Integrating Responsible Investing into TIAA Investment Portfolio

Christine W. Lai
Professor, Department of Business Administration
Director of Research Center for Artificial Intelligence in Investment and Asset Management
College of Management
National Taiwan Normal University, Taiwan
Email: cwlai@ntnu.edu.tw

Shih-Chuan Tsai
Professor, Graduate Institute of Management
College of Management
National Taiwan Normal University, Taiwan
E-mail: chuant@ntnu.edu.tw

†‡ Christine W. Lai is at Department of Business Administration, College of Management, National Taiwan Normal University, Taipei, Taiwan, R.O.C; E-mail: cwlai@ntnu.edu.tw. Tel: +886 2 77493304; Fax: +886 2 23222668; Shih-Chuan Tsai is at Graduate Institute of Management, College of Management, National Taiwan Normal University, Taipei, Taiwan, R.O.C. E-mail: chuant@ntnu.edu.tw. Christine W. Lai gratefully acknowledges the financial supports from the Ministry of Science and Technology in Taiwan (111-2410-H-003-143-MY2).

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Abstract

Teachers Insurance and Annuity Association (TIAA), since its inception in 1918, has been well-known for providing employees' pension system to American educational, academic, and research units. TIAA investors hope to integrate ESG into the investment portfolio, while seeking competitive long-term performance, to have a positive and long-term impact on the industry's future and the social environment. This study explores whether adding ESG into the fund system of TIAA can significantly improve portfolio performance or not? According to the ESG scores of individual stocks provided by FTSE Russell, this study finds that using the ESG scores and the individual scores of E, S, and G as the indicators for selecting stocks to construct the portfolio can optimize the performance of TIAA's investment portfolio.

Keywords: TIAA; ESG; Efficient Portfolio

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1. Research Purpose

Teachers Insurance and Annuity Association (TIAA)[1], since its inception in 1918, has been well-known for providing employees' pension system to American educational, academic, and research units. Up to the first quarter of 2021, TIAA held US$ 1.3 trillion in assets under management, it offers services to more than 15,000 institutions, including Harvard, Massachusetts Institute of Technology (MIT), and its customers have more than five million accounts. From 1918 to the end of March, 2021, TIAA has paid more than US$ 505 billion in pension-related benefits. The features of this system include portable accounts[2]; it also allows participants to freely choose the variable annuity or funds they want to buy in the account.

In recent years, the concept of sustainable operations has been widely developed around the world; the social responsibilities undertaken by enterprises and the relationship between business operations and the environment have begun to receive more and more attention. In 1980s and 1990s, TIAA played an important role in the corporate governance movement[3]. Up till today, TIAA has spared no effort to promote ESG. Because investors of TIAA are from educational and public institutions, ESG investing is not just philosophical but is integrating ESG into the investment portfolio, seeking competitive long-term performance as well as having a lasting positive impact on the industry's future and the social environment. Specifically, TIAA has integrated climate risk into investment portfolio management. TIAA expects its global real estate portfolio under management (US$ 133 billion at the end of June 2021) to achieve net zero carbon emissions by 2040. TIAA also estimates that its general account under its management (US$ 280 billion) will fulfill net zero carbon emissions by 2050. In addition, in 2021,

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[1] TIAA established College Retirement Equities Fund (CREF) in 1952 to jointly (TIAA-CREF) operate this system during 1952~2016. After 2016, the name of CREF was dropped, and TIAA-CREF became TIAA.

[2] The portable account means that once a participant joins the retirement system, even if he/she changes jobs in the future, as long as he/she is still in the educational and research system, the relevant rights and interests of the participant can still be extended. Other features include: employer matching contribution, which ratio is different among institutions, particular redemption age (generally, age 59½ with early withdrawal penalties, and receiving required minimum distributions (that is, once the participant reaches the age of 70½ or 72 for those born after July 1, 1949, the required minimum distributions must be activated). In addition, the issue of tax is more complicated and thereby is not explained in detail here.

[3] Retirement funds including TIAA and California Public Employees Retirement System (CalPERS) established the Institutional Investor Responsibility Center (IRRC) in 1972 to help investors understand corporate governance issues. These institutions are also founding members of the Council of Institutional Investors (CII), which assists in advocating pension funds and work with other institutional investors to implement the following policies: greater independence of board members, independent audit and compensation committees, and repeal of poison pill provisions, support for shareholder proposals, and due diligence governance guidelines for institutional investors, etc.

TIAA had announced that it hopes to consider ESG factors in all funds and investment portfolios in the future.

Based on the mutual funds included by TIAA, we explore whether adding ESG to the TIAA fund system can significantly improve portfolio performance or not? This research includes the following two themes:
(1) According to the individual stocks' ESG scores provided by FTSE Russell, we study whether using the ESG scores and the individual scores of E, S, and G as the indicators for selecting stocks to construct an investment portfolio, respectively, can optimize TIAA's investment portfolio performance or not? The Mean-Variance Spanning Test is used to conduct the spanning test of the efficient frontier.

(2) (Active management) whether using individual stock's ESG score and individual scores of E, S, and G matched with the characteristic of the company (growth-type or value-type) can optimize the TIAA's investment portfolio performance or not?

In the long-term investment strategy, one view is that the stocks of companies with substantial growth prospects will provide investors with high returns in the long term whereas another view is that the best investment strategy is to choose stocks that can be purchased at prices lower than the companies' intrinsic values and hold them for a long time. Accordingly, for the characteristic of a company, we especially consider if it is a growth or value-type stock.

2. Literature Review

For portfolio efficiency in retirement investing, Siegel (1994) shows that with longer horizons, mean-variance maximizers would invest more wealth in stocks. Benartzi and Thaler (1995) find that a 50-50 allocation between equity and debt is plausible for myopic loss-averse investors. Ballente and Green (2004) and others also note that risk aversion may change with age. These theoretical results are broadly consistent with the rule of thumb advice of investment practitioners, that the percentage allocation to equity should be around 100 minus the individual's age. Angus et al. (2007) utilize value-at-risk approach to assess the effects of risk aversion that is manifested as loss avoidance, and then assess how optimal portfolio weights evolve as the employee approaches retirement. Their results are consistent with Ameriks and Zeldes (2004)'s finding that a tendency for people to shift completely out of equity around the time of retirement. Poterba and Wise (1998) document the cohort effects. Heaton and Lucas (2000) observe that portfolio holdings for retirement could be influenced by non-traded assets. They find that entrepreneurs with large holdings of risky illiquid assets tend to hold market assets that are more liquid. They also find that equity ownership decreases with age.

