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YOSHINO Naoyuki and YUYAMA Tomonori

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Financial Research Center (FSA Institute)
Financial Services Agency
Government of Japan
3-2-1 Kasumigaseki, Chiyoda-ku, Tokyo 100-8967, Japan

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ESG/Green Investment and Allocation of Portfolio Assets

YOSHINO Naoyuki* **YUYAMA Tomonori****

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Abstract

This article examines the current portfolio allocation in ESG and Green projects. Traditional investments focus on rates of return and risks associated with investment. Environmental, Social and Governance (ESG) or Green factors are additional components that investors have to pay attention to. Environmental protection is very important. However, as we see the current different definitions of ESG or Green factors lead to distorted allocations in portfolio investments. In order to bring portfolio allocations to a desirable direction, global taxation on pollution or creation of an accurate Green credit rating based on emissions of various pollutants are recommended.

Keywords: ESG (Environmental, Society and Governance); Green investment; Green credit rating; optimal portfolio allocation and GHG taxation.

* Professor Emeritus (Economics) of Keio University, Director of Financial Research Center at Japan Financial Services Agency, and Visiting Professor at GRIPS, Tokyo Japan.
e-mail: yoshino@econ.keio.ac.jp
** Director, Macroeconomic and Market Analysis Office, Strategy Development and Management Bureau, Japan Financial Services Agency.
e-mail: tomonori.yuyama@fsa.go.jp
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1. ESG Investment

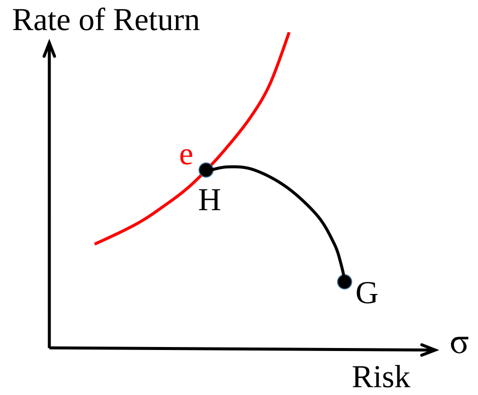
In recent years, "ESG investment" has become a popular trend in the field of asset management. ESG stands for Environmental, Society, and Governance, and investments that take ESG factors into account are called ESG investments. ESG investments are investments in companies that value these ESG factors and investments that take these factors into account when investing.

The United Nations set up 17 Sustainable Development Goals (SDGs) with a target to achieve by 2030. The main agenda is to "leave no one behind." SDGs provide a shared blueprint for peace and prosperity of people and the planet for the current generation and future generations. The creation of the SDG targets has been a major factor in the progress of ESG investments. The UN global agenda clarified the importance of the development of Green energy and reducing pollutants, such as CO2, NOx, and plastics; however, data show that, based on the current mechanism, it is not possible to achieve these goals. If the current trajectory of global fossil-fuel use continues, the planet's temperature is likely to rise by 4–6 C above the pre-industrial level. Greenhouse gas (GHG) emissions cause climate change, and global warming is now indisputable. In order to reduce GHG emissions, investors are requested to make their investment decisions based not only on the rate of return but also the ESG or "greenness" of companies. The most disappointing aspect of the contemporary global Green economy is the low rate of investment (Sachs *et al*. 2019).

In order to increase the rate of return in Green investment, a tax should be levied on emissions of CO2, NOx, and plastics, and the revenues can be distributed to Green sectors in order to increase the rate of return on Green investment so as to attract more investors. Another proposal is to establish an accurate credit rating of greenness of each company by measuring emission of CO2, NOx, plastics etc. which is disclosed to achieve optimal portfolio allocation.

Institutional investors use the services of different ESG rating companies, which define the criteria of ESG. Traditionally, investors watched (1) rate of return from investments and (2) risks associated with investments. The ESG component is an additional factor that investors must consider. Investors now make their portfolio allocations by studying three factors: (i) risk, (ii) rate of return, and (iii) ESG. As the criteria of ESG by each ESG rating company are different, their measurements are also different, and these can distort optimal portfolio investments. Much academic literature has been produced on the importance of Green finance and investment in the deployment of renewable energy projects for GHG emission reduction. However, we could not find any study that developed a model for calculating optimal portfolio allocations for investment in ESG. This article shows that the best policy will be to tax on emission of GHGs and pollutants such as CO2, NOx, and plastics globally by applying the same tax rate, forcing investors to focus on rate of return and risk after tax. Alternative method to achieve best policy for environment is to make accurate credit rating based on emissions of CO2, N2O, plastics etc.

Figure 1 shows a portfolio frontier between asset H and Green investment G. It also shows an investor's utility function by a red curve. If the rate of return from Green investment is lower than asset H and if the risk associated with investing in Green energy is higher than asset H, no investor would like to invest in Green projects. It is important to increase the rate of return from Green projects by injecting collected taxes from CO2, NOx, and plastics so that private investors will be interested in investing in Green projects.



