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Sustainable Provision of Medical Services with Radiation in Digital Industrial Revolution

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Abstract

Digital Industrial revolution has been promoted mainly by centralized corporations. In digital economies theory of multi stakeholders fucuses on the combination with 3 types of stakeholders; inside, outside and external stakeholders. Digital economies raise the weight of outside stakeholders in the communication scheme, but the evaluation of external stakeholders is underestimated in the system. The disruption among stakeholders in participating the information and communication mechanism brings the social welfare loss in global communities. The centralized mechanism in digital economies propels to raise the scale of production but brings more social welfare losses than the decentralized sustainable mechanism. To achieve sustainable global communities, we should design and develop legislative or institutional initiatives for every stakeholder to improve participation on the communication mechanism. The principle on sustainable communication mechanism is applicable to enhance performance of medical services system with radiology.

Keywords: Disruption; Multi Stakeholders; Sustainable governance; Participation of external stakeholders

Introduction

Innovation of ICT has improved feasibility to proceed with many knowledge and information in a short term. At the same time, simultaneous methods of communication have developed to enlarge global economies and communities. As the participants of the system become to increase, both quality and quantity of knowledge and information in the communication system are expected to enhance. When stakeholders participate the digital communication system, they could obtain benefits of network effects. Development of ICT reforms communication mechanism by facilitating two way communication in local and global communities[1]. Digital industrial revolution induces every stakeholder to contribute on improvement of communication efficiency in the network system.

However, some multinational corporations are dominant in centralized network of global market economies. Digital economies have pursued to grow in the centralized scheme. The centralized system is featured by top down decision mechanism and the corporation mainly fucuses on the concerns related in market transactions. This centralized system brings differences of the intensities in communication between the corporation and stakeholders. This communication system becomes to cause disruption in global and local communities. This paper explores theoretically the social welfare loss occurred by this disruption from the theory of multi stakeholders[2]. Global economies exhibit that the market mechanism cannot prevent social welfare loss from rising. Legislation and regulation are enforced conventionally to decline the significant social welfare loss. The regulatory policies to seek social reform inevitably restrict standards or codes improving sustainable governance of the corporation[3]. This paper explores theoretically the institutional reform for sustainable communities by focusing on structural changes of stakeholders.

Reminding that development of radiology technology are closely related with the digital industrial revolution, the investigation in this paper is applicable for the problems in the field of radiology and medical imaging. The development of radiology does not only enable to enlarge medical stuffs participating project of investigation but also to enhance qualities of medical service by involving specialists with well knowledge. However, the theory of multi stakeholders provides significant implications for reform of medical services with radiation to achieve sustainable governance.

Digitalization and legislative reforms

The preceding explorations of this article are stated as follows. Coase [6] presents a seminal theoretical approach on the contracts between the corporation and stakeholders. Many discussants investigate institutional theories of market and organization[4]. Arrow [10] argues that economic theory should explores problems of corporate social responsibility (CSR). Tirole [11] applies an incentive theory on CSR in view of shareholder value. Since the 1990s the theory of multi stakeholders becomes to be applicable to developing global economies. In Japanese article Tanaka [12] presents the theoretical framework with multi stakeholders to explore CSR. The theory of stakeholders enhances influence on global communities[5]. Stakeholders are classified into inside stakeholders, outside stakeholders and external stakeholders. The theoretical model extends applications toward the fields of sustainable governance in cooperative corporation; Tanaka [15] and in regional vitalization; Tanaka [16-17].

Tanaka [1] argues that a decentralized scheme is necessary to achieve sustainability by solving misallocation of wealth. In 21th century global corporations that dominate digital economies are required to modify centralized system to achieve sustainable communities[6]. This paper explores that the digital economies can

[1] Tanaka[1] discusses that stakeholders in digital economies perform two way communication but that the system of communication is centralized.

[2] Many researches such as Hindman[2], Paus [3] and Baecker[4] explore that the issues of disruption occur in the development of digital economies.

