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The Influence of 2020 California Wildfire on ESG Investment in Equilibrium Based on Sustainable Investment Model

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Abstract: With the change of climate and the pursuit for a balanced development between economy and society, green companies in the ESG investment have received much attention in recent years. At the same time, there are some extreme environmental events that may have influence on the market attitude towards ESG investment, thus affecting the benefits of ESG investors. In order to study the impact of 2020 California Wildfire, this research constructs the optimal portfolios considering ESG investors' ESG preference based on the portfolio theory for both the before-fire and after-fire periods. Then the portfolio performance is quantified by using a sustainable investment model in the equilibrium market. It is found that the difference between the return of ESG portfolio and the market portfolio was larger before the fire, representing an insufficient market attention on the ESG investment. However, the gap was narrowed after the fire. Meanwhile, despite lower investor surplus, after-fire ESG investors had larger alphas than before. Therefore, the 2020 California Wildfire raised the market attention on ESG investment, which reduced the actual financial losses of ESG investors.

Keywords: Wildfire, ESG preference, portfolio theory, sustainable investment model, investor surplus.

1. Introduction

On Sep.4th, 2020, a serious wildfire broke out in the National forests of Sierra Leone, California. The fire lasted more than two months, destroying over 2 million acres and robbing 31 people of their lives. Because of its devastating influence, it was recorded as the largest wildfire in the American modern history[1].

In the financial market, ESG investing, which refers to a sustainable investment strategy, is now emerging. It contains three essential elements, environmental, social and governance factors. The environmental factor refers to the business impact on natural environment. Companies should take measures to manage their waste, limit their pollution or preserve biodiversity during their production. The social factor represents the employee situations including inner relationships and social impact. The governance factor describes the firm management, transparency and ethical practices[2]. Though the ESG investment is closely correlated with the environmental events and many studies have proved that wildfire can enhance the pessimism towards environmental risks thus influencing house values

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[3,4] , there are limited studies focusing on the impact of these extreme environmental events such as wildfires on stock market especially with ESG preference from the investors in the current world which can help both government and investors set up accurate policies and investment strategies. As a result, this research is going to find out whether the symbolic 2020 California Wildfire can affect the financial market by arousing the preference towards ESG investment and what impact it will bring to those ESG investors who contribute to the emerging ESG investment in the equilibrium market.

Pástor et al. have set up a sustainable investment model under the equilibrium situation which can help quantify the investors' ESG preference[5]. According to the model, the assets in the market can be divided into green assets and brown assets. Green assets can generate positive social impact while brown firms impose negative externality and may suffer from ESG risks. The alpha of green assets is usually negative because ESG investors can obtain non-pecuniary utilities from investing in those green assets which can compensate part of the financial losses. At the same time, investors in the market can be divided into two groups, ESG investors and non-ESG investors[5]. For those ESG investors, they have positive ESG tastes and above-average ESG preference, so besides the market portfolio, their optimal portfolio will also include the ESG portfolio which is based on the greenness of firms. The optimal portfolio of ESG investors has the structure of long green and short brown. Besides, greener firms will have larger weights[5]. This research will construct the ESG investors' optimal portfolio based on these constraints by using essential indicators in the portfolio theory to define the best performer.

In an equilibrium market, all the investors will hold the market portfolio which may not be the optimal portfolio for those ESG investors because they can get extra return from their optimal portfolio. It means that the ESG investors have to sacrifice for their optimal portfolio when the market is in equilibrium. The maximum sacrifice is defined as Δ. Besides, α refers to the return an ESG investor actually sacrifices. These two types of returns will be quantified based on the model above and there will be a comparison between the them which will show how the changing market attitude towards ESG investment brought by the wildfire will affect the gain and loss of ESG investors.

This paper is organized as follows. Section 2 presents the data. Section 3 describes the method of portfolio construction and the changing market attitude reflected in the results. Section 4 analyzes the quantifiable results of Δ, α and investor surplus of those ESG investors. Then suggestions on policy making are provided based the impact of the fire. Section 5 concludes.

