Analysis of COVID-19 on Resource-related Industries
Based on Fama and French Five-Factor Model

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ABSTRACT

CAPM model and Fama-French model are frequently used in the field of the portfolio. This paper will discuss the application of the Fama-French five-factor model in the impact of COVID-19 on four industries dominated by commodities and give possible reasons. To study the outbreak's impact on the gold, mines, coal, and oil industry before and after the outbreak, this report adopts the Fama-French five-factor model theory for analysis, and the data are processed by multiple linear regression to obtain the desired results. The results showed that MKT, SMB, HML, RMW, and CMA changed in different degrees in four industries before and after the epidemic. Therefore, after a "black swan" event such as COVID-19, investors should consider the impact of different factors on different sectors separately, rather than generalizing about all relevant sectors.

Keywords: Fama-French five-factor, multiple linear regression, COVID-19, gold, mines, coal, oil.

1. INTRODUCTION

Since February 2020, the impact of COVID-19 on commodities has not been totally eliminated. In this period, the industrial chain of commodities has been severely impacted by the pandemic. Supply chain blockade also leads to a decline in productivity, and huge consumption potential has not been unleashed during this period. One of the most famous events about commodities is the crude oil futures (WTI). May contract falls to the negative price. As the concentration rate of the vaccine increases, the economic impact of COVID-19 is becoming less and less, and logistics disruptions have greatly improved. At the same time, commodity prices have risen sharply as demand recovered. To accurately assess the extent of the impact of COVID-19 on commodity markets, it is necessary to use the Capital asset pricing model (CAPM) to measure market changes before and after the pandemic [1]. CAPM is the first equilibrium model of financial asset pricing, and it is also the first financial asset pricing model that factors can test. The primary significance of CAPM is to establish the relationship between capital risk and return and clearly indicate that the expected rate

of return of securities is the sum of the risk-free rate of return and risk compensation. It reveals the internal structure of security return. However, a large number of empirical studies in the 1980s found that the actual operation of the stock market was not consistent with CAPM, and many scholars found many abnormal phenomena. Fama and French pointed out that a three-factor model could be established to explain the return rate of stocks. According to the model, the excess return of a portfolio can be explained by its exposure to three factors: market portfolio return (Rm-Rf), market value factor (SMB), and book to market ratio factor (HML). After that, Fama and French added profitability factor (RMW) and investment patterns factor (CMA) variables to the original three-factor model to establish a five-factor model, and they analyze and research the security market in many countries, they found that compared with the three-factor model, the five-factor pricing model has better explanatory power. Therefore, this paper will adopt the Fama-French five-factor model as the theoretical basis for analysis.

Fama and French find out that the beta value of a stock in the market does not account for the differences in returns between different stocks, so they came up

with the Fama-French model, and this was a great step in the history of the world economy. There are still many researchers trying to find out more about the model. Griffin et al. examined whether country-specific or global versions of Fama and French's three-factor model better explain time-series variation in international stock returns. Regressions for portfolios and individual stocks indicate that domestic factor models explain much more time-series variation in returns and generally have lower pricing errors than the world factor model. In addition, decomposing the world factors into domestic and foreign components demonstrates that the addition of foreign factors to domestic models leads to less accurate in-sample and out-of-sample pricing. Practical applications of the three-factor model, such as cost of capital calculations and performance evaluations, are best performed on a country-specific basis. His findings do not support the notion that there are benefits to extending the Fama and French three-factor model to a global context. Country-specific three-factor models are more useful in explaining average stock returns than are world and international versions [1]. Huang confirmed that Fama-French five-factor model was superior to other traditional asset pricing models in explaining the returns of Individual stocks in China from 1994 to 2016. This paper compared the performance of traditional assets pricing models, such as Sharpe-Lintner Capital Asset Pricing Model (CAPM), Fama-French three-factor model, Carhart four-factor model, and Fama-French five-factor model. He pointed out that the five-factor model performs better than others in explaining individual stock returns. However, the addition of investment and profitability factors only slightly improved the performance of the model, which means that the explanatory power of these two factors to stock returns is incremental but small [2].