[3] The legal coding of capital is an ingenious process without which the world have never attained the level of wealth that exists today; yet the "process itself has been largely hidden from view." In Pistor [5] p.3.

[4] Willamson [7-9] provides significant consideration on issues of organizations.

[5] Mansell [14] p2 describes that "stakeholder theory plays a valuable role in highlighting the importance of theorizing about the social responsibilities of business and of generating academic debate on this issue."

decrease the social welfare loss by incorporating with a legislative scheme. This reform of governance scheme is demonstrated theoretically to improve sustainability of global communities.

Digital economies have enlarged the scale of stakeholders by propelling development of the communication systems. Many stakeholders become to share the communication scheme and provide voluntary contributions to improve the system. Although voluntary provision of public goods provides theoretical foundation on development of digital communication mechanism, the structure of stakeholders changes in the process of digitalizing economies and societies. Tanaka [19] investigates that outside stakeholder takes the first place, the inside and the external stakeholders are the second and the third places in intensities of the contribution to improve communication[7]. The outside stakeholder leads the development of communication mechanism and digital industrial revolution. A sustainable decentralized scheme could decline distributional problems of payments among inside and outside stakeholders[8]. Figure 2 in Tanaka [19] expresses that the digital industrial revolution promotes to reform inequal payments including three inside, outside and external stakeholders, and to decline the social welfare loses. However, the structural changes including the institution and legislation are necessary to solve inequal distribution of income. We should accurately investigate appropriate social and economic reforms. This paper explores how legislative reforms raise the impact from digitalization of economies to solve the disruption problems.

Sustainable Governance of Digital Economies

The theoretical model of decentralization presented by Tanaka [15] explores the sustainable governance of global communities. Tanaka [17] explains that corporations in digital economies perform centralized governance. Initiatives to seek sustainability develop inevitably decentralized framework of governance. In the process of digital industrial revolution, the decentralized mechanism is supposed to function incompletely. The centralized scheme that dominates digital economies is ensured to bring social welfare losses caused by market and government failures. The legislation and regulation are reformed to improve inclusion of external stakeholders into the corporative governance. To decline social welfare losses, global communities require the corporation to improve performance of governance. By using the following model, theories on multi stakeholders explore how reform of legislation influences social welfare.

Corporation is assumed to perform private profit $\pi(x)$ brought by production x and payment t_i for stakeholder i; $i = 1, \cdots, n$. In communities with multi stakeholders, sustainability of corporation is supposed to depend on the evaluation of stakeholders $V_i(x, t_i)$, for $i = 1, \cdots, n.$. While the corporation could raise net profit cooperatively with the related companies, it should manage many risks such as social and regional environment problems with many residents. To classify stakeholders according to relations with the corporation is an effective method for the theories of multi stakeholders. The stakeholder i that increases its benefit with production x is stated by a positive stakeholder and is defined mathematically by $\frac{\partial V_i}{\partial x} \geq 0$. The stakeholder i decreasing its evaluation of the corporation with x is described by a negative stakeholder and is supposed to satisfy mathematical expression $\frac{\partial V_i}{\partial x} < 0$. Tanaka [12] and [15] demonstrate that sustainable communities are constructed in a decentralized framework. That is, social and economic systems that are composed with communication mechanism and stakeholders structure could exhibit indication of sustainability in global communities. By using advanced digital technologies, corporations in the digital economies are assumed to perform centralized system. Tanaka [12] presents the theoretical model of stakeholders to investigate digital industrial revolution and classifies stakeholders in digital economies into 3 groups; inside stakeholder, outside stakeholder and external stakeholder. By expressing notation mathematically, inside, outside and external stakeholders are denoted by $1, \cdots, n_0; n_0 + 1, \cdots, n_1, and\ n_1 + 1, \cdots, n.$ The system of radiation service is performed with the 3 types of stakeholders. The inside stakeholders have surely provided medical radiation services before the digital industrial revolution. Recently, innovation of ICT has increased largely outside stakeholders connected with the digital network. Rising outside stakeholders are developing medical radiation services industry in a large scale. We should reform the legislation to improve benefits of the external stakeholders who are not included in the network of medical services with radiation.

