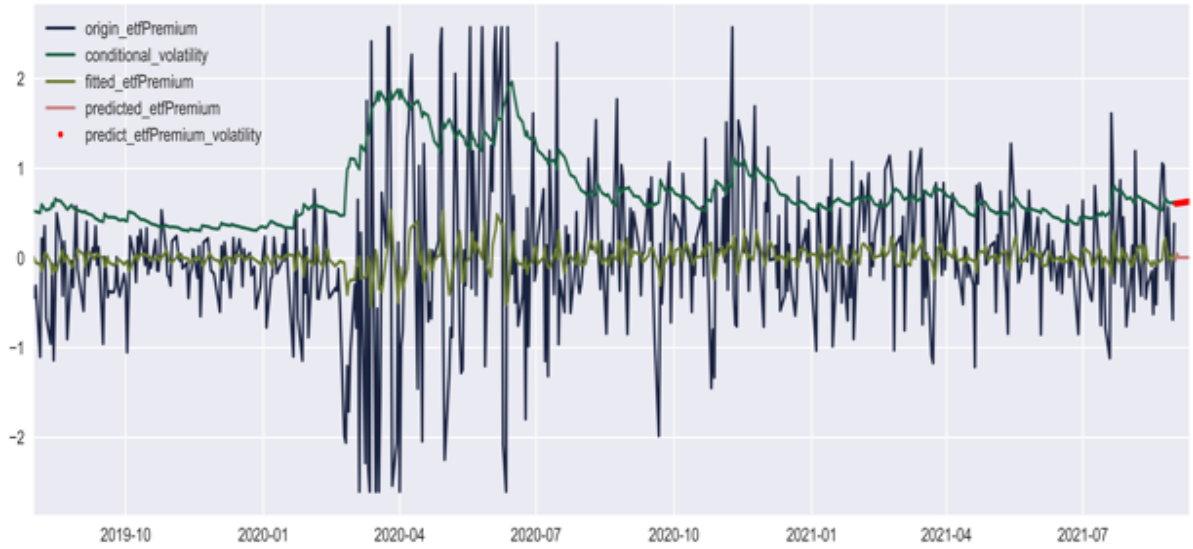

Figure 6. Time Series Prediction of factor: ETF Premium

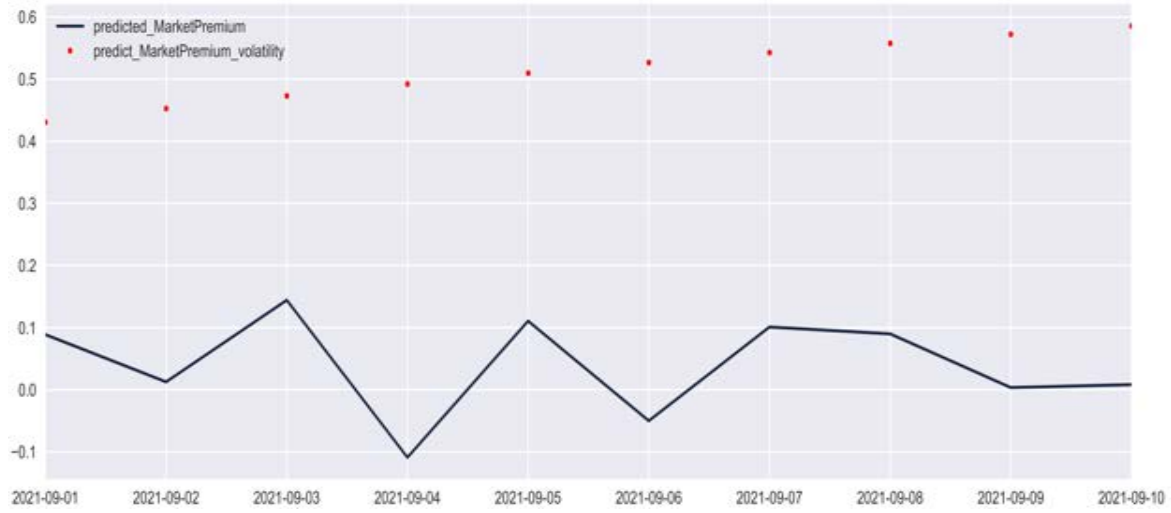

Figure 7. Time Series Prediction of factor: ETF Premium (Zoomed in)