Source: Authors' depiction.

Figure 1: Low rate of return on Green investment

2. Different Definitions of ESG

When institutional investors make ESG investments, they often refer to ESG scores provided by ESG rating agencies, and they often invest in companies with high ESG scores. The ESG indexes such as MSCI and FTSE used by institutional investors are composed of companies with high ESG scores. However, it has been noted that ESG scores for the same companies differ widely from one assessment agency to another, and that they do not tend to converge (GPIF 2019, Chatterji *et al*. 2016, Berg *et al.* 2019).

The reason for this is that the evaluation methodologies and criteria for ESG scores vary from one evaluating organization to another. For example, (1) some agencies use its own criteria to evaluate a company's ESG efforts, (2) some agencies assign a score based on the degree of disclosure, (3) some agencies use a score based on whether or not the company has an ESG policy, (4) some agency uses a score based on actual ESG activities such as CO2reduction by judging from performance, and so on (Table 1). It also raises issues whether ESG scores actually reflect ESG activities and outcomes of companies (Chatterji *et al.* 2009, Drempetic *et al.* 2019). Table 1 summarizes the definition of ESG scores and evaluation methodologies provided by the major ESG rating agencies.

The different standards on ESG and SDGs are not only a problem for ESG rating agencies at the corporate level. Recently, even on a country basis, the EU, China and the International Organization for Standardization (ISO) have been trying to establish separate standards for green finance and other issues (MUFJ Research and Consulting, 2020). In particular, the EU has a classification of activities, called the EU Taxonomy, and is said to be a strict regulation that aims for a strict definition of sustainable economic activity. In China, the National Development and Reform Commission and the People's Bank of China have also formulated a catalog of green industry guidance, which sets green standards to be applied nationwide and defines green eligibility. However, too many disparate and rigid definitions of what is green and what contributes to ESG and SDGs in different countries can affect investment activities not only in each country, but also at the global level.

Table 1: ESG scores and evaluation methodologies of major ESG rating agencies

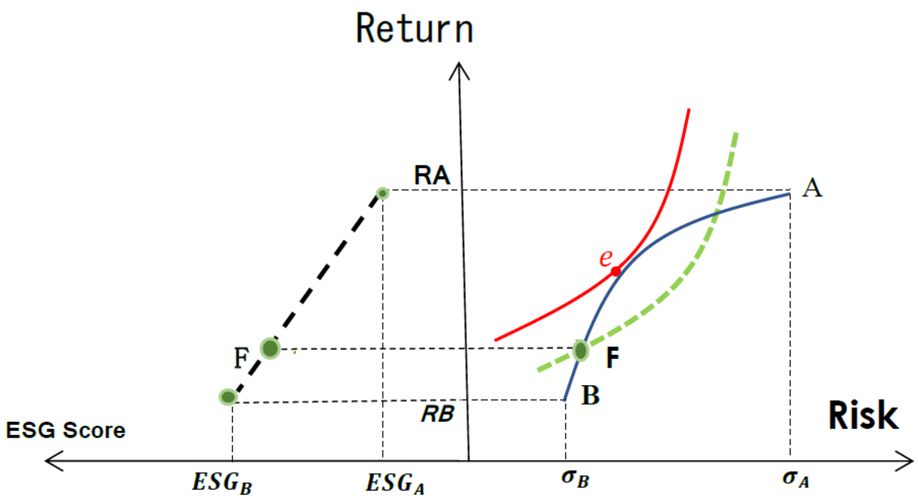
ESG Scores	Overview of Rating Methodology
Bloomberg ESG Disclosure Scores	Evaluating by degree of ESG disclosure
FTSE Russell's ESG Ratings	Evaluating by ESG risks based on disclosure and commitment to policy development and improvement
ISS Quality Score	Evaluating governance (board composition, shareholder and takeover defenses, compensation and remuneration, and audit and risk monitoring)
MSCI ESG Ratings	Evaluating by 37 key ESG issues
RobecoSAM Corporate Sustainability Assessment	Evaluating by economy, environment and society. Governance is included in the economy.
Sustainalytics' ESG Risk Ratings	Evaluating by ESG measures, disclosures, and the level of the problem
Thomson Reuters ESG Scores	Evaluating by 10 categories (environment [resource use, emissions, and innovation], society [employees, human rights, local communities, and product responsibility], and governance [management, shareholders, and CSR strategy]).

Source: Bloomberg, ESG rating organization websites, and Yuyama *et al*. (2020).

Table 2: Examples of ESG/SDG-related standard development movements in different countries.

	Standard Development Movement
EU	Through the EU Taxonomy, the criteria for classifying economic activity as environmentally compatible or not have been established
China	Develop a green industry guidance catalog and green standards to be applied nationally
International Organization for Standardization (ISO)	Moves to set standards for greenhouse gases, environmental performance, and green finance

Source: MUFJ Research and Consulting (2020).