[6]Tanaka [18-19] explores the structural change of stakeholders brought by the digital industrial revolution.

[7]The expressions (8)-(10) in Tanaka [19] exhibit the relation.

[8]Figure 2 in Tanaka [17] illustrates a comparative analysis between decentralized scheme and digital economies.

Inside stakeholders share relatively stable interests with the corporation. Because they are connected with corporation by basing on common interests, they tend to construct cooperative relation with corporation easily. They are exemplified by regular customers, business partners and employees. As the inside stakeholders are expected to obtain additional benefits beyond the regular market transactions, inside stakeholders are assumed to be featured as positive stakeholders. Outside stakeholders take occasional relation with the corporation and are exemplified by irregular employees and consumers. They obtain benefits in market transactions. They could not obtain privileged network benefits from the production of the corporation but must burden costs to participate in the network of corporation. They are assumed to be negative stakeholders. As gig workers and many of consumers using internets are included in this group, the digital revolution increases the outside stakeholders. Medical services with radiation become more easily available for advanced information and knowledge in digital network. For External stakeholders have not any market transaction with the corporation and do not take any positive benefits in network effect of communication. Enhancing welfare of external stakeholders is appearing more closely related with problems of climate change. The residents who cannot participate in digital networks[9] are external stakeholders. They bring a major cause of disruption of societies.

In the multi stakeholders societies the corporation is assumed to maximize total value of the private net profit and the estimated evaluations of inside and outside stakeholders. The digital communication forms two way scheme between the corporation and stakeholders. The efficiencies of communication with inside and outside stakeholders are expressed by the indexes $\beta(x)$ and $\gamma(y)$. The corporation is supposed to share larger interest with inside stakeholders than with outside stakeholders; $\beta(x) > \gamma(y)$ for any x and y. $\beta(x)$ is supposed to increase connectivity of communication and exhibits rising function of production, $\beta'(x) > 0$. Each stakeholder i offers effort y_i to convey information and knowledge to improve communication. The efficiency of communication is increasing function with total effort $y = \sum_{i=1}^{n} y_i$. As outside stakeholders could raise productivity with enhancing digital environment, the efficiency index satisfies formally the inequality $\gamma'(y) > 0$. The effort y is related with the digital innovation. It is possible that digital revolution brings enhancement of y and transfer of stakeholders from the inside and external into the outside. Although proposition 3 of Tanaka H and C [21] discusses reform of stakeholders, to simplify the analysis this paper explores the behavior of the stakeholders without structural change. The corporation maximizes net benefit written by (1).

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

By differentiating (1) with $x, t_1, \cdots, t_n$, the first order conditions are written by (2), …, (5).

$$\frac{d\pi}{dx} = \sum_{i=1}^{n_0} - \left\{\frac{d\beta(x)}{dx}(V_i(x,t_i) - y_i) + \beta(x)\frac{\partial V_i(x,t_i)}{\partial x}\right\} - \gamma(y)\sum_{i=n_0+1}^{n_1}\frac{\partial V_i(x,t_i)}{\partial x}. \quad (2)$$

$$\frac{\partial V_i(x,t_i)}{\partial t_i} = \frac{1}{\beta(x)}, \quad i = 1, \ldots, n_0. \quad (3)$$

$$\frac{\partial V_i(x,t_i)}{\partial t_i} = \frac{1}{\gamma(y)}, \; i = n_0 + 1, \ldots, n_1. \quad (4)$$

$$t_i = 0, \quad \frac{\partial V_i(x,0)}{\partial t_i} > 0, \quad i = n_1 + 1, \ldots, n. \quad (5)$$

The above expression (5) implies that the external stakeholders do not receive any payment from the corporation. Contrasting that (3) and (4) present inside and outside stakeholders to receive payments, (5) indicates that external stakeholders do not take any payment. The above 3 expressions indicate a problem of disrupting incomes in the digital economies.