On the ESG part, Riedl and Smeets (2017) examine whether social preferences or return expectations determine socially responsible investments (SRI). Haber et al. (2022) find that young investors are more willing to support environmental and social issues (e.g., by giving up part of their retirement savings) than older investors, and that returns are an important consideration for the willingness to invest. Baker et al. (2022) interpret the fees for ESG funds using a revealed preference approach to conclude that investors

are willing to pay an average of 20 basis points to invest in funds with an ESG mandate. Giglio et al. (2023) find that a higher proportion of young investors select moral reasons as their primary motivation for ESG investments. However, actual ESG investments only become substantial when investors expected positive excess returns. Other related literature on "climate finance" studies the role of climate risk in affecting returns and investments in financial markets (Heinkel et al., 2001; Andersson et al., 2016; Broccardo et al., 2020; Hong et al., 2021; Oehmke and Opp, 2020; Pedersen et al., 2021; Alekseev et al., 2022; Alok et al., 2020; Bolton and Kacperczyk, 2021, 2020; Flammer et al., 2021; Giglio et al., 2021c; Hartzmark and Sussman, 2019; Krueger et al., 2020; Acharya et al., 2023). For recent reviews of this growing field, see Giglio et al. (2021a) and Hong et al. (2020).

3. Whether using the ESG scores of individual stocks as stock selection indicators can optimize the performance of TIAA's investment portfolio or not? The Mean-Variance Spanning Test is used to test the efficient frontier.

This research uses the ESG data provided by FTSE Russell. The data are divided into four levels (as shown in Table 1), namely, Rating, Pillars, Themes, and Indicators. The final ESG Rating construction process is to first examine each company by the bottom-level indicator and obtain the corresponding score. Next, the theme is calculated with reference to the score obtained by the indicator, and then the theme score will be obtained. Further calculating up layer by layer will finally get a comprehensive score, that is, ESG score. For the detailed process, please refer to the "Guide to FTSE Sustainable Investment Data used in FTSE Russell Indexes."[4]

Table 1 Four levels of FTSE Russell's ESG data

Level	Name	Explanation
1	Rating	Calculate the weighted average of all three pillar scores and give a rating using a 1-5 rating scale, where 5 is highest rating, which is used to measure the company's performance in the ESG field.
2	Pillars	The ESG rating model includes three pillars: 1) Environment (E), 2) Society (S), and 3) Corporate Governance (G), each of which has related theme items.

[4] (https://research.ftserussell.com/products/downloads/Guide_to_FTSE_Sustainable_Investment_Data_used_in_FTSE_Russell_Indexes.pdf)

3	Themes	The three pillars include various themes. For example, in the scope of the environmental, water conservation, tax transparency in the field of corporate governance, etc., are considered, a total of 14 items.
4	Indicators	FTSE uses more than 300 evaluation indicators, and each theme includes 10-35 indicators for evaluation. On average, a company has a total of 125 evaluation indicators.

(1) Research Data-TIAA's Fund Information

The source of TIAA's fund information is the database of the CRSP Survivor-Bias-Free US Mutual Funds compiled by The Center for Research in Security Prices (CRSP) Research Center of The University of Chicago Booth School of Business. Data were from January 2018 to January 2020; data frequency was monthly.

(2) ESG Portfolio Construction

Our research objects were the US listed companies. Sampling time was from January 1, 2018 to January 1, 2020; data frequency was monthly. As to the ESG score rating and the individual score rating of E, S, and G, we followed the third report of the research series (Study of relationships among ESG scores, stock returns and risks—gap analysis of different companies' characteristics, using the US market as an example) and found that the significance of the relative rating impact is better (the relative rating follows the principle of equally allocating samples using the method of division by five and selects different points of tangency every year so that each point of tangency just equally divides the company sample size with five orders). Therefore, this study continues to use relative rating to adjust the stocks' ESG scores.

The process of constructing the ESG investment portfolio was as follows. We first screened stocks from the relative ESG scores and the individual scores of E, S, and G on January 1, 2018, constructed the equal-weighted investment portfolio, and held the investment portfolio till July 1, 2018. Since the ESG scores are assessed every six months, this research also adjusted the components of the investment portfolio every six months. For example, based on the ESG scores of stocks announced on July 1, 2018, we screened eligible stocks under the same conditions and then adjusted the existing ESG investment portfolio.

(3) Mean-Variance Spanning Test

This research mainly adopted the Mean-Variance Spanning Test method suggested

by Huberman and Kandel (1987)[5] to observe the significant influence of the newly added ESG investment portfolio into the TIAA fund system on the optimization of TIAA's investment portfolio. Specifically, since Markowitz (1952) proposed the Efficient Frontier algorithm, it has become an important cornerstone of modern investment portfolio theory. The Mean-Variance Spanning Test, via adding a new ESG asset, observes the movement between the minimum variance portfolio and the tangency portfolio, estimating whether the newly added ESG asset is statistically significant on optimizing TIAA's investment portfolio. This study used Likelihood Ratio (LR) test, Lagrange Multiplier (LM) test, Wald test, and F-test of the most rigorous stepwise testing. In addition, since TIAA had numerous funds, during the actual testing, in order to be in line with the number of time series observations and the number of companies limited by the Mean-Variance Spanning Test, this study first used K-means clustering to group TIAA's funds in order to cover the whole information of TIAA's funds and then conducted tests. In order for the cluster analysis to cover the overall information of TIAA's funds as much as possible, this research conducted a series of tests, as detailed in Appendix 1.

(4) Finding: Is it possible to optimize the performance of TIAA's investment portfolio by using the ESG scores of individual stocks as stock selection indicators to construct the investment portfolio?

I. Can using ESG Level 1, that is, the combined score of E, S, and G as the stock selection indicator to construct the investment combination, optimize the performance of TIAA's investment portfolio?

Table 2 shows the optimization results of constructing investment portfolios based on ESG Level 1 as the screening criteria to be added to the original TIAA investment portfolio. From Table 2, it can be seen that investment portfolio constructs of both Scores 1 and 5 could significantly optimize the TIAA investment portfolio. In view of the statistics or the significance levels, the portfolio with the ESG Score 5 significantly improves the portfolio performance, which are better than those of the portfolio with ESG Score 1.

[5] Huberman, G. and S. Kandel, 1987. Mean-Variance Spanning, *Journal of Finance, 42*(4), 873-888.

Table 2 Optimization results after the original TIAA included the investment combination constructed by using ESG scores as the screening criteria (Mean-Variance Spanning Test)

Asset	F-test	LR	LM	Wald
ESG Score 1	3.068* (0.079)	9.906*** (0.007)	8.179*** (0.002)	12.156** (0.017)
ESG Score 5	5.45** (0.018)	16.439*** (0.000)	12.047*** (0.000)	23.253*** (0.002)

Note: This study used Likelihood Ratio (LR) test, Lagrange Multiplier (LM) test, Wald (Wald) test, and F-test. *** denotes significant at significance level of 1%. ** denotes significant at significance level of 5%. * denotes significant at significance level of 10%.

Figure I shows the efficient frontiers after adding the investment portfolios of ESG scores 5 and 1 to TIAA, respectively. After adding ESG Score 5 into the investment portfolio (the right-hand side of Figure 1), the efficient frontier expanded significantly to the upper left at the Minimum Variance Portfolio position (lowest risk).

