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Research article

Sustainable investment strategies and a theoretical approach of multi-stakeholder communities

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Abstract: The digital industrial revolution continues to expand the global network of economies and societies. Nevertheless, difficulties of sustainability such as climate change and disruption have become more severe. Multi-stakeholders are crucially important to resolve difficulties posed to sustainability in global communities. Sustainable communities are expected to be constructed through competitive and cooperative schemes of multi-stakeholders. Sustainable global communities must reform centralized economies with top down systems and must move toward decentralized mechanisms known as bottom-up societies. Sustainable investment strategies to support environment, society and governance (ESG) presumably improve social welfare. The main findings presented herein are summarized as explained hereinafter. First, this article describes that multi-stakeholders can introduce a decentralized incentive scheme into global economies and can provide mathematical expressions of sustainable investment strategies. Secondly, the decentralized formulation described herein is used to evaluate the improvement of ESG initiatives by the decrease of social welfare losses. The formulation states mathematically relative relations among the investment strategies. Thirdly, this mathematical model explores the social welfare effects of initiatives to enhance standards, regulations, and legislations. Empirically, one finds that integration strategies have grown remarkably as a core part of social institutional reform for sustainability. Finally, initiatives to improve social evaluation by individuals who are excluded from market transaction are demonstrated to decrease social welfare losses greatly. These findings can promote initiatives to alleviate the disruption difficulties faced by communities.

Keywords: ESG; integration; multi-stakeholders; risk coefficient; screening of investment; sustainable investment strategies

JEL Codes: D81, D85, F64, F65, H43, O35

1. Introduction

Since the beginning of the 21st century, multinational corporations have undertaken massive innovation of Intelligence and Communication Technology (ICT) and have contributed to the expansion of global markets. Growing global communities have confronted global markets and governmental failures such as those associated with climate change, financial crises, and the Covid 19 pandemic. The global crises have demonstrated empirically that myopic behaviors of corporations to seek their own self-interests do not bring maximization of social welfare in global communities. Particularly, behaviors in market economies can contribute to global economic development, but they can also sometimes trigger great crises affecting global communities. When the crises occur, the negative effects are likely to expand greatly to a global scale. To mitigate and prevent large crises, sustainable mechanisms must be designed for global economies and societies. During global financial crises, short-term investments seeking profit exacerbate financial market fluctuations and destabilize global communities. However, sustainable investments undertaken with a long-term perspective are necessary to improve economies, societies, and environments in global communities. In 2006, the United Nations[1] proposed the Principle of Responsibility Investment (PRI), which describes guidelines for sustainable environment, society, and governance (ESG) issues.

Earlier studies are described first. Arrow (1973) argues that theoretical economics should contribute to improving issues of corporate social responsibility (CSR). Tirole (2001) explores one stakeholder model with shareholder value by application of an economic theory of incentives. In one early study, Tanaka (2004) presents a multi-stakeholder analysis of CSR by developing the incentive theory. This multi-stakeholder model integrates theories of market mechanisms and explorations of legislation and instruction derived from work reported by Coase (1937) and Williamson (1975, 1986, 1990), and others. In later work, Tanaka (2016) describes that this multi-stakeholder analysis provides the theoretical foundation for ESG issues. To achieve sustainability, the corporation should perform cooperatively with both stakeholders in market economies and in non-market societies. Using market and legislative initiatives, Tanaka (2017) then evolves the multi-stakeholder model to explore the sustainability of global communities. Subsequently, Tanaka (2019b, 2019c) shows that the digital industrial revolution has supported the growth of some large multinational corporations. The multi-stakeholder model in the digitalization of economies and societies theoretically explores issues of sustainable communities[2]. Other work by Tanaka (2018, 2019a, 2020b) shows that large global corporations develop centralized network systems of production and distribution, simultaneously, and shows that global networks lead to vulnerable communities. More recently,

[1] UNEP FI and Global Compact (2006).

[2] Baecker (2019), Hindman (2018), Paus (2018), and other discussants describe that innovations of digital technologies can bring disruption in the communities.

Tanaka (2020c, 2021b) investigates the model of multi-stakeholders to improve the sustainability social and economic systems. Other studies by Tanaka (2020a, 2021a, 2021c) explore that structural change of stakeholders brought by the digital industrial revolution influences sustainable communities and green bond issuance. Tanaka (2022) explains that sustainable systems of medical radiation services are based on the cooperative provision of services by stakeholders of all types. The sustainability problems of global communities are solvable not by a single stakeholder approach but by the analysis of multi-stakeholders.

Main results obtained from this study are summarized as described hereinafter. First, ESG investments are guided by the principle presented by the Global Sustainable Investment Alliance (GSIA). Although the guideline classifies categories of ESG investment, this classification has not defined the theoretical foundation completely. This article presents attempts at a theoretical foundation on ESG investments by GSIA for sustainable global communities. Although the GSIA presents some different methods of evaluation, this paper demonstrates that social welfare analysis can produce a basic index to evaluate ESG investments of different types. Second, this theoretical model indicates that sustainable investments enhance norms to mobilize initiatives for sustainable communities. Findings confirmed that sustainable investments propel social reforms to improve the standards of markets, legislations regulations, and residents' involvement. Third, considering that social welfare analysis integrates the social welfare of all stakeholders, these findings indicate that the risk coefficients are a key concept in the initiatives of sustainable investment strategies.

This paper is organized as explained below. Section 1 explores PRI and ESG investments. Section 2 presents discussion that the theoretical model of multi-stakeholders investigates structural changes of global communities in the digital revolution. Section 3 explores cost–benefit analysis of incentive mechanisms for sustainable communities. A decentralized cooperative scheme is built into the digitalizing market system. As described in Section 4, the concepts of ESG strategies classified by GSIA are investigated theoretically. The implications of all ESG strategies are explored through the evaluation of social welfare. Section 5 clarifies that those digitalized economies bring stakeholders the differentiated social welfare loss. Comparative analysis among stakeholders proves that external stakeholders take the greatest social welfare losses in globalized economies and proves that ESG strategies often target the improvement of benefits of external stakeholders. Section 6 includes an empirical exploration showing that ESG strategies improve decentralized mechanisms mainly by integration of ESG factors. Section 7 is the conclusion. This theoretical explanation of how sustainable investment strategies improve ESG explains the effects of parameters such as the risk coefficient and explains how efficient communication reduces social welfare losses. This estimation method is applicable to risk management of global crises. Through collaboration, Tanaka H. has produced Sections 1–5 and 7; Tanaka C. has provided Section 6.