Source: Authors' depiction.

Figure 2: Comparison between traditional portfolio investment and ESG investment

Figure 2 shows a comparison between traditional portfolio investment and investment taking ESG factors into account. The red curve denotes the utility curve of investors when they focus only on (i) rate of return and (ii) risks associated with investment. The blue curve between A and B denotes the efficiency frontier of two investments A and B in the first quadrant. The optimal portfolio allocation can be achieved at point "e". When investors have to take ESG factors into account, an additional second quadrant must be added for the allocation of portfolio investments. The second quadrant measures the degree of ESG criteria. Suppose investment in B achieves higher ESG points compared to investment A. Investors have to allocate more to B compared to investment A. The chart shows that the optimal portfolio allocation is not point "e" but has to be point "F" where much more investment is allocated to company B.

However, the degree of ESG differs depending on which ESG scores each investor uses, as is shown in Table 1. Point "F" is not a unique point, but there can be many different patterns of allocations based on the ESG rating agencies. Therefore, optimal portfolio allocations would be distorted by the different definitions of consulting companies. A detailed mathematical explanation is provided in Section 4.

3. Green Bonds

A similar argument can be applied to Green bond investment. Table 3 shows the Green Bond Principles defined by the International Capital Market Association (ICMA). In Japan, the Development Bank of Japan (DBJ) has issued green bonds for the construction of commercial buildings that reduce CO2 and are environment friendly. The Japan Housing Finance Agency has issued green bonds for the construction of environment friendly housing. Both of these bonds satisfy the criteria defined by the ICMA. However, they do not accurately indicate by how much CO2, NOx and other polluting gases are reduced. It can be said that some green bonds are 80% green and 20% gray, and others 90% green and 10% gray. But as long as the criteria defined by the ICMA are met, a green bond can be issued.

Table 3: Green Bond Principles (GBP) 2018

(i) renewable energy

(ii) energy efficiency

(iii) pollution prevention and control

(iv) environmentally sustainable management of living natural resources and land use

(v) terrestrial and aquatic biodiversity conservation

(vi) clean transportation

(vii) sustainable water and wastewater management

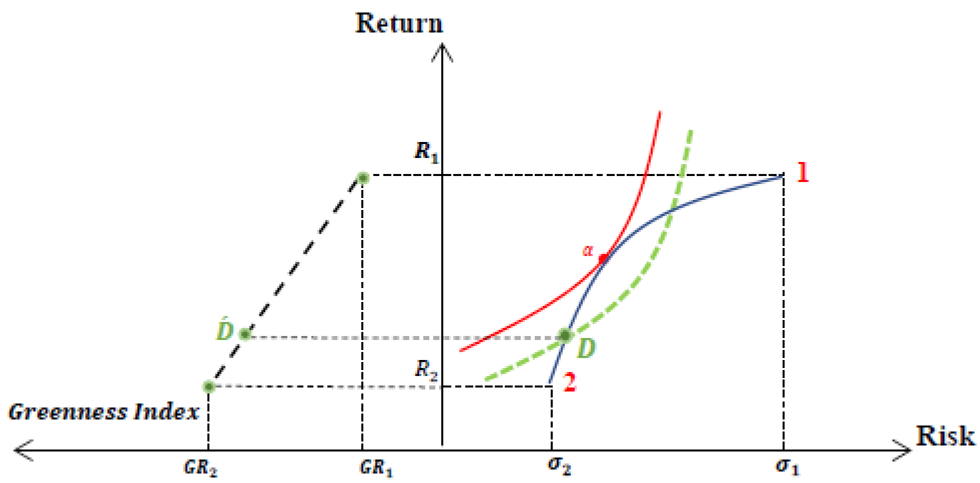
(viii) climate change adaptation

(ix) eco-efficient and/or circular economy adapted products, production technologies and processes

(x) green buildings

Source: The Green Bond Principles: Voluntary Process Guidelines for Issuing Green Bonds, ICMA, June 2018

Figure 3 shows the greenness index in the second quadrant. As in the case of ESG investment, investors are now taking greenness into account in addition to the rate of return and risks associated with investments. Since a green bond is not necessarily 100% green, portfolio allocations can be distorted by current definitions of such bonds depending on consulting companies.



Source: Authors' depiction.

Figure 3: Utility function: rate of return, riskiness and green bonds

4. Theoretical Model of ESG Investment and Portfolio Selection

4.1 Model by incorporating the ESG indicator in the investors' utility function

In this subsection, we modify the conventional portfolio utility function by incorporating the ESG indicator[1]. First, equation (1) represents the traditional portfolio utility function, which includes risk and rate of return.

$$U(R_t, \sigma_t^2) = R_t - \beta\sigma_t^2 \tag{1}$$

Where Rt is the rate of return and σ is risk, coefficient β represents the relative weight by investors to risk compared to the rate of return. If investors focus more on the rate of return compared to the risk, the value of β becomes small. On the other hand, if investors care more about risks compared with the rate of return, the value of β will be larger.