Moreover, when the risk tolerance gradually increased, the efficient frontier obviously

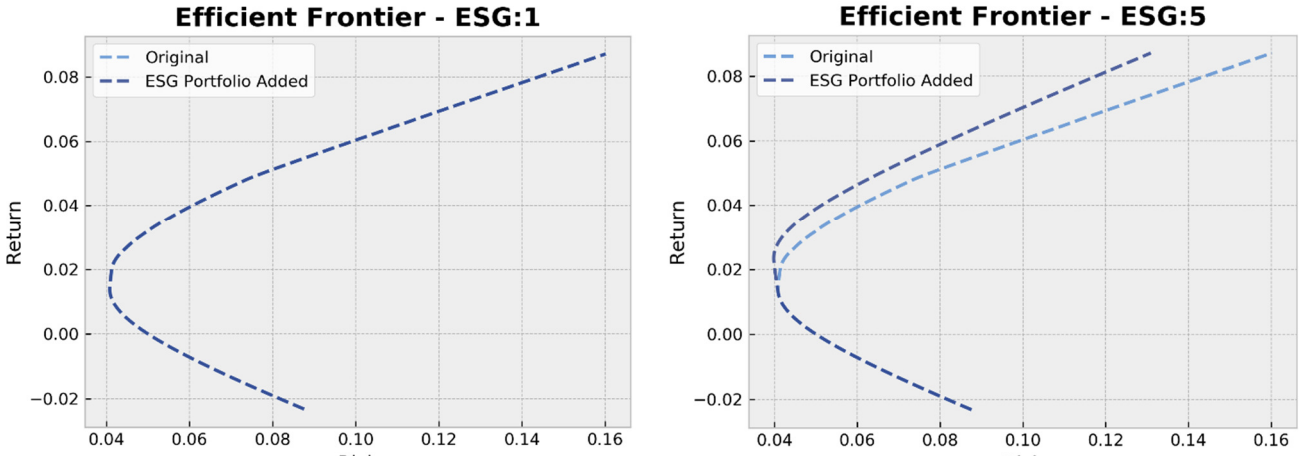

Figure 1 Changes of efficient frontiers after the original TIAA included the investment combination constructed by using ESG scores as the screening criteria (ESG=1 vs. ESG=5)

moved toward the upper left, meaning that compared with TIAA's existing investment portfolio, the new investment portfolio will get more returns from the perspective of the same risk.

After adding ESG Score 1 into the investment portfolio (the left-hand side of Figure 1), the efficient frontier moved less obviously toward the upper left. In view of Table 2 and Figure 1 together, the efficient frontiers in Figure 1 were estimates without considering

the status of the estimated value change (i.e., standard error) whereas the statistics used in Table 2 had considered the situation of the estimated value change. Therefore, although the efficient frontier in the left-hand side of Figure 1 moved less obviously to the upper left, the statistics in Table 2 indicated that adding the investment portfolio of the ESG Score 1 to TIAA could still optimize the TIAA portfolio whereas the effect was less significant than that of adding the investment portfolio of the ESG Score 5 to TIAA.

II. Can using ESG Level 2, that is, individual scores of E, S, and G as the stock selection indicators to construct a portfolio, optimizes the performance of TIAA's investment portfolio?

Environment (E): In terms of using E, S, and G aspects as the screening criteria, Table 3 displays the test results of the environment (E) aspect, the investment portfolio constructs of both Scores 1 and 5 could significantly optimize the TIAA portfolio. Also, as shown in Table 2, results of ESG scores, in view of the statistics or the significant levels, exhibit that Score 5 had better investment portfolio than that of Score 1. Figure 2 shows that after adding investment portfolios of E scores 1 and 5 to TIAA, respectively, the efficient frontier of E Score 5 expanded more obviously than the efficient frontier of E Score 1 toward the upper left at the Minimum Variance Portfolio position (lowest risk). When the risk increased, adding investment portfolios of E scores 1 and 5 to TIAA investment portfolios, respectively, could expand the efficient frontiers toward the upper left while the expansion rate of Score 5 is slightly larger. Therefore, compared to the investment portfolio of E Score 1, adding the investment portfolio of E Score 5 to TIAA will help improve performance regardless of various degrees of risk that investors are willing to take, and the results are statistically significant.

Table 3 Optimization results after the original TIAA included the investment combination constructed by using E individual scores as the screening criteria (Mean-Variance Spanning Test)

E/S/G	Score	F-test	LR	LM	Wald
E	1	3.095*	9.986***	8.232***	12.274**
		(0.077)	(0.007)	(0.002)	(0.016)
	5	4.446**	13.79***	10.599***	18.401***
		(0.032)	(0.001)	(0.000)	(0.005)

Note: This study used Likelihood Ratio (LR) test, Lagrange Multiplier (LM) test, Wald (Wald) test, and F-test. *** denotes significant at significance level of 1%. ** denotes significant at significance level of 5%. * denotes significant at significance level of 10%.

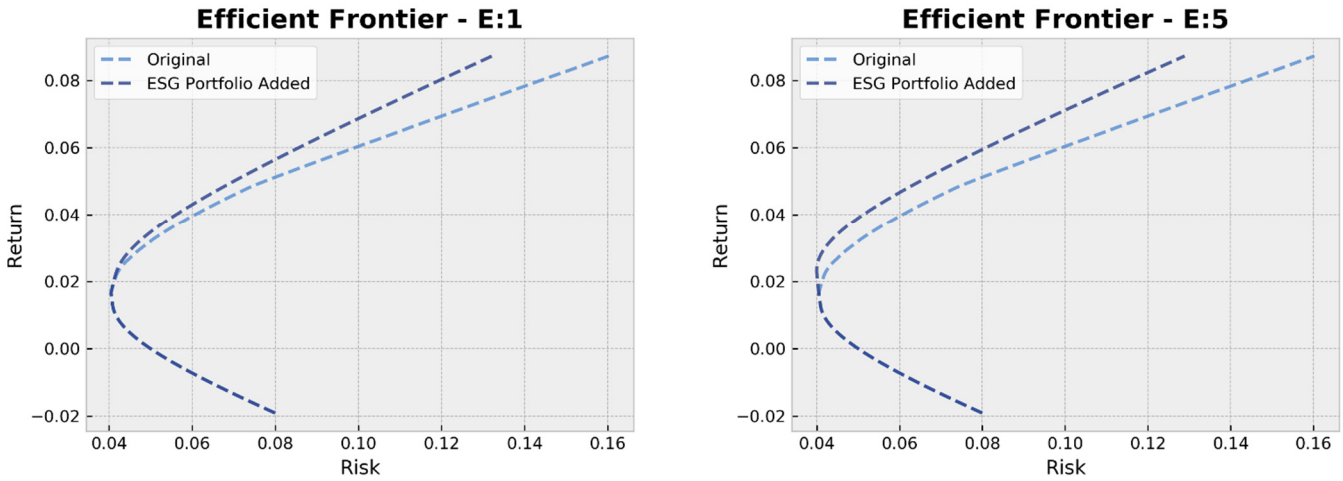

Figure 2 Changes of efficient frontiers after the original TIAA included the investment combination constructed by using individual E scores as the screening criteria (E=1 vs. E=5)

Social (S): In terms of using social responsibility as the selection criterion, as shown in Table 4, the research findings show that all S individual scores, regardless of high or low score levels, can be used to construct the investment portfolio with a significant optimization effect on the TIAA investment portfolio. In view of the statistics or the significant levels, a portfolio with an E total score 5 is better than a portfolio with an E total score 1.