2. Data

The portfolio construction uses the adjusted close prices (considering the stock split and the dividend payment) of NASDAQ-100 equal-weighted index (NDXE) and the included firms (https://nz.finance.yahoo.com/), ranging from Jan.3rd 2017 to Aug.2nd 2024. Because the benchmark weight distribution of stocks in the ESG portfolio should keep in line with the one of market portfolio so that the weights in ESG portfolio can then reflect the pure impact of the greenness. All the data will be divided into four groups. Jan.3rd 2017 to Dec.31st 2019 is the before-fire group, Sep.4th 2020 to Dec.29th 2023 is the after-fire group while the rest data of 2020 and 2024 are back-testing groups.

The asset classification uses MSCI ESG ratings (https://finance.sina.com.cn/esg/grade.shtml)[6]. The companies are assumed to stay in their ESG rating groups for the whole time period.

Figure 1 shows the classification of firms in NDXE based on MSCI ESG ratings. All the B, BB and BBB firms are classified as brown assets while the leader groups in MSCI ESG ratings (AAA & AA) are considered as green assets in order to balance the number between the two asset types. Since the A level group is the average group according to MSCI ESG ratings, these firms are excluded from both the green and brown assets[5].

The averaged interest rates of 10-year US Treasury of the two periods (before and after the fire) are set as risk-free rates, which are 2.4586% and 2.5946% separately (https://www.federalreserve.

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gov/DataDownload/default.htm). Since a small proportion of the companies have been listed in the market in recent two or three years, their adjusted close prices are limited. Therefore, these companies are dropped from the ESG portfolio construction.

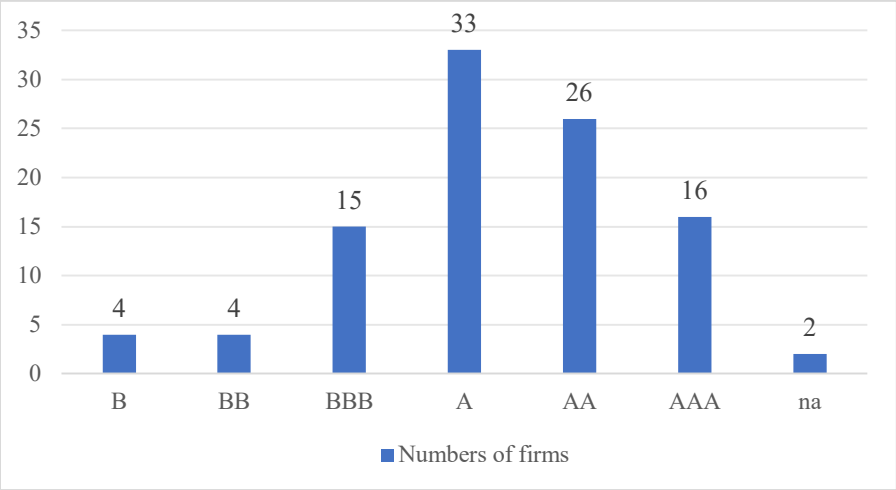

Figure 1: Classification of firms in NDXE

3. Portfolio Construction

This section will show the detailed process of optimal portfolio construction and explain some of the findings on the portfolio return of the two time periods.

3.1. Rating Group Portfolio Construction

Based on the daily close prices, averaged daily return and covariance are calculated and multiplied by 252 to compute the yearly return and covariance because it is assumed that there are 252 trading days in a year. The portfolio construction follows certain constraints including:

$$\sum w_i = 1 \ (w_i \in [0,1]) \tag{1}$$

in which w_i refers to the weight of each ESG rating group portfolio.

In order to construct the optimal portfolio, three types of portfolios are considered. First is the portfolio with the maximum Sharpe ratio. Sharpe ratio refers to a measure of risk-adjusted return and can be calculated by:

$$P = \frac{W^T \mu - R_f}{\sqrt{W^T \Sigma W}} \tag{2}$$

in which W refers to the weight vector, μ is the average return, R_f represents the risk-free rate while Σ is the covariance matrix of the assets. Highest Sharpe ratio represents a largest return relative to the risk taken[7].