2) HML

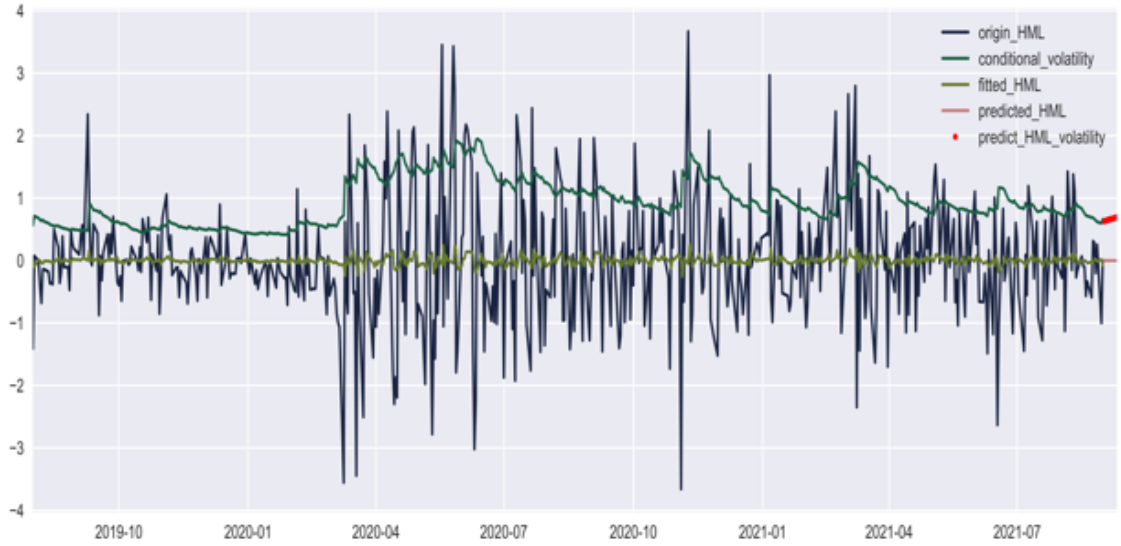

Figure 8. Time Series Prediction of factor: HML

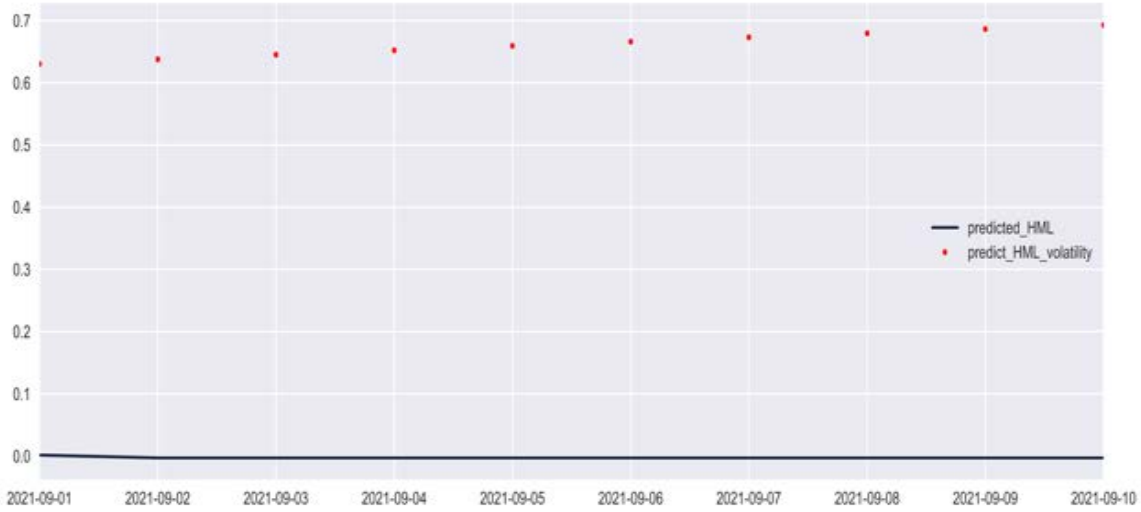

Figure 9. Time Series Prediction of factor: HML (Zoomed in)