Rate of Return:

$$R_t = \alpha_t R_t^A + (1 - \alpha_t) R_t^B,$$

where A = Company (or asset) A, B = Company (or asset) B (2)

Risks:

$$\sigma_t^2 = \alpha_t^2 (\sigma_t^A)^2 + (1 - \alpha_t)^2 (\sigma_t^B)^2 + 2\alpha_t (1 - \alpha_t)\sigma_t^{AB} \tag{3}$$

[1] This part of the discussion is an extension and application to the case of ESG of the theoretical model shown by Yoshino *et al.* (2020).

We can consider ESG investments in the new portfolio utility function by the following equations:

ESG levels are described as follows:

$$ESG_t^A = a_t^1\left(CO_2{}^A{}_t\right) + a_t^2\left(NO_X{}^A{}_t\right) \tag{4}$$

$$ESG_t^B = b_t^1\left(CO_2{}^B{}_t\right) + b_t^2\left(NO_X{}^B{}_t\right) \tag{5}$$

where 1 is the CO2, and 2 is the NOx exposed by companies A and B. In equations (4) and (5), the coefficients of ($a_t^1,\ a_t^2$) and ($b_t^1,\ b_t^2$) are different from one consulting company to another. Next, we set the utility function in equation (6), which includes all the three elements discussed; the rate of return, risk and ESG. The new variable ESG subject to the constraints are presented in equation (9):

$$\mathrm{U}(R_t, \sigma_t^2, ESG_t) = R_t - \beta\sigma_t^2 + \gamma(ESG_t) \tag{6}$$

$$\text{s.t. } R_t = \alpha_t R_t^A + (1-\alpha_t)R_t^B \tag{7}$$

$$\sigma_t^2 = \alpha_t^2(\sigma_t^A)^2 + (1-\alpha_t)^2(\sigma_t^B)^2 \tag{8}$$

$$ESG_t = \alpha_t(ESG_t^A) + (1-\alpha_t)(ESG_t^B) \tag{9}$$

Substituting equations (7), (8), and (9) into equation (6), we obtain the optimal level of portfolio function, expressed in equation (10).

$$U = \alpha_t R_t^A + (1-\alpha_t)R_t^B - \beta\{\alpha_t^2(\sigma_t^A)^2 + (1-\alpha_t)^2(\sigma_t^B)^2 + 2\alpha_t(1-\alpha_t)\sigma_t^{AB}\} + \gamma\{\alpha_t(ESG_t^A) + (1-\alpha_t)(ESG_t^B)\} \tag{10}$$

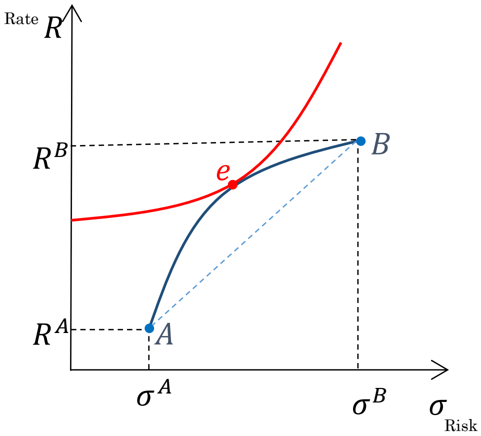
Obtaining the first-order conditions for the ratio between asset A (share = α_t) and asset B (share = 1-α_t), equation (11) can be shown as follows:

$$\frac{\partial U}{\partial \alpha_t} = (R_t^A - R_t^B) - \beta\{2\alpha_t(\sigma_t^A)^2 + 2(1-\alpha_t)(\sigma_t^B)^2\} + (2-4\alpha_t)\sigma_t^{AB} + \gamma(ESG_t^A - ESG_t^B) = 0 \tag{11}$$

Writing equation (11) for the α_t results in equation (12):

$$\alpha_t = \frac{\frac{1}{2\beta}(R_t^A - R_t^B) - (\sigma_t^B)^2 - \sigma_t^{AB} + \frac{\gamma}{2\beta}(ESG_t^A - ESG_t^B)}{(\sigma_t^A)^2 - (\sigma_t^B)^2 - 2\sigma_t^{AB}} \tag{12}$$

Equation (12) indicates the share of the allocation to asset A. The last term in the numerator is an additional component that affects the allocation between asset A and asset B. If ESG_t^A is larger than ESG_t^B, the portfolio allocation to asset A will become more significant, as shown in Figure 2. Figure 4 shows the traditional portfolio investment, determined by the rate of return and risks. Point "e" is the optimal portfolio allocation. Figure 2 shows the case where ESG is included in the utility function, where point "*F*" becomes the optimal portfolio allocation because asset A shows a higher ESG score compared to asset B.