Second is the minimum variance portfolio which is considered to have the lowest volatility and outperform especially in the emerging market with the increasing of global economy uncertainties[8]. The variance can be computed by:

$$VaR = W^T \Sigma W \tag{3}$$

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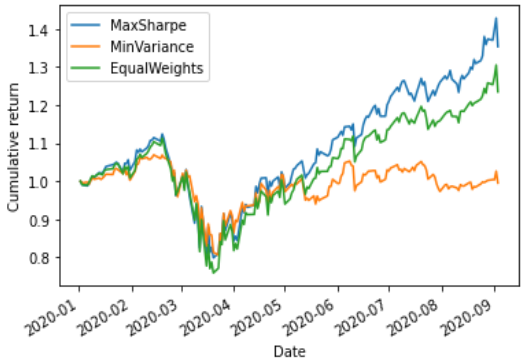
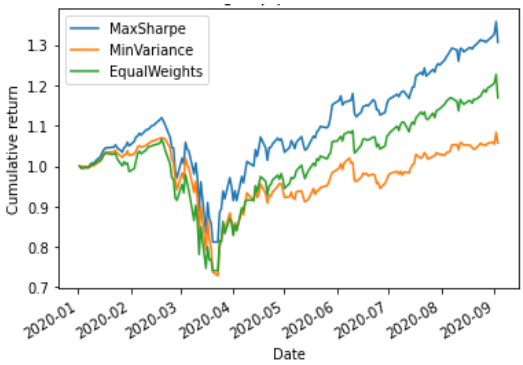
Besides, the equal-weighted portfolio is included because it is an ideal asset allocation that the investors may choose[9].

3.2. Back Test

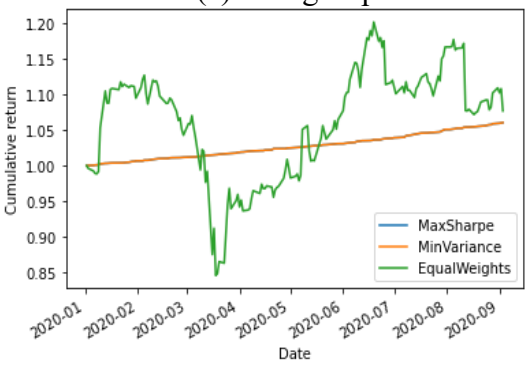
The back test is conducted by calculating the cumulative return of the 2019 and 2024 portfolio with initial capital of $1 in the three portfolios above. Figure 2 shows the back-testing results. For B group before the fire and BBB group after the fire, the best performer can not be distinguished directly, so an additional indicator Calmar ratio is calculated.



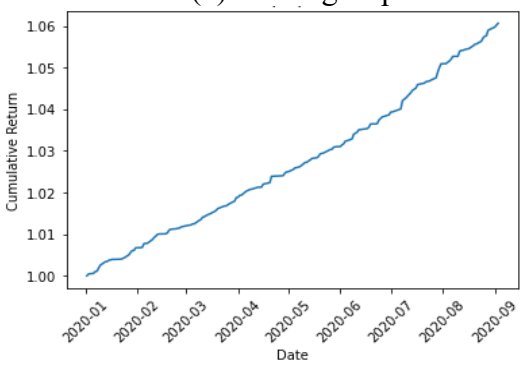
(a): AA group.



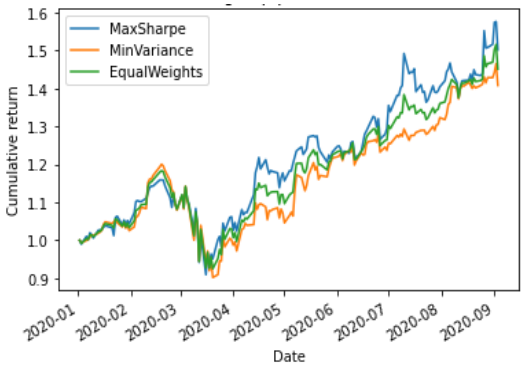
(b): AAA group.



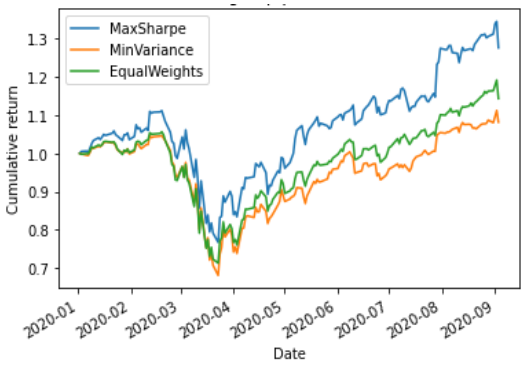
(c): B group.



(d): B group MaxSharpe.



(e): BB group.



(f): BBB group.

Panel A: Before-fire group.

