Evaluating the Impact of the Pandemic on the US Agriculture Industry based on Fama-French 5-factor Pricing Model

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Abstract. Covid-19 has unprecedentedly influenced industries in the global area, and this paper studies the significance of Covid-19 in impacting the agriculture industry in the USA. The paper collects data from Kenneth. French-Data library dividing the data into four stages, and the Fama-French 5-factor pricing model involves the process of data analysis. According to the result obtained from the multiple linear regression, the coefficient of market risk remained significant throughout the period observed, the coefficient of SMB turned out insignificant after the pandemic, the coefficient of HML only remained significant at the point of breakout and during the pandemic, the coefficient of RMW remained in insignificance all the time, and the coefficient of CMA turned out insignificance since the breakout of Covid-19. Therefore, Covid-19 did not significantly influence the agriculture industry in the USA.

Keywords: Covid-19; Fama-French; US Agriculture

1   Introduction

The agriculture industry as the primary industry ensuring sufficient food supply and industrial raw materials is decisive to the living standard of people. With support from

a stable agriculture industry, the food supply is secure, the domestic market is stable, and the starving crisis can be eliminated from its roots. Therefore, the protection of the agriculture industry is a task essential for every government. However, more than the regular administrative protection of the agriculture industry is needed to handle the security of the agriculture industry; the government has to face any unexpected or even unprecedented threats to the security of the industry. Taking Covid-19 as an example; during that period, the laborers in the industry were discouraged from working, the food supply channel was blocked, and consumer favor shifted dramatically, which was never seen before.

The pricing model can demonstrate the specific change in the value stock of the agriculture industry over time in statistics, estimating the pandemic's significance in impacting the industry's stock value, and figuring out the industry's reaction to the pandemic. To the government, it can provide information about how the pandemic will shape the industry to the government, enabling the government to come out with more realistic and feasible emergent policies to handle the pandemic next time. To investors, it can figure out the stocks which has the highest return rate and which has the minimum risk, maximizing investors' profits.

The pandemic's impact on the US agriculture industry draws many scholars' attentions. Some of them attempted to argue the impact of Covid-19 on the agriculture industry from the demand side: Weersink et al. explained that Covid-19 shifted consumers' favors, which people tended to purchase foods that were relatively low prices and could be preserved, and intensively weakened America's capacity of food supply and caused a deviant change of local food prices [1]. Goetz et al. found that restaurants, as the most important windows for American consumers purchasing agricultural products, were shut down due to the Covid-19 policy, causing a crisis of food selling and accessing [2]. Luckstead et al. Kept similar viewpoints with the preceding scholars: they found that Covid-19 induced economic uncertainty causing a significant shift in food consumption. The food sales of restaurants and bars struggled, while the food sales of grocery stores and online food retailers significantly increased. This abrupt shift in consumer favor pressed the united states food supply chain and further disrupted the labor market [3].

The argument of how the pandemic influenced the supply side of the industry also existed: Larue found that the American food industry faced two issues caused by Covid-19: the shortage of labor force and the restrictions over the global food supply

chain [4]. Chenarides et al. found the inelastic performance of the American food supply chain during the Covid-19 period, and this inelastic performance exposed the inefficiency of the chain[5]. Poudel et al. declaimed that the food supply chain distortion caused a food security problem during the pandemic. Moreover, they attributed distortion to Covid-19, which was blamed for interrupting agricultural tasks [6]. Ridaura et al. found that the negative impact of the pandemic is restricted by the scale of companies: Large corporations had preserved a large number of ingredients, so there was little impact on its cost of production, but Covid-19 did reduce its market and foreign investment; Covid-19 had a destructive impact over middle size corporations whose cost of production went up, but the demand of their goods went down; Covid-19 had an insignificant impact over small and tiny companies because their primary aim of plow lands was to feed themselves [7]. Bochtis et al. claimed a risk that the spread of Covid-19 might destructively affect labors' productivity, harming the food security [8] .

Some of them also concluded the impact of the pandemic on the industry from the marco perspective: Beckman and Countryman constructed a model to estimate Covid-19's impact on each country's industries, and they found that the US agriculture industry was thought to be most damaged [9]. Höhler and Lansink found that the fluctuation of US agricultural stock surpassed Covid-19's impact on the US food industry by calculation [10].