As COVID-19 spread worldwide, remarkable influence on human activities has attracted researchers' and experts' eyes. They paid a lot of attention to working on changes that happened and solutions to problems. In the large picture, Sharif et al. used the continuous wavelet transform, the wavelet coherence, and the wavelet-based Granger causality tests to analyzed the connections between the COVID-19 epidemic, oil price volatility shocks, stock markets, geopolitical risks, and the US economic policy uncertainty in a time-frequency framework. They found that the US markets initially reacted to oil shocks instead of news of COVID-19 from Wuhan and elsewhere. However, the COVID-19 crisis immediately escalated and resulted in uncertainty affecting economic policy, which confirmed their original assumption that oil in the US economy remains a major source of systemic risk. At the same time, the spread of COVID-19 increased uncertainty due to the unpredictable severity of the response to the influenza pandemic [3].

At the same time, Jong et al. used the Markov-switching approach method to study the impact of COVID-19 on commodities. They tended to use tourist industry stock price as a proxy variable to establish the relationship between different crises and tourism demand forecast. The empirical results showed that highly infectious diseases had a negative impact on the performance of the tourist industry stock. And there was a positive correlation between international crude oil price, gold price, and stock price [4]. There is also some relationship between the variables. Jawadi et al. researched the stock market, exchange rate, and the real estate market in the US affected by the oil price change over the last decade, including the period of COVID-19. It models the dynamics of the returns and tests the impact of volatility of the oil market on these dynamics. The study indicates that there is a positive and significant relationship between the stock market and oil price shock and a negative relationship between the US dollar and oil price. At the same time, there is no significant impact on the US real estate market by oil price [5]. Wiemba et al. study the US equity market during the COVID-19 period in the first half of 2020. There is a record rise, then a record falls in prices, and then a record recovery. Throughout the period, there was extreme volatility and much short-term momentum, with fear and greed alternating. The VIX index signalled the market direction. The roles of the 10-year government bond, the S&P500, Apple Computer stock are studied and the massive Fed and government stimuli that fuelled the rebound, despite extremely weak fundamentals [6].

While gropes of researchers focus on natural resources and human-made energy. Meher et al. researched the destruction and downward movement of demand and supply of crude oil and natural gas because of COVID-19, using oil and gas price volatility listed on India's multi commodity exchange. It is based on 1568 observations and the application of EGARH (exponential generalized autoregressive conditional heteroscedasticity). The daily log returns were calculated to make data stationery and checked by Augmented dickey-fuller test (ADF). The study indicates that there is asymmetric volatility in crude oil prices and no leverage effect on natural gas due to the spread of COVID-19 [7]. Zhong et al. reviewed how the pandemic impacts the electricity industry from firstly the implications for electricity demand and Supply; Secondly the challenges for power system operation and control; the implications on market, investment, and regulation; and finally, the external effects. Analyzing academic papers, reports, news, and public data proved that the electricity consumption decreased in most countries with the lockdown policy, but the residential loads have increased. With the decrease of demand, Coal-fired power generation was influenced the most. The electricity price falls in the main market worldwide

[8]. Due to these impacts on resources, stock and price were focused. Guesmi et al. researched the effect of COVID-19 on the energy futures markets, especially on crude oil and natural gas S&P GS Indexes. It employed the structural VAR model with time-varying coefficients and stochastic volatility (TVP-SVAR model). It indicates the importance of investor expectations in future commodity price changes, and then it shows that the response of commodities to the epidemic varies across time. Overall, the spread of the COVID-19 in the U.S. had a negative impact on commodity futures markets. The short-term prospects for commodity futures markets will depend on the effectiveness of government policies [9]. Yousef et al. investigated the implications of the spread of COVID-19 on gold spot prices. They use GARCH and GJR-GARCH models based on daily gold returns over the period 2012-2020 to analyze the impact of the coronavirus on the volatility of gold returns. And they find a positive correlation between the increasing number of global coronavirus cases and increases in gold price [10]. The impacts above cause plenty of inconvenience and decrease of efficiency to the human society, many people try to find a way to recover it. Cai et al. believe that to recover the manufacturing industry, it was important to analyze the impact caused by COVID-19 on it. This research is mainly about analysing the impacts COVID-19 caused at the beginning and the future. The main impact was the Interruption of raw material and spare parts, and the logistics also faced interference. Researchers claimed that the supply chain could be digitalized in the future to keep it working [11]. Fu et al. find out that COVID-19 has had a prominent negative effect on the energy companies' performance by evaluating the energy industry's performance using the panel data and Difference-in-Difference model. The researchers worked for solutions to the impacts to get the market recovered. As a result, in the first quarter of 2020, the industry performance declined. Companies' income declined because COVID-19 hurt their productivity, and they failed to cover the fixed costs. Researchers claimed that managers should pay attention to fixed expenses [12].