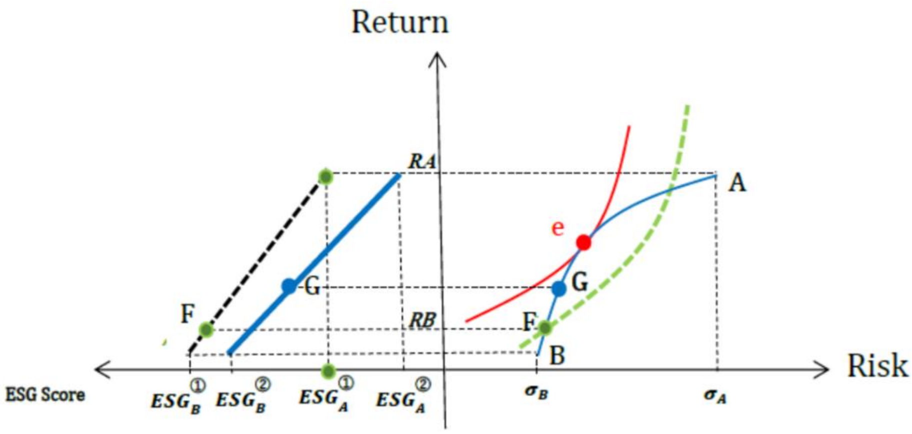


Source: Authors' depiction.

Figure 4: Traditional portfolio investment selection

However, the measure of ESG differs from one ESG rating company to another. Investors select an ESG rating company to allocate their portfolio based on its definition of the ESG. The asset allocation of each investor results in distorted portfolio allocation based on the different weights of $(a_t^1,\ a_t^2)$ and $(b_t^1,\ b_t^2)$ as in equations (4) and (5). Thus, each investor will choose a different portfolio based on the consulting company they chose.

In the second quadrant ESG score is measured together with the rate of return and risks associated in portfolio investment in the first quadrant in Figure 5.



Source: Authors' depiction.

Figure 5: Portfolio allocation when ESG factors are taken into account

Markowitz (2005) states the following assumptions in the above simple CAPM model: (A1) Transaction costs and other illiquidities can be ignored. (A2) All investors hold mean-variance-efficient portfolios. (A3) All investors hold the same (correct) beliefs about means, variances, and covariances of securities. (A4) Every investor can lend all she or he has or can borrow all she or he wants at the risk-free rate. Brennan and Lo (2010) claim that the result for two assets as is used in the above model cannot be generalized for many assets, as some assets/portfolios will certainly have negative weights as $n \rightarrow \infty$. Therefore, the above model used in this paper has to have limited number of assets rather than infinity number of assets. DeMiguel, Garlappi and Uppal (2009) find that naive diversification (1/n allocation to each asset) often beats simple optimal allocation as is used in this model. Even if naïve 1/n allocation to each asset were introduced, additional allocation of ESG investment will distort the original allocation of 1/n by the amount of ESG investment. Therefore, similar argument can be applied to naïve 1/n asset allocation explained in this section.

5. Empirical Application of the Theory

Stock prices of two companies are selected to show theoretical application of the model in previous section to real data. Company A shows rate of return as 0.067 (=R_A) and its risk, which is measured by standard error of stock price (σ_A), is 1.537. Company B shows the rate of return as 0.003 (=R_B) and its risk as 1.316 (=σ_B). Covariance of these two stocks are -0.087 (σ_{AB}).
ESG scores of these two companies are different by the ESG rating agencies as is summarized in Table 4.

Table 4: Empirical application of the theory

ESG Score	No Rating	RobecoSAM	Sustainalytics	Bloomberg
ESG score of company A	-	8.6	9.6	2.9
ESG score of company B	-	1.8	1.3	3.9
Value of α	0.57	0.71	0.74	0.54

Note: Each ESG score is converted to a 10-point scale for comparison.
Source: Based on each company's 2019 actual stock returns, standard deviation, covariance, and ESG score. Author's calculations based on equation (12) from Bloomberg data

By setting the values of γ=0.015, and β=0.005, the optimal portfolio allocation are different for scores based on RobecoSAM, Sustainalytics and Bloomberg, as shown in Table 4. Values of α (where α denotes allocation of portfolio between two assets A and B, equation (12)) are different from one agency to another. The allocation of assets between A and B changes depending on which ESG rating agencies' ESG score is used for the portfolio allocation. Higher the ESG score is, higher the α, and thus higher the investment allocation. For example, since Sustainalytics is the highest ESG score for Company A, investors following this rating will have the highest allocation to Company A. On the other hand, the Bloomberg score is lower for Company A than for Company B, resulting in a smaller investment allocation. If we do not take into account the ESG score, the investment allocation to Company A is 0.57. The example shown here proves the validity of the theoretical model developed in Section 4. In this empirical analysis, very small weight for greenness factor or ESG factor will make a big difference in portfolio asset allocation as is shown in Table 4.