2. Digital industrial revolution and stakeholders

Section 2 introduces theoretical model analyses after explaining why a theory of multi-stakeholders can elucidate sustainable global communities in digitalized economies. Tanaka (2018) argues that major multinational corporations promote centralized economic systems in global economies. Tanaka (2019b) provides a theoretical model showing that the digital industrial revolution accelerates development of the centralized global system. However, centralized economic and social systems have brought some severe difficulties such as climate change and disruptions in

the sustainability of global communities. Growing global market economies have increased social welfare losses. Tanaka (2019a) shows that rehabilitation of decentralized mechanisms can lower social welfare losses and can raise sustainability in global communities.

This paper presents theoretical underpinnings of the market and social mechanisms by which the corporation constructs sustainable global communities. Corporations are assumed to indicate private for-profit firms and non-profit or government organizations[3]. The conditions of sustainable communities should be based on evaluations of all stakeholders. It must be assumed for this discussion that all mathematical functions are continuously differentiable. However, to simplify the explanation, differential functions are approximated by linear curves. The evaluation of stakeholders is exhibited by $V_i(x,t_i)$,*i=1,⋯;n*,, where $V_i(x,t_i)$ is increasing with t_i for any i. It is stated by using a mathematical expression $\frac{\partial V_i}{\partial t_i} \geq 0, i = 1, \cdots, n$. The theoretical model relies on the assumption that production x of the corporation achieves private net profit $\pi(x)$ and leads to payment t_i for stakeholder i where $i = 1, ..., n$. The marginal net private profit, which is assumed to be decreasing according to standard microeconomics, is written as $\pi^{'}(x) < 0$. According to interests with production of the corporation, stakeholders are classified into two groups. Stakeholder i, which raises its benefit by production of corporation x, is defined by a positive stakeholder. Positive stakeholder i is expressed mathematically as $\frac{\partial V_i}{\partial x} \geq 0$. Stakeholder i, which is a decreasing function of the evaluation of production x, is defined by a negative stakeholder and is expressed as $\frac{\partial V_i}{\partial x} < 0$. Earlier works Tanaka (2020b, 2020c) indicate that the digital industrial revolution promotes centralized features in globalized communities. Digitalization of economies and societies reforms the structure of stakeholders. For example, the enlargement of markets and communications using the internet increase stakeholders of new types such as gig workers and SNS users. Oskam (2019) discusses theoretically that consumers are explored as stakeholders in sharing economies to develop city tourism. Particularly, the internet network develops relations among corporations and stakeholders. In communities with advanced digital technologies, Tanaka (2019b) presents a theoretical model of stakeholders that classifies stakeholders into three groups: inside stakeholder, outside stakeholder, and external stakeholder.

Inside stakeholders can share interests with the corporation by constructing long-term and stable relations. Inside stakeholders are represented by influential business partners and regular customers and employees. Beyond regular market transactions, inside stakeholders are expected to obtain additional benefits. However, they abruptly take burdens brought by matters of the corporation. To simplify the theoretical analysis, inside stakeholders are classified as positive stakeholders[4]. Outside stakeholders are assumed to have occasional relations with the corporation. They are irregular employees and consumers. They mainly obtain benefits in occasional market transactions. They are unable to obtain positive marginal net benefits from production of the corporation without compensation of any market payments. They are assumed to be defined as negative stakeholders.

[3] Mansell (2013) explores sustainability problems from a theory of stakeholders in a wide perspective. This book develops a narrative explanation about issues of stakeholders. However, this paper presents a mathematical model to investigate global communities constructed by stakeholders.

[4] This report states the following assumptions. Inside stakeholders are positive stakeholders. Outside and external stakeholders are negative stakeholders. Some exceptions to the above classification probably occur. For example, some outside stakeholders might be positive stakeholders. If the definitions above are satisfied with a large majority of stakeholders, then the main results presented herein based on optimal conditions (2)–(5) are assured.

Since the expanding transactions from use of the internet produce various markets, the digital revolution increases outside stakeholders. Outside stakeholders evolve global communities with easy access for advanced information and knowledge in digital networks. External stakeholders do not make market transactions with the corporation. Although many indifferent stakeholders are associated with the corporation, external stakeholders are recognized as negative stakeholders. They can influence its sustainability considerably. External stakeholders are exemplified by residents, activists seeking social reforms, and environmental NGOs[5]. Legislation can improve benefits of external stakeholders. Inside, outside, and external stakeholders are $1, \cdots, n_0; n_0 + 1, \cdots, n_1, and\ n_1 + 1, \cdots, n.$

3. Sustainable conditions of corporate governance

Section 3 presents discussion of theoretical foundations for sustainable governance in global economies with rising digital industries. The sustainable framework requires legislative and voluntary initiatives for global communities and provides theoretical foundation communities with risk governance to improve disruption difficulties. Social mechanisms must induce corporations to be cooperative and competitive so that the corporations can achieve sustainability with multi-stakeholders. Sustainable social mechanisms must reform market mechanisms to be responsible for social needs. By viewing dominant market mechanisms in global economies, corporations cannot maintain complete communication with stakeholders of all types. The corporation is assumed to maximize the total value of private net profit and estimated evaluations of inside and outside stakeholders in digitalized communities[6]. The corporation obtains only incomplete evaluations of stakeholders in communication mechanisms. The efficiencies of communication with inside and outside stakeholders are observed to be different and distinguished respectively by the indexes β(x) and $\gamma(y)$, where β(x) is derived from impure altruism, as proposed by Andreoni (1990). The corporation shares greater intensity of communication with inside stakeholders than with outside stakeholders. The feature of the communication mechanism is presented mathematically by the expression β(x) > $\gamma(y)$ for any *x* and *y*. Moreover, β(x) presumably obtains increasing connectivity of communication with production and presents an increasing function as $\beta'(x) > 0$. However, the digital industrial revolution improves digital communications in two-way scheme between the corporation and stakeholders. Each stakeholder *i* provides effort y_i for a communication mechanism to convey information and knowledge efficiently. The network system of information indicates that the efficiency of communication is an increasing function with total effort $y = \sum_{i=1}^{n} y_i$. Because effort *y* implies information and knowledge shared in the communication network, *y* is assumed to be private or voluntary provided public goods that Roberts (1984) and many others have explored. If outside stakeholders contribute to enhancement of the digital environment, then the efficiency index formally leads to the inequality $\gamma'(y) > 0$. Effort *y* implicitly presents an index of the digital innovation. The digital revolution is presumed to bring a transformation of stakeholders: from the