The world economy impacted by the COVID-19 dramatically makes human activities different in many ways. This paper aims to figure out the specific effect of COVID-19 on the mentioned natural resources (gold, mines, coal, and oil) market. This paper provides a review based on the Fama-French five-factor and analyses how the industry was impacted and how it could be recovered. In that case, researchers and stakeholders would know about the current market better and make the correct decision about it.

2. METHOD

2.1. CAPM model

The capital asset pricing model (CAPM) is a formula for calculating an asset's theoretically acceptable needed rate of return. The CAPM was introduced by William F. Sharpe (1964) and John Lintner (1965) [13] independently, built on Harry Markowitz's prior work on diversification and contemporary portfolio theory [13]. The following list summarizes the simplifying assumptions that lead to the basic version of the CAPM. 1. There are many investors, each with a little endowment (wealth) compared to the total endowment of all investors. 2. Each investor sets aside the same amount of money for the same amount of time. 3. Investments are limited to a universe of publicly traded financial assets. 4. Investors pay no taxes on returns and no transaction expenses (commissions and service charges) on securities trades. 5. All investors utilize the Markowitz portfolio selection model because they are rational mean-variance optimizers. 6. Every investor looks at assets in the same way and has the same economic outlook. We obtain the capital asset pricing model (CAPM).

$$R_{it} - R_{ft} = \beta_i(R_{mt} - R_{ft}) \qquad (1)$$

R_{it} is the expected return on the capital asset. R_{ft} stands for the risk-free rate, and $R_{it} - R_{ft}$ is the stock's excess return, and β_i is the sensitivity of predicted excess asset returns to expected excess market returns. whereas $R_{mt} - R_{ft}$ is the market's excess return.

2.2. Fama–French three-factor model

The Fama-French three-factor model (FF3F), according to Fama and French [13], is a new asset pricing model that extends on CAPM by incorporating two more components, namely size, and book-to-market. When the two additional risk factors are combined with the original market risk factor in CAPM, the FF3F performs better on stock return estimation. The Fama and French three-factor mathematical formula is as follows:

$$R_{it} - R_{ft} = \beta_i(R_{mt} - R_{ft}) + s_i SMB_t + h_i HML_t$$
(2)

SMB_t ("Small minus Big") is the difference between returns on a portfolio of small-size stocks and portfolio of big-size stocks, HML_t ("High minus Low") is the difference between returns on a portfolio of high-book-to-market ratio stocks and low book-to-market ratio stocks. s_i, h_i are the coefficients of the factors.

2.3. Fama–French five-factor model

Fama and French created a five-factor model (FF5F) in 2015 [14], incorporating the two variables profitability and investment into their earlier three-factor model. The Fama and French five-factor mathematical formula is as follows:

$$R_{it} - R_{ft} = \beta_i(R_{mt} - R_{ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t$$

(3)

The difference between returns on a portfolio of stocks with Robust profitability and returns on a portfolio of stocks with Weak profitability is known as RMW_t ("Robust Minus Weak"), and CMA_t ("Conservative Minus Aggressive") is the difference between returns on a portfolio of stocks that have conservative investment and portfolio of stocks that have aggressive investment. r and c_i are the coefficients of the factors.