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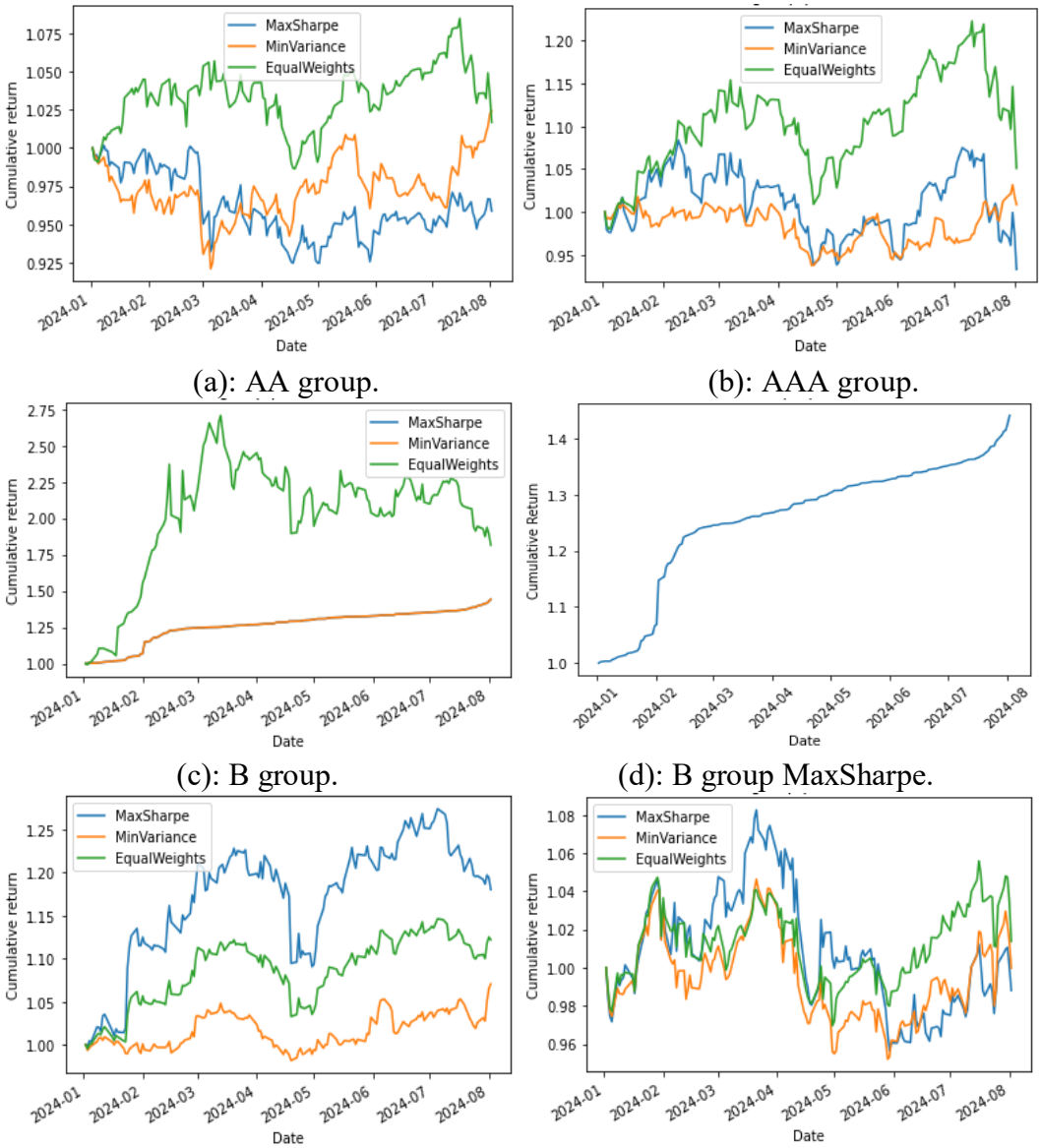

(a): AA group. (b): AAA group.

(c): B group. (d): B group MaxSharpe.

(e): BB group. (f): BBB group.

Panel B: After-fire group.

Figure 2: Back-testing results.