[5] Cassier et al. (2018) and Choudrie et al. (2018) specifically examine important social difficulties attributable to external stakeholders according to definitions presented herein.

[6] Richardson and Nam (2014) consider issues of shrinking cities related to globalized digital systems. Rifkin (2014) specifically examines the revolution of global network caused by internet and communications technologies. Tanaka (2021b) shows that the digital industrial revolution changes the transaction costs of global communities.

inside and external into the outside[7]. To simplify the analysis, the following exploration discusses stakeholder behavior without structural change. The corporation is assumed to maximize net benefit, written as (1).

To explore the sustainable provision of medical radiation services, Tanaka (2022) presents a decentralized scheme of public services. The expanding global communities have been increasing the weight of external stakeholders. The external stakeholders raise the importance of global community sustainability. When the corporation becomes responsible for sustainable global communities, its objective function of maximization is expected to include an evaluation of external stakeholders. The preceding articles facilitate incentive schemes leading to the evaluation of external stakeholders into social net benefits[8]. Activation of bottom up decision mechanisms in governance is expected to improve corporate sustainability. External and internal stakeholders must be evaluated appropriately in a decentralized social system. According to the theoretical framework presented by Tanaka (2022), the net benefit function is defined mathematically as Eq. (1), which reflects evaluations of the three stakeholder types: inside, outside, and external. Particularly, the evaluation of the external stakeholders is exhibited by the last term on the right side of Equation (1).

$$NB = \Pi(x) + \beta(x)\sum_{i=1}^{n_0}\{V_i(x,t_i) - y_i\} + \gamma(y)\sum_{i=n_0+1}^{n_1}\{V_i(x,t_i) - y_i\} - t - \sum_{i=1}^{n}\varphi_i\{\alpha_i - V_i(x,t_i)\}. \quad (1)$$

The sustainable performance of corporate governance is expected to reflect evaluations not only of a small group but also of all stakeholders in the community. Sustainable governance facilitates incentive initiatives to increase the integrated evaluations of stakeholders. Equation (1) presents an incentive mechanism that improves the performance of a corporation on the basis of social evaluation. The incentive mechanism guides economies and societies using standards for voluntary activities or regulations and legislation for enforcement[9]. It is presumed theoretically that each stakeholder i has a target α_i to be achieved by the corporation. Explicit or implicit social contracts between the corporation and stakeholders are constructed. The incentive mechanism employing standards, legislations, and regulations and other factors are designed to meet the social contracts. When actual evaluation V_i denotes the gap from the target or standard α_i, then the corporation is forced to decrease the gap with a rising penalty or regulatory enforcement required by stakeholder i. Illegal activities or violations of social standards incur legal or social penalties. An increasing function φ_i simply describes mathematically that gap $\alpha_i - V_i$ brings the corporation a social cost $\varphi_i(\alpha_i - V_i)$. Consequently, the value $\alpha_i - V_i$ provides the index of social risks defined by the risk coefficient of $\frac{d\varphi_i}{d(\alpha_i - V_i)}(\alpha_i - V_i)$.

To explore sustainable strategies of the corporation we differentiate (1) with variables x, $t_1,\ldots, t_n$ to produce conditions (2)–(5), maximizing the net benefit. Equation (2) exhibits the first-order differential condition with production x to maximize net benefit in the incentive mechanism. The

[7] Proposition 3 of Tanaka (2021c) explores the transformation effects.
[8] Tanaka (2019b, 2019c, 2020a) argues that investigating external stakeholders is an important approach for disruption in digital economies.
[9] Pistor (2019) argues on page 3 that coding strategies of capital lead to creation of wealth and decreased inequality.

right side of Equation (2) presents the marginal net private profit of the production. The left side of Equation (2) shows the external social cost of production. The external social cost is the sum of the three terms. The first term on the right side of the Equation (2) represents the marginal net benefit of the inside stakeholders with production. The second and the third terms on the right side of Equation (2) state the marginal social cost of the outside stakeholders and incentive marginal cost with production. Equation (2) implies that the decentralized system provides to a corporation a communication scheme sufficient to balance marginal private profit with marginal social cost. The marginal social cost includes incentive penalties to construct sustainable communities in the third term of Equation (2).

$$\frac{d\Pi}{dx} = \sum_{i=1}^{n_0} -\left\{\frac{d\beta(x)}{dx}(V_i(x,t_i) - y_i) + \beta(x)\frac{\partial V_i(x,t_i)}{\partial x}\right\} - \gamma(y)\sum_{i=n_0+1}^{n_1}\frac{\partial V_i(x,t_i)}{\partial x}$$

$$- \sum_{i=1}^{n}\frac{d\varphi_i}{d(\alpha_i - v_i)}\frac{\partial v_i(x,t_i)}{\partial x} \quad (2)$$

Equation (2) shows how global communities improve sustainability in the decentralized mechanism. Raising the connection of inside stakeholders lowers the marginal transaction cost between corporations and inside stakeholders. However, the development of digital networks and the incentive scheme of governance change the relative marginal communication costs among the stakeholders of three types. Equation (2) shows that the decentralized scheme transforms the communication cost into transaction costs of the corporation. The marginal net profit on the left side of Equation (2) is a decreasing function. Because the minus sign is multiplied on the right side of Equation (2), the networks of inside stakeholders represent the first term of the right side by a decreasing function, but negative stakeholders of outside and external stakeholders exhibit an increasing function in the second and the third terms of this side. Furthermore, the digital industrial revolution denoted by the communication coefficient $\gamma(y)$ and the incentive schemes of sustainability presented by risk coefficients raise the increasing slopes of the second and third terms. The effect leads to a decline in over-production[10] that burdens communities with social welfare losses. Whereas social reforms to improve digital communications and corporative governance can accompany large amounts of sustainability investments, many stakeholders raise the risk coefficients. Consequently, the overproduction that probably causes social welfare losses leads to contraction of global communities.