3. RESULTS

TABLE 1. Regression of gold before COVID-19 and during COVID-19

Factor	2019.5 to 2020.2 before COVID-19				2020.3 to 2020.12 during COVID-19			
	Coefficients	Standard error	t-value	P-value	Coefficients	Standard error	t-value	P-value
Intercept	0.128	0.104	1.228	0.221	0.053	0.198	0.270	0.787
MKT	0.040	0.124	0.319	0.750	0.594	0.092	6.481	0.000
SMB	-0.335	0.233	-1.436	0.152	0.507	0.236	2.144	0.033
HML	-0.402	0.239	-1.682	0.094	-0.535	0.194	-2.754	0.006
RMW	-0.840	0.390	-2.155	0.032	-0.807	0.394	-2.049	0.042
CMA	0.766	0.461	1.660	0.098	0.856	0.505	1.697	0.091

TABLE 2. Regression of mines before COVID-19 and during COVID-19

Factor	2019.5 to 2020.2 before COVID-19				2020.3 to 2020.12 during COVID-19			
	Coefficients	Standard error	t-value	P-value	Coefficients	Standard error	t-value	P-value
Intercept	0.013	0.056	0.238	0.812	0.163	0.105	1.551	0.122
MKT	1.026	0.067	15.202	0.000	1.023	0.049	20.766	0.000
SMB	0.453	0.126	3.587	0.000	0.605	0.126	4.787	0.000
HML	0.318	0.130	2.457	0.015	0.368	0.103	3.576	0.000
RMW	0.396	0.213	1.863	0.064	0.060	0.211	0.283	0.778
CMA	0.217	0.250	0.869	0.386	0.088	0.269	0.327	0.744

TABLE 3. Regression of coal before COVID-19 and during COVID-19

Factor	2019.5 to 2020.2 before COVID-19				2020.3 to 2020.12 during COVID-19			
	Coefficients	Standard error	t-value	P-value	Coefficients	Standard error	t-value	P-value
Intercept	-0.354	0.126	-2.812	0.005	0.213	0.224	0.951	0.343
MKT	0.849	0.150	5.642	0.000	1.016	0.105	9.684	0.000
SMB	1.768	0.282	6.276	0.000	0.565	0.269	2.098	0.037
HML	0.329	0.289	1.139	0.256	0.728	0.219	3.318	0.001
RMW	0.776	0.474	1.637	0.103	-0.193	0.449	-0.429	0.668
CMA	0.017	0.558	0.031	0.976	0.850	0.573	1.485	0.139

TABLE 4. Regression of oil before COVID-19 and during COVID-19

Factor	2019.5 to 2020.2 before COVID-19				2020.3 to 2020.12 during COVID-19			
	Coefficients	Standard error	t-value	P-value	Coefficients	Standard error	t-value	P-value
Intercept	-0.086	0.058	-1.478	0.141	-0.046	0.131	-0.353	0.725
MKT	1.088	0.070	15.561	0.000	1.114	0.061	18.189	0.000
SMB	0.233	0.131	1.777	0.077	0.322	0.157	2.049	0.042
HML	0.969	0.134	7.221	0.000	1.015	0.128	7.926	0.000
RMW	0.170	0.220	0.772	0.441	-0.519	0.262	-1.982	0.049
CMA	-0.201	0.259	-0.775	0.439	0.209	0.334	0.625	0.533

To research the impact of COVID-19 on the four industries: gold, mines, coal, and oil in the U.S stock market, the researchers opted Fama-French 5-factor model to experiment. The data was downloaded from the Kenneth R. French-Data Library. The researchers selected the data about these four industries from 2019.5 to 2020.2 before COVID-19 and from 2020.3 to 2020.12 during COVID-19, which provides a better

comparison to highlight the effect of COVID-19 on the industries. Then, the researchers conducted multiple regressions on the data for each industry and compared their significance by using t-value and obtain some results:

As table 1 illustrates, the MKT during COVID-19 is higher than before in the gold market, which means that gold is more volatile than the market. And the SMB and

HML become significant. In table 2, after regression, the characteristics of factors of mines are similar by comparing the data before and during COVID-19. From table 3, the coefficient of coal's intercept is negative, representing the anomaly, but the coefficient becomes positive, and the anomaly is eliminated during COVID-19. And the HML is significant during COVID-19 compared to before. Focusing on the oil market in table 4, its coefficients of intercept are both negative. There is an anomaly. And the t-value of MKT is greater than 1, which shows that the volatility of oil is higher than the market's volatility. Affected by the COVID-19, the factors SMB and RMW both become significant.