Digital Medical Services and Legislation

Tanaka [19] explores that the digital industrial revolution influences distribution of income with enlarging outside stakeholders. This structural change of stakeholders means an indirect effect on disruption by transforming external stakeholders into outside stakeholders. To compensate the market arrangement, this paper investigates the effects of legislations and regulations on economies and societies to improve participation of external stakeholders on communication scheme. Tanaka [12-13] etc. propose the risk term in the theoretical analysis of corporate governance. The stakeholder i takes target $\alpha_i (\geq V_i(x,t_i))$ for the corporation. The stakeholder i is supposed to require the penalty or regulation on the corporation. The penalty on the corporation is exhibited by increasing function φ_i of the gap $\alpha_i - V_i(x,t_i)$. The derivatives of this function satisfy the inequalities $\varphi_i'(\alpha_i - V_i(x,t_i)) > 0\,(\alpha_i - V_i(x,t_i)) > 0$ *and* φ_i''. The corporation expresses voluntarily commitment α_i acceptable for stakeholders or engages duties or codes α_i by contracts

[9]Choudrie, Tsatsou and Kruria,[20] and Hindman [2] exhibit the issues related with external stakeholders.

with them. The function φ_i states increasing penalty on the corporation when the gap is rising.

The corporation coordinated with the mechanism of the sustainable governance changes maximizing expression (1) into (6).

$$NB = \Pi(x) + \beta(x)\sum_{i=1}^{n_0}\{V_i(x,t_i) - y_i\} + \gamma(y)\sum_{i=n_0+1}^{n_1}\{V_i(x,t_i) - y_i\} - t - \sum_{i=n_1+1}^{n}\varphi_i\{\alpha_i - V_i(x,t_i)\}. \quad (6)$$

The first order conditions of differentiation are exhibited by (3), (4),(7) and (8).

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

$$-\sum_{i=n_1+1}^{n}\frac{d\varphi_i}{d(\alpha_i - V_i)}\frac{\partial V_i(x,t_i)}{\partial x}. \quad (7)$$

$$\frac{\partial V_i(x,t_i)}{\partial t_i} = \frac{1}{\frac{d\varphi_i}{d(\alpha_i - V_i)}(\alpha_i - V_i)}, \quad i = n_1 + 1, \ldots, n. \quad (8)$$

In multi stakeholders communities, the corporation is obliged to take commitment α_i formally and informally for each stakeholder i. In particular, α_i shows that codes or standards as well as legislations are expected to bring sustainability in global communities. Expressions (7) and (8) explore the implication of sustainable governance in the digital industrial revolution.

This paper demonstrates that α_i is an efficient index to improve sustainability and disruption of communities. To achieve a guiding index of sustainable governance the corporation adds the third term of the right hand in (7) to the corresponding expression (2). For example, contribution on climate change problems is expected to enhance sustainable governance of the corporation by accompanying an improving evaluation of external stakeholders. In mathematical model, initiatives to increase α_i are supposed to raise $\alpha_i - V_i(x,t_i)$ and $\varphi_i'(\alpha_i - V_i(x,t_i)$. As external stakeholders are classified into the negative stakeholder, rising α_i increases the third term in (7) positively. Effects of α_i are illustrated by using Figure 1 and 2. Firstly, Figure 1 explores the impact of α_i on the production. The right hand of expression (2) exhibits the curve 0I in digital economies. Rising α_i presents the curve 0H including evaluation of external stakeholders. The left hand of (7) expresses that marginal net profits decreasing with x by the curve AJ. Comparing two intersections the curves AJ and 0I and the curves 0H, points C and E indicate that production x^* is greater than x^{**}.