Table 4 Optimization results after the original TIAA included the investment combination constructed by using S individual scores as the screening criteria (Mean-Variance Spanning Test)

E/S/G	Score	F-test	LR	LM	Wald
S	1	3.385*	10.828***	8.788***	13.551**
		(0.063)	(0.004)	(0.001)	(0.012)
	5	4.55**	14.072***	10.761***	18.893***
		(0.030)	(0.001)	(0.000)	(0.005)

Note: This study used Likelihood Ratio (LR) test, Lagrange Multiplier (LM) test, Wald (Wald) test, and F-test. *** denotes significant at significance level of 1%. ** denotes significant at significance level of 5%. * denotes significant at significance level of 10%.

As shown in Figure 3, after including the investment portfolio of S Score 1, the expansion of the efficient frontier is not obvious. On the other hand, after including the investment portfolio of S Score 5, the expansion of the efficient frontier efficiency is obvious, moving toward the upper left. In view of Table 4 and Figure 3 together, the

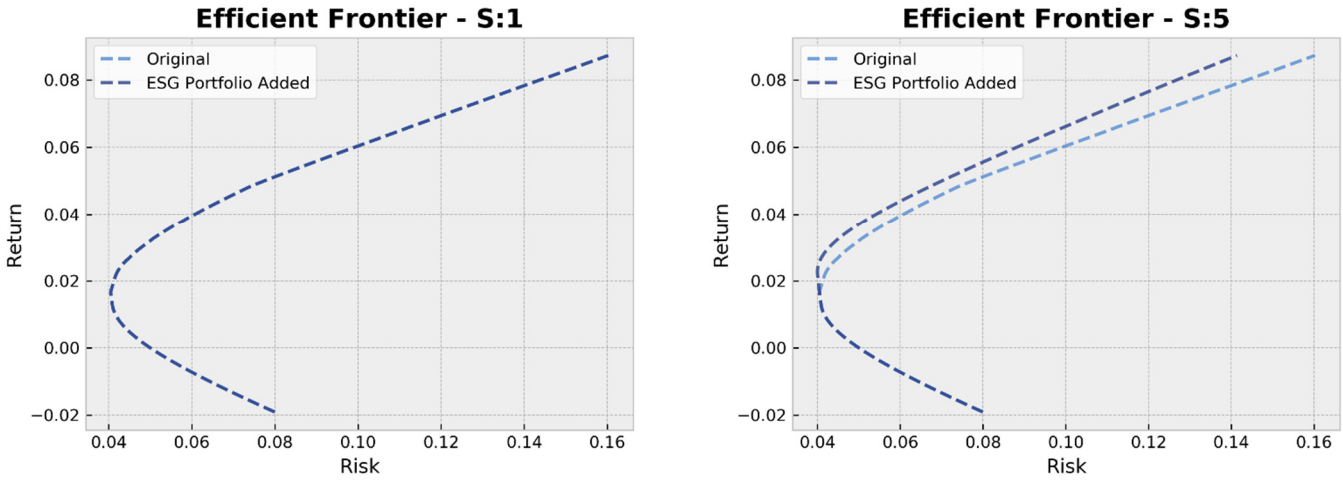

Figure 3 Changes of efficient frontiers after the original TIAA included the investment combination constructed by using individual S scores as the screening criteria

efficient frontier in Figure 3 were estimates without considering the status of the estimated value change (i.e., standard error) whereas the statistics used in Table 4 had considered the situation of the estimated value change. As a result, although the efficient frontier in the left-hand side of Figure 3 moved less obviously to the upper left, the statistics in Table 4 showed that adding the investment portfolio of the S Score 1 to TIAA could still optimize the TIAA portfolio, but the effect was less significant than that of adding the investment portfolio of the S Score 5 to TIAA.

Governance (G): Table 5 shows the results of using the corporate governance aspect as the screening criterion. The investment portfolios screened by G Scores 1 and 5 could significantly optimize the TIAA's investment portfolio, but the effect was different from effects of ESG total scores, E individual scores, and S individual scores. In terms of the governance, the test result of G Score 1's effect was more significant than that of G Score 5's effect.

Table 5 Optimization results after the original TIAA included the investment combination constructed by using G individual scores as the screening criteria (Mean-Variance Spanning Test)

E/S/G	Score	F-test	LR	LM	Wald
G	1	10.102***	27.162***	16.565***	49.096***
		(0.002)	(0.000)	(0.000)	(0.000)
	5	3.988**	12.531***	9.856***	16.269***
		(0.043)	(0.002)	(0.000)	(0.007)

Note: This study used Likelihood Ratio (LR) test, Lagrange Multiplier (LM) test, Wald (Wald) test, and F-test. *** denotes significant at significance level of 1%. ** denotes significant at significance level of 5%. * denotes significant at significance level of 10%.

As shown in Table 5, although the investment portfolios screened by G Scores 1 and 5 could significantly optimize the TIAA's investment portfolio, the impact was different depending on the risk, which can be seen from the efficient frontiers in Figure 4. Specifically, Figure 4 shows that adding G Scores 1 and 5, respectively, at the Minimum Variance Portfolio position (lowest risk), could both move the efficient frontiers to the upper left. Moreover, at the Minimum Variance position, adding G Score 1's investment portfolio to the portfolio could make the efficient frontier move significantly to the upper left, even larger amplitude than the efficient frontier movement of adding G Score 1's investment portfolio (Minimum Variance position). When the risk increased, adding G Scores 1 and 5, respectively, could both move the efficient frontiers to the upper left. Furthermore, compared to G Score 1, adding G Score 5's investment portfolio could make the efficient frontier move more to the upper left. Because this study's Mean-Variance Spanning Test considered simultaneously the minimum variance portfolio and the two-point movement of the tangency portfolio, as a whole, as shown in Table 5, the test results show that G Score 1 was more significant than G Score 5. The efficient frontiers further tell us that when the degree of risk that investors are willing to bear increases (higher than the minimum variance portfolio position (lowest risk), adding the investment portfolio of G Score 5 to TIAA will benefit even more.