4. DISCUSSION

4.1. Gold Industry

Based on the findings on COVID-19's impact on the gold market, the MKT during COVID-19 is higher than before. As a result, gold is more volatile than the stock market. And the SMB and HML become significant. First, let's focus on the MKT factor. Bad news tends to increase the volatility of gold returns to a greater extent than good news. Therefore, increases in the number of coronavirus cases (i.e., a bad news indicator) will increase gold returns volatility. The continued lack of knowledge about the virus and corresponding difficulty faced by economists to estimate its full eventual economic impact may mean that gold prices are likely to remain subject to market volatility for some time to come [7]. Then we look at the SMB factor, which becomes significant after experiencing an epidemic. This shows that the gold industry is determined by the size of companies because to ensure the liquidity of gold, people prefer to choose large companies and companies with more financial security. The HML factor demonstrates the relative movement of the stock in response to the book-to-market ratio premium. Compared to the era before the breakout of the epidemic, it is apparent that investors' investing styles have shifted due to the pandemic's impact on the gold sector, with investors preferring to invest in value firms with consistent earnings high book value.

The U.S. government responded to the situation in mid-March by slashing interest rates in what constitutes the first emergency cut since the 2008 crisis, indicating that officials expect the virus to have a significant negative impact on the world economy. The general uncertainty created by the situation leads to many important questions, one of which concerns the virus's impact on the gold market. During a crisis, most companies and investors seek out assets that are negatively correlated with other assets. These are known as haven assets, and they are expected to gain (or at least maintain) value during periods of economic downturn. Gold is such an asset; As the ongoing situation increases the global demand for gold, both gold prices and the volatility of returns will also increase. Due to gold's position as a "safe haven" asset during times of economic instability tends to be uncorrelated or even negatively associated with other assets, which tend to lose value during such times. As a result of this property, gold investment is an important diversification asset in portfolios. and earlier crises saw comparable increases in gold prices and return volatility, but the general gold market remained quite steady.

4.2. Mine Industry

Mine is a comprehensive class that was comprised of a great number of different kinds of minerals. To help with understanding and analysing, this class is separated into Non-Metallic and Industrial Metal Mining before the discussion.

Firstly, the Non-Metallic Mines. The non-metallic mines are usually referred to as all kinds of mines with economic value except fossil fuel. This class of mines is mostly used in the following aspects: (1) agriculture, people, use a mass of rare light earth, phosphorus, potassium, etc., to boost and maintain the yields of the crops. (2) industrial, non-metallic mines are widely used in manufacturing because of their physical and chemical property such as thermostability and electric insulative. (3) constructional mineral materials for building account for 90% of the total output of non-metallic minerals. Secondly, the metallic mines. Unlike the class above, this class of mines is mostly used to extract the metallic element or compound for producing in the industry. No matter which kind of mine it is, it will take part in people's everyday life everywhere.

In Table 2, it is shown that the coefficient of MKT for mines before the breakout of COVID-19 is close to the data after breakout close to 1, which means the sensitivity of the mining industry is always close to the market. Because of this, most fluctuation in this industry follows the fluctuation of the whole market. That might be because the mines are rigid demand for humans, whether there is COVID-19 or not.

4.3. Coal Industry

Table 3 shows the changes in the coal industry before and after the epidemic. In this table, the book-to-market ratio factor (HML) has a significant change before and after the epidemic. Before the outbreak, from May 2019 to February 2020, HML was 1.139, which did not significantly indicate investors' investment preference in the coal industry in this period. After the outbreak of the epidemic, from March 2020 to December 2020, HML was 3.318. Compared with the period before the outbreak of the epidemic, it clearly indicates that the investment style of investors has

changed after the impact of the epidemic on the coal industry, and investors are more inclined to invest in value stocks with stable profits and high book value.