The optimal conditions of payment $t_1, \cdots, t_n$ indicate effects on social welfare under the given initiatives for sustainability investments. Optimal conditions (3)–(5) show that the stakeholders of three types obey different conditions. The three conditions indicate that the stakeholders receive different payments and evaluations. The marginal evaluation of payments for stakeholder *i* on the left side of (3)–(5) is presumably a decreasing function of t_i. Policies to improve the efficiency of communication $\beta(x)$, $\gamma(y)$ and the risk coefficient increase t_i and the welfare of the stakeholder *i*. Sustainability investment effects are explored indirectly by the payment increment. Sustainability initiatives must be evaluated with comparison among stakeholders of different types.

The effective sustainable investment for stakeholders of each type is explored by conditions (3)–(5). First, the optimal conditions with inside stakeholders are expressed as

[10] Tanaka (2020c) proves that decentralizing revisions decrease social welfare losses by lowering over-production.

$$\frac{\partial V_i(x,t_i)}{\partial t_i} = \frac{1}{\beta(x)+\frac{d\varphi_i}{d(\alpha_i-V_i)}(\alpha_i-V_i)}, i = 1, \dots, n_0. \quad (3)$$

Secondly, the optimal conditions with outside stakeholders are

$$\frac{\partial V_i(x,t_i)}{\partial t_i} = \frac{1}{\gamma(y)+\frac{d\varphi_i}{d(\alpha_i-V_i)}(\alpha_i-V_i)}, \quad i = n_0+1, \dots, n_1. \quad (4)$$

Thirdly, the optimal conditions with external stakeholders are

$$\frac{\partial V_i(x,t_i)}{\partial t_i} = \frac{1}{\frac{d\varphi_i}{d(\alpha_i-V_i)}(\alpha_i-V_i)}, \quad i = n_1+1, \dots, n. \quad (5)$$

Conditions (3)–(5) are associated with the following situations. The inequality $1 > \beta(x) > \gamma(y)$ implies that inside stakeholders probably achieve closer relations with the corporation than outside stakeholders do. The initiatives taken to raise the risk coefficients effectively improve welfare and payment for all stakeholders. Because the effects of the policies are different, the incentives should be compared among stakeholders.

4. ESG and PRI

The preceding section 3 presents exploration of a policy framework with sustainable governance of communities. Section 4 presents discussion showing that the policy framework leads to important implications for an ESG approach to sustainable communities. Particularly by considering optimal conditions (2)–(5), sustainable initiatives on ESG strategies are demonstrated theoretically to contribute to the improvement of sustainable economies and societies. To develop the theoretical analysis of ESG strategies, this section presents an exploration of the concepts of ESG presented by the GSIA. The Global Sustainable Investment Review 2012[11] presents the following analytical ESG concepts that present definitions of sustainable investment strategies. Many researchers explore the relations between investment strategies and sustainable communities. Sciarelli (2021) makes the assumption that integration strategies of ESG give a key contribution to the sustainable development of responsible investment. That work provides empirical evidence by comparing integration approaches among corporations. It is demonstrated, as described hereinafter, that the optimal conditions (2)–(5) for sustainable corporative governance develop a numerical exploration of the concepts of ESG. The sustainable investment strategy concepts are classified into the following categories A–F.

A. Screening of investments. **(A.1)**. Norms-based screening. Performances of corporations related to economies, societies, and environments are assumed to be evaluated by many stakeholders. The theoretical model of sustainable corporate governance defines the norm of legislations and regulations by parameter α_i for each stakeholder i. Conditions (3)–(5) show that an initiative to raise α_i for any stakeholder i increases the risk coefficient. Furthermore, the marginal social costs exhibited by the right side of the conditions decline. Consequently, the corporation increases payments to improve environmental, social and governance factors. Norms-based screening is explored by the effects of α_i on conditions (3)–(5).

[11] The following concepts are based on page 4 of GSIA (2013).

(A.2). Negative/exclusionary screening. Negative effects of corporations are based on evaluations of negative stakeholders. With negative stakeholders, outside stakeholders might partially convey their evaluation to the corporation in market transactions, but external stakeholders included in the same negative stakeholders probably have no opportunities to communicate with the corporation with regard to economic activities. Failures in the communication mechanism cause great social welfare losses. Raising α_i for external stakeholder i enhances ESG investment by particularly addressing negative factors of evaluations. This type of screening decreases the welfare loss at the maximum of the area of triangle DSN in Figure 1 below.

(A.3). Best-in-class/positive screening. GSIA 2020[12] states that "Investments in sectors, companies or projects are selected by the result of positive ESG performance relative to industry peers, and that the screened samples are expected to achieve a rating above a defined threshold." For this screening, the investment is a great increase of production. Related stakeholders are presumed to be limited to some inside stakeholders such as major shareholders and investors. This screening specifically evaluates positive stakeholders and exhibits the guiding rule by expression (3). The expression indicates that the corporation raises $\beta(x)$ to the present connection of communication and the risk coefficient with selected inside stakeholders: improving trusty relations between the corporation and positive stakeholders enhances sustainable investment. This screening was undertaken to decrease social welfare losses as indicated by the area of triangle LGN in Figure 1 below.

B. Integration of ESG factors. ESG integration is expected to improve evaluations of social and environmental factors and economic issues. Expression (1) exhibits an integrated value of ESG. Variables β and γ expressing evaluation of social and economic systems and parameters of codes α_i influence the integrated values. Tanaka (2022) demonstrates by producing a figure[13] that reforming codes α_i, $i = 1, \ldots, n$, appropriately improves information of the corporation to change the marginal social cost correctly. The codes might be modified to decrease the social welfare loss. To explore the integration of ESG factors more closely, conditions (3)–(5) provide methods to analyze welfare by changing parameters such as β, γ and α_i.