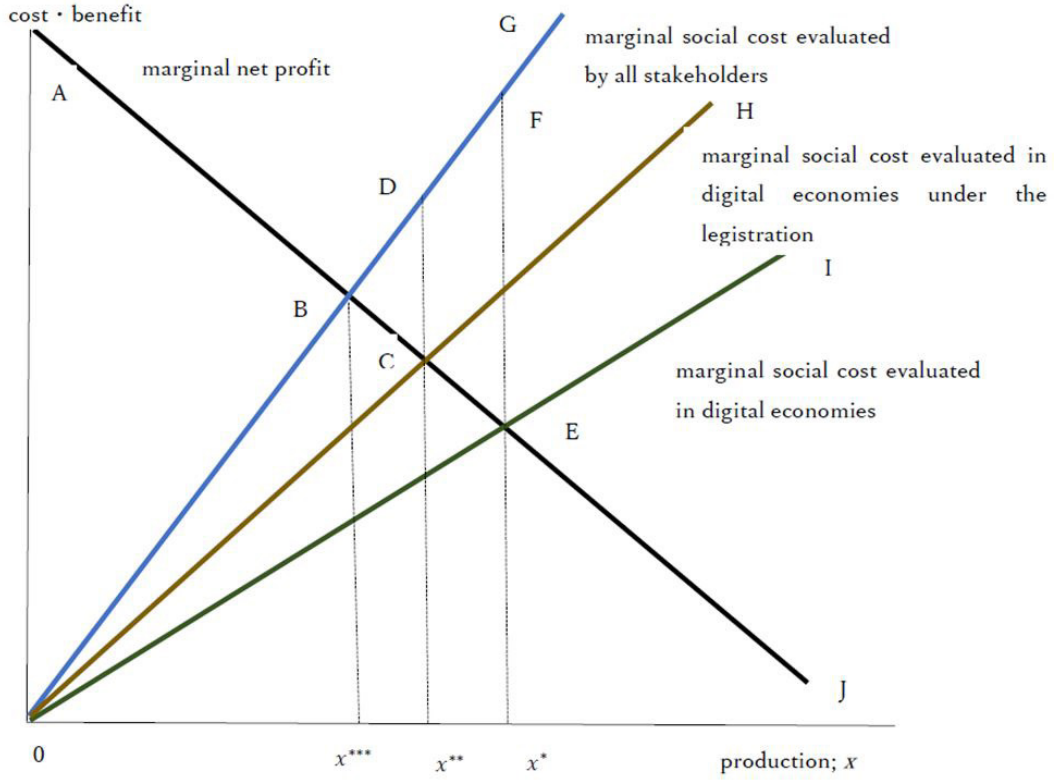

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Figure 1: Legislation and digital economies

It is supposed that marginal social cost evaluated by stakeholders is depicted 0G in Figure 1 and defined by

$$\sum_1^n \frac{\partial V_i}{\partial x}(x, t_i). \quad (9)$$

With comparative analyses of (2), (7) and (9), we explore the effect of social welfare brought by inclusion of external stakeholders. The following assumption 1 states explicitly the implication of the results.

Assumption 1. A close communication between the corporation and inside stakeholders approaches β approximately to 1. However, as the corporation presents looser connection with outside and external stakeholders than the inside stakeholders, the inequalities $1 > \gamma(y) > 0,\ and\ \ 1 > \frac{d\varphi_i}{d(\alpha_i - V_i)} > 0$ are satisfied.

Assumption 1 describes that the curves 0G, 0H, 0I are depicted in descending order. The relation of intersections B,C, E takes the following consequence. The initiatives to improve inclusion of external stakeholders decrease production x* to x** but lower the social welfare loss expressed by the area of the trapezoid DCEF. In the framework of digital revolution, economies grow but decline social evaluation by external stakeholders. The cooperative performance reflecting evaluation of external stakeholders lowers market failures of global economies. This result is explained in Proposition 1. Enforcement of restricting standard and code on radiation services lowers the communication gap between the corporation and external stakeholders. Legislation that the evaluation of external stakeholders is required to regulate governance of the corporation reduces the production but lower the social welfare losses.