3) SMB

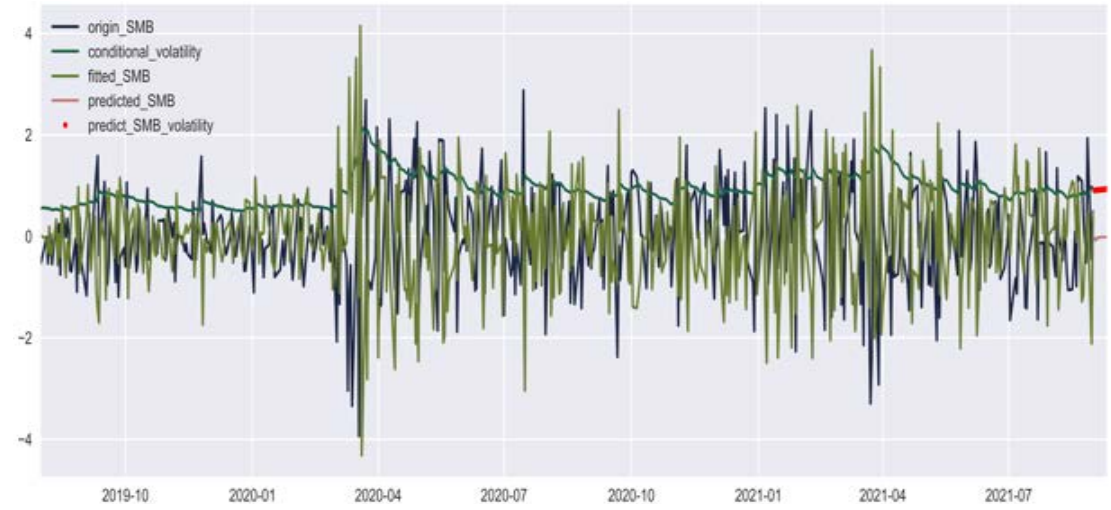

Figure 10. Time Series Prediction of factor: SMB

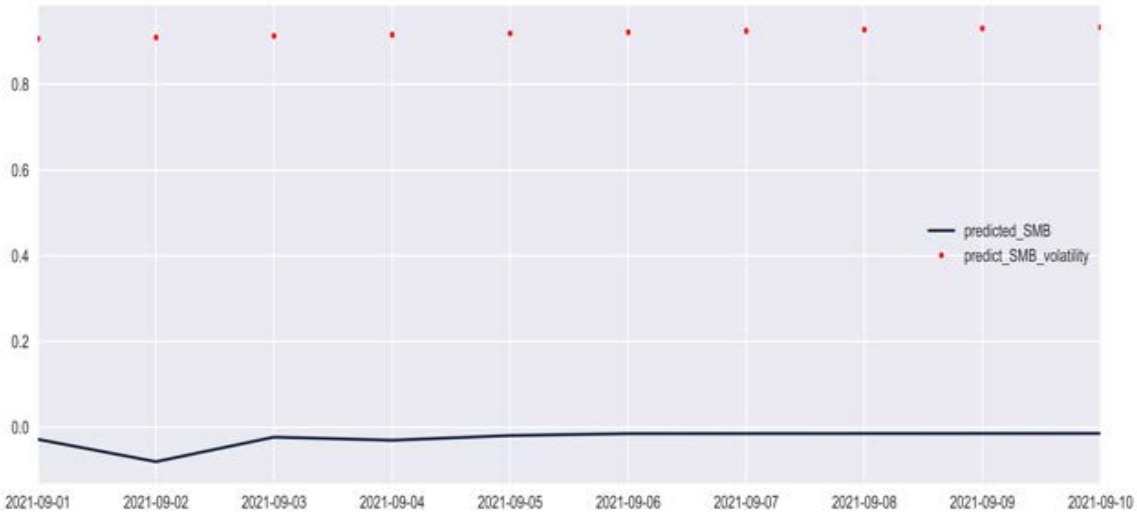

Figure 11. Time Series Prediction of factor: SMB (Zoomed in)