Since Calmar ratio refers to the relationship between the return and the maximum drawndown, investors prefer to choose the portfolio with larger Calmar ratio[10]. As shown in Table 1, for before-fire group B the maximum Sharpe ratio portfolio has the largest Calmar ratio while for after-fire group BBB the equal-weighted portfolio performs the best. Table 2 shows that except B asset, all the other asset return decreases after the fire. It happens when investors have higher demands on the greener assets and show less interests in browner assets.

Table 1: Calmar ratio.

	B (Before-fire)	BBB (After-fire)
MaxSharpe	12372.9495	-0.0584
MinVariance	7417.0963	0.1021
EqualWeights	0.6583	0.4446

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Table 2: Returns of each rating group portfolio.

	B	BB	BBB	AA	AAA
Before-fire	0.0508%	0.1178%	0.1450%	0.1202%	0.1514%
After-fire	0.2189%	0.0490%	0.0546%	0.0846%	0.0884%
Difference	0.1681%	-0.0688%	-0.0904%	-0.0356%	-0.0630%

3.3. ESG Portfolio Construction

The same procedure is repeated when constructing the ESG portfolio, but the constraints contain another two rules:

$$w_{AAA} > w_{AA} > 0, w_B < w_{BB} < w_{BBB} < 0 \quad (4)$$

It is based on the long green and short brown structure in the ESG portfolio and the assumption that the greener the firm is, the heavier its weight will be[5]. Since the minimum variance portfolio performs more stable than the maximum Sharpe ratio portfolio, the final after-fire ESG portfolio return (0.0577%) can be computed and is lower than the before-fire one of 0.1655%.

Table 3 shows that the weights in the ESG portfolios in the two time periods are the same, which confirms with the assumption that the company greenness may not be impacted by the fire. Therefore, the difference in the ESG portfolio return only comes from the changes in asset return shown in Table 2.

Table 3: Weights in the ESG portfolios.

	B	BB	BBB	AA	AAA
Before-fire	-0.3	-0.2	-0.1	0.75	0.85
After-fire	-0.3	-0.2	-0.1	0.75	0.85

3.4. Optimal Portfolio Construction

The optimal portfolio for the investors should be:

$$(1-\phi) * \text{market portfolio} + \phi * \text{ESG portfolio} \quad (5)$$

in which ϕ is negatively correlated the subjective variable risk aversion[5]. To cover several possibilities, ϕ is set to change from 0.1 to 1 in 0.1 increments. The return of the optimal portfolio (r^*_{ESG}) is mainly related with the difference between the return of market portfolio and ESG portfolio, which reflects the market attitude towards the ESG investment. Larger difference represents lower market attention on the ESG investment because the ESG preference is not fully reflected in the market prices. As shown in Table 4, after the wildfire broke out, the market starts to pay more attention on the ESG investment, thus leading to smaller difference. Meanwhile, the market return is lower, both of the two factors contribute to lower optimal portfolio return.

The excess return is correlated with both the risk-free rate and the optimal portfolio return. Since the risk-free rate after the fire is larger due to the constant rate increase, the excess return is even lower than before.

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Table 4: Optimal portfolio excess returns.

	ϕ =0.1	ϕ =0.2	ϕ =0.3	ϕ =0.4	ϕ =0.5
Before-fire	-2.3837%	-2.3738%	-2.3638%-	-2.3538%	-2.3439%
After-fire	-2.5467%	-2.5456%	-2.5445%	-2.5434%	-2.5423%
	ϕ =0.6	ϕ =0.7	ϕ =0.8	ϕ =0.9	ϕ =1
Before-fire	-2.3339%	-2.3239%	-2.3140%	-2.3040%	-2.2940%
After-fire	-2.5413%	-2.5402%	-2.5391%	-2.5380%	-2.5369%
The market portfolio returns: (1) Before-fire:0.0659% (2) After-fire:0.0468%					

4. Performance Comparison

This section will show the quantitative results of the ESG investor performance based on the equilibrium situation (the investors all hold the market portfolio) and the optimal portfolios which have already been built. Then a comparison will be made between the performance in the two time periods.