C. Sustainability-themed investing such as sustainable agriculture, green buildings, lower carbon tilted portfolio, gender equity, and diversity. This type of investment strategy supports the related stakeholders to address the sustainability theme actively. The mode of market transactions is not expected to improve the exemplified themes considerably. Because the related stakeholders are concerned mainly with outside stakeholders, this sustainable strategy should use appropriate conditions to choose a suitable combination of stakeholders and codes as exhibited by (5). Furthermore, the social welfare loss of these themes is analyzed by the area of triangle DSN in Figure 1 below.

D. Impact/community investing. Investments to improve welfare evaluation are analyzed in related fields. Impact investment is explored by application of the appropriate condition for targeted investments from conditions (3)–(5). Condition (5) shows complementary community investment t_i for resident i of communities. The social welfare loss to be targeted in community investment is expressed by the area of triangle DSN in Figure 1 below.

[12] This statement is referred from 7 pages of GSIA (2021). However, the expression is modified partially to be readable easily.
[13] The figure resembles Figure 1 in an earlier work by Tanaka (2022).

F. Corporate engagement and shareholder action. This strategy related to appropriate contract or regulation is investigated by α_i in the theoretical model. The contract sometimes contains payments as important matters. Conditions (3)–(5) develop welfare analysis for each stakeholder *i* with provision of payment t_i.

5. Legislation and regulation

The GSIA proposes various sustainable investment strategies as denoted by A–F. Each strategy is designed to provide an appropriate initiative according to the stakeholder type. By comparing social welfare losses among stakeholders, section 5 presents a method of risk governance to decrease gaps of welfare losses. Because sustainable investment requires the construction of more decentralized processes into corporate governance, corporate organization is expected to change the communication mechanism in multi-stakeholders' communities. The preceding section expresses sustainable investment strategies by the mathematical form of parameters β, γ and α_i, for $i = 1, \ldots, n$. The sustainability of global financial systems is improved by initiatives to be proved from analyses of the parameters. Financial systems are expected to improve sustainability through accompanying reform of regulatory enforcements and legislations. Sustainable investment strategies can select appropriate initiatives for stakeholders of each type.

Sustainable frameworks that have been produced by financial markets have been explored theoretically. Tanaka (2004, 2017) and others define the risk coefficient. The sustainability of communities is evaluated by social welfare losses. Expression (6) shows a key concept in social welfare analysis.

$$1 > \beta(x) + \frac{d\varphi_i}{d(\alpha_i - V_i)}(\alpha_i - V_i) > \gamma(y) + \frac{d\varphi_i}{d(\alpha_i - V_i)}(\alpha_i - V_i) > \frac{d\varphi_i}{d(\alpha_i - V_i)}(\alpha_i - V_i) > 0,\ i = 1, \cdots, n. \quad (6)$$

The marginal costs of stakeholders are exhibited in Figure 1. Condition (6) expresses that the denominators of the right sides of Equations (3)–(5) are ordered as descending. The right sides of Equations (3)–(5) are depicted respectively as curves KK', HH', and CC'. Tanaka (2018) defines the first best solution of sustainable governance by using the net benefit of the corporation (7) corresponding to the second best solution (1)[14].

$$NB_F = \Pi(x) + \sum_{i=1}^{n}\{V_i(x, t_i) - t_i\}. \quad (7)$$

The first best optimal condition regarding payment t_i is stated simply as

$$\frac{\partial V_i(x, t_i)}{\partial t_i} = 1, \quad i = 1, \ldots, n. \quad (8)$$

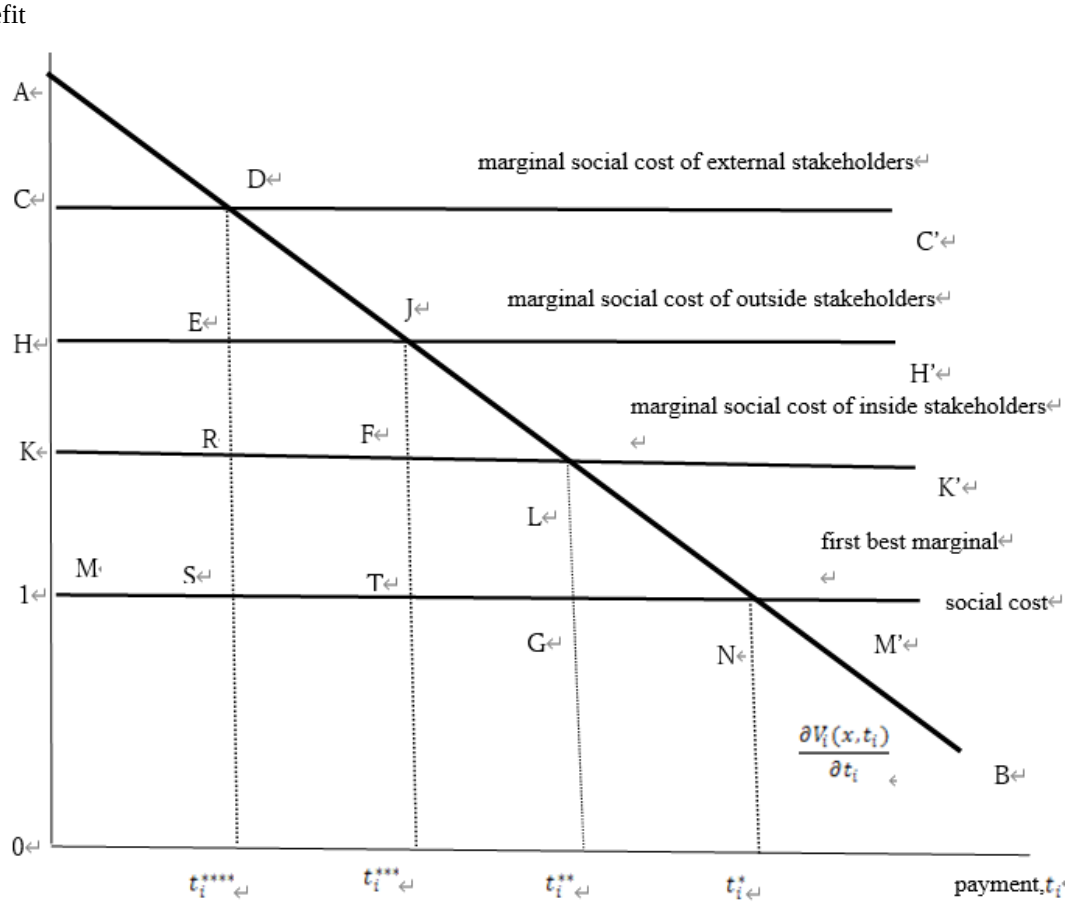
The right side of (8) presents the first best marginal social cost 1. It is exhibited by curve MM'. Figure 1 depicts that the optimal solution of Equation (3) as indicated by the intersection point L between AB and KK'. The optimal points stated by Equations (4) and (5) are points J to intersect AB

