Game Theory Analysis of Self-Awareness and Politeness

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Abstract

This paper studies human irrational behavior from the perspective of behavioral economics. Through the establishment of a game model, we can understand why people do not seek help from others when they are clearly in trouble. By adding politeness and self-awareness as influencing factors, people's help-seeking and help-giving behavior was clarified by seeking Bayesian Nash equilibrium. As a result, we clarified the relationship between politeness, self-awareness and the willingness of the help seekers as well as the helpers. Specifically, on one hand, from the perspective of the help seekers, we can distinguish people who are likely to seek help from who are unlikely to seek help. On the other hand, from the perspective of helpers, we can distinguish people who are likely to help from who are unlikely to help others.

Keywords: Game Theory; Bayesian Nash equilibrium; Self-awareness; Politeness; Behavioral economics

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1. Introduction

This study explores the psychological mechanism of human help-seeking and help-giving behavior based on game theory. Take Japanese society as an example, living in Japan, the Japanese often refuse to ask for help. One important reason is politeness. In order not to make trouble for others, Japanese people treat others politely. However, if help seekers care about making trouble for others too much, it's hard to seek for help (Bendixsen & Wyller, 2019; Martochhio, 2005). On the other hand, from the aspect of helpers, helpers will feel sympathy for help seekers when they are asked for help, so they would decide to help or not immediately (Bohns & Flynn, 2015). Besides, self-awareness is also an important reason why help seekers can be embarrassed (Barbee, Rowatt & Cunningham, 1996). In this study, self-awareness is to speculate about what others think of themselves. In other words, people with strong self-awareness would care too much about others' opinions. People with low self-awareness would less likely care about what others think. In order not to be looked down upon by others, help seekers with strong self-awareness are relatively difficult to send a signal. For the same reason, in order not to be looked down upon by others, helpers with strong self-awareness may help others forcibly if they are asked. Hashimoto (2015) stated that there are two reasons to explain: the first reason why help seekers do not ask is that if their help-seeking is low yield and high cost to helpers, help seekers would also have negative emotions such as debt and apology. This politeness as human nature will affect people's help-seeking behavior. The second reason is that if help seekers accept helper's assistance, they're afraid they won't be able to repay and being ungrateful, so they have to suppress their request in advance. From a game theory perspective, this study does not consider the action of future recompense and only analyzes from the nature of self-awareness. We assume that people with self-awareness should care about how others think of themselves, and can thus affect their help-seeking behavior accordingly.

The research objective of this study is as follows: On one hand, from the perspective of the help seekers, it is important to distinguish people who are likely to seek help from who are unlikely to seek help. On the other hand, from the perspective of helpers, it is also important to distinguish people who are likely to help from who are unlikely to help others. This study is thus expected to make important contributions by analyzing human help-seeking and giving behavior from the aspects of politeness and self-awareness. We would be able to clarify the relationship between politeness, self-awareness and the willingness of the help seekers as well as the helpers. Consequently, to fulfill the objectives of the study, we first set up the game theory model. After that, we find the Bayesian Nash equilibrium. Finally, the results of equilibrium are summarized.

2. Model

In this study, we firstly established a game model, which is given by Harsanyi (1967) and adopted by many researchers, such as Myatt & Wallace (2004); Huang & Zhu (2020).

The characters on the stage are player A as a help-seeker and player B as a helper. A can be people with the low ability signed as L or high ability signed as H. Player B can also be people with the low ability or high ability. The utility function of each player is:

$$U = U_1 + U_2 + U_3$$

U_1 is the utility of the actual cost paid. U_1 is related to the basic cost c and the ability cost of that player, thus, $U_1 = -ac$; from player A's point of view, if player B does not help him, he has to work on it by himself, that is $U_{A1} = -a_A c$; If Player B helps, he can do it without effort, that is $U_{A1} = 0$; from player B's point of view, if he helps player A, he has to make his own efforts, that is $U_{B1} = -a_B c$; If he does not help, he does not have to make effort, that is $U_{B1} = 0$. The player with high ability cost less; on the contrary, the player with low ability cost more.

U_2 is the utility of self-awareness, which is related to the degree of self-awareness , represented by α, and the speculation about how others think of himself, represented by $E(a)$. Thus, $U_2 = -\alpha[E(a) - a]$. $E_B\left(a_{A-Seek}\right)$ means player B speculates on A's ability when player A seeks for help; $E_B\left(a_{A-Not\ seek}\right)$ means player B speculates on player A's ability when player A doesn't seek for help; $E_A\left(a_{B-Help}\right)$ means player A speculates on player B's ability when player B helps; $E_A\left(a_{B-Not\ help}\right)$ means player A speculates on player B's ability when player B doesn't help. U_3 is the effect of politeness, and the degree of politeness β (0 < β < 1) is related to the basic cost and his actual ability, thus, $U_3 = -\beta ca$.

Player A's utility in seeking help is:

$$U_{A-Seek} = -\alpha_A\left[E_B\left(a_{A-Seek}\right) - a_A\right] - \beta_A ca_B$$

Player A's utility when he doesn't seek help is:

$$U_{A-Not\ seek} = -a_A c - \alpha_A\left[E_B\left(a_{A-Not\ seek}\right) - a_A\right]$$

The utility of player B's help is:

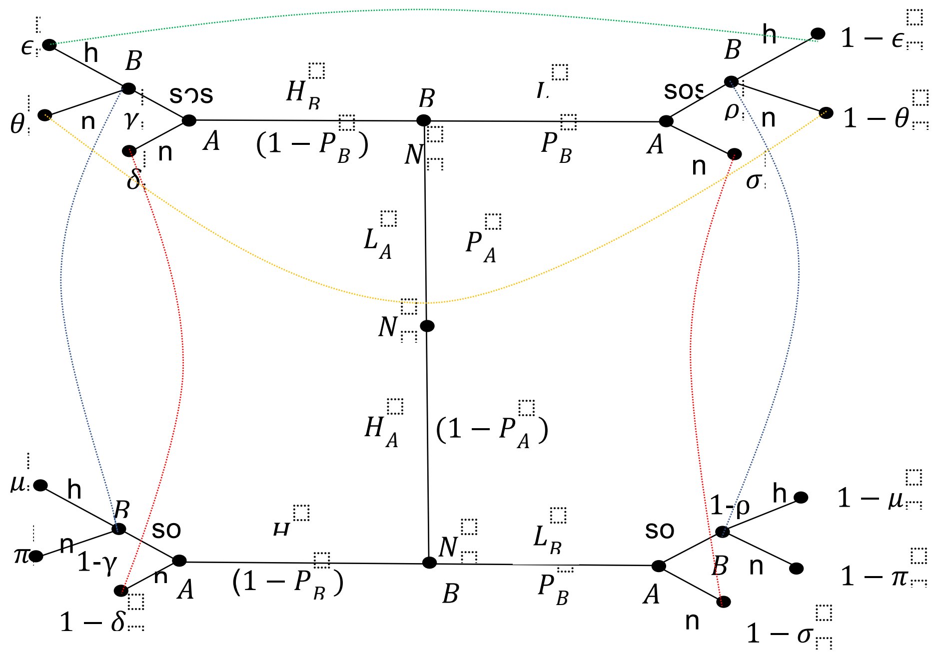
$$U_{B-Help} = -a_B c - \alpha_B\left[E_A\left(a_{B-Help}\right) - a_B\right]$$

The utility of player B without help is:

$$U_{B-Not\ help} = -\alpha_B\left[E_A\left(a_{B-Not\ help}\right) - a_B\right] - \beta_B ca_A$$

When the difference between the ability predicted by others and his actual ability is positive, it is α_1; and when it is negative, it becomes α_2. The relationship between α_1 and α_2 is $0 < \alpha_1 < \alpha_2$ as follows:

Nature enters twice in this game. The game tree is as follows:



The probability of L_A with high ability is P_A; The probability of H_A with low ability is $(1-P_A)$; L_A's probability of seeking help is q; its probability of not seeking help $1-q$; The probability of H_A's help-seeking is q'; Its probability of not seeking for help is $1-q'$. Let the probability of L_A be P_A, the probability of H_A be $(1-P_A)$. Let the probability of L_B be P_B, the probability of H_B be $(1-P_B)$. The probability of L_B giving help is r', its probability of not help is $1-r'$. The probability of H_B giving help is r, its probability of not help is $1-r$. Thus, the belief of player A and B at each point is:

$$\gamma = \frac{(1-P_B)qP_A}{qP_A\left(1-P_B\right)+q'\left(1-P_B\right)(1-P_A)} = \frac{qP_A}{qP_A+q'(1-P_A)} \quad、\quad 1-\gamma = \frac{q'(1-P_A)}{qP_A+q'(1-P_A)} \quad、$$

$$\rho = \frac{P_B qP_A}{qP_A P_B+q'P_B(1-P_A)} = \frac{qP_A}{qP_A+q'(1-P_A)} \quad、\quad 1-\rho = \frac{q'(1-P_A)}{qP_A+q'(1-P_A)} \quad、$$

$$\varepsilon = \frac{(1-P_B)qP_A r}{qP_A\left(1-P_B\right)r+qP_B P_A r'} = \frac{(1-P_B)r}{\left(1-P_B\right)r+P_B r'} \quad、\quad 1-\varepsilon = \frac{P_B r'}{\left(1-P_B\right)r+P_B r'} \quad、$$

$$\mu = \frac{(1-P_B)(1-P_A)q'r}{q'\left(1-P_B\right)(1-P_A)r+q'P_B(1-P_A)r'} = \frac{(1-P_B)r}{\left(1-P_B\right)r+P_B r'} \quad、\quad 1-\mu = \frac{P_B r'}{\left(1-P_B\right)r+P_B r'} \quad、$$

$$\theta = \frac{(1-P_B)P_A q(1-r)}{q\left(1-P_B\right)P_A(1-r)+qP_B P_A(1-r')} = \frac{(1-P_B)(1-r)}{\left(1-P_B\right)(1-r)+P_B(1-r')} \quad、\quad 1-\theta = \frac{P_B(1-r')}{\left(1-P_B\right)(1-r)+P_B(1-r')} \quad、$$

$$\pi = \frac{(1-P_B)(1-P_A)q'(1-r)}{q'\left(1-P_B\right)(1-P_A)(1-r)+q'P_B(1-P_A)(1-r')} = \frac{(1-P_B)(1-r)}{\left(1-P_B\right)(1-r)+P_B(1-r')}、1-\pi = \frac{P_B(1-r')}{\left(1-P_B\right)(1-r)+P_B(1-r')}、$$

$$\delta = \frac{(1-q)P_A\left(1-P_B\right)}{(1-q)P_A\left(1-P_B\right)+(1-q')\left(1-P_B\right)(1-P_A)} = \frac{(1-q)P_A}{(1-q)P_A+(1-q')(1-P_A)} \quad、$$

$$1-\delta = \frac{(1-q')\left(1-P_B\right)(1-P_A)}{(1-q)P_A\left(1-P_B\right)+(1-q')\left(1-P_B\right)(1-P_A)} = \frac{(1-q')(1-P_A)}{(1-q)P_A+(1-q')(1-P_A)}$$

Therefore, if player A seeks for help, player B is in two situations: help and not help. Take the utility of player A when player B helps as U_{AseekO}, and the utility of player A when player B doesn't help A as U_{AseekX}. Thus,

$$U_{A-SeekO} = -\alpha_A\left[E_B\left(a_{A-Seek}\right)-a_A\right]-\beta_A c a_B$$

$$U_{A-SeekX} = -a_A c - \alpha_A \left[E_B\left(a_{A-Seek}\right) - a_A\right]$$

Player A's utility is:

$$U_{A-Seek} = P_B \left[r' U_{A-SeekO} + (1-r')U_{A-SeekX}\right] +$$
$$(1-P_B)[rU_{A-SeekO} + (1-r)U_{A-SeekX}]$$

$$U_{A-Not\ seek} = -a_A c - \alpha_A \left[E_B\left(a_{A-Not\ seek}\right) - a_A\right]$$

In the case of H_A with high ability:

$$\left[E_B\left(a_{A-Seek}\right) - H_A\right] = \left(1-P_B\right)\left[L_A\gamma + H_A(1-\gamma)\right] + P_B\left[L_A\rho + H_A(1-\rho)\right] - H_A$$

$$= \left[L_A\gamma + H_A(1-\gamma)\right] - H_A > 0$$

$$\left[E_B\left(a_{A-Not\ seek}\right) - H_A\right] = \left(1-P_B\right)\left[L_A\delta + H_A(1-\delta)\right] + P_B\left[L_A\sigma + H_A(1-\sigma)\right] - H_A$$

$$= \left[L_A\delta + H_A(1-\delta)\right] - H_A > 0$$

Therefore, α_A of both parties is α_{A1}. Player A's utility in seeking help is:

$$U_{A-Seek} = P_B\left[r' U_{A-SeekO} + (1-r')U_{A-SeekX}\right]$$
$$+(1-P_B)[rU_{A-SeekO} + (1-r)U_{A-SeekX}]$$
$$= [P_B r' + (1-P_B)r]U_{A-SeekO} + [P_B(1-r') + (1-P_B)(1-r)]U_{A-SeekX}$$
$$= [P_B r' + \left(1-P_B\right)r]\{-\alpha_{A1}\left[\left[L_A\gamma + H_A(1-\gamma)\right] - H_A\right] - \beta_A c a_B\} + [P_B(1-r')$$
$$+\left(1-P_B\right)(1-r)]\{-cH_A - \alpha_{A1}\left[\left[L_A\gamma + H_A(1-\gamma)\right] - H_A\right]\}$$

Player A's utility when he doesn't seek for help is:

$$U_{A-Not\ seek} = -a_A c - \alpha_A \left[E_B\left(a_{A-Not\ seek}\right) - a_A\right]$$

$$= -H_A c - \alpha_{A1} \left[\left[L_A \, \delta + H_A \left(1-\delta\right) \right] - H_A \right]$$

In the case of L_A with low ability:

$$\left[E_B \left(a_{A-\text{seek}} \right) - L_A \right] = \left(1 - P_B\right) \left[L_A \, \gamma + H_A \left(1-\gamma\right) \right] + P_B \left[L_A \, \rho + H_A \left(1-\rho\right) \right] - L_A$$

$$= \left[L_A \, \gamma + H_A \left(1-\gamma\right) \right] - L_A < 0$$

$$\left[E_B \left(a_{A-Not\ seek} \right) - H_A \right] = \left(1 - P_B\right) \left[L_A \, \delta + H_A \left(1-\delta\right) \right] + P_B \left[L_A \, \sigma + H_A \left(1-\sigma\right) \right] - L_A$$

$$= \left[L_A \, \delta + H_A \left(1-\delta\right) \right] - L_A < 0$$

Therefore, α_A of both parties are α_{A2}. When player A seeks for help, the utility is:

$$U_{A-Seek} = P_B \left[r' U_{A-SeekO} + \left(1-r'\right) U_{A-SeekX} \right]$$

$$+ (1 - P_B)[r U_{A-SeekO} + (1-r) U_{A-SeekX}]$$

$$= [P_B \, r' + (1 - P_B) r] U_{A-SeekO} + [P_B \left(1 - r'\right) + (1 - P_B)(1-r)] U_{A-SeekX}$$

$$= [P_B \, r' + \left(1 - P_B\right) r]\{-\alpha_{A2} \left[\left[L_A \, \gamma + H_A \left(1-\gamma\right) \right] - L_A \right] - \beta_A c a_B\} + [P_B \left(1 - r'\right)$$

$$+ \left(1 - P_B\right)\left(1-r\right)]\{-c L_A - \alpha_{A2} \left[\left[L_A \, \gamma + H_A \left(1-\gamma\right) \right] - L_A \right]\}$$

Player A's utility when he doesn't seek for help is:

$$U_{A-Not\ Seek} = -L_A c - \alpha_{A2} \left[\left[L_A \, \delta + H_A \left(1-\delta\right) \right] - L_A \right]$$

In the case of H_B with high ability:

$$\left[E_A \left(a_{B-Help} \right) - a_B \right] = P_A \left[L_B \left(1-\varepsilon\right) + H_B \, \varepsilon \right] + \left(1 - P_A\right) \left[L_B \left(1-\mu\right) + H_B \, \mu \right] - H_B$$

$$= L_B \left(1-\varepsilon\right) + H_B \, \varepsilon - H_B > 0$$

$$\left[E_A \left(a_{B-Not\ help} \right) - H_B \right] = P_A \left[L_B \left(1-\theta\right) + H_B \, \theta \right] + \left(1 - P_A\right) \left[L_B \left(1-\pi\right) + H_B \, \pi \right] - H_B$$

$$= L_B\left(1-\theta\right) + H_B\,\theta - H_B\ > 0$$

Therefore, α_B of both parties are α_{B1}. At this time, the utility of player B when he helps is:

$$U_{B-Help} = -H_B c - \alpha_{B1}\left[E_A\left(a_{B-Help}\right) - H_B\right]$$
$$= -H_B c - \alpha_{B1}[\,L_B\,(1-\varepsilon) + \varepsilon H_B\ - H_B\,]$$

The utility of player B when he doesn't help is:

$$U_{B-Not\ help} = -\alpha_{B1}\left[E_A\left(a_{B-Not\ help}\right) - H_B\right] - \beta_B c a_A$$

$$= -\alpha_{B1}\left[L_B\,(1-\theta) + H_B\,\theta - H_B\right] - \beta_B c a_A$$