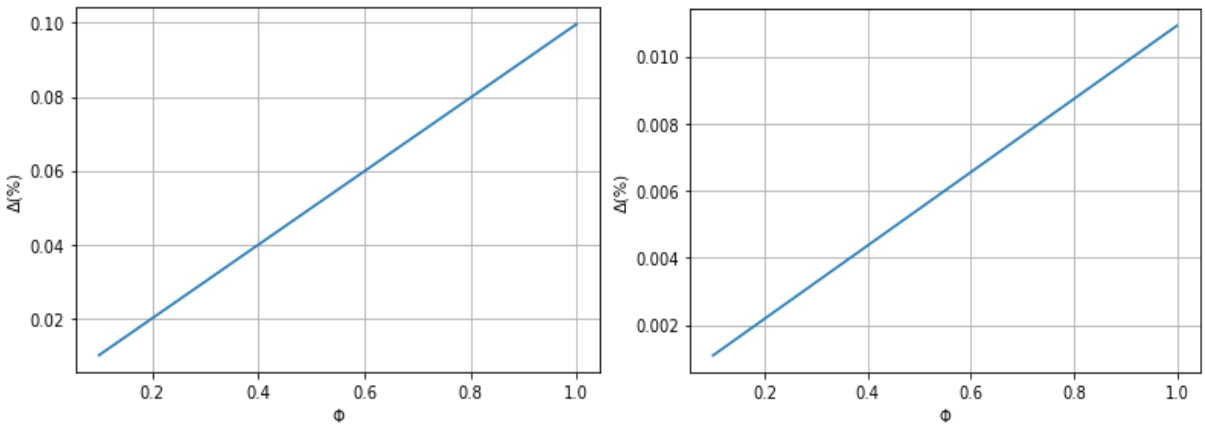
4.1. Parameters

There are two critical parameters that should be defined.

First is Δ which represents the maximum excess return the investor has to sacrifice to hold his/her optimal portfolio. According to the equation:

$$\Delta = r^*_{ESG} - r^*_M \tag{6}$$

in which r^*_{ESG} refers to the excess return when holding the investor's optimal portfolio and r^*_M represents the excess return an ESG investor will obtain when he/she is forced to hold the market portfolio[5]. Δ is only related with the difference between the ESG portfolio return and the market return. Figure 3 shows the Δ with changing ϕs. Before the fire, the ESG portfolio return is much higher than the market portfolio return (0.0996% > 0.0109%), which means that the ESG investor has to sacrifice more under the equilibrium situation. Besides, since ϕ is inversely proportional to risk aversion, an investor with more risk aversion has a smaller ϕ. It can also be observed from Figure 3 that the Δ is positively correlated with ϕ. Therefore, a more risk-aversed ESG investor is willing to sacrifice less.



Panel A: Before-fire group. Panel B: After-fire group

Figure 3: Δ of ESG investors.

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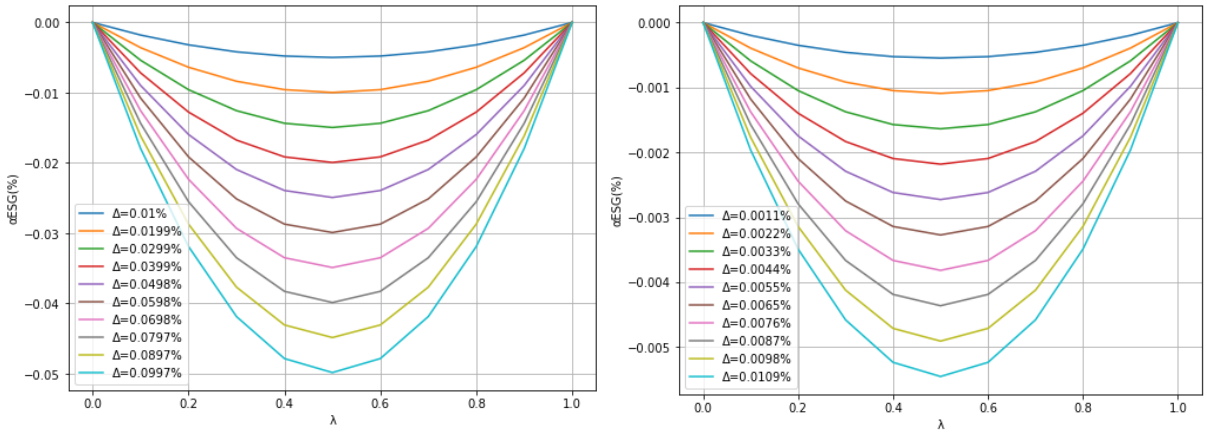
Another parameter λ, representing the proportion of the ESG investors' wealth in the market, is set to change from 0 to 1 in 0.1 increments[5].