[14] The following paragraph was rewritten from (9) and (11) of earlier work by Tanaka (2018).

and HH' and point D to connect AB and CC'. The optimal payments of inside, outside, and external stakeholders are denoted as $t_i^{**}, t_i^{***} and\ t_i^{****}$.

The right side of Equation (8) expresses the first best marginal social cost, represented by curve MM'. The optimal conditions with payments imply that the stakeholders of three types are associated with different social welfare losses. The welfare losses of inside stakeholders are expressed by the area of triangle LGN, outside stakeholders by the area of triangle JTN, and external stakeholders by the area of triangle DSN. The social welfare losses of external, outside, and inside stakeholders are ordered downwardly. Optimal conditions with payments imply that the stakeholders of three types are associated with different social welfare losses. The stakeholders of three types obtain differentiated burdens to be solved.

Tanaka (2020) reports that the digital industrial revolution raises $\gamma(y)$ and lowers $\beta(x)$. When $\gamma(y)$ and $\beta(x)$ are assumed as constants, the vertical lengths of triangles, DS, JT and LG, are arranged by changing risk coefficients. Considering that the related social welfare losses are exhibited by the triangles, DSN, JTN and LGN, raising risk coefficients increase payments and lower social welfare losses in the stakeholders of three types. Conditions (3), (4), and (5) imply that payments for external, outside and inside stakeholders satisfy the inequality of $t_i^* > t_i^{**} > t_i^{***} > t_i^{****}$. Initiatives to raise risk coefficients bring different effects for each stakeholder to decline social welfare losses. The results derived from this section are summarized in Proposition 1.



Source: produced by the author.

Figure 1. Social costs of risk.

Proposition 1.

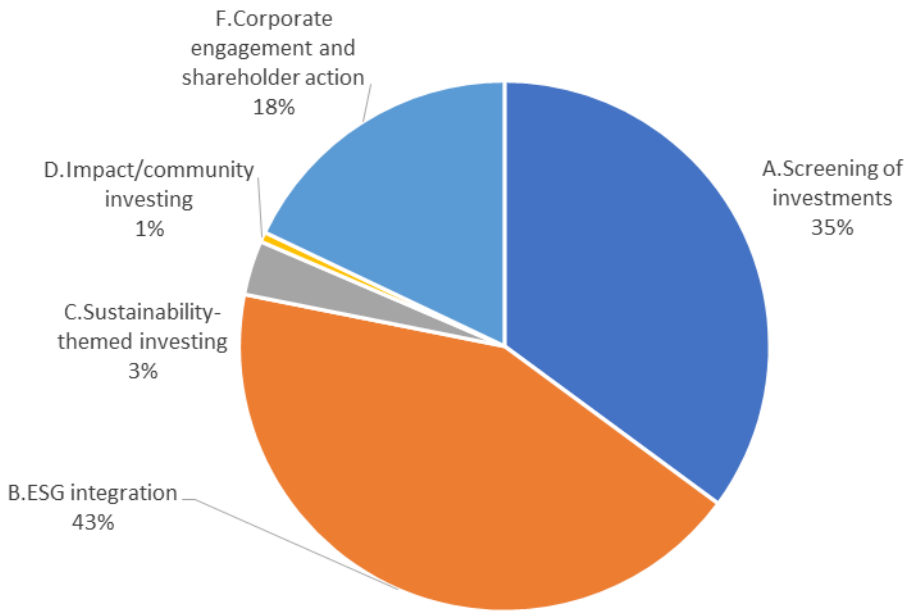
Sustainable investments facilitate initiatives that improve the evaluation of social welfare. Globalizing markets have entailed different degrees of social welfare losses for stakeholders of three types. The initiatives to raise the risk coefficients of all stakeholders improve social welfare by decreasing the loss to each stakeholder. Because social welfare losses are ordered descending such as external, outside, and inside stakeholders, the sustainable investment strategies used to enhance the risk coefficients of the external stakeholders appear to take priority in many situations.

6. Empirical exploration of initiatives of sustainable investment strategies

Section 6 presents the view that sustainability strategies, introduced in Section 4, are used as an influential principle in the field of ESG. Section 5 has explained that the theory of multi-stakeholders creates an important and significant foundation on that principle. This section then proceeds to show that the approach of multi-stakeholders can produce more empirical implications than the principle of sustainability strategies. Because the initiatives tend to indicate particular social reforms, empirical exploration of sustainable investments gives a prospective to the end of social reforms guided by financial innovation. This section describes an empirical inspection of ESG and PRI based on theoretical explorations from Sections 2–5. We initiate empirical investigations by stating the data source of this study. Figures 2 and 3, and Table 1 are produced from data of the Global Sustainable Investment Review 2020 (GSIA). Sustainable investments as defined by the GSIA are calculated collectively worldwide for areas such as Europe, and also the United States, Japan, Canada, Australia, and New Zealand.