In the case of L_B:

$$\left[E_A\left(a_{B-\mathrm{help}}\right) - a_B\right] = P_A\left[L_B\left(1-\varepsilon\right) + H_B\,\varepsilon\right] + \left(1-P_A\right)\left[L_B\left(1-\mu\right) + H_B\,\mu\right] - L_B$$
$$= L_B\left(1-\varepsilon\right) + H_B\,\varepsilon - L_B\ < 0$$

$$\left[E_A\left(a_{B-no\quad help}\right) - a_B\right] = P_A\left[L_B\left(1-\theta\right) + H_B\,\theta\right] + \left(1-P_A\right)\left[L_B\left(1-\pi\right) + H_B\,\pi\right] - L_B$$

$$= L_B\left(1-\theta\right) + H_B\,\theta - L_B\ < 0$$

Therefore, α_B of both parties are α_{B1}. At this time, the utility of player B when he helps is:

$$U_{B-Help} = -L_B c - \alpha_{B2}\left[E_A\left(a_{B-Help}\right) - L_B\right]$$
$$= -L_B c - \alpha_{B2}[\,L_B\,(1-\varepsilon) + \varepsilon H_B\ - L_B\,]$$

The utility of player B when he doesn't help is:

$$U_{B-Not\ help} = -\alpha_{B2}\left[E_A\left(a_{B-Not\ help}\right) - L_B\right] - \beta_B c a_A$$

$$= -\alpha_{B2}\left[L_B\,(1-\theta) + H_B\,\theta - L_B\right] - \beta_B c a_A$$

3. Equilibrium Analysis

Now let's analyze the equilibrium. For player A and player B, when they decide their strategy, because they would select the strategy with larger utility, thus we should compare the difference of the utility of players' different selection.

In the case of H_B :

$$U_{B-Help} - U_{B-Not\ help}$$

$$= -H_B c - \alpha_{B1}\left[L_B\,(1-\varepsilon) + H_B\,\varepsilon - H_B \right] + \alpha_{B1}\left[L_B\,(1-\theta) + H_B\,\theta - H_B\right] + \beta_B c a_A$$

$$= \alpha_{B1}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - H_B)$$

In the case of L_B :

$$U_{B-Help} - U_{B-Not\ help}$$

$$= -L_B c - \alpha_{B2}\left[E_A\left(a_{B-Help}\right) - L_B\right] + \alpha_{B2}\left[E_A\left(a_{B-Not\ help}\right) - L_B\right] + \beta_B c a_A$$

$$= -L_B c - \alpha_{B2}\left[L_B\,(1-\varepsilon) + H_B\,\varepsilon - L_B\right] + \alpha_{B2}\left[L_B\,(1-\theta) + H_B\,\theta - L_B\right] + \beta_B c a_A$$

$$= \alpha_{B2}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - L_B)$$

In the case of H_A :

$$U_{A-Seek} - U_{A-Not\ Seek}$$

$$= [P_B\,r' + \left(1 - P_B\right)r]\{-\alpha_{A1}\left[\left[L_A\,\gamma + H_A\,(1-\gamma)\right] - H_A\right] - \beta_A c a_B\} + [P_B\left(1 - r'\right)$$

$$+ \left(1 - P_B\right)(1-r)]\left\{-cH_A - \alpha_{A1}\left[\left[L_A\,\gamma + H_A\,(1-\gamma)\right] - H_A\right]\right\}$$

$$+ H_A c + \alpha_{A1}\left[\left[L_A\,\delta + H_A\,(1-\delta)\right] - H_A\right]$$

$$= -\alpha_{A1}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B\,r' - P_B\,r\right)c(H_A - \beta_A a_B)$$

In the case of L_A :

$$U_{A-Seek} - U_{A-Not\ seek}$$

$$= [P_B\,r' + \left(1 - P_B\right)r]\{-\alpha_{A2}\left[\left[L_A\,\gamma + H_A\,(1-\gamma)\right] - L_A\right] - \beta_A c a_B\} + [P_B\left(1 - r'\right)$$

$$+ \left(1 - P_B\right)(1-r)]\left\{-cL_A - \alpha_{A2}\left[\left[L_A\,\gamma + H_A\,(1-\gamma)\right] - L_A\right]\right\} + L_A c$$

$$+\alpha_{A2}\left[\left[L_A\,\delta + H_A\,(1-\delta)\right] - L_A\right]$$

$$= -\alpha_{A2}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B\,r' - P_B\,r\right)c(L_A - \beta_A a_B)$$

Player belief:

$$\varepsilon = \frac{\left(1 - P_B\right)r}{\left(1 - P_B\right)r + P_B\,r'}、\theta = \frac{\left(1 - P_B\right)(1-r)}{}、\rho = \gamma = \frac{qP_A}{qP_A + q'\left(1 - P_A\right)}、$$

$$\delta = \frac{(1-q)P_A}{(1-q)P_A + (1-q')\left(1 - P_A\right)}、$$

Furthermore, B with high ability can expect A's ability as $a_A = \gamma\,L_A + (1-\gamma)\,H_A$ .The ability of B with low ability can expect A's ability as $a_A = \rho\,L_A + (1-\rho)\,H_A$ We thus substitute them into utility function. In addition, Player A with either the high ability or low ability would decide to seek help or not, player B with either the high ability or low ability would decide to help or not. When player A is helped by player B with high ability, r = 1; when player B with high ability doesn't help, r = 0; when player B with low ability helps, $r' = 1$; when player B with low ability doesn't help, $r' = 0$ When player A with low ability seek for help, q = 1; when player A with low ability doesn't seek for help, q = 0; when player A with high ability seeks for help $q' = 1$, when player A with high ability doesn't seek for help $q' = 0$. In summary, there are situations including $r = 1, r = 0, r' = 1, r' = 0, q = 1, q = 0, q' = 1, q' = 0$. As a result, there are 16 combinations. According to calculating there are nine equilibriums. The following section will discuss these equilibriums.

The first equilibrium is: H_B help; L_B not help; L_A seek; H_A not seek

① $r = 1, r' = 0, q = 1, q' = 1$

In the case of H_B:

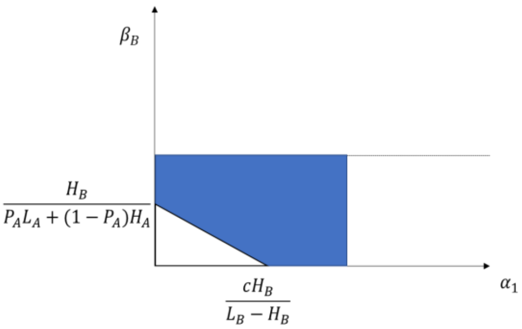
$$U_{B-Help} - U_{B-Not\,help} = \alpha_{B1}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - H_B)$$

$$= \alpha_{B1}(L_B - H_B) + c(\beta_B\,[\,P_A\,L_A + \left(1 - P_A\right)H_A\,] - H_B)$$

In order to meet the condition $U_{B-Help} - U_{B-Not\,help} > 0$, there must be:

$$\beta_B > -\alpha_{B1}\frac{\left(L_B - H_B\right)}{c[P_A L_A + \left(1 - P_A\right)H_A]} + \frac{H_B}{[P_A L_A + \left(1 - P_A\right)H_A]}$$

The relationship between β_B and α_{B1} is shown in the following figure:



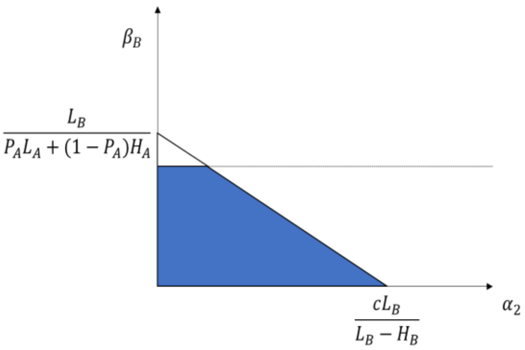
In the case of L_B:

$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B2}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - L_B)$$
$$= \alpha_{B2}(L_B - H_B) + c(\beta_B a_A - L_B)$$

In order to meet the condition $U_{B-\text{help}} - U_{B-\text{not help}} < 0$, there must be:

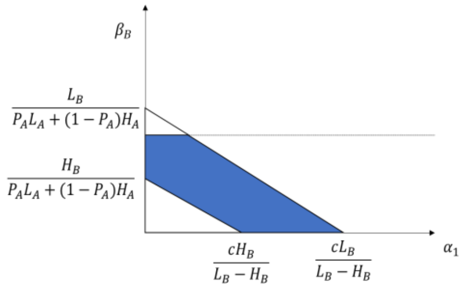
$$\beta_B < -\alpha_{B2}\frac{\left(L_B - H_B\right)}{c[P_A L_A + \left(1 - P_A\right)H_A]} + \frac{L_B}{P_A L_A + \left(1 - P_A\right)H_A}$$

The relationship between β_B and α_{B2} is shown in the following figure:



Next, let $H_B = H_A, L_B = L_A, P_B = P_A, \alpha_{B1} = \alpha_{A1} = \alpha_1, \alpha_{B2} = \alpha_{A2} = \alpha_2, \beta_A = \beta_B$. In this case, set the difference between α_1 and α_2 to ξ. Thus, $\alpha_2 - \alpha_1 = \xi$. Because player B must meet the conditions of H_B and L_B, we thus find the union set of H_B and L_B. To put the two figures above together, we must distinguish between occasions between $\frac{cL_B}{L_B - H_B} - \xi > \frac{cH_B}{L_B - H_B}$ as case 1_B and $\frac{cL_B}{L_B - H_B} - \xi < \frac{cH_B}{L_B - H_B}$ as case 2_B. At this point:

Case 1_B: Case 2_B: $\emptyset$

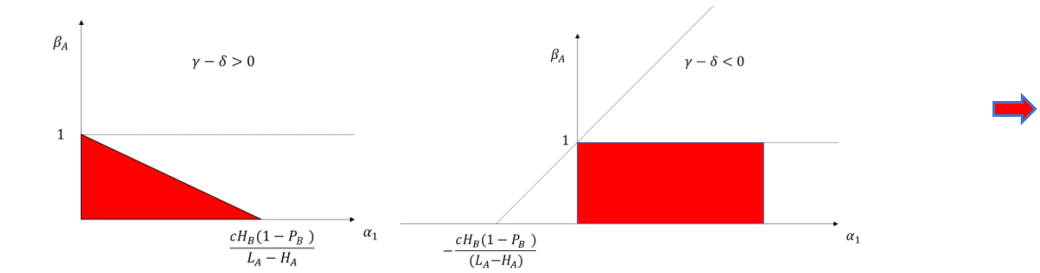


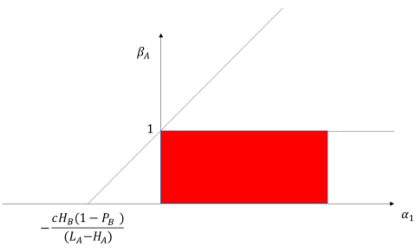
In the case of H_A

$$U_{A-Seek} - U_{A-Not\ seek}$$
$$= -\alpha_{A1}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B\, r' - P_B\, r\right) c(H_A - \beta_A a_B)$$
$$= -\alpha_{A1}(\gamma - \delta)\left(L_A - H_A\right) + (1 - P_B) c(H_A - \beta_A H_B),$$

Therefore, in order to meet the condition $U_{A\text{-Seek}} - U_{A\text{-Not seek}} > 0$, there must be:

$\beta_A < -\alpha_{A1} \frac{(\gamma - \delta)\left(L_A - H_A\right)}{cH_B (1 - P_B)} + \frac{H_A}{H_B}$. Because there are $(\gamma - \delta) > 0$and $(\gamma - \delta) < 0$, The relationship between β_A and α_{A1} is shown in the following figure:





In the case of L_A

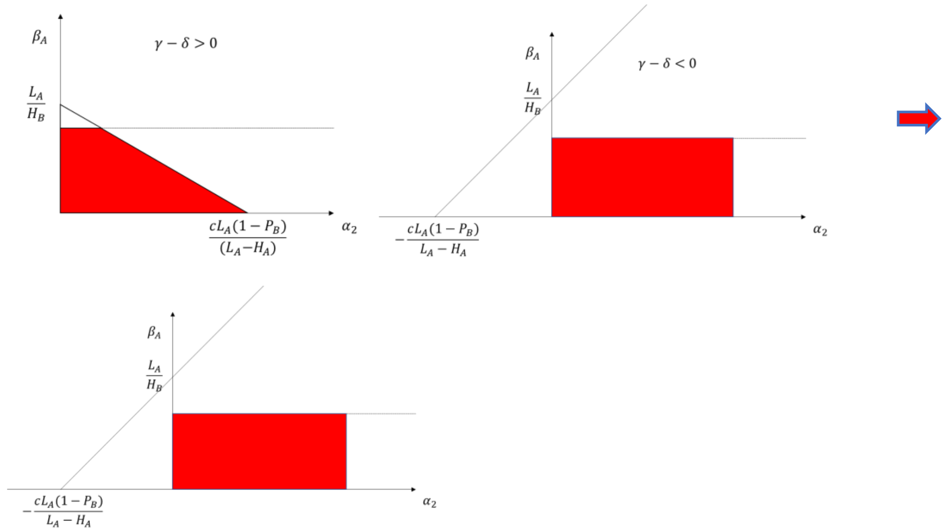
$$U_{A-Seek} - U_{A-Not\ seek} = -\alpha_{A2}(\gamma - \delta)\left(L_A - H_A\right) + \left(1 - P_B\right) c(L_A - \beta_A a_B)$$
$$= -\alpha_{A2}(\gamma - \delta)\left(L_A - H_A\right) + \left(1 - P_B\right) c(L_A - \beta_A H_B])$$

Therefore, in order to meet the condition $U_{A-Seek} - U_{A-Not\ seek} > 0$, there must be:

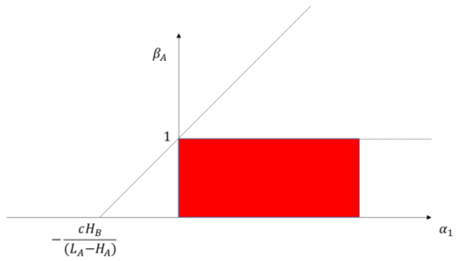
$$\beta_A < -\alpha_{A2} \frac{(\gamma - \delta)\left(L_A - H_A\right)}{cH_B\left(1 - P_B\right)} + \frac{L_A}{H_B}.$$

Because there are $(\gamma - \delta) > 0$ and $(\gamma - \delta) < 0$, the relationship between

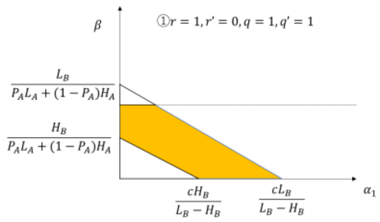
β_A and α_{A2} is shown in the following figure:



Because player B must meet the conditions of H_A and L_A, we thus find the union set of H_A and L_A. Owing to $\xi > 0$, $-\frac{cL_A(1-P_B)}{L_A-H_A} - \xi$ must be less than $-\frac{cH_A(1-P_B)}{L_A-H_A}$. Therefore:



Player A and B must satisfy all of the conditions of game equilibrium case1_B or case2_B. Thus, the result that satisfies the conditions of player A and B is 0 < ξ < C. The figure is as follows:



② $r = 1, r' = 0, q = 1, q' = 0$

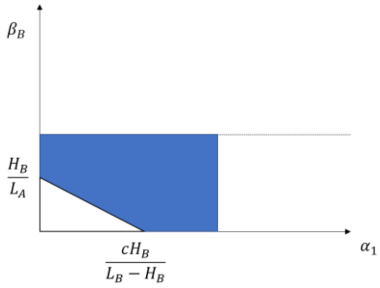
In the case of H_B

$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B1}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - H_B)$$
$$= \alpha_{B1}(L_B - H_B) + c(\beta_B L_A - H_B)$$

Therefore, in order to meet the condition $U_{B-help} - U_{B-not\ help} > 0$, there must be:

$$\beta_B > -\alpha_{B1}\frac{(L_B - H_B)}{cL_A} + \frac{H_B}{L_A}$$

The relationship between β_B and α_{B1} is shown in the following figure:



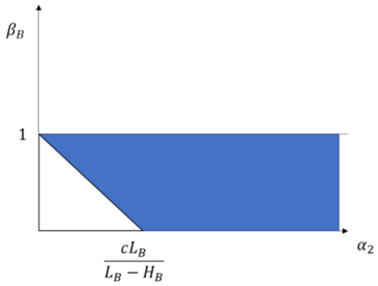
In the case of L_B

$$U_{B-Help} - U_{B-Not\ help} == \alpha_{B2}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - L_B)$$
$$= \alpha_{B2}(L_B - H_B) + c(\beta_B L_A - L_B)$$

Therefore, in order to meet the condition $U_{B-help} - U_{B-not\ help} < 0$, there must be:

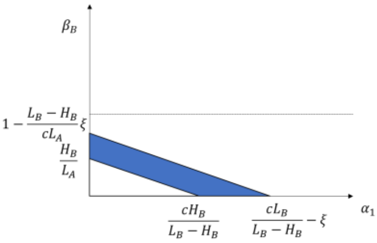
$$\beta_B < -\alpha_{B2}\frac{(L_B - H_B)}{cL_A} + \frac{L_B}{L_A}$$

The relationship between β_B and α_{B2} is shown in the following figure:



To put the two figures above together, we must distinguish between occasions between $\frac{cL_B}{L_B - H_B} - \xi > \frac{cH_B}{L_B - H_B}$ as case 1_B and $\frac{cL_B}{L_B - H_B} - \xi < \frac{cH_B}{L_B - H_B}$ as case 2_B. At this point:

Case 1_B: Case 2_B: $\emptyset$



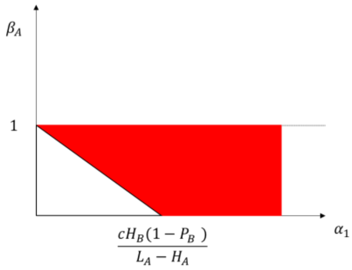
In the case of H_A

$$U_{A-Seek}-U_{A-Not\ seek}$$
$$=-\alpha_{A1}(\gamma-\delta)\left(L_A-H_A\right)+(r+P_B r'-P_B r)c(H_A-\beta_A a_B)$$
$$=-\alpha_{A1}\left(L_A-H_A\right)+(1-P_B)c(H_A-\beta_A H_B)$$

Therefore, in order to meet the condition $U_{A-seek}-U_{A-not\ seek}<0$ there must be:

$$\beta_A>-\alpha_{A1}\frac{\left(L_A-H_A\right)}{c(1-P_B)H_B}+1$$

The relationship between β_A and α_{A1} is shown in the following figure:



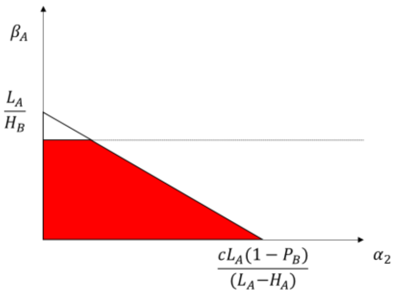
In the case of L_A

$$U_{A-Seek}-U_{A-Not\ seek}=-\alpha_{A2}(\gamma-\delta)\left(L_A-H_A\right)+\left(1-P_B\right)c(L_A-\beta_A a_B)$$
$$=-\alpha_{A2}\left(L_A-H_A\right)+\left(1-P_B\right)c(L_A-\beta_A H_B)$$

Therefore, in order to meet the condition $U_{A-seek}-U_{A-not\ seek}>0$ there must be:

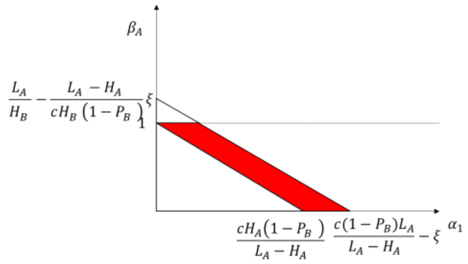
$$\beta_A<-\alpha_{A2}\frac{\left(L_A-H_A\right)}{cH_B\left(1-P_B\right)}+\frac{L_A}{H_B}$$

The relationship between β_A and α_{A2} is shown in the following figure:

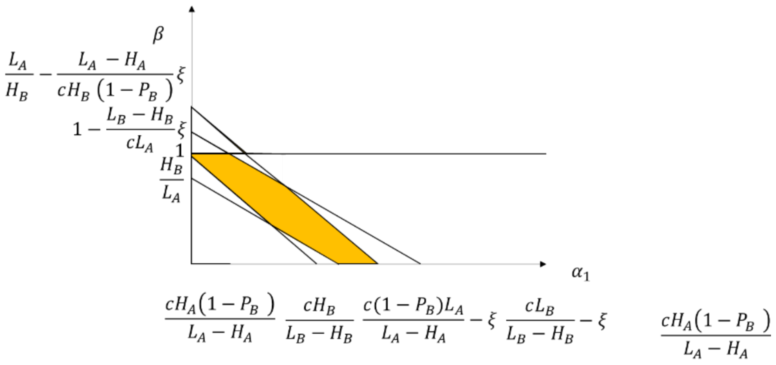


To put the two figures above together, we must distinguish between occasions between $\frac{cL_A\left(1-P_B\right)}{L_A-H_A}-\xi>\frac{cH_A\left(1-P_B\right)}{L_A-H_A}$ as case 1_A and $\frac{cL_A\left(1-P_B\right)}{L_A-H_A}-\xi<\frac{cH_A\left(1-P_B\right)}{L_A-H_A}$ as case 2_A. At this point:

Case 1_A: Case 2_A: $\emptyset$



Player A must satisfy all of the conditions of game equilibrium case1_A. Player B must satisfy all of the conditions of game equilibrium case1_B. To satisfy both case1_A and case1_B, there must be $0<\xi<c\left(1-P_B\right)$. The figure is as follows:



③ $r=1, r'=0, q=0, q'=0$

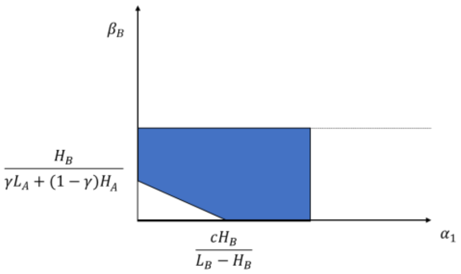
In the case of H_B

$$U_{B-Help}-U_{B-Not\ help}=\alpha_{B1}(L_B-H_B)(\varepsilon-\theta)+c(\beta_B a_A-H_B)$$
$$=\alpha_{B1}(L_B-H_B)+c(\beta_B[\gamma L_A+\left(1-\gamma\right)H_A]-H_B)$$

Therefore, in order to meet the condition $U_{B-Help}-U_{B-Not\ help}>0$ there must be:

$$\beta_B>-\alpha_{B1}\frac{\left(L_B-H_B\right)}{c[\gamma L_A+\left(1-\gamma\right)H_A]}+\frac{H_B}{\gamma L_A+(1-\gamma)H_A}$$

The relationship between β_B and α_{B1} is shown in the following figure:



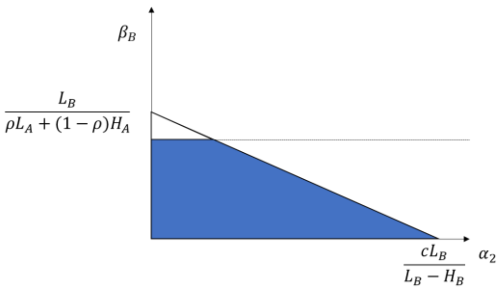
In the case of L_B

$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B2}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B \alpha_A - L_B)$$
$$= \alpha_{B2}(L_B - H_B) + c(\beta_B[\rho L_A + (1-\rho)H_A] - L_B)$$

Therefore, In order to meet the condition $U_{B-Help} - U_{B-Not\ help} < 0$ there must be:

$$\beta_B < -\alpha_{B2}\frac{(L_B - H_B)}{c[\rho L_A + (1-\rho)H_A]} + \frac{L_B}{\rho L_A + (1-\rho) H_A}$$

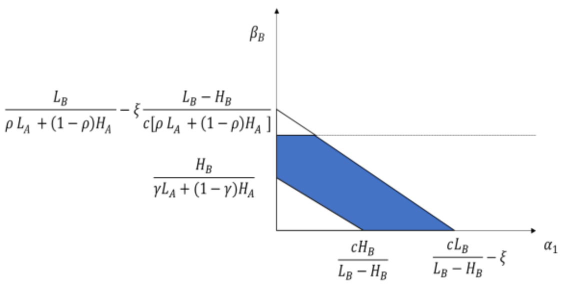
The relationship between β_B and α_{B2} is shown in the following figure:



To put the two figures above together, we must distinguish between occasions between $\frac{cL_B}{L_B - H_B} - \xi > \frac{cH_B}{L_B - H_B}$ as case 1_B and $\frac{cL_B}{L_B - H_B} - \xi < \frac{cH_B}{L_B - H_B}$ as case 2_B. At this point:

Case 1_B:

Case 2_B: $\emptyset$



In the case of H_A

$$U_{A-Seek} - U_{A-Not\ seek}$$

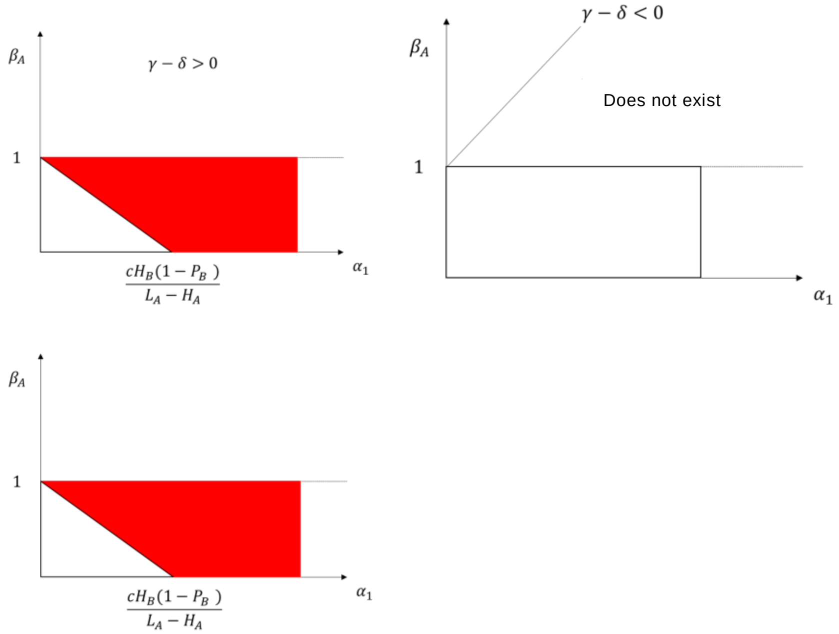
$$= -\alpha_{A1}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B r' - P_B r\right) c \left(H_A - \beta_A a_B\right)$$

$$= -\alpha_{A1}(\gamma - \delta)\left(L_A - H_A\right) + \left(1 - P_B\right) c(H_A - \beta_A H_B)$$