Proposition 1. In the digital economies legislations and corporative governance rules are expected to improve inclusion of external stakeholders. This social reform requires restricting production of the corporation but decreases social welfare loses.

Legislation and Disruption

Tanaka [17] demonstrates that (3), (4), and (5) indicate the mechanism to cause income disruption in digital economies. By focusing on efficient index of social system such as transaction cost, Tanaka [22-23] argue that digitalization of economies enlarges outside stakeholders. It is possible that the reform of stakeholders improves the problems of the disruption. However, (5) shows that centralized economies do not bring external stakeholders any payment. Proposition 1 states that reforming governance with legislations and regulations to promote social inclusion of external stakeholders could enhance social welfare. We should explore how sustainable governance could solve problems of disruption. This section demonstrates that initiatives to raise inclusion of external stakeholders improve the problems of disruption.

The society is supposed to bring the scheme that the corporation is forced to communicate with external stakeholders formally and informally. The mathematical framework describes that the corporation makes payments according to (8). Figure 2 illustrates how legislation changes disruption in digitalizing economies. It is assumed that the request of external stakeholder *i* for the corporation is written by α_i. If reform of legislation or regulation could raise α_i, increasing $\frac{d\varphi_i}{d(\alpha_i - V_i)}$ moves the line EF downwardly and shifts the intersection G with the curve CD to raise payment for external stakeholder t_i . Considering that (5) shows payment condition of external stakeholders without legislative institution, the gap t_i^* between points C and G depicts rising incomes brought by effective communication scheme of the corporation with external stakeholders. When many external stakeholders are excluded from the benefits of the digital economies, α_i is estimated by 0 for almost external stakeholder *i*.

Legislative and institutional reforms for sustainable governance are required to present α_i a positive value. Rising the standards or the limits improve inequalities related with problems of external stakeholders.

Proposition 2. By raising risk coefficient institutional coordination is decline inequalities of societies. However, the decentralized mechanism raises altruistic coefficient and improve disruption or inequalities in the external stakeholders.

Tanaka [12-13] and [15] state that sustainable income distribution depends on altruistic and risk coefficients δ[10]. The decentralized mechanism presents the optimal condition

$$\frac{\partial V_i(x, t_i)}{\partial t_i} = \frac{1}{\delta + \frac{d\varphi_i}{d(\alpha_i - V_i)}}, \quad i = n_1 + 1, \ldots, n. \quad (10)$$

with the comparative analysis of digital economies (8). The right hand of expression (10) is exhibited by the line JH in Figure 2. The optimal point G is replaced by the intersection K. The payment for the external stakeholder *i* increases from t_i^* to t_i^{**}. The altruistic coefficient enhanced in the decentralized mechanism could decline inequalities in external stakeholder. While radiology have been greatly developed by increasing outside stakeholders, external stakeholders cannot take enough

[10] Tanaka [15] p.645 expression (3).