6. GHG Taxation, Green Credit Rating and Optimal Portfolio Allocation for ESG Investment

6.1 GHG Taxation

A standard global GHG taxation (taxing CO2 and NOx) will give us a new rate of return on assets A and B, presented in this sub-section[2]. Tax rates can be adjusted based on the progress of pollution reduction. If the pollution reduction is slow compared to the target, the global tax rate can be adjusted by the same rate.

$$U\left(\tilde{R}_t, \tilde{\sigma}_t^2\right)=\tilde{R}_t - \beta\tilde{\sigma}_t^2 \tag{13}$$

$$T_t^A = \frac{t_1({CO_2^A}_t)+t_2({NO_X^A}_t)}{Y_t^A} \tag{14}$$

[2] This part of the discussion is also an extension and application to the case of ESG of the theoretical model shown by Yoshino *et al*. (2020).

$$T_t^B = \frac{t_1(CO_2{}^B{}_t) + t_2(NO_X{}^B{}_t)}{Y_t^B} \tag{15}$$

Equation (13) shows the new utility function of investors based on the "after-tax rate of return" and "after-tax risk." In equations (14) and (15), T_t^A and T_t^B denote the GHG tax rate charged to companies A and B, respectively. Y_t^A and Y_t^B are the total outputs of companies A and B, respectively. t_1 and t_2 show the tax rate on CO2 and NOx, which have the same rates globally. The tax rate on CO2 is the same for companies A and B, and the tax rate of NOx is the same for companies A and B. These rates need to be the same globally to avoid distortion of investments between different countries.

$$\tilde{R}_t^A = R_t^A - T_t^A \tag{16}$$

$$\tilde{R}_t^B = R_t^B - T_t^B \tag{17}$$

Equations (16) and (17) show the "after-tax rate of return" of company A and company B. The optimal allocation of assets between company A and B is computed as equations (18) and (19) that show the optimal rate of return and risk, respectively:

$$\tilde{R}_t = \tilde{\alpha}_t \tilde{R}_t^A + (1 - \tilde{\alpha}_t)\tilde{R}_t^B \tag{18}$$

$$\tilde{\sigma}_t^2 = \tilde{\alpha}_t^2(\tilde{\sigma}_t^A)^2 + (1 - \tilde{\alpha}_t)^2(\tilde{\sigma}_t^B)^2 + 2\tilde{\alpha}_t(1 - \tilde{\alpha}_t)\tilde{\sigma}_t^{AB} \tag{19}$$

Next, to find the optimal portfolio allocation ratio between asset A and asset B, we obtain the first-order condition of the utility function for $\tilde{\alpha}$:

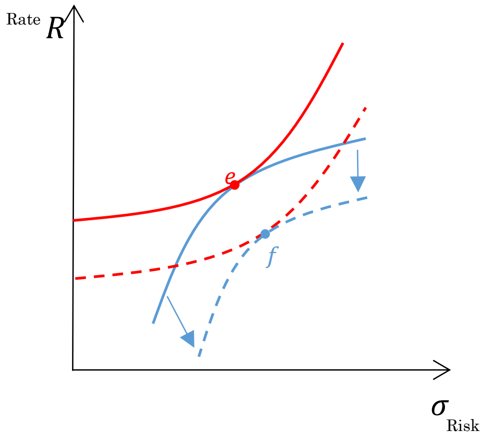
$$\frac{\partial U}{\partial \tilde{\alpha}_t} = (\tilde{R}_t^A - \tilde{R}_t^B) - \beta\{2\tilde{\alpha}_t(\tilde{\sigma}_t^A)^2 + 2(1 - \tilde{\alpha}_t)(\tilde{\sigma}_t^B)^2\} + (2 - 4\tilde{\alpha}_t)\tilde{\sigma}_t^{AB} = 0 \tag{20}$$

Finally, we obtain the optimal level of portfolio allocation as in equation (21):

$$\tilde{\alpha}_t = \frac{\frac{1}{2\beta}\left(\tilde{R}_t^A - \tilde{R}_t^B\right) - (\tilde{\sigma}_t^B)^2 - \tilde{\sigma}_t^{AB}}{(\tilde{\sigma}_t^A)^2 - (\tilde{\sigma}_t^B)^2 - 2\tilde{\sigma}_t^{AB}} \tag{21}$$

Evidently, as in equation (21), investors do not need to consider ESG as an additional item, as shown in equation (12). Instead, investors maximize their utility based only on the rate of return and the risk after tax. The optimal portfolio allocation is as shown in equation (21). The $\tilde{\alpha}_t$

indicates the optimal portfolio as shown in Figure 6 by point *f*. *f* is the optimal point after the adoption of the international GHG taxation scheme.