Therefore, In order to meet the condition $U_{A-Seek} - U_{A-Not\ seek} < 0$ there must be:

$$\beta_A > -\alpha_{A1}\frac{(\gamma - \delta)\left(L_A - H_A\right)}{cH_B\left(1 - P_B\right)} + 1$$

When $(\gamma - \delta) > 0$ and $(\gamma - \delta) < 0$, the relationship between β_B and α_{B2} is shown in the following figure:



In the case of L_A

$$U_{A-Seek} - U_{A-Not\ seek} = -\alpha_{A2}(\gamma - \delta)\left(L_A - H_A\right) + \left(1 - P_B\right) c\left(L_A - \beta_A a_B\right)$$

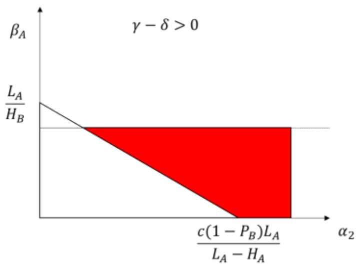
$$= -\alpha_{A2}(\gamma - \delta)\left(L_A - H_A\right) + \left(1 - P_B\right) c(L_A - \beta_A H_B)$$

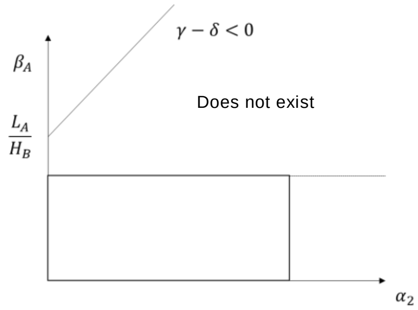
Therefore, In order to meet the condition $U_{A-Seek} - U_{A-Not\ seek} < 0$ there must be:

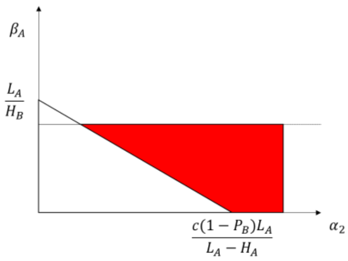
$$\beta_A > -\alpha_{A2}\frac{(\gamma - \delta)\left(L_A - H_A\right)}{cH_B\left(1 - P_B\right)} + \frac{L_A}{H_B}$$

When $(\gamma - \delta) > 0$ and $(\gamma - \delta) < 0$, the relationship between β_A and α_{A2} is shown in the following figure:

:



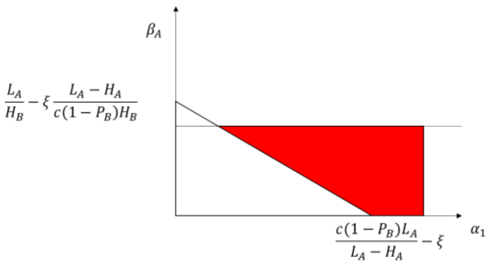




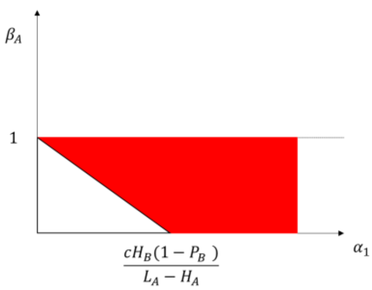
Owing to:

$\alpha_2 - \alpha_1 = \xi$, $\frac{cL_A\left(1-P_B\right)}{L_A-H_A} - \xi > \frac{cH_B\left(1-P_B\right)}{(L_A-H_A)}$ as case 1_A, $\frac{cL_A\left(1-P_B\right)}{L_A-H_A} - \xi < \frac{cH_B\left(1-P_B\right)}{L_A-H_A}$ as case 2_A are as follows:

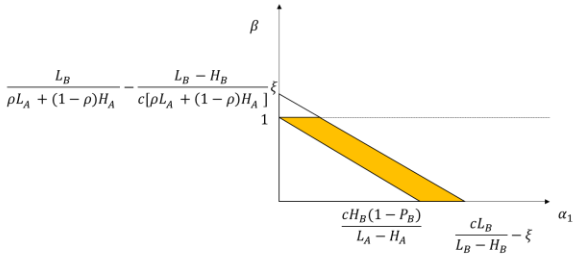
Case 1_A:



Case 2_A:



Player A must satisfy all of the conditions of game equilibrium case1 A and player B must satisfy all of the conditions of game equilibrium case1 B and case 2_B. Because case 2_B is an empty set, the union set of case 2_B and case 1_A is also an empty set. To satisfy both case1_B and case1_A, there must be $0 < \xi < c\left(1-P_B\right)$. To satisfy both case$1_B$ and case2_A, there must be $c\left(1-P_B\right) < \xi < c$. Both of them are shown in the following figure:



④ $r = 0, r' = 0, q = 1, q' = 1$

In the case of H_B

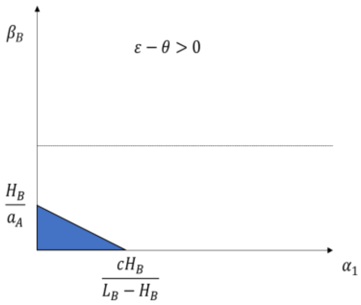
$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B1}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - H_B)$$

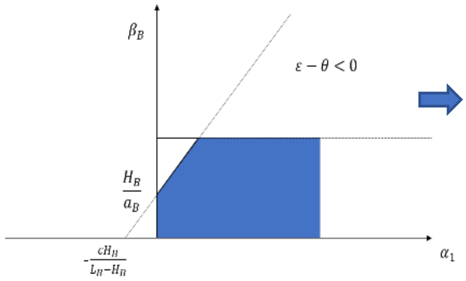
$$= \alpha_{B1}(L_B - H_B)[\varepsilon - (1 - P_B)] + c(\beta_B[P_A L_A + (1 - P_A)H_A] - H_B)$$

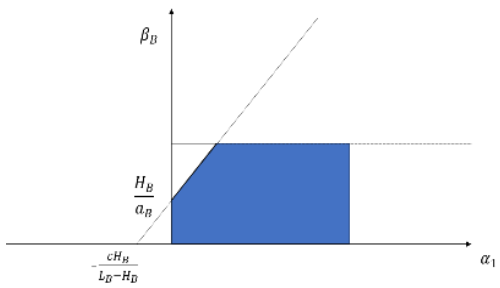
Therefore, In order to meet the condition $U_{A-Help} - U_{A-Not\ help} < 0$ there must be:

$$\beta_B < -\alpha_{B1}\frac{\left(L_B - H_B\right)[\varepsilon - (1 - P_B)]}{c[P_A L_A + (1 - P_A)L_A]} + \frac{H_B}{P_A L_A + (1 - P_A)L_A}$$

When $(\varepsilon - \theta) > 0$ and $(\varepsilon - \theta) < 0$, the relationship between β_B and α_{B1} is shown in the following figure:







In the case of L_B

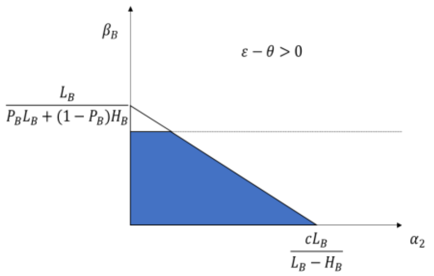
$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B2}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - L_B)$$

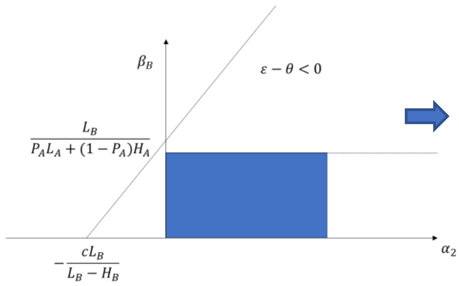
$$= \alpha_{B2}(L_B - H_B)[\varepsilon - (1 - P_B)] + c\{\beta_B[P_A L_A + (1 - P_A)H_A] - L_B\}$$