The two figures and the table are modified from Figure 7 in the GSIA (2021), according to the classification in section 4. Figure 2 shows the percentage composition of sustainable investing strategies in 2020. Summing up the two terms of A. screening of investments consisting of norms–based screening and negative/exclusionary screening, positive/best–in–class screening, and B. ESG integration presents a large amount of 78% for sustainable investment. That finding implies that enhancement of ESG investments accompanies institutional reforms such as standard, legislation, regulation, and others.

Issues of sustainable communities have increased in the long term. However, the most interested topics of sustainability have alternated since the beginning of the 21st century. Changing targets of sustainability demand new initiatives to resolve difficulties. This paper presents an exploration showing that the digital industrial revolution introduces important difficulties related to sustainable issues. The appearance of new crucially important problems is expected to influence sustainable investment strategies. Figure 3 and Table 1 show that sustainable investments change differently among strategies. It is readily apparent that ESG integration has grown considerably. This investment strategy seeks to obtain a decentralized institutional mechanism to revise increasing social problems such as disruption and climate change issues. Remarkable increases of this investment strategy in recent years exhibit the importance of social reform to construct sustainable communities. Screening of investments is large, but it has remained roughly unchanged. This investment strategy relates to high risk coefficients, meaning that the enhancement of risk coefficients is necessary to support this important initiative for sustainable communities.



Source: Global Sustainable Investment Review 2020.

Figure 2. Percentage of sustainable investing strategies in 2020

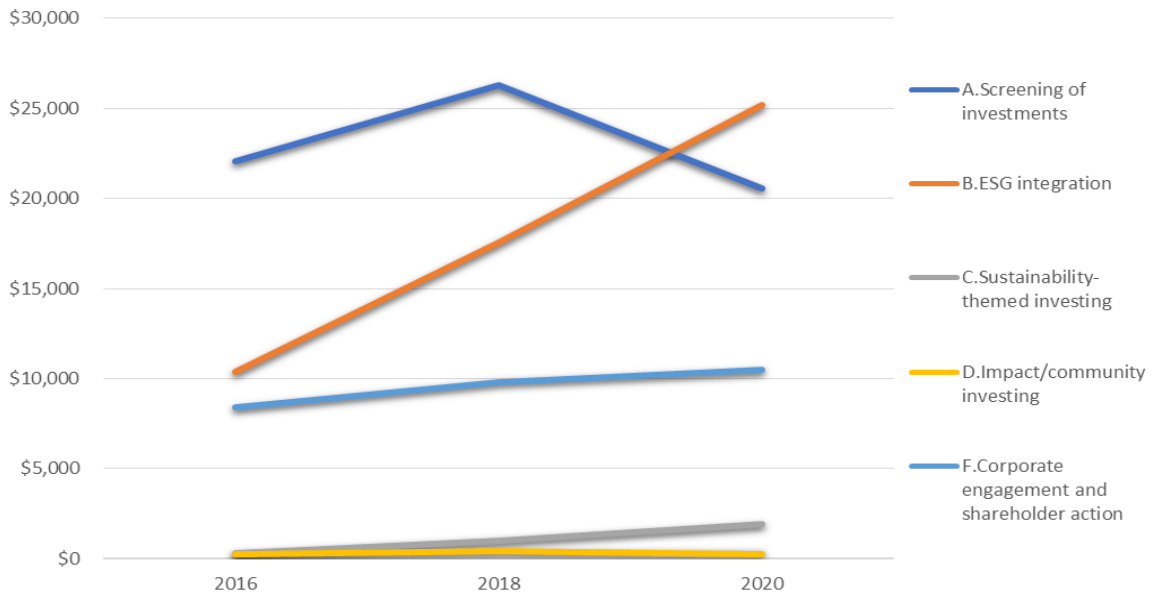
Table 1. Global Growth of Sustainable Investing Strategies 2016-2020.

Investment strategies\years	**2020**	**2018**	**2016**
A. Screening of investments	$20,554	$26,292	$22,077
Norms-based screening	$4,140	$4,679	$6,195
Negative/exclusionary screening	$15,030	$19,771	$15,064
Positive/best-in-class screening	$1,384	$1,842	$818
B. ESG integration	$25,195	$17,544	$10,353
C. Sustainability-themed investing	$1,948	$1,018	$276
D. Impact/community investing	$352	$444	$248
F. Corporate engagement and shareholder action	$10,504	$9,835	$8,385

Source: Global Sustainable Investment Review 2020. (US billion dollars)

Sustainable investment strategies require long-term financial systems to proceed with projects for sustainable communities. Tanaka (2021c) explores that green bond issuance for sustainable communities should improve social welfare by raising the involvement of outside and external stakeholders by comparison with dominant systems of inside stakeholders. Future sustainable investment is expected to emphasize bonds such as green bonds because bonds can establish a scheme to expand cooperative financial systems appropriately. Sustainable green finance complements ESG investments. Figure 4 presents numerical data provided by Bloomberg NEF

(Bloomberg L.P.)[15], showing the growth of sustainable debt worldwide. The definitions of these debts such as green bonds, green loans, social bonds, and sustainability bonds conform to Bloomberg L.P. and differ from those of GSIA. The graph shows only the sustainable debt market from the perspective of the issuer (borrower) and does not include investments such as stocks. Data are of the period, for a region wider than that of the GSIA. It is regarded as effective to regard movements of sustainable investments worldwide.