3.4 Factor Model Goodness with Time Series Application

3.4.1 Prediction Result:

1) Delta

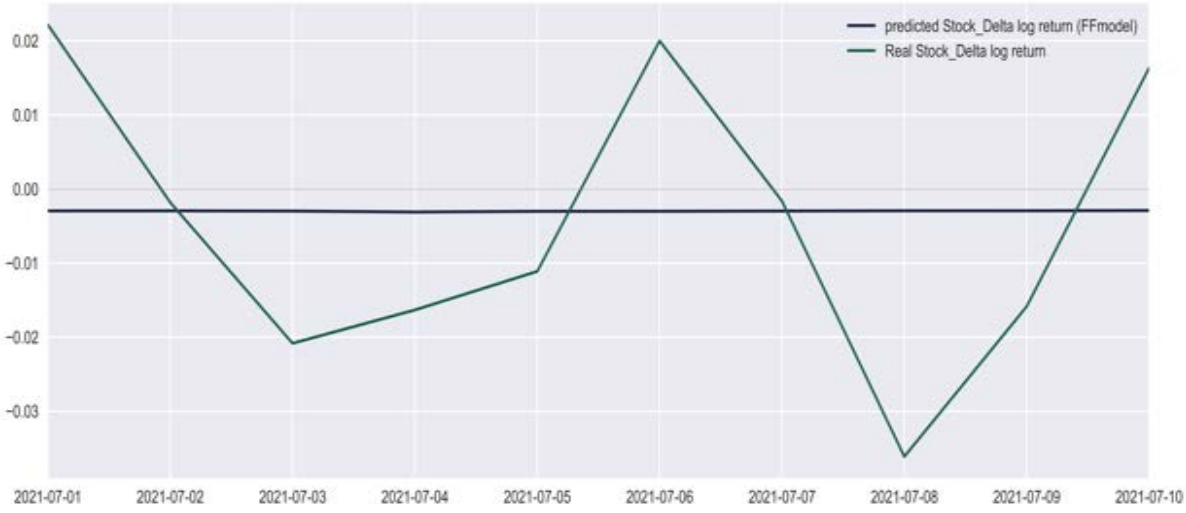

Figure 12. Prediction result of Delta log return using Fama-French 3-factor Model