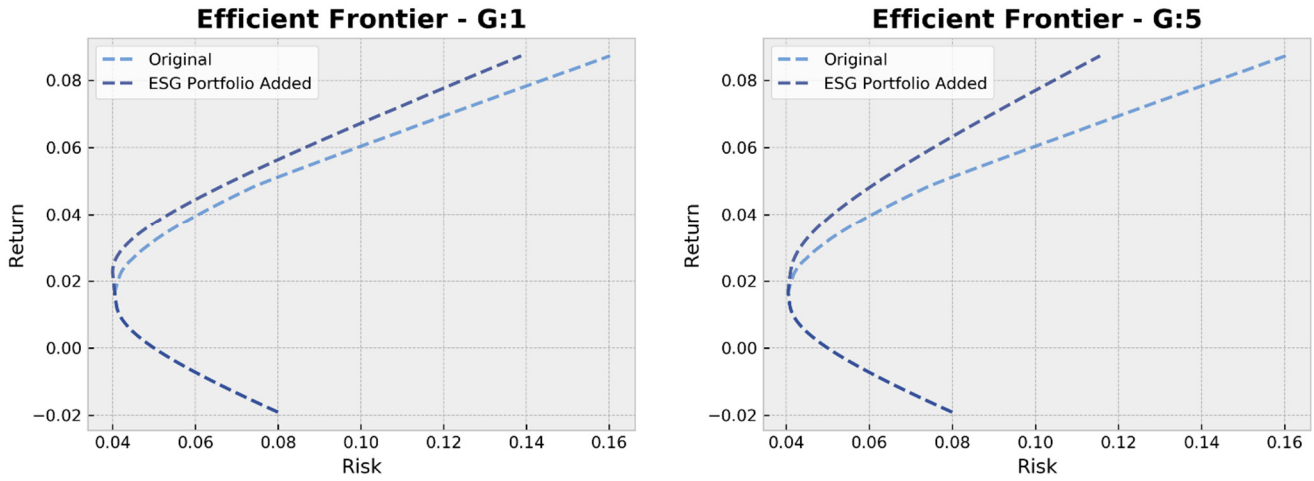

Figure 4 Changes of efficient frontiers after the original TIAA included the investment combination constructed by using individual G scores as the screening criteria (G=1 vs. G=5)

4. (Active management) whether using individual stock's ESG score and individual scores of E, S, and G, based on the FTSE Russell Index, matched with the characteristic of the company (growth-type or value-type) as the indicator for selecting stocks to construct the investment combination can optimize the TIAA's investment portfolio performance or not?

In light of long-term investment strategies, analysts often mention growth or value-type stocks. One view is that stocks of companies with substantial growth prospects will provide investors with high returns over the long term. Another view is that the best investment strategy is to choose stocks that can be purchased at a price lower than the company's embedded value. In this section, we used the ESG score and the individual scores of E, S, and G matched with company's characteristic (growth or value-type) to be the indicator for selecting stocks to construct an investment portfolio and explored if this can optimize the TIAA's investment portfolio performance or not? We used the same screening method as the previous section to construct ESG investment portfolio. In addition to each period's ESG (or E, S, G) score, we added the relative score of the company's characteristic factor (also using relative rating, Score 1 to Score 5) as the screening criteria.

Both academia (such as Fama & French factor model) or the industries found that it is useful to use the simple book book-to-market ratio to measure the characteristic of the company--growth or value-type type. This study first formed an investment portfolio based on the company's book-to-market ratio and the ESG score. In addition to each

period's ESG score, we added the relative score of the company's book-to-market ratio (also using relative rating, Score 1 to Score 5) as the screening criteria. Results are as shown in Table 6.

Table 6 Optimization results after the original TIAA included the investment combination constructed by using ESG scores and book-to-market ratios as the screening criteria (Mean-Variance Spanning Test)

		ESG Score 1	ESG Score 5
Book-to-market ratio	1 (low, growth-type)	0.695	4.879**
		(0.515)	(0.025)
	3	1.501	4.988**
		(0.257)	(0.023)
	5 (high, value-type)	0.425	0.999
		(0.662)	(0.393)

Note: This table needs to use aspects of the ESG score and the book-to-market ratio to construct the investment portfolio, so the table only shows the most stringent test, F-test. *** denotes significant at significance level of 1%. ** denotes significant at significance level of 5%. * denotes significant at significance level of 10%.

Table 6 is based on aspects of the ESG score and the book-to-market ratio to construct the investment portfolio, so the table only shows the most stringent test, F-test. Findings of this study showed that a portfolio constructed by a company with a low book-to-market ratio (growth-type) matched with a high ESG score could significantly optimize TIAA's investment portfolio. Specifically, as shown in Table 6, after adding the investment portfolios of book-to-market ratio Score 1 with ESG Score 5 and book-to-market ratio Score 3 with ESG Score 5 to TIAA, respectively, both efficient frontiers significantly expanded. However, other portfolios had no such statistical significance. Therefore, for active management, using the ESG scores of individual stocks matched with low book-to-market ratios (growth-type stocks) as the stock selection indicator to construct the investment combination can optimize the TIAA's investment portfolio performance.

Figure 5 shows the results of efficient frontiers. On the left side of the figure, after adding the investment portfolio of book-to-market ratio Score 1 (growth-type) with ESG Score 5, the efficient frontier obviously expanded. On the right side of the figure, after adding the investment portfolio of book-to-market ratio Score 5 (value-type type) with ESG Score 5, the efficient frontier did not obviously expand except that the minimum variance portfolio moved slightly toward the upper left. These result echoes with those of Table 6. Therefore, when conducting active management, using the ESG score of individual stocks matched with growth-type stocks (low book-to-market ratios) as the stock selection indicator to construct the investment combination can optimize the performance of the TIAA's investment portfolio.

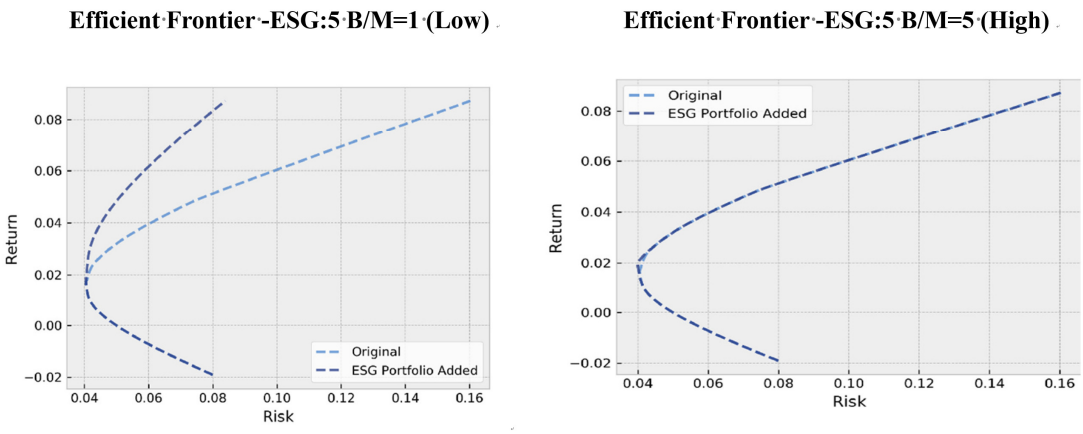

Figure 5 Changes of efficient frontiers after adding ESG scores and book-to-market ratios (relative rating) to the original TIAA (ESG=5 & Book to Market Ratio=1 vs. ESG=5 & Book to Market Ratio=5)

Next, using ESG Level 2 (i.e., individual scores of E, S, and G) matched with the company's book-to-market value ratio as a stock selection indicator to construct an investment mix to explore whether it can optimize the performance of TIAA's investment portfolio or not? The results are presented in Table 7 and are described as follows:

Environment (E): In terms of using the E score of the environmental rating aspect as the screening condition, when the E score = 5 was used as the condition matched with the company's book-to-market ratio, this study found that growth-type stocks (companies), via choosing relative excellent environmental rating (E score = 5), will help select stocks suitable for inclusion in the TIAA investment portfolio and will have a significant optimization effect on the overall TIAA performance.

