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Green Space Agreement and External Diseconomy: Observation using the Game Theory
緑地協定と外部不経済：ゲーム理論による考察

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緑地保全・形成を促進する有効な手法の 1 つである緑地協定の締結について、提携ゲームを活用し、そのメカニズムについて分析を行った。その結果、緑地協定締結の人数やフリーライダーの人数は、緑地不配慮に伴う外部不経済の大きさ、それに対する行政の課税の実施率、に依存することがわかった。また、それらは、地価と緑地不配慮に伴う外部不経済による地価の下落の度合いにも左右されることも確認された。

Keywords: green space agreement, coalition game, external diseconomy, tax enforcement rate, decline of land price

1. Introduction

Green space is said to provide wind block, fire protection, prevention of soil erosion, dust control, sound insulation, air purification, climate balance, conservation of biodiversity, environmental protection function such as the formation of resource-circulating society and amenity functions such as scenery, space and comfort (e.g. Hoyano and Hagiwara, 1983; Minemura et al., 2002; Tabata, 2011). The interest in green space has risen in Japan since the global effort on sustainable development affected by endeavours such as the Rio Summit (See Ministry of Land, Infrastructure, Transport and Tourism (2014)). This paper focuses on the mechanism of the formation of a green space agreement, which is a tool used to maintain green space and applies the coalition game for the analysis. Since the negligence of green space may cause external diseconomy and affect the decline in land prices (e.g. Hasegawa et al. (2007); Maruyama et al. (1995)), the model takes into consideration the incurrence of such cost. Section 2, presents two propositions from the coalition game of the green space agreement and Section 3 will provide a simple conclusion.

2. Green Space Agreement and the Coalition Game

We will assume a new development site. A green space agreement will be considered by the participants for the conservation and creation of green space. When households plan building with consideration for green space before the construction starts, the cost per unit area is B yen for each household. On the other hand, if construction starts without green space consideration, cost such as from external diseconomy may occur. For example, according to the Broken Windows Theory (Wilson and Kelling, 1982) the deterioration of the environment can have a number of negative impacts such as increased crime, decline in sanitation levels leading to further deterioration of the environment and a decline in land prices. Therefore, the cost from the external diseconomy will be split in two in the analysis. First, there will be the cost of burden to each household considerable to the external diseconomy from the neglect in green space. This is when a Pigovian tax is imposed on each household. The second will be the opportunity cost to each household from the decline in land prices due to green space neglect. These two costs to the households will be calculated based on per unit area and will be assumed to be $\rho T + \delta L$ yen. Here, T will represent the tax imposed on the external diseconomy from green space neglect and p will be the rate of enforceability of the tax by the government and δ will be the rate of decline in land prices effected by green space neglect and L will represent the land price. If we assume that x households built without green space consideration, the cost to rectify this will be $x(\rho T + \delta L)$ yen per unit area for each household.

Next, we will examine the conditions that a green space agreement is formed considering the relationship between the cost of building with green space consideration and the cost when building without.

When $B < \rho T + \delta L$, the cost of building with the advance consideration of green space is less than the cost of not taking green space into consideration, so the household will take green space into consideration when building. Thus, the need for households to form a green space agreement does not exist. When $n(\rho T + \delta L) < B$, even if all the households built without green space consideration, since the cost is cheaper than taking green space into consideration, each household will build without green space consideration. This implies that the cost of taking green space into consideration is too high for each household. In this case, it will also not be necessary to form a green space agreement.

When $\rho T + \delta L < B < n(\rho T + \delta L)$, if a number of households built with green space consideration, the cost may become cheaper, so discussions about green space consideration may occur. Thus, in this case, there is a possibility of a green space

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agreement. Hence, further analysis will be conducted.

Here, the set of players in the coalition game is defined as *N*. The subset of players within the set will be coalition *S* and any other coalition will be represented as *N-S*. In this case, the number of members within coalition *S* will be *s* and the number of members in coalition *N-S* will be *n-s*.

① When both coalition *S* and coalition *N*-S build with green space consideration, the cost to coalition *S* is:

$$E(S) = sB. \tag{1}$$

② When both coalition *S* and coalition *N*-S build with green space consideration, the cost to coalition *N-S* is:

$$E(N-S) = (n-s)B. \tag{2}$$

③ When coalition *S* builds with green space consideration and coalition *N-S* does not, the cost to coalition *S* is:

$$C(S) = s\{B + (n-s)(\rho T + \delta L)\}. \tag{3}$$

④ When coalition *S* builds with green space consideration and coalition *N-S* does not, the cost to coalition *N-S* is:

$$F(N-S) = (n-s)^2(\rho T + \delta L). \tag{4}$$

⑤ When coalition *S* does not build with green space consideration and coalition *N-S* does, the cost to coalition *S* is:

$$F(S) = s^2(\rho T + \delta L). \tag{5}$$

⑥ When coalition *S* does not build with green space consideration and coalition *N-S* does, the cost to coalition *N-S* is:

$$C(N-S) = (n-s)\{B + s(\rho T + \delta L)\}. \tag{6}$$

⑦ When both coalition *S* and coalition *N*-S does not build with green space consideration, the cost to coalition *S* is:

$$D(S) = sn(\rho T + \delta L). \tag{7}$$

⑧ When both coalition *S* and coalition *N*-S does not build with green space consideration, the cost to coalition *N-S* is:

$$D(N-S) = (n-s)n(\rho T + \delta L). \tag{8}$$

When the cost to coalition *S* is greater when coalition *S* builds with green space consideration and coalition *N-S* does not; than the cost to coalition *S* when both coalition *S* and coalition *N-S* do not build with landscape consideration, in other words, when $C(S) > D(S)$, from (3) and (7), $s\{B + (n-s)(\rho T + \delta L)\} > sn(\rho T + \delta L)$ is derived and the following is obtained.