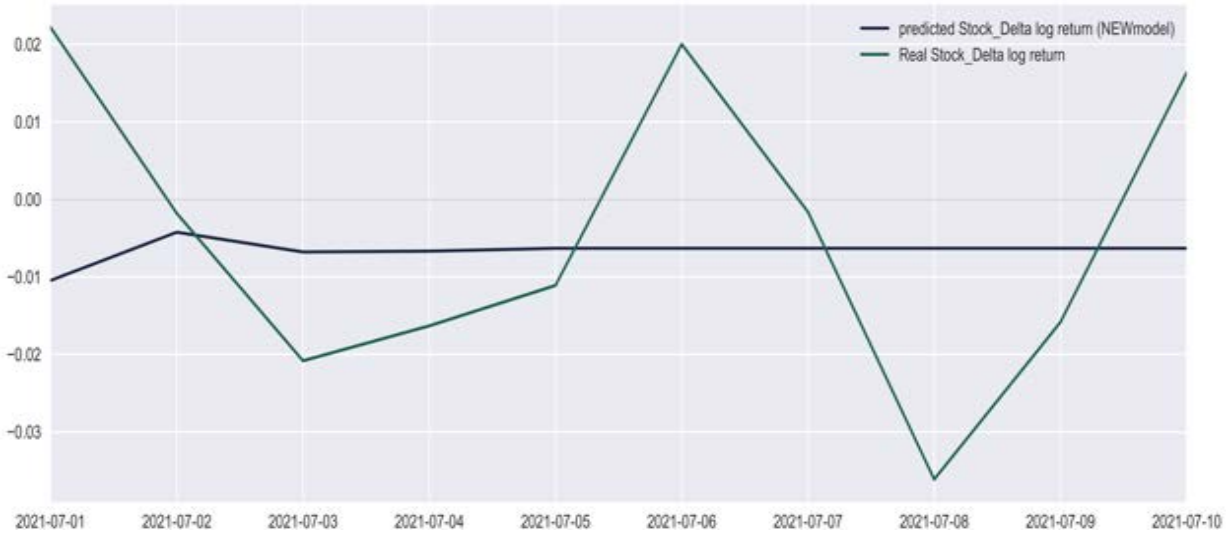

Figure 13. Prediction result of Delta log return using new model

Table 8. Prediction Result for Delta

	Date	Real Stock Delta log return	Predicted volatility	FF model predicted return	New model predicted return
0	2021-09-01	0.022175	0.632592	-0.002950	-0.010466
1	2021-09-02	-0.001810	0.634687	-0.002940	-0.004246
2	2021-09-03	-0.020827	0.636762	-0.002972	-0.006792
3	2021-09-04	-0.016321	0.638818	-0.003103	-0.006687
4	2021-09-05	-0.011110	0.640856	-0.003008	-0.006319
5	2021-09-06	0.020003	0.642875	-0.003002	-0.006319
6	2021-09-07	-0.001632	0.644876	-0.002965	-0.006319
7	2021-09-08	-0.036117	0.646859	-0.002932	-0.006319
8	2021-09-09	-0.015852	0.648825	-0.002933	-0.006319
9	2021-09-10	0.016336	0.650772	-0.002897	-0.006319

Figures 12 and 13 show the prediction results for Delta, FF, and the new model respectively. The prediction result of FF is quite different from that of the new model, but the prediction trend of the new model is more consistent with the real Delta log return. For example, 2021-09-02 to 2021-09-03 accurately predicted the downward trend and the upward trend of the following day, as shown in Table 8.