Social (S): Next, we used the S score of the social responsibility aspect as the screening condition. When using the S individual score matched with the company's book-to-market ratio, this research found that as to growth-type stocks (companies) with book-to-market ratio score = 1 or value-type stocks (companies) with book-to-market ratio score = 5, the evaluation of social responsibility aspect has no significant optimization effect on the overall TIAA performance.

Governance (G): When using the G score of the corporate governance aspect as the screening condition, this study found that growth-type stocks (companies) with book-to-market ratio score = 1 had relatively the best performance of corporate governance (G score = 5). After adding to TIAA, they had statistically significant positive impacts on the overall TIAA performance. On the other hand, value-type stocks (companies) with the book-to-market ratio score = 5 had relatively the best performance of corporate governance and have no significant optimization effects on the overall TIAA

performance.

Table 7 Optimization results after the original TIAA included the investment combination constructed by using E individual scores and book-to-market ratios as the screening criteria (Mean-Variance Spanning Test)

.		E Score 1	E Score 5
Book-to-market ratio	1 (low, growth-type)	0.83	7.533***
		(0.456)	(0.006)
	3	1.49	4.049**
		(0.259)	(0.041)
	5 (high, value-type)	1.57	1.231
		(0.243)	(0.322)
		S Score 1	**S Score 5**
Book-to-market ratio	1 (low, growth-type)	0.297	2.52
		(0.748)	(0.116)
	3	2.151	7.664***
		(0.153)	(0.006)
	5 (high, value-type)	2.473	0.31
		(0.120)	(0.738)
		G Score 1	**G Score 5**
Book-to-market ratio	1 (low, growth-type)	3.848**	3.434*
		(0.047)	(0.061)
	3	4.325**	2.364
		(0.034)	(0.130)
	5 (high, value-type)	0.343	1.275
		(0.715)	(0.310)

Note: This table needs to use aspects of E, S, and G's individual scores and the book-to-market ratio to construct the investment portfolio, so the table only shows the most stringent test, F-test. *** denotes significant at significance level of 1%. ** denotes significant at significance level of 5%. * denotes significant at significance level of 10%.

Figure 6 shows the efficient frontier results of multiplying E Score 5 by book-to-market ratio. As to growth-type companies (left chart), after including the investment portfolio of E Score 5 into TIAA, the efficient frontier had obvious expansion. However, as to value-type companies (right chart), after including the investment portfolio of E Score 5 into TIAA, the efficient frontier had no obvious expansion. These results correspond

to those of Table 7. Thus, when conducting active management, for growth-type companies, using the highest relative rating of E scores as the stock selection indicator to construct the investment combination can optimize the performance of the TIAA's investment portfolio.

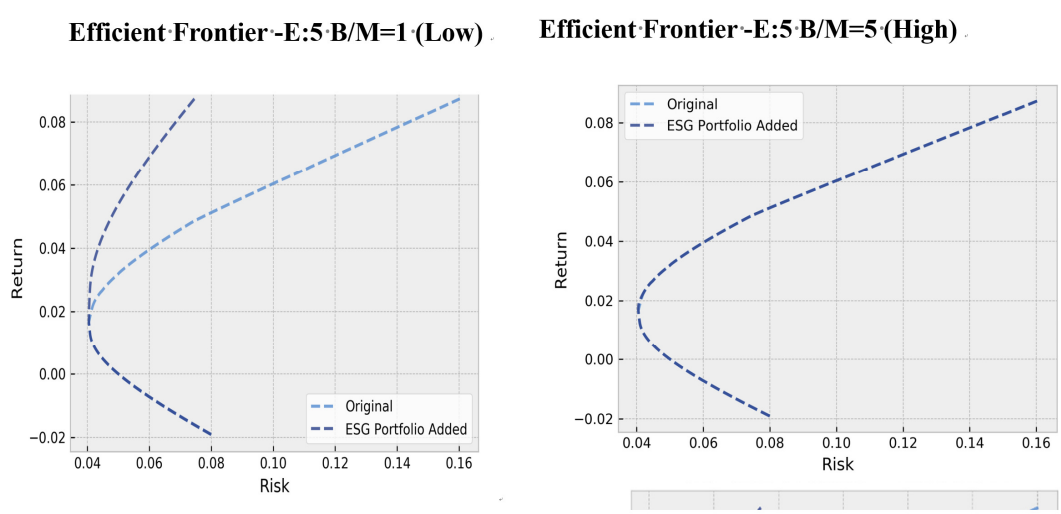

Figure 6 Changes of efficient frontiers after the original TIAA included the investment combination constructed by using growth-type versus value-type companies with E score 5
(E=5 & Book to Market Ratio=1 vs. E=5 & Book to Market Ratio=5)

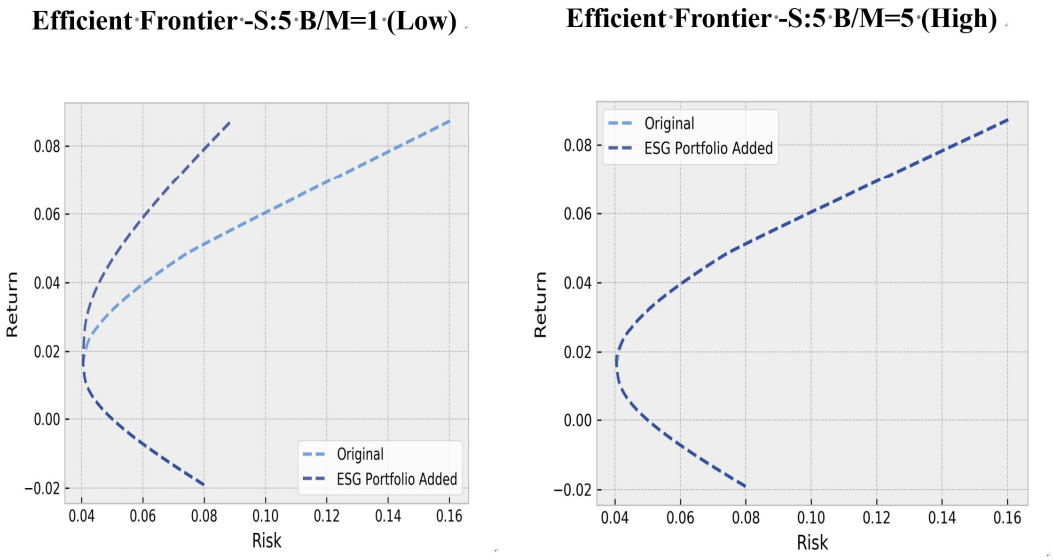

Figure 7 Changes of efficient frontiers after the original TIAA included the investment combination constructed by using growth-type versus value-type companies with S score 5
(S=5 & Book to Market Ratio=1 vs. S=5 & Book to Market Ratio=5)