Source: Authors' depiction.

Figure 6: International GHG taxation scheme

6.2 Green credit rating

Another way is to make a credit rating of a company based on its greenness, which is a comparable measure of its GHG emission. If company A's GHG emission is zero, it is rated AAA, but one with a large emission would be rated as BB, etc. An accurate measuring of GHG will provide an accurate green credit rating of each company to investors. Table 5 shows an example of green credit rating based on emissions of CO2, NOx, and plastics. These ratings will facilitate investors to decide on investment in Green projects by watching a single green credit rating without being concerned about different criteria.

Table 5: Green Credit Rating (Example)

Credit Rating	Greenness (%)	CO2	NOx	Plastic	N2O etc
AAA	100 ～ 90	AAA	AAA	AAA	……
AA	90 ～ 80	A	AA	AAA	……
A	80 ～ 70	A	AA	BBB	……
BBB	70 ～ 60	BBB	BB	A	……
BB	60 ～ 50	BB	BB	BB	……
B	50 ～ 40	B	B	B	……
CCC	40 ～ 30	CCC	B	CCC	……
CC	30 ～ 20	CC	C	CCC	……
C	20 ～ 10	C	C	C	……

Source: Authors' depiction.

$$\mathrm{U}(R_t, \sigma_t^2, Green_t) = R_t - \beta\sigma_t^2 + \gamma(Green_t) \tag{22}$$

$$\text{s.t.} \quad R_t = \alpha_t R_t^A + (1 - \alpha_t) R_t^B \tag{23}$$

$$\sigma_t^2 = \alpha_t^2 (\sigma_t^A)^2 + (1 - \alpha_t)^2 (\sigma_t^B)^2 \tag{24}$$

$$Green_t = \alpha_t (Green_t^A) + (1 - \alpha_t)(Green_t^B) \tag{25}$$

Where greenness index is based on the following two equations.

$$Green_t^A = a_t^1 \left(CO_2{}^A{}_t\right) + a_t^2 \left(NO_X{}^A{}_t\right) \tag{26}$$

$$Green_t^B = b_t^1 \left(CO_2{}^B{}_t\right) + b_t^2 \left(NO_X{}^B{}_t\right) \tag{27}$$

Optimal portfolio allocation now depends not only on rate of return and risks but also depends on greenness index $Green_t^A$ and $Green_t^B$.

$$\alpha_t = \frac{\frac{1}{2\beta}(R_t^A - R_t^B) - (\sigma_t^B)^2 - \sigma_t^{AB} + \frac{\gamma}{2\beta}(Green_t^A - Green_t^B)}{(\sigma_t^A)^2 - (\sigma_t^B)^2 - 2\sigma_t^{AB}} \tag{28}$$

Unique value of α_t is obtained from a single green credit rating.

7. Relation between ESG Investment and Stock Prices

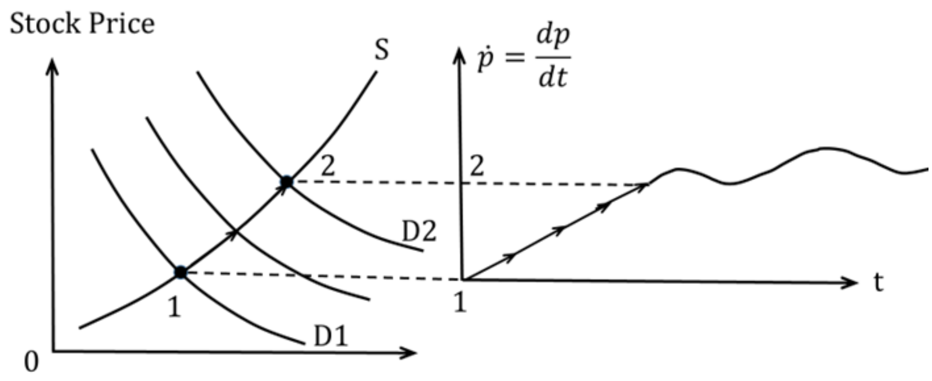
There are various analysis on the relation between ESG investment and stock prices. One view is that ESG investment will increase stock prices since it pushes companies to move for better environment. Another view is that ESG investment does not necessarily push stock prices up since they are not influenced by ESG investment alone but rather by the performance of the company.