2) Spirit

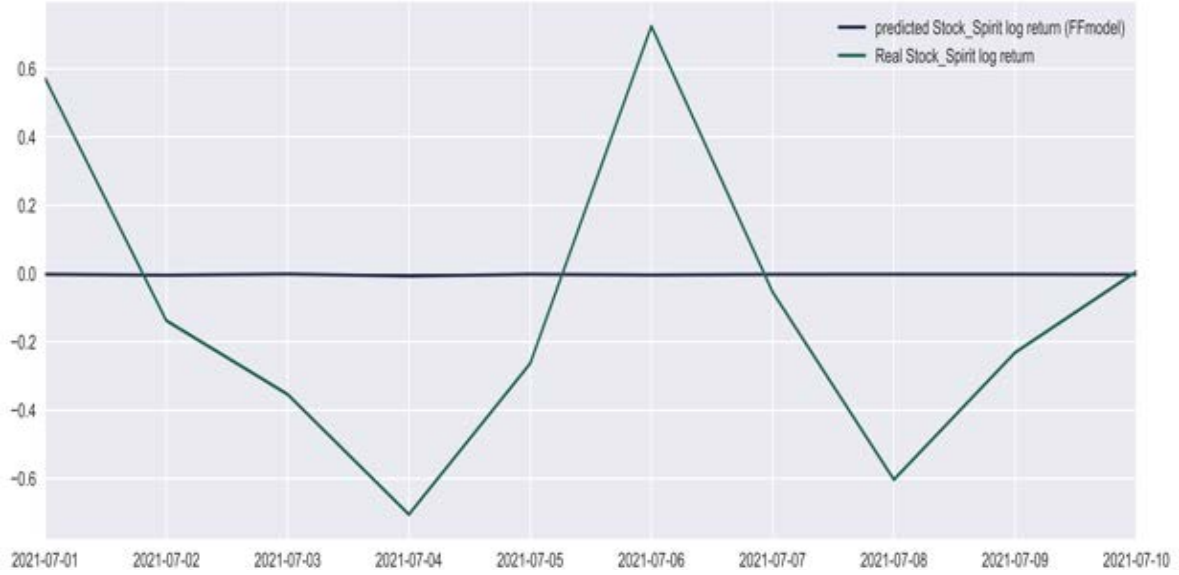

Figure 14. Prediction of Spirit using Fama-French Model

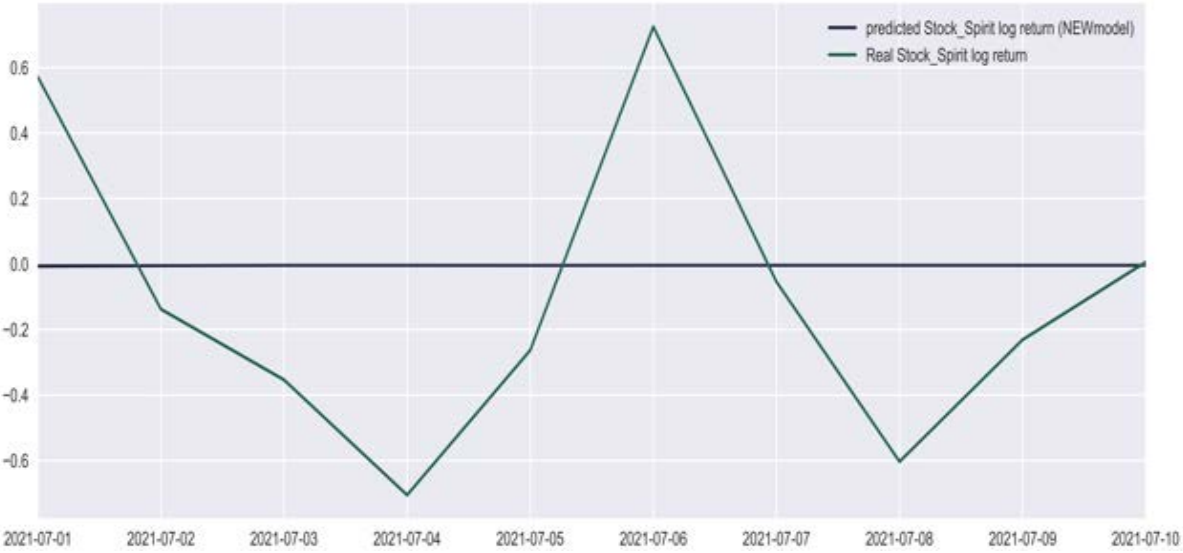

Figure 15. Prediction of Spirit using new model

Figures 14 and 15 show the predicted results for Spirit, FF model, and the new model respectively. FF's predictions are almost identical to those of the new model. Not much difference, as shown in Table 9.

Table 9. Prediction Result for Spirit

	Date	Real Stock Spirit log return	Predicted volatility	FF model predicted return	New model predicted return
0	2021-09-01	0.571783	0.530843	-0.001689	-0.006589
1	2021-09-02	-0.137742	0.535133	-0.004070	-0.004508
2	2021-09-03	-0.353630	0.539333	-0.000914	-0.003530
3	2021-09-04	-0.705499	0.543446	-0.006695	-0.003530
4	2021-09-05	-0.263356	0.547474	-0.001614	-0.003687
5	2021-09-06	0.724802	0.551421	-0.003521	-0.003433
6	2021-09-07	-0.053982	0.555288	-0.001913	-0.003433
7	2021-09-08	-0.603432	0.559078	-0.001684	-0.003433
8	2021-09-09	-0.231068	0.562793	-0.001745	-0.003433
9	2021-09-10	0.006162	0.566436	-0.002363	-0.003433