Figure 7 shows the efficient frontier results of multiplying S Score 5 by book-to-market ratio. As to growth-type companies (left chart), after including the investment portfolio of S Score 5 into TIAA, the efficient frontier expanded toward upper left. As to value-type companies (right chart), after including the investment portfolio of S Score 5 into TIAA, the efficient frontier had no obvious expansion toward upper left. However, when reviewing these results together with those of Table 7. Findings shown in Figure 7 indicated that both growth-type stocks (companies) and value-type stocks (companies) with S Score 5 had no significant optimization effect on the overall TIAA. The reason for this inconsistency is that the efficient frontiers in Figure 7 were estimated values without considering the status of the estimated value change (i.e., standard error) whereas the statistics used in Table 7 had considered the situation of the estimated value change. Accordingly, for growth-type companies, adding the investment portfolio of S Score 5 to TIAA made the efficient frontier expand toward upper left, but the estimated value changed greatly, leading to the statistical insignificance after considering the standard error.

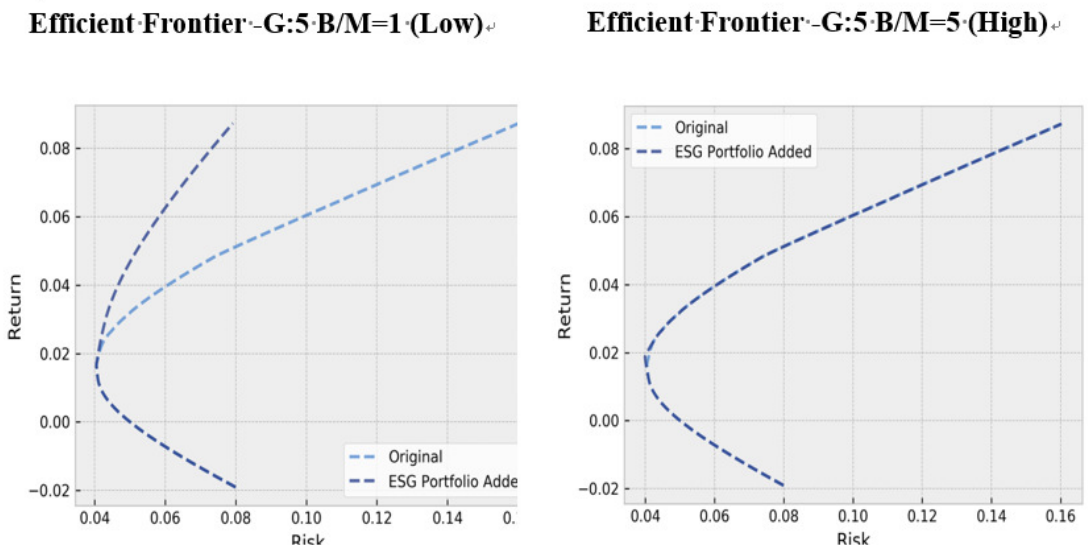

Figure 8 Changes of efficient frontiers after the original TIAA included the investment combination constructed by using growth-type versus value-type companies with G score 5
(G=5 & Book to Market Ratio=1 vs. G=5 & Book to Market Ratio=5)

Findings in Table 7 show that when using the G score of the corporate governance aspect as the screening condition, for growth-type stocks, a high corporate governance score had a significant optimization effect on the overall TIAA performance, but the result was not significant for value-type stocks. This result is also verified in Figure 8. Figure 8 shows the efficient frontier results of multiplying G Score 5 by book-to-market ratio. As to growth-type companies (left chart), after including the investment portfolio of G Score 5 into TIAA, the efficient frontier had obvious expansion. In contrast, as to value-type companies (right chart), after including the investment portfolio of G Score 5 into TIAA, the efficient frontier had no obvious expansion. These results correspond to those of Table 7. Hence, when conducting active management, for growth-type

companies, using the highest relative rating of G scores as the stock selection indicator to construct the investment combination can optimize the performance of the TIAA's investment portfolio.

5. Conclusion

Since TIAA's establishment in 1918, it has been well-known for providing American education, academic, and research units with a pension system for employees. Since TIAA's investors are from educational and public institutions, TIAA's investors hope to seek competitive long-term performance and, in the meantime, integrate ESG into the investment portfolio so as to have a lasting positive impact on the industry's future and the social environment. This study explores how to add ESG to the TIAA fund system in the hope of significantly improving the performance of the investment portfolio.

According to the individual ESG scores provided by FTSE Russell, this study used Mean-Variance Spanning Test for analysis. The study found that using the highest relative rating ESG score or the highest rating individual scores of E, S, and G as the screening criteria to construct the investment combination can optimize the performance of TIAA's investment portfolio. In particular, including companies with the highest ESG level (relative rating) into the combination of TIAA's portfolio can significantly improve the return of the Minimum Variance Portfolio. Also, regardless of the level of risk investors are willing to take, the investment combination can optimize TIAA's investment portfolio performance while the formal Mean-Variance Spanning Test also found consistent and statistically significant results. Likewise, including companies with the highest E level (relative rating) into the combination of TIAA's portfolio also has statistically significant results in expanding the minimum variance portfolio and the efficient frontier.

In view of conducting active management, this study further used the ESG score and individual scores of E, S, and G matched with the company's characteristic (growth-type or value-type) as stock selection indicators to construct investment portfolio. The research findings are quite consistent: The impacts of the ESG score and individual scores of E, S, and G on TIAA's portfolio performance are different for growth-type and value-type companies. Specifically, choosing a growth-type company (relatively lowest book-to-market ratio) matched with relatively excellent environmental rating (E Score 5) and relatively excellent corporate governance rating (G Score 5) as the stock selection indicator to construct the investment mix can optimize TIAA's portfolio performance. However, this effect is not significant in value-type companies.

On the whole, previous studies had not determined the impact of ESG scores and individual scores of E, S, and G s on performance and were still seeking ways to incorporate ESG scores and individual scores of E, S, and G into the active asset management. This study found that adding the company with the highest ESG level (relative rating) or the company with the highest E level (relative rating) to form an

investment mix to be added to TIAA can significantly increase the return of the Minimum Variance Portfolio and optimize TIAA's portfolio performance. In addition, when performing active management, the ESG score or the individual scores of E, S, and G must be matched with the characteristic of the company--especially growth-type companies to have a better effect.