In March and April 2020, when the epidemic was at its worst, delays in the resumption of work by many coal companies and coupled with some road traffic restrictions disrupted some coal shipments and sales. Coal supply has been affected, and coal production was reduced in 2020. As the epidemic has been brought under control in the United States, coal companies have gradually recovered. The impact of the epidemic on the coal demand industry is more serious. Since the beginning of the year, many downstream industries have stopped production or stopped work, and the demand for coal has fallen sharply. When the epidemic was serious from February to March 2020, the demand entered an extremely depressing period. The supply and demand pattern of the coal market has shown that the supply growth rate is significantly higher than the demand growth rate for many consecutive years. As a result of coal supply and demand staged imbalance, the history of rapid decline in coal prices may be repeated. Coal supply exceeds demand is a long-term trend, and the outbreak of the epidemic has accelerated this trend.

As the two main energy sources, coal and oil have a strong mutual substitution. In addition, the emergence of solar, wind, natural gas, and other new energy technologies will continue to replace coal, and leading to a gradual decline in coal demand and further pressure on coal prices. Compared with small growth enterprises, coal companies with higher book value have a stronger ability to maintain profitability, so investors favor them more.

4.4. Oil Industry

Table 4 reveals how the oil market was affected by COVID-19. The factors SMB and RMW become significant during COVID-19 compared to before. As for the factor SMB, it is a market size factor and represents small minus big. After the regression, the factor SMB is significant, and its t-value is positive (2.049), so the investment preference is to invest in a portfolio of small-size stocks. The t-value of the factor RMW is negative (-1.982), which means the investors' preference is to invest in a portfolio of stocks that have weak profitability instead of robust profitability.

Traditionally, oil was called "black gold, " showing its importance in the global economy and international trade. It can be considered the engine of the economy around the world. The oil price has high volatility excess and depends on the economic situations, business cycle, and economic crisis. In the world, the amount of oil supply is controlled by OPEC, and the oil consumption is driven by producing transportation fuel, fuel oil for heating and electricity generation and

chemical products, etc. Due to the spread of COVID-19 worldwide, which caused lockdowns in various countries and shaken economic activities, global financial, and commodity markets, the world economy is generally on a downward trend. Because of the pandemic, global industrial production was reduced, which lowered the consumption of oil. The OPEC decided to set the price through regulating supply but was refused by other oil-producing countries, such as Russia. So, the barrel price decreased as well based on the theory of supply and demand. According to the data in the OPEC, the oil demand declined sharply during the pandemic. As the world's largest consumer of oil, the oil price in the United States even became negative in April 2020.

From BP's Statistical Review of World Energy 2021, the COVID-19 pandemic dramatically impacted energy markets, and the drop in energy consumption was driven mainly by oil, which contributed almost three-quarters of the net decline [15]. The average oil price was $41.84/bbl (blue barrel) in 2020, oil production fell for the first time since 2009, by 6.6 million b/d (barrels daily) in 2020 driven by both OPEC -)4.3 million b/d) and non- OPEC(-2. 3million b/d(, the consumption of oil fell by a record 9.1 million barrels per day (b/d), or 9.3% and the oil demand fell most in the US (-2.3 million b/d).

The impact of the epidemic on the oil industry is visible and significant. Therefore, the stocks with small-size and weak-profitability have a smaller decrease than big-size and robust-profitability companies in the period of a depressed economy from March 2020 to December 2020.

5. CONCLUSION

To investigate the impact of the COVID-19 on the commodity stock market in the U.S, the researchers employ the Fama-French 5-factor model to analyze average value-weighted returns of goal, mines, coal, and oil industry and conduct multiple linear regression on the data. By discussing the changes in each industry, some findings are reached: gold is a volatile stock, and the small size and low book-to-market ratio stock is better. The stock of mines has high volatility, and it is relatively unaffected, with little change before and after the pandemic. Coal is a volatile stock, and the high book-to-market ratio is more preferred. As a volatile stock, the oil stocks with small-size and weak-profitability have a smaller decrease. Compared to the changes among these industries, they all have their own unique characteristics. Thus, the investors should have a fuller understanding of industry characteristics, consider more factors and choose more familiar areas when investing during the Black Swan Period.

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