3) Mesa

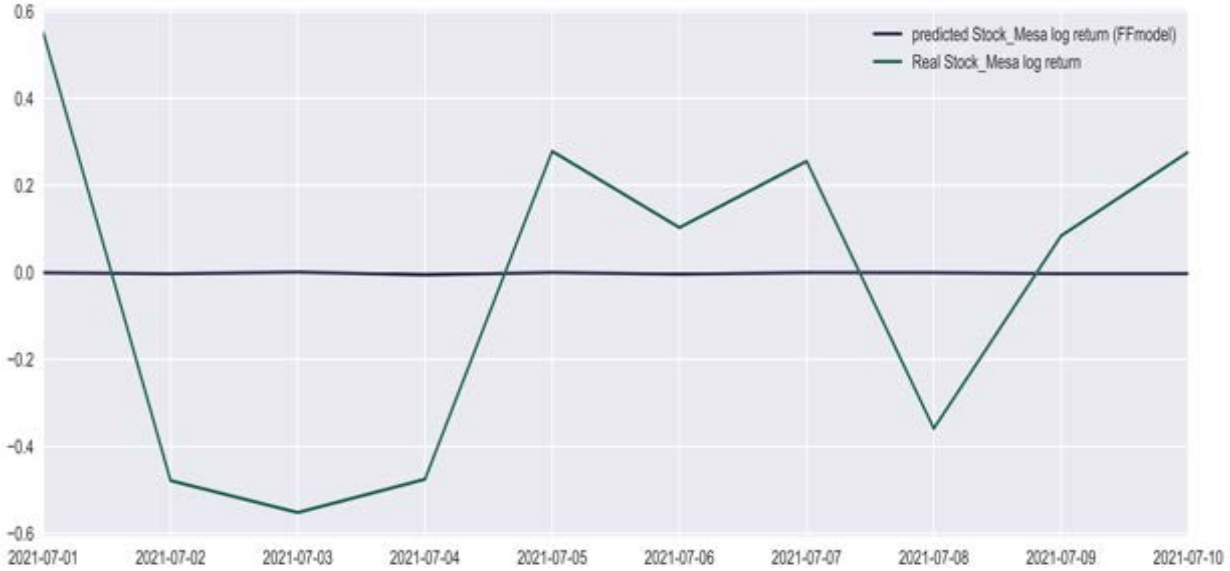

Figure 16. Prediction result of Mesa log return using Fama-French 3-factor Model

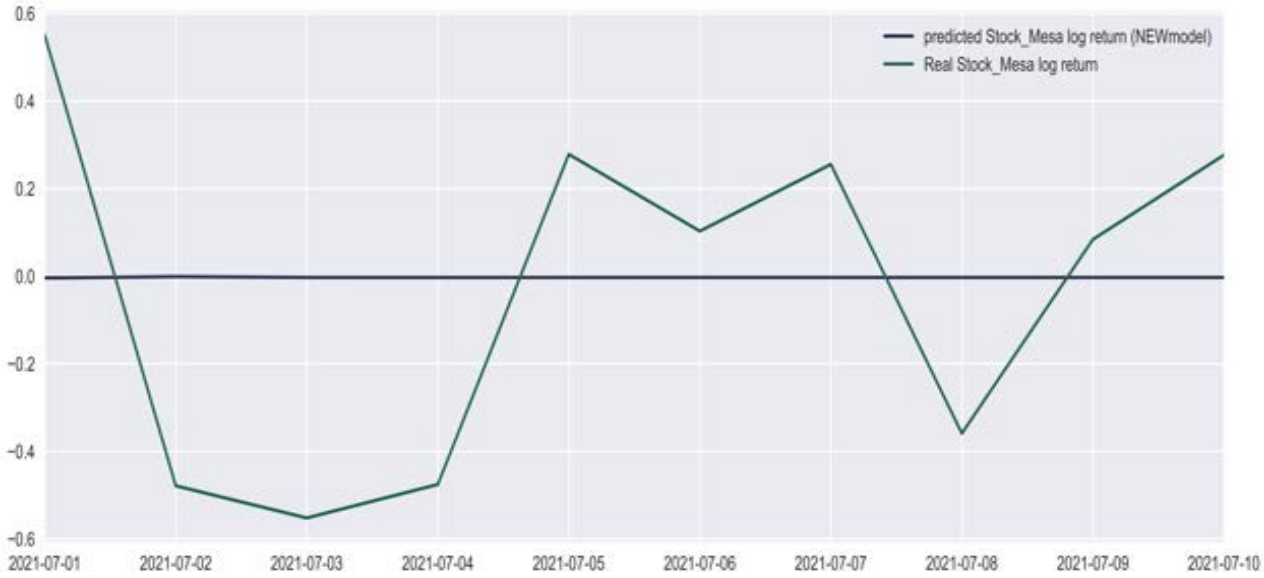

Figure 17. Prediction result of Mesa log return using new model

Figures 16 and 17 show the predictions for MESA, FF model, and the new model respectively. The predictions were almost the same, as shown in Table 10.

Table 10. Prediction Result for Mesa

	Date	Real Stock Delta log return	Predicted volatility	FF model predicted return	New model predicted return
0	2021-09-01	0.550253	0.531148	-0.000791	-0.004020
1	2021-09-02	-0.478692	0.565193	-0.003086	-0.000916
2	2021-09-03	-0.552114	0.594671	0.000481	-0.002680
3	2021-09-04	-0.475576	0.620444	-0.005619	-0.002698
4	2021-09-05	0.278247	0.643146	-0.000294	-0.002672
5	2021-09-06	0.102774	0.663260	-0.004097	-0.002661
6	2021-09-07	0.255331	0.681162	-0.000491	-0.002661
7	2021-09-08	-0.358981	0.697158	-0.000753	-0.002661
8	2021-09-09	0.083827	0.711494	-0.002817	-0.002661
9	2021-09-10	0.276401	0.724377	-0.002703	-0.002660

3.4.2 RMSE of the two model using Time Series Prediction of factors to predict two models

Table 11. RMSE comparison of two models

Stock	Capital Size	Fama-French Model	New model	Smaller test RMSE
Delta	Big	0.01833	0.01894	Fama-French Model
Spirit	Median	0.44451	0.44495	Fama-French Model
Mesa	Small	0.37739	0.37813	Fama-French Model

In the end, we found that the Fama-French Model was better for RMSE, as shown in Table 11 and Table 12.