4.2. Result Analysis

Alphas of the ESG investors can be calculated based on the equation[5]:

$$\alpha_{ESG} = -2\lambda(1-\lambda)\Delta \tag{7}$$

Figure 4 plots that the α_{ESG} during the whole time period are negative and the alpha lines are in the 'U' shape with the lowest point when λ=0.5. It is because when λ changes from 0 to 0.5, the market is still dominated by the non-ESG investors. When the number of ESG investors becomes larger, their stronger ESG preference will push the optimal portfolio excess return to deviate largely from the market excess returns, which means that they actually sacrifice more. However, when λ changes from 0.5 to 1, ESG investors dominate the market, so the market will start to reflect their preference. The α_{ESG} will return back to 0 at last when the market is full of ESG investors and fully reflects their ESG preference. Comparing the two time period, it can be found that in the time series, λ is not the main factor to affect the α_{ESG}, because the α_{ESG} after the fire are less negative than the before ones, which shows that the ESG investors actually sacrifice less when investing in their optimal portfolio after the fire.



Panel A: Before-fire group. Panel B: After-fire group

Figure 4: α of ESG investors.

However, the absolute values of the minimum α_{ESG} are smaller than Δ, which means that an ESG investor actually sacrifices lower returns than he/she has to. The compensation comes from the reflection of his/her ESG taste in the equilibrium return which is called the investor surplus[5].

The distance between the colorful lines and the benchmark line in Figure 5 can reflect the investor surplus. The benchmark lines with the slope of -1 refer to the situation when the return an ESG investor is willing to sacrifice equals to what he/she actually sacrifices. The colorful lines represents that there is a difference between $|\alpha_{ESG}|$ and Δ. When the ESG investors dominate the market, the reflection of their ESG preference in the market prices will be more evident with the increase in the number of ESG investors.

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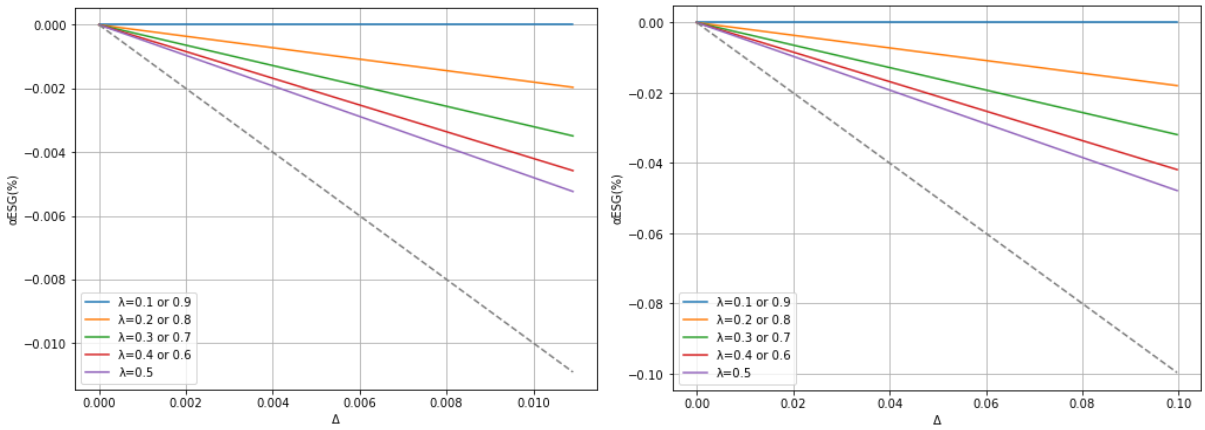