7.1 Co-movement of ESG investment and stock prices

Fluctuations of stock prices can be explained as follows. The demand for a stock depends on the rate of return (R), risk (σ) and ESG investment. Many investors started to build portfolios based on environmental concern. The ESG investment will rise until a certain level of ESG investment is achieved ($\underline{ESG}$). Institutional investors have their target level of ESG investment in mind. The demand for ESG investment would increase as long as the current ESG investment is smaller than the target level ($\underline{ESG}$-ESG). As institutional investors increase their portfolios while $\underline{ESG}$-ESG is positive, stock prices will rise (equation (29)). However, when ESG investment reaches the target level of $\underline{ESG}$, stock prices will stop increasing (Equation (30)). Therefore, the positive correlation between ESG investment and stock prices is observed only when current ESG investment is lower than the target level of ESG.

$$\frac{dp}{dt} = \dot{p} = \lambda\{D(R, \sigma, \underline{ESG} - ESG) - S(r, Y)\} \tag{29}$$

$$\frac{dp}{dt} = \dot{p} = \lambda\{D(R, \sigma) - S(r, Y)\} \quad \text{when ESG=}\underline{\text{ESG}}\text{ is achieved} \tag{30}$$



Source: Authors' depiction.

Figure 7: Fluctuation of stock prices and ESG investment

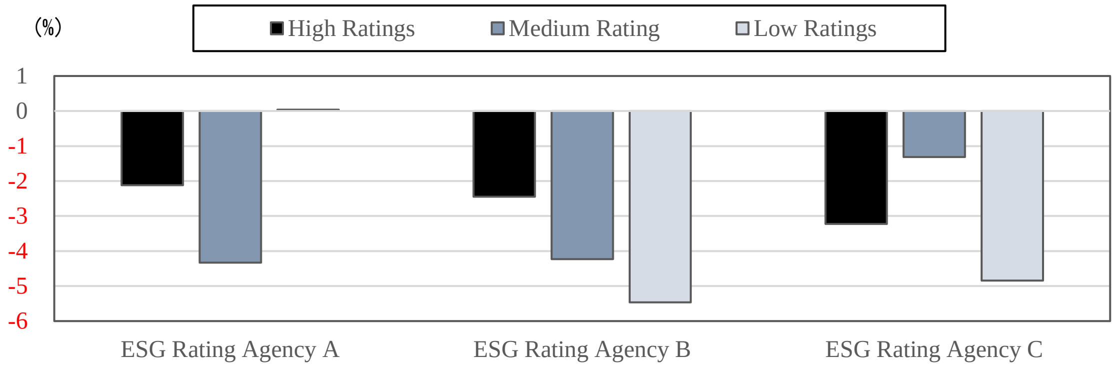
7.2 ESG investment and the rate of return

Some investors seek for higher rate of return believing that ESG investment will push up the actual rate of return on the companies such as wind power and solar power. Equation (31) describes such a case. ESG investment will expand their business and will push up stock return.

$$\frac{dp}{dt} = \dot{p} = \lambda\{D(R(1 + g(ESG), \sigma) - S(r, Y)\} \tag{31}$$

$$\frac{\delta p}{\delta t} = \lambda \left\{\frac{\delta \mathrm{D}}{\delta(ESG)}\right\} > 0 \tag{32}$$

If such domestic companies as wind power and solar power are competitive compared to foreign companies in the same sector, and if they can sell their products extensively, equations (31) and (32) will hold. However, in the case of wind power, Japanese companies lost their competitiveness compared to European companies and they have withdrawn from the market.



Note: Only stocks covered by each ESG rating agency are aggregated. The estimation period is the first quarter of 2020 (December 30, 2019 to March 31, 2020).
Source: Authors' calculations from Bloomberg data.

Figure 8: ESG score (high-medium-low quintile) and stock returns (first quarter of 2020)

Figure 8 shows the relation between stock performance and the ESG rating. Rating agency B gives ESG scores that are in parallel with the stock performance. However, rating agencies A and C rank ESG scores un-correlated with stock performances. This example empirically shows that positive correlations between stock performance and ESG rating cannot be seen.

8. Conclusion & Policy Implications

SDGs, ESG and Green investment are important policy objectives that we have to achieve for sustainable environment and sustainable growth. However, each ESG rating company has its own criteria for measuring ESG. Investors' portfolio allocations become distorted due to the lack of global standardized criteria for such measurement. To achieve clean energy and environment-related ESG, we recommend the adoption of international GHG taxation systems and the credit rating of greenness of each company based on GHG emissions to be used by investors.

Finally, although adopting an international taxation system for GHG and plastics is desirable, it might be difficult for developing countries. Therefore, we recommend starting such a system in regions where economic cooperation and economic integration exist, like the European Union or the Association of Southeast Asian Nations. Another policy proposal is to make a global green credit rating of companies based on their emissions of pollutants such as CO2, NOx, plastics etc., which will drive investors toward optimal portfolio allocation.

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Financial Research Center（FSA Institute）
Financial Services Agency
Government of Japan

3-2-1 Kasumigaseki, Chiyoda-ku, Tokyo 100-8967, Japan

TEL：03-3506-6000（ext. 3552）
FAX：03-3506-6716
URL：http://www.fsa.go.jp/frtc/english/index.html