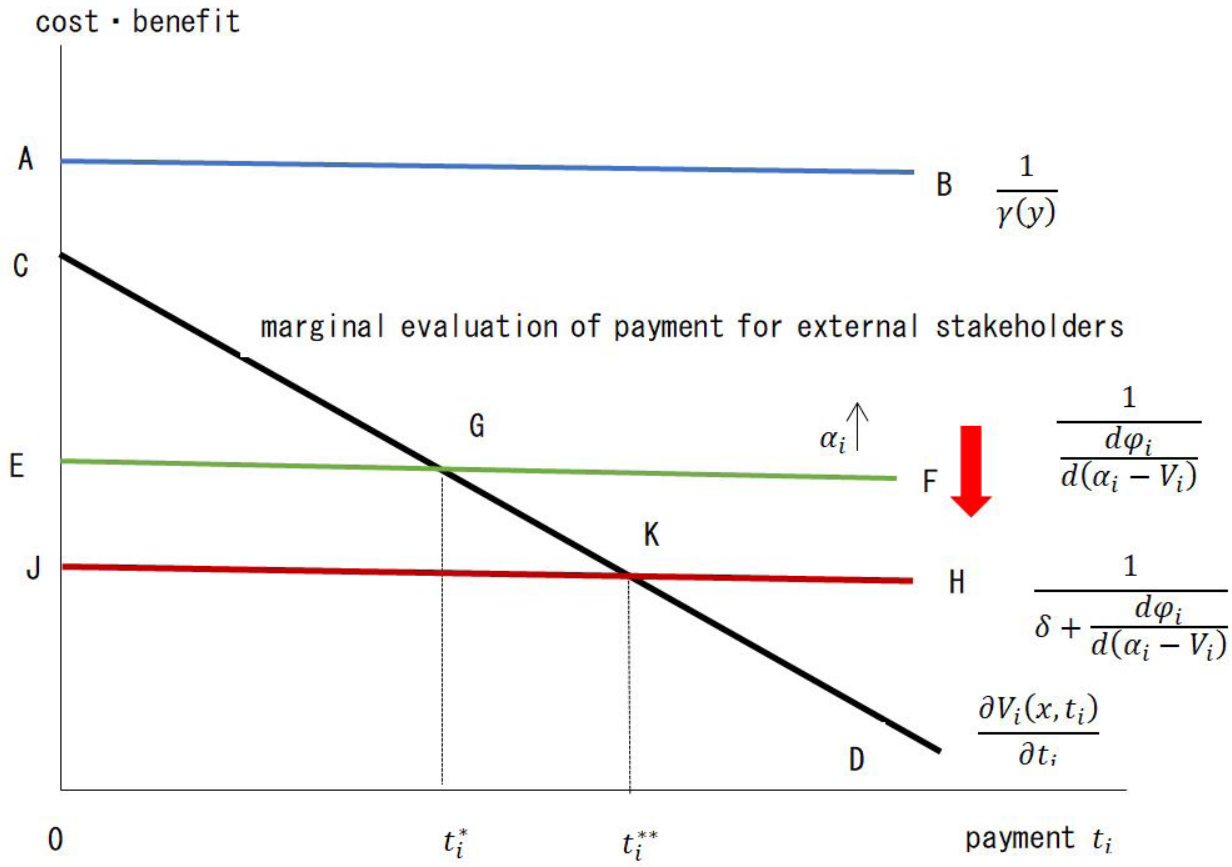

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Figure 2: Disruption and legislation for external stakeholders

benefits from the medical network of advanced technology. The legislation that participates external stakeholders on the medical network brings a complementary payment for the stakeholder *i*.

Conclusion

The digital industrial revolution has developed medical services brought by innovation of radiology. The innovation of digital technologies makes possible to accelerate cooperation with many types of specialists for the medical services. Enlarging activities are digitally transacted in global markets. Many stakeholders become more connected with global markets. By exploring the theory of multi stakeholders, Tanaka [19] discusses that the digital industrial revolution changes the structure of stakeholders. Inside and external stakeholders partially transform into outside stakeholders. It is possible that rising outside stakeholders grow economies and decline income disruption. However, digitalization of economies is not expected to complete transformation of stakeholders. As digitalizing medical services is increasing fixed costs, outside stakeholders should bear rising price for services. The high medical services are not affordable for low incomed residents. Market prices of medical services with radiation bring the external stakeholders who are not connected with the advanced technology of medical radiation services.

The legislation estimates exactly evaluation of external stakeholders so that they can participate market transaction. The corporation should bear additional payments for external stakeholders. Digitalization of medical service elaborates legislation to achieve sustainable communities. The legislation declines overprovision of medical services with radiation.

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