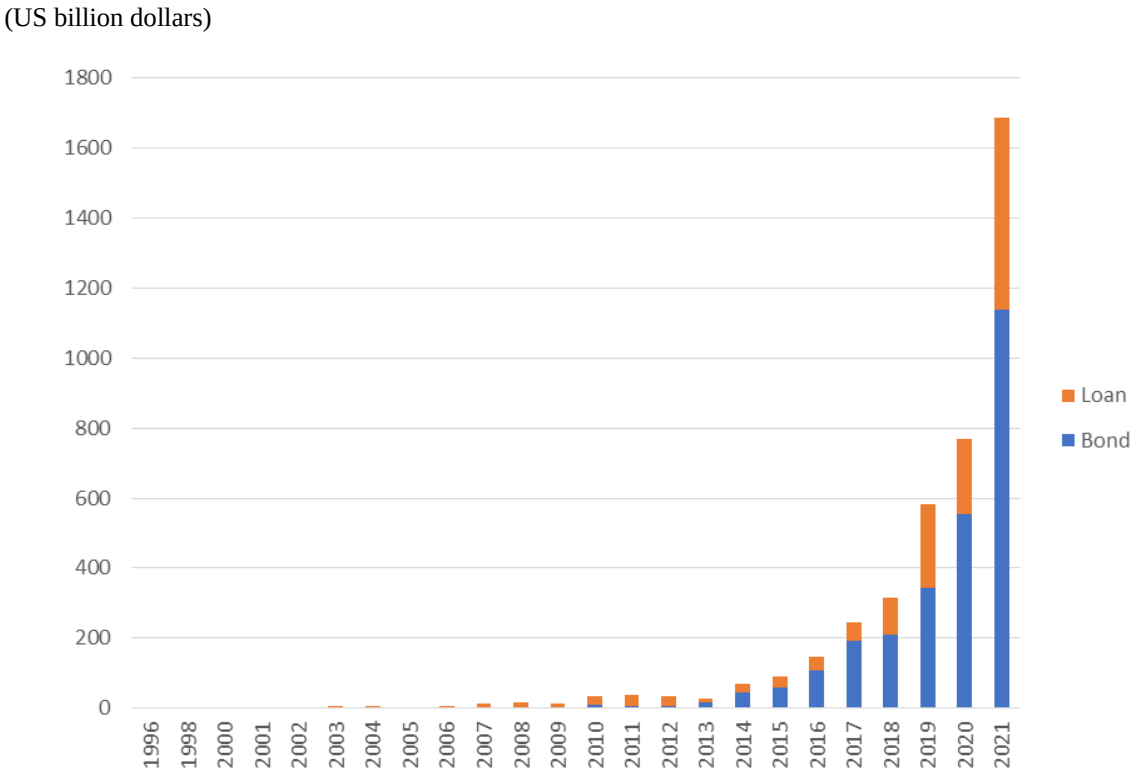
Source: Global Sustainable Investment Review 2020.

Figure 3. Global growth of sustainable investing strategies 2016–2020.

Figure 4[16] shows that sustainable debt growth after 2014 has been remarkable: the growth rate is 25% or more per year. Especially after 2014, bond growth has been more noticeable than that for loans. In general, bonds have more diversity in financing sources than loans. Therefore, stakeholders are becoming more widespread in the real economy and the world economy. Figure 4 implies that the issuance of bonds has developed among diverse communities of multi-stakeholders. This trend is apparent worldwide. Tanaka (2021c) verifies that bond issuance sustainability depends on the development of decentralized communications. Figure 4 presents empirically that sustainable communities have become to need cooperative scheme of multi-stakeholders exemplified by bond issuances. Section 6 concludes that ESG linked with sustainable investment strategies improves cooperative scheme of global finance.

[15] Details of the data can be confirmed from the related page below. Bloomberg Anywhere members can access these data sources and internet pages: https://www.bnef.com/interactive-datasets/2d5d59acd9000026; accessed, 25 March 2022. Data definition and description: User guide for BNEF's sustainable debt tool and sustainability-linked debt tool is available at https://www.bnef.com/interactive-datasets/2d5d59acd9000026/user-guide; accessed, 25 March 2022

[16] The data source has been referred previously in footnote 15.



Source: Bloomberg NEF

Figure 4. Growth of sustainable debt issuance for several decades.

7. Concluding remarks

Sustainable investment strategies improve decentralization of corporative governance in global communities. The digital industrial revolution has decreased communication costs of transactions. Whereas corporations have expanded stakeholders related with market transactions, other stakeholders remain with no benefit of markets. Alternatively, they cannot receive sufficient payments from market transactions. The growth of global economies is spreading negative externalities worldwide. Consequently, over-evaluation of net social benefits occurs. It might lead to diverse difficulties of sustainability such as climate change and disruption of global communities.

A numerical index of social welfare should be explored to resolve numerous and diverse difficulties simultaneously and appropriately. Discussions in earlier sections can be summarized as follows. The optimal conditions of social welfare derived from expression (1) provide theoretical foundations of sustainable investment strategies in ESG. Furthermore, ESG initiatives to improve communication schemes increasingly involve stakeholders and reduce social welfare losses. Enhancement of risk coefficients decreases social welfare losses for stakeholders of all types. However, raising the risk coefficient of external stakeholders presents more effective initiatives to decrease social welfare losses than those of the other inside and outside stakeholders.

Main contributions included in this paper are presented below.

1. A decentralized governance system is presented for global corporations performing centralized systems to contribute sustainable global communities. This article provides a theoretical framework for a corporation to proceed with a decentralized system.

2. Theoretical verification is presented that sustainable investment strategies improve decentralized system. Reforms of legislation and regulations promoted by the investment strategies are evaluated by decreasing social welfare losses in global societies.
3. Although sustainable investment strategies are used empirically as an influential index of ESG, the theoretical framework can explore more difficulties of sustainable communities than the investment strategies. The relative relations among investment strategies are exhibited mathematically.
4. To investigate difficulties of digitalization and community disruption, stakeholders are classified as inside, outside, and external stakeholders. This theoretical framework demonstrates that the risk coefficient and communication indexes are key policy tools for the reduction of social welfare losses.
5. This article demonstrates that the theoretical framework can construct not only a foundation for sustainable investment strategies. It can also provide an important analytical model for sustainability.

Policy implications and further research are stated as described below. After this exploration of the decentralized system to achieve sustainable communities, a theoretical explanation was given for how sustainable investment strategies improve ESG. This theoretical analysis graphically exhibits the effects of parameters in decentralized systems such as risk coefficients, and that efficient communications reduce social welfare losses. This estimation is expected to be applicable for many fields. Global societies have confronted some great crises such as climate change, the Covid 19 pandemic, financial crises, and war in Ukraine. Such a series of global crises demands theoretical methods of risk management. The results presented herein are expected to be applicable for various global crises. Initiatives by which ESG can solve global crises consistently will be pursued in further research in this field.

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Conflict of interest

All authors declare that they have no conflict of interest.

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