The paper plans to use the Fama-French 5-factor pricing model to study the specific change in the US agriculture industry caused by the pandemic, analyzing processed stock value data and providing constructive advice for the government and the investors. The advice might contribute to the improvement of agriculture industry's administrative protection measurements in an emergency, securing the food supply, and might provide an efficient investing strategy to the investors.

2   Methodology

This paper processes data by using the Fama-French 5-factor model. Out of the consideration of result accuracy, the paper gives up using the CAMP model because it fails to account for pricing factors other than the market factor. Moreover, some researches reflect that the limitation existing in the CAMP model potentially induces

a series of severe financial crises that further damage the economic market, such as a financial bubble and a stock market crash. The Fama-French 5-factor model, which contains more determinants to the pricing, has been proven able to cover most situations. Therefore the Fama-French 5-factor model is proposed and shown below:

$$Ri\text{-}Rf = beta_1(Rm\text{-}Rf) + beta_2SMB + beta_3HML + beta_4RMW + beta_5CMA \qquad (1)$$

Where Ri indicates the anticipated return rate of a specific industry; Rf is the return rate of an investment with zero risk; Rm means the average rate of return of the whole market; SMB refers to the return rate of an industry's market capitalization scale; HML presents the spread in returns between companies with a high book-to-market value ratio (value stocks) and companies with a low book-to-market value ratio(growth stocks); RMW compares the returns rate of the firms with high profitability and the firms with weak profitability; CMA measures the difference of the aggressive investment tendency and the conservative investment tendency between companies.

3   Result

This paper analyzes the data reflecting the changes in market capitalization, profitability, investment tendency, investment return rate, and firm value to obtain a statistical description of the US agriculture stock market's performance throughout the Covid-19 event. We use data from F-F_Research_Data_5_Factors_2x3_[daily] and Agric of 49_Industry_Portfolios_[Daily] in Kennethr. French-Data library, performing multiple linear regressions with the periods 20180615-20200312, 20200312-20201124, 20201124-20220919, and 20220919-20221230 to obtain coefficients. These periods represent the four stages of the Covid event: before, the beginning, during, and the end.

Table 1. Coefficient of 5-factor model of agriculture industry before the Covid-19

	Coefficients	Standard error	t Stat	P-value
Intercept	-0.03	0.04	-0.77	0.44
Mkt-Rf	0.76	0.04	20.3	0.00

SMB	0.53	0.08	6.63	0.00
HML	0.09	0.08	1.23	0.22
RMW	0.18	0.13	1.38	0.17
CMA	0.51	0.16	3.25	0.00

Table 2. Coefficient of 5-factor model of agriculture industry during the Covid-19

	Coefficients	Standard error	t Stat	P-value
Intercept	-0.06	0.09	-0.61	0.54
Mkt-Rf	0.75	0.04	17.2	0.00
SMB	0.74	0.11	6.66	0.00
HML	0.22	0.09	2.40	0.02
RMW	-0.02	0.19	-0.09	0.93
CMA	-0.06	0.24	-0.23	0.82

Table 3. Coefficient of 5-factor model of agriculture industry during the Covid-19

	Coefficients	Standard error	t Stat	P-value
Intercept	-0.03	0.04	-0.80	0.42
Mkt-Rf	0.61	0.04	16.2	0.00
SMB	0.44	0.06	7.27	0.00
HML	0.23	0.01	4.83	0.00
RMW	-0.02	0.06	-0.30	0.77
CMA	0.00	0.09	0.03	0.98

Table 4. Coefficient of 5-factor model of agriculture industry after the Covid-19

	Coefficients	Standard error	t Stat	P-value

Intercept	-0.14	0.16	-0.87	0.39
Mkt-Rf	0.84	0.12	6.75	0.00
SMB	0.51	0.39	1.30	0.20
HML	0.63	0.35	1.84	0.07
RMW	-0.05	0.32	-0.17	0.87
CMA	-0.21	0.49	-0.44	0.66

4   Discussion

4.1   The Coefficient of Mkt - RF

According to the content in Tables 1 to 4, beta1 always remained in significance. It conveyed the information that the agriculture industry in USA was insensitive to the fluctuation of the whole market, at least within a limited time. On the one hand, the main agricultural products in the United States are corn, wheat, soybeans, and cotton. These agricultural products are closely relative to the production of staple food and daily goods. Hence, the demand for these agricultural products is inelastic, which means the percentage change in demand is less than the percentage change in prices. On the other hand, the agriculture industry in USA is highly mechanized, USA owns tremendous abroad market, smoothing the fluctuation of demand and supply. For example, American agriculture is over 95% mechanized in 2022 and creates massive export revenue, 144B US-dollars in 2018 and 141B US-dollars in 2019. After the breakout of Covid-19, its export revenue increased to 149B US-dollars in 2020 and 177B US-dollars in 2021. As a result, the US agriculture industry was insignificantly influenced by Covid-19 in general.