Table 12. Fama-French Model

	Date	Real Stock Mesa Log return	Predicted volatility	FF model predicted return	New model predicted return
0	2021-09-01	0.550253	0.531148	-0.000791	-0.004020
1	2021-09-02	-0.478692	0.565193	-0.003086	-0.000916
2	2021-09-03	-0.552114	0.594671	0.000481	-0.002680
3	2021-09-04	-0.475576	0.620444	-0.005619	-0.002698
4	2021-09-05	0.278247	0.643146	-0.000294	-0.002672
5	2021-09-06	0.102774	0.663260	-0.004097	-0.002661
6	2021-09-07	0.255331	0.681162	-0.000491	-0.002661
7	2021-09-08	-0.358981	0.697158	-0.000753	-0.002661
8	2021-09-09	0.083827	0.711494	-0.002817	-0.002661
9	2021-09-10	0.276401	0.724377	-0.002703	-0.002660

The reason why Fama-French 3-Factor Model is better than modified model but not outcompete a lot is that we use both time series and factor model to predict the future trends of stock returns. Processing more models and overlaying models may lead the final results deviate from the real trend of data.

The advantage of using time series analysis is that this method is simple and accurate. The disadvantage of using this method is that if we try to predict the future trends based on the historical data, we are not sure whether the trend will be similar to the trend in the past.

3.4.3 Correct ratio of the two models

Table 13. Correct ratio of the two model

Stock	Capital Size	Fama-French Model	New model	Larger correct ratio
Delta	Big	0.7	0.7	Same
Spirit	Median	0.7	0.7	Same
Mesa	Small	0.3	0.4	New model

For Delta and Spirit, Correct ratio of these two models is the same. For Mesa, the difference between the Fama-French model and the new model is minimal that we can ignore it. In summary, the two models are similar. Although Fama-French Model looks slightly more efficient on RMSE perspective, it is about the same on correct ratio. But New model is better for small-cap stocks, as shown in Table 13.

In sum, based on the previous analysis and the data, our modified model is better than the original Fama-French 3-factor model when predicting the future stock returns of airline companies.

4. Conclusion

The main purpose of this paper is to introduce a modified Fama-French 3-factor model based on Time Series Analysis. The introduced modeling switches the market premium to ETF premium and keep other two factors the same and uses to predict the airline stock returns. Compared to the classic Fama-French 3-factor model, using ETF premium narrows down the range of sector and it contains different categories of stocks from the sector. At the empirical stage, we did a thorough comparison between the modified Fama-French 3-factor model and the traditional Fama-French 3-factor model. By observing and comparing the results that we have, the value of RMSE, p-value, adjusted R-squared, Correct Ratio of modified model is better (smaller) than the traditional Fama- French 3-Factor model. The predicted volatility of modified model it more stable than the model using Market Premium as one of the factors. Also, the modified model has either similar prediction with the traditional model or closer to the real stock return trend.

Our research has some limitations. First, we looked only at the impact on stocks during the coronavirus pandemic. The COVID-19 pandemic is highly contagious, so that it has a huge and lasting impact on all industries. Unlike other types of disasters, the industries affected, and the duration of the appearance are relatively short. Second, we analyzed only the U.S. stocks, not the entire global market which may have regional restrictions. At the same time, we analyzed just the aviation industry. Since the aviation industry was one of the hardest hits during the pandemic, the results of the study will be more extreme than those of other industries. In the factor model, we only compare the market factor and ETF factor, so this does not mean that our model is absolutely the best. Since only Delta and Spirit have ETFs, they don't represent all of them. Time Series forecasts are not necessarily applicable to all stocks. We chose to use the Time Series model only to compare the two Factor models based on this model. If it's for prediction, other models may have a better performance than Time Series.

The significance of this research is that our results show the industry factor is the better one comparing to the market factor when it comes to the prediction of stock prices under the background of the Covid pandemic in the United States. When something unpredictable just like the breakout of the pandemic, there are certainly some unfavorable industries under such a situation. At this time, the market factor in the factor model can hardly explain the trend of stocks belonging to the industry. Therefore, factors that can represent a particular industry’s performance became the more proper ones in explaining the stock price.

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