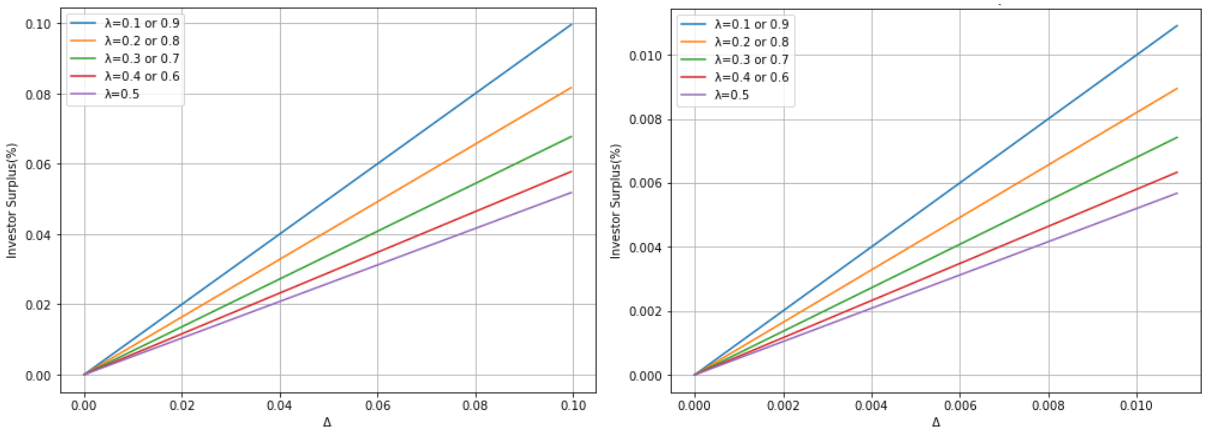
Panel A: Before-fire group. Panel B: After-fire group.

Figure 5: The indirect indication of investor surplus.

The value of the investor surplus can be calculated by[5]:

$$\tau = \Delta\left[1 - 2\lambda(1-\lambda)\right] = \Delta - |\alpha_{ESG}| \tag{8}$$

Figure 6 shows that the before-fire investor surplus is larger than the after-fire one, which represents that though the ESG investors may obtain more compensation from the equilibrium return, they still have to suffer greater financial loss to hold their optimal portfolio. It is because the market attention paid on the ESG investment is still not enough, which again highlights the influence brought by the 2020 California Wildfire.



Panel A: Before-fire group. Panel B: After-fire group.

Figure 6: Investor surplus.

4.3. Influence of the 2020 California Wildfire

The 2020 California Wildfire was the largest recorded wildfire season in the modern history of United States with over a 2 million-acre area consumed, which has aroused the public attention on the health impact and damages brought by the fire[11].

From the aspect of the financial market, the wildfire can be caused by the resource exploitation and pollution in the production activities of those companies relying on oil and gas which may reduce the recovery capability of forests[12]. When the wildfire breaks out, the supply chain of certain companies may be disrupted, leading to negative impacts on their production and revenues. More

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seriously, the wildfire can increase credit risks and market fluctuations. Therefore, investors start to turn to those green firms which are eco-friendly.

As shown in this data research, before the 2020 California Wildfire, insufficient attention on the ESG investment made those ESG investors sacrifice more in the equilibrium market. However, after the fire lights up the ESG preference in the market, the ESG investors' financial losses are reduced.

As a result, currently in the equilibrium market with ESG preference, the return of the ESG investors is closely correlated with the market attitude. Though the environmental disasters can boost investors' ESG preference, the cost is high. Thus, some initiatives should be taken. If there are policies that can promote the development of those green companies by encouraging renewable resources and offering preferential taxes, the ESG investment will naturally be motivated by higher return. Besides, the publicity channels should be broadened to help more investors know about the ESG investment.

5. Conclusion

ESG investment can be influenced by non-financial factors including environmental disasters. This article focuses on the impact of the serious 2020 California wildfire on the market attitude towards ESG investment and ESG investors. Based on MSCI ESG ratings and portfolio indicators such as Sharpe ratio and variance, ESG investors' optimal portfolio with greenness consideration in NDXE is constructed.

It can be found that before the wildfire the market didn't pay much enough attention on the ESG investment, so the preference of ESG investors could not be fully reflected in the market prices, thus leading to a large difference between the excess return of market portfolio and ESG portfolio. In the equilibrium market, the ESG investors then suffered from a great loss even though they could obtain high investor surplus. However, the wildfire unfortunately broke out, bringing forest deterioration, air pollution and even loss of life. Because of its devastating impact, people began to change their attitudes. In the financial market, investors started to have more ESG preference which pushed the market return move closer to their expected return.

As a result, despite the larger investor surplus, insufficient market attention on the ESG investment leads to larger financial losses of those ESG investors under the equilibrium situation, thus leading to even less willingness for investors to invest in green assets, which is a vicious circle. At the same time, though the influence of the environmental disasters have aroused ESG awareness among investors, it is time for us human beings to do something spontaneously instead of just passively adjusting to negative events.

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