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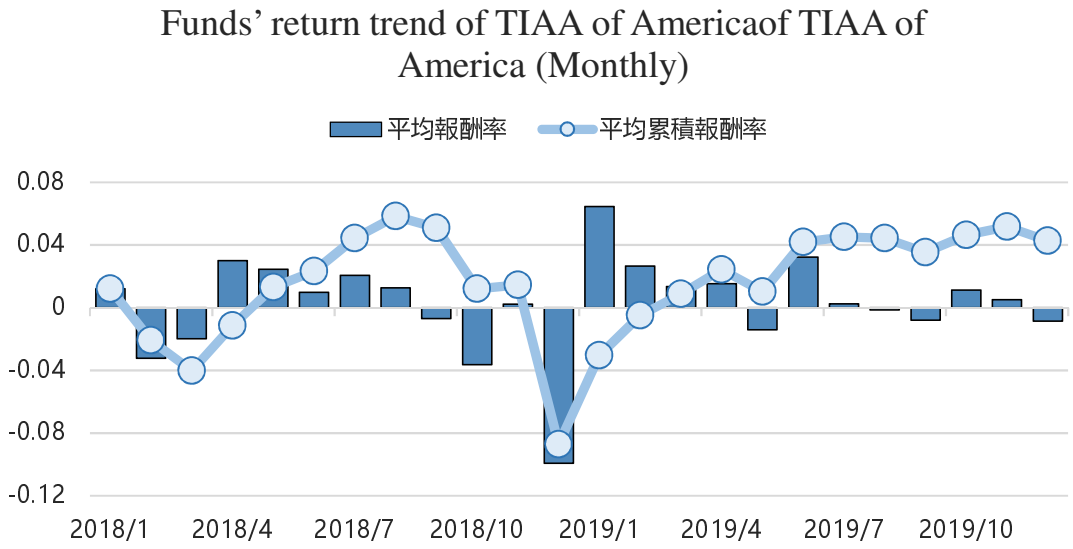
Appendix 1 K-means Clustering

This study first used K-means clustering to cluster funds into 10 groups in the TIAA system through similar fund returns and volatility. Each group covers dozens of TIAA funds. Starting from FTSE Russell's complete stock ESG scores, the Figure 1 of appendices shows average returns and cumulative average returns of all funds of TIAA



of America during sampling time. From January, 2018 to December, 2019, the average

Figure 1 of the appendix Funds' return trend of TIAA of America (monthly)

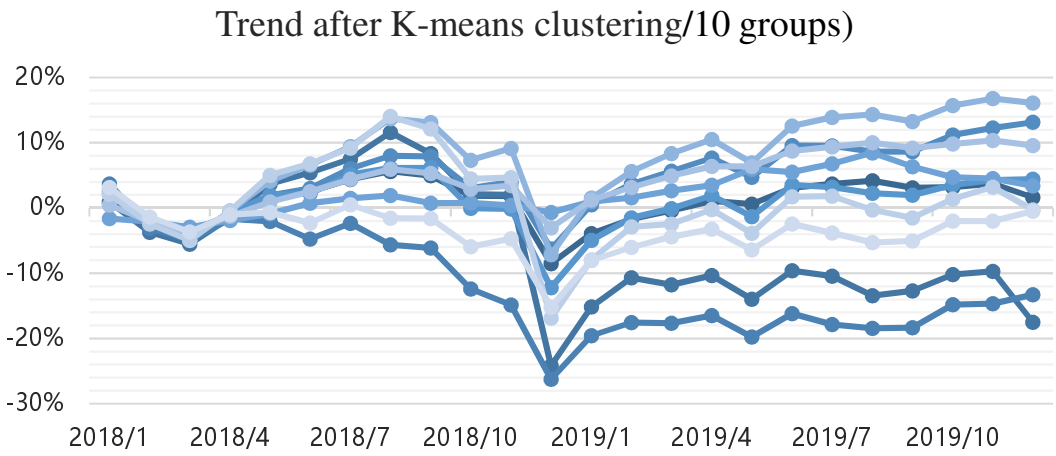
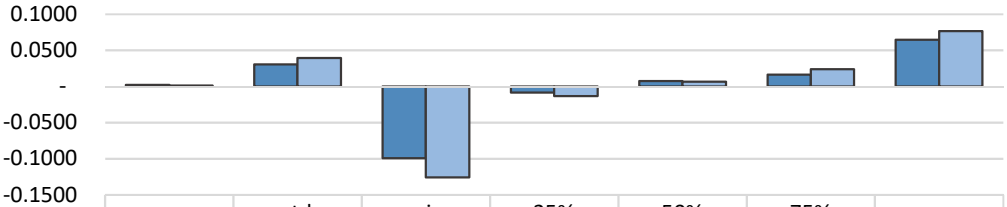


Figure 2 of appendix Funds' return trend of TIAA of America after K-means clustering (monthly)

return rate of the US University Endowment Funds was about 4% .

Figure 2 of the appendix is the trend chart of the cumulative average returns of each group after K-means clustering. It can be found that the trend of each group is similar to the overall return trend of TIAA's funds. It is obvious that the return information had not disappeared significantly after clustering. Specifically, the average monthly return of the all TIAA funds was 0.24%, and the average monthly return of each group after clustering was between -0.54% to 0.73% (see Note 5[6] for details, bottom of this page). The average of the descriptive statistics of each group after clustering was not obviously different from that of the descriptive statistics of each group before clustering, as clearly shown in Figure 3 of the appendix.



	mean	std	min	25%	50%	75%	max
TIAA	0.0024	0.0307	-0.0993	-0.0082	0.0075	0.0166	0.0646
Groups Avg.	0.0014	0.0396	-0.1258	-0.0134	0.0065	0.0239	0.0767

Figure 3 of appendix Comparing descriptive statistics before versus after clustering funds of TIAA of America

The return rate, the trend chart, and descriptive statistics indicate that the funds' overall return information of TIAA of America did not lose due to clustering. Therefore, in this study, it was rational that the clustered assets were used as the basic investment portfolio to observe whether there was a significant impact after the addition of the ESG investment combination.

6

	TIAA	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10
mean	0.0024	-0.0049	-0.0054	0.0040	0.0073	0.0011	0.0024	0.0003	0.0058	0.0017	0.0015
std	0.0307	0.0454	0.0691	0.0214	0.0467	0.0280	0.0400	0.0352	0.0352	0.0593	0.0120
min	-0.0993	-0.1333	-0.2568	-0.0625	-0.1492	-0.0984	-0.1197	-0.1116	-0.0986	-0.2057	-0.0194
25%	-0.0082	-0.0279	-0.0300	-0.0065	-0.0066	-0.0074	-0.0062	-0.0104	-0.0026	-0.0221	-0.0089
50%	0.0075	-0.0024	0.0070	0.0058	0.0184	0.0057	0.0047	0.0004	0.0101	0.0108	0.0023
75%	0.0166	0.0251	0.0308	0.0173	0.0298	0.0153	0.0236	0.0228	0.0257	0.0331	0.0107
max	0.0646	0.0902	0.1195	0.0439	0.0933	0.0501	0.0857	0.0717	0.0722	0.1073	0.0234