$$\mathrm{s} < {}^{B}/_{(\rho T + \delta L)}. \tag{9}$$

Hence, it suggests that when the number of green space supporters is less than the rate of the cost of building with green space consideration; to the total of the expected tax and decline in land prices from the external diseconomy from building without green space consideration, the green space agreement does not get established.

On the other hand, when the cost to coalition *S* is lesser when coalition *S* builds with green space consideration and coalition *N-S* does not; than the cost to coalition *S* when both coalition *S* and coalition *N-S* do not build with landscape consideration, in other words, when, $C(S) < D(S)$, from (3) and (7), $s\{B + (n-s)(\rho T + \delta L)\} < sn(\rho T + \delta L)$ and $n \geq s$, obtaining the following.

$$n \geq \mathrm{s} > {}^{B}/_{(\rho T + \delta L)}. \tag{10}$$

Proposition 1

When the number of supporters of the green space agreement is greater than the ratio of the total amount of the expected tax considerable to the external diseconomy and the decline in land prices from green space neglect; to the green space considerate building cost, the green space agreement will be formed.

This implies that when the number of supporters of the green space agreement are over a certain level, the green space agreement is formed. It also suggests that the larger the number of supporters of the agreement, the cost to improve the deterioration of the green space per household will be less. Thus, it is understood that the best outcome is a unanimous support of the green space agreement.

Furthermore, if we observe the relationship between each variable and the number of supporters of the green space agreement in results (10), we learn that the cheaper the cost of supporting the agreement, the agreement is able to be formed with less supporters. Moreover, the greater the tax on the external diseconomy due to green space neglect, the agreement is also formed with less supporters. The greater the ability of the government to enforce taxes due to external diseconomy from green space neglect also leads to a green space agreement with less number of supporters. It was also found that the higher the price of land, the agreement is formed with less number of supporters. Finally, it was observed that the greater the decline in land prices due to green space neglect, the less number of supporters required for a green space agreement to be formed.

Next, we will attempt to analyse the conditions of when a universal agreement is not achieved in an area.

Here, we will first assume that a coalition *S* was formed and a green space agreement was established and building with green

space consideration was conducted based on this. The cost to remaining coalition *N-S* to build with green space consideration and the cost to build without will be (2), (4) respectively. $E(N-S) > F(N-S)$, in other words, when the cost for coalition *N-S* to build without green space consideration is less than to build with consideration, then the following is obtained.

$$(n-s)B > (n-s)^2(\rho T + \delta L). \tag{11}$$

(11) can be rewritten as follows.

$$n - s < B/(\rho T + \delta L). \tag{12}$$

Proposition 2

When coalition S, which builds with green space consideration exists and the number of participants in the remaining group N-S is less than the ratio of the cost of greens space considerate building to the total amount of the expected tax considerable to the external diseconomy and the decline in land prices from green space neglect, the remaining group N-S will not form a green space agreement.

From the results above, we learn that there is a case where the cost is cheaper for coalition *S* to build with green space consideration than without and cheaper for coalition *N-S* to build without. In this case, if the green space considerate building by coalition *S* has an impact on the external economy to the area and coalition *N-S* within, coalition *N-S* can be considered a free rider. This suggests that at the border point of $B/(\rho T + \delta L)$, a split is made into a proactive group for green space and a passive group concerning green space consideration.

Furthermore, if we observe each variable and the number of supporters of the green space agreement in results (12), we learn that the capability to host free riders are greater when the cost from the result of the green space agreement is higher. Moreover, when the tax on the external diseconomy due to green space neglect is greater, the ability to host free riders is less. When the government's ability to enforce these taxes are greater, the capacity to host free riders are less. The higher the land prices also limits the free riders as well as the greater the decline in land prices due to green space neglect.

3. Conclusion

With the interest in green space continuing to grow in Japan, this paper uses the coalition game to attempt to analyse the mechanism of the formation of a green space agreement. The model takes into consideration the cost incurred from the expected tax and the possible decline in land prices due to the external diseconomy caused by green space neglect. As a result, the green space agreement is only possible when a certain level of supporters are gained and the most preferable outcome is when the support is unanimous. On the other hand, it was found that the existence of free riders can be the cause of preventing a unanimous support of the green space agreement. Moreover, the number of supporters of the green space agreement and the number of free riders depends on the size of the external diseconomy from green space neglect and the enforceability of taxes by the government. This also affected by land prices and the degree of decline of land prices due to the external diseconomy from the green space neglect.

By taking these observations into consideration the situation of the support of green space agreement and the occurrence of free riders can be understood and may provide insight into future policies concerning green space conservation and development.

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