4.2   The Coefficient of SMB

As shown in Tables from 1 to 4, beta2 remained significant and positive before the end of the pandemic. The positive sign of beta2 indicated that the return rate of small companies was better than big companies during these three periods. The risk premium might be responsible for the positive sing of beta2. The risk premium refers to a phenomenon that speculators favor small companies' stocks which have high

variation in their prices. Hence, people might purchase more stocks of small corporations than big corporations before the end of pandemic. Moreover, the elasticity of supply could also be a possible factor: the supply of big agricultural corporations was commonly inelastic because it was relatively time-consuming to grow grains and short storage time for some agricultural products. However, consumers' demands and tastes were rapidly shifting during the pandemic, which meant these big corporations might suffer during the stage breakout and during Covid-19. Therefore, the return of small agricultural corporations was better than large corporations before the breakout, at the point of the breakout, and during Covid-19.

After the pandemic, beta2 became insignificant, meaning there was no obvious difference in the return rate of small and big companies. The end of the pandemic removed all restrictions imposed on production and international trade, enabling big corporations to reach economic of scale on grain selling. It might stimulate their stocks' values to rise, approaching a close return rate with small companies.

4.3   The Coefficient of HML

Beta3 was found only significant in Table 2 and Table 3, which meant beta3 was only significant at the point of breakout and during Covid-19. beta3 was also positive in these two tables, indicating that the value stocks performed better than the growth stocks. Value stocks are thought to trade below what they are worth. Growth stocks refer to stocks that can outperform the overall market over time because of their future potential. However, the demand for the products of growth stocks is usually elastic. This is because most growth stocks have not yet been dominated in the whole market, which means they are not likely to be necessities whose demands are inelastic. While value stocks are usually well-established corporations whose goods have been widely accepted, the demand for these corporations' goods is thought to be inelastic. Therefore, because of the serious recession in the aggregate demand caused by the pandemic, people's demands for growth stocks are more likely to be cut than value stocks. Therefore, the growth stock's return rate falls below the value stock's.

4.4   RMW Remained Insignificant

The coefficient of RMW always remained insignificant, which might be attributed to the high mechanization of the US agriculture industry. Because mechanization reduces the significance of labors' skills in determining the variation in the quality of agricultural products, the qualities of the US agricultural products are closed. So the difference in profit margins of American agricultural companies is not large enough to make RMW significant.

4.5   CMA was Only Significant before the Pandemic

Since the pandemic breakout, the US government provided more subsidies to US farmers. For example, the US government expanded the expenditure on subsidizing the US agriculture sector to the historical summit, 45.6B US dollars, in 2020. The subsidy incredibly reduced the industry's production cost, encouraging US related-companies to expand their supply as much as possible. The US agricultural producers turned out to be aggressive commonly, and the net revenue of the US agriculture sector increased by 43% in 2020. Therefore, the coefficient of CMA became insignificant after the breakout of the pandemic.

5   Conclusion

The paper discusses the significance of the agriculture industry and the impact of Covid-19. The paper processes data from Kennethr. French-Data library by using several linear regressions to obtain the pricing model of the US agriculture industry. Finally, the paper analyzes the meanings behind each data and explains the reason for the fluctuation of each coefficient. The paper finds that the value stock of the US agriculture industry is insignificantly affected by the pandemic in general, explained by the coefficient of market risk, which remained significant all the time. However, the coefficient of SMB became insignificant after the end of Covid-19, the coefficient of HML only remained significant at the start and during the pandemic, the coefficient of RMW always remained insignificant, and the coefficient of CMA turned out insignificant since the breakout of Covid-19. To investors, it is always more conserved to invest in the US agriculture industry than other industries. Meanwhile, investing in small agricultural corporations will likely get the highest

return rate. To the government, growth stocks are the most vulnerable during the pandemic, so there should be some policies benefiting growth stocks if it is in another emergency.

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