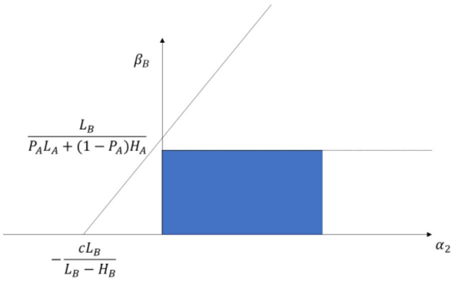
Therefore, in order to meet the condition $U_{B-Help} - U_{B-Not\ help} < 0$ there must be:

$$\beta_B < -\alpha_{B2}\frac{(L_B - H_B)[\varepsilon - (1 - P_B)]}{c[P_A L_A + (1 - P_A)H_A]} + \frac{L_B}{[P_A L_A + (1 - P_A)H_A]}$$

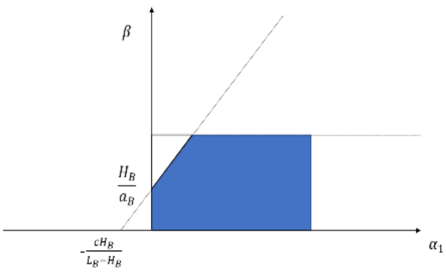
When $(\varepsilon - \theta) > 0$ and $(\varepsilon - \theta) < 0$, the relationship between β_B and α_{B2} is shown in the following figure:







Owing to $\xi > 0$, $-\frac{cL_B}{L_B - H_B} - \xi$ must be less than $-\frac{cH_B}{L_B - H_B}$. Therefore, the union set is:



In the case of H_A

$$U_{A-Seek} - U_{A-Not\ seek}$$

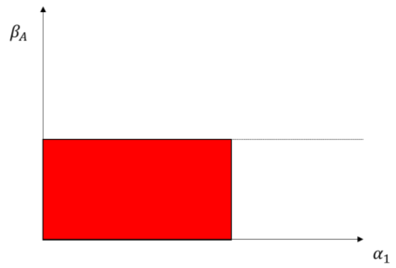
$$= -\alpha_{A1}(\gamma - \delta)(L_A - H_A) + (r + P_B r' - P_B r)c(H_A - \beta_A a_B)$$

$$= -\alpha_{A1}(P_A - \delta)(L_A - H_A)$$

Therefore, In order to meet the condition $U_{A-Seek} - U_{A-Not\ seek} > 0$ there must be:

$(P_A - \delta) < 0$

When $(\gamma - \delta) < 0$, the relationship between β_A and α_{A1} is shown in the following figure:

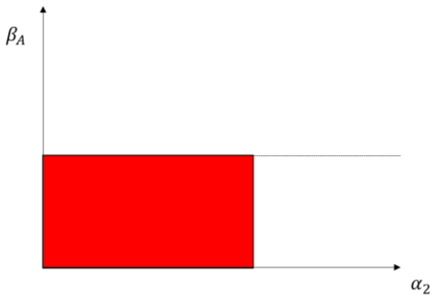


In the case of L_A

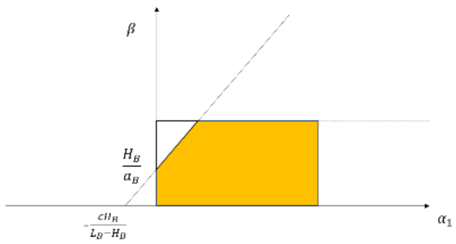
$$U_{A-Seek} - U_{A-Not\ seek} = -\alpha_{A2}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B r' - P_B r\right)c(L_A - \beta_A a_B)$$

$$= -\alpha_{A2}(P_A - \delta)\left(L_A - H_A\right)$$

Therefore, in order to meet the condition $U_{A-Seek} - U_{A-Not\ seek} > 0$ there must be: $(P_A - \delta) < 0$, When $(\gamma - \delta) < 0$, the relationship between β_A and α_{A2} is shown in the following figure:



The condition of player B and player A is $0 < \xi$. As shown in the following figure,



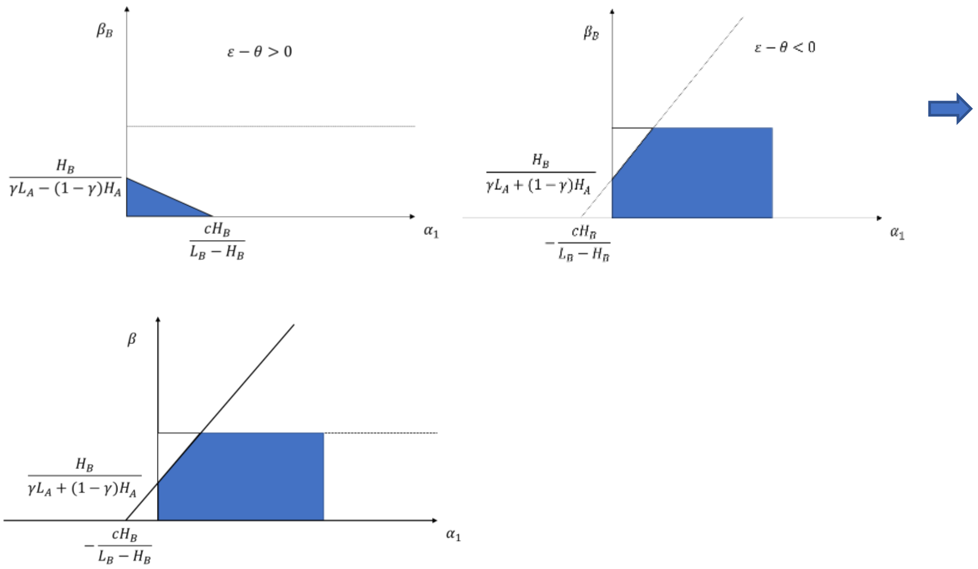
⑤ $r = 0, r' = 0, q = 0, q' = 0$

In the case of H_B

$$U_{B-Seek} - U_{B-Not\ seek} = \alpha_{B1}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - H_B)$$

$$= \alpha_{B1}(L_B - H_B)[\varepsilon - (1 - P_B)] + c(\beta_B[\gamma L_A + (1-\gamma)H_A] - H_B)$$

Therefore, in order to meet the condition $U_{B-Seek} - U_{B-Not\ Seek} < 0$ there must be: $(\beta_B < -\alpha_{B1}\frac{\left(L_B - H_B\right)[\varepsilon-(1-P_B)]}{c[\gamma L_A+(1-\gamma)H_A]} + \frac{H_B}{[\gamma L_A+(1-\gamma)H_A]}$, when $\left(\varepsilon-\theta\right) > 0$ and $\left(\varepsilon-\theta\right) < 0$, the relationship between β_B and α_{B1} is shown in the following figure:



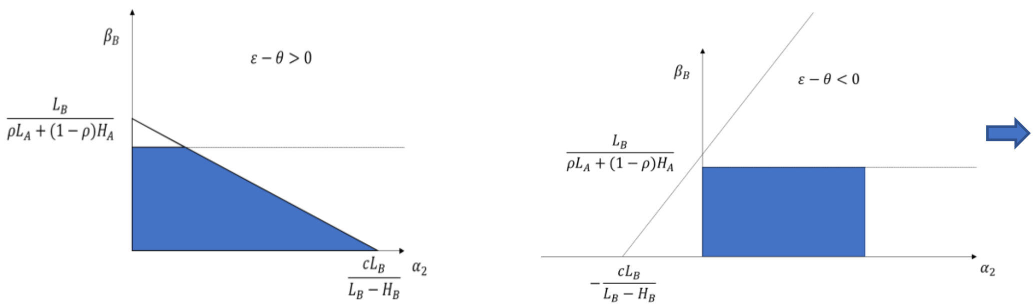
In the case of L_B

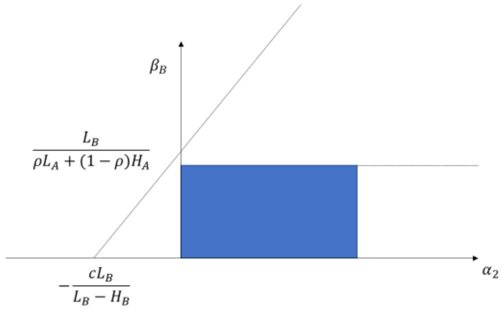
$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B2}(L_B - H_B)(\varepsilon-\theta) + c(\beta_B a_A - L_B)$$
$$= \alpha_{B2}(L_B - H_B)[\varepsilon-(1-P_B)] + c\{\beta_B[\rho L_A + \left(1-\rho\right)H_A] - L_B\}$$

Therefore, in order to meet the condition $U_{B-Help} - U_{B-Not\ help} < 0$ there must be:

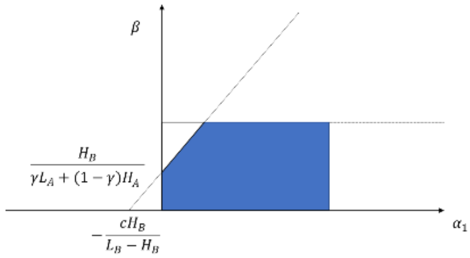
$$\beta_B < -\alpha_{B2}\frac{\left(L_B - H_B\right)[\varepsilon-(1-P_B)]}{c[\rho L_A + \left(1-\rho\right)H_A]} + \frac{L_B}{[\rho L_A + \left(1-\rho\right)H_A]}$$

When $\left(\varepsilon-\theta\right) > 0$ and $\left(\varepsilon-\theta\right) < 0$, the relationship between β_B and α_{B2} is shown in the upper right of the following figure:





Since $\xi > 0$, $-\frac{cL_B}{L_B - H_B} - \xi$ is always smaller than $-\frac{cH_B}{L_B - H_B}$. Thus, the union set is



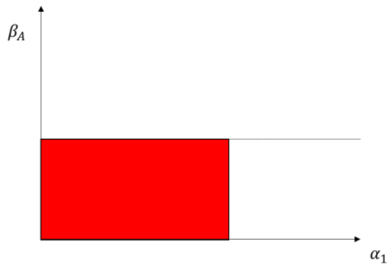
In the case of H_A

$$U_{A-Seek} - U_{A-Not\ seek}$$

$$= -\alpha_{A1}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B r' - P_B r\right) c(H_A - \beta_A a_B)$$

$$= -\alpha_{A1}(\gamma - P_A)\left(L_A - H_A\right)$$

Therefore, in order to meet the condition $U_{A-Seek} - U_{A-Not\ seek} < 0$ there must be: $(\gamma - P_A) > 0$, when $(\gamma - \delta) > 0$, the relationship between β_A and α_{A1} is shown in the upper right of the following figure:

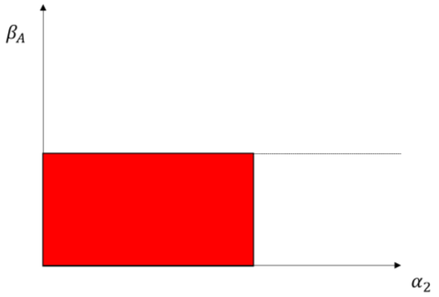


In the case of L_A

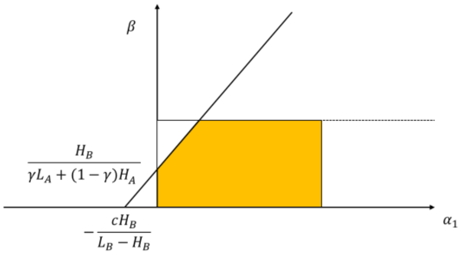
$$U_{A-Seek} - U_{A-Not\ seek} = -\alpha_{A2}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B r' - P_B r\right) c(L_A - \beta_A a_B)$$

$$= -\alpha_{A2}(\gamma - P_A)\left(L_A - H_A\right)$$

Therefore, in order to meet the condition $U_{A-Seek} - U_{A-Not\ seek} < 0$, there must be: $(\gamma - P_A) > 0$, when $(\gamma - \delta) > 0$, the relationship between β_A and α_{A2} is shown in the following figure:



Player B's all conditions and player A's all conditions must be met. Thus, the result is $0 < \xi$. The figure is shown as follows:



⑥ $r = 1, r' = 1, q = 0, q' = 0$

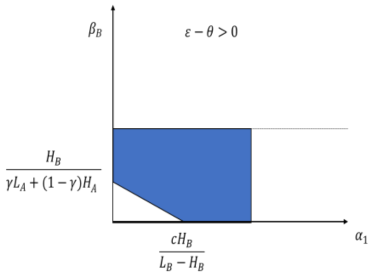
In the case of H_B

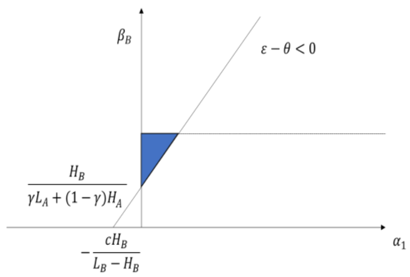
$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B1}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - H_B)$$
$$= \alpha_{B1}(L_B - H_B)[(1 - P_B) - \theta] + c(\beta_B[\gamma L_A + (1-\gamma)H_A] - H_B)$$

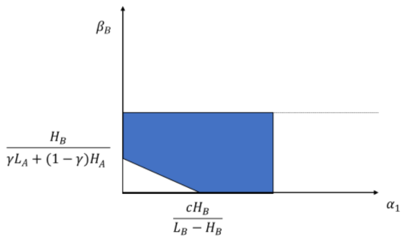
Therefore, in order to meet the condition $U_{B-Help} - U_{B-Not\ help} > 0$, there must be:

$$\beta_B < -\alpha_{B1}\frac{(L_B - H_B)[(1 - P_B) - \theta]}{c[\gamma L_A + (1-\gamma)H_A]} + \frac{H_B}{[\gamma L_A + (1-\gamma)H_A]}$$

When $(\varepsilon - \theta) > 0$ and $(\varepsilon - \theta) < 0$, the relationship between 、β_B and α_{B1} is shown in the following figure:







In the case of L_B

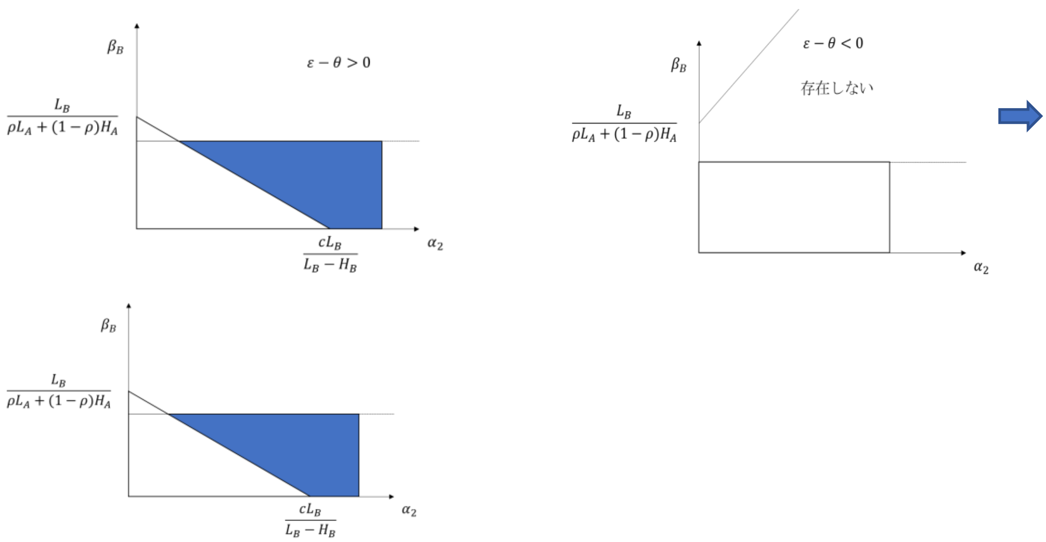
$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B2}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - L_B)$$

$$= \alpha_{B2}(L_B - H_B)[\left(1 - P_B\right) - \theta] + c\{\beta_B[\rho L_A + (1-\rho)H_A] - L_B\}$$

Therefore, in order to meet the condition $U_{B-Help} - U_{B-Not\ help} > 0$, there must be:

$$\beta_B < -\alpha_{B2}\frac{\left(L_B - H_B\right)[\left(1 - P_B\right) - \theta]}{c[\rho L_A + (1-\rho)H_A]} + \frac{L_B}{[\rho L_A + (1-\rho)H_A]}$$

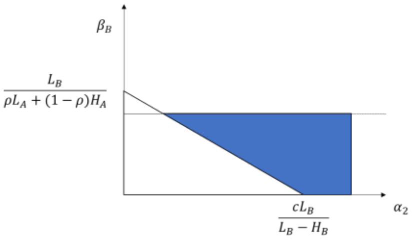
When $(\varepsilon - \theta) > 0$ and $(\varepsilon - \theta) < 0$, the relationship between β_B and α_{B2} is shown in the following figure:



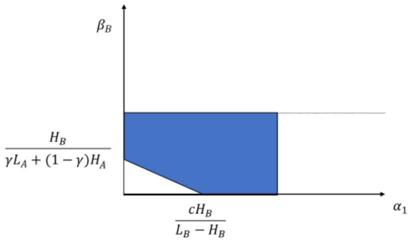
To combine the two figures above together, we must distinguish between occasions between $\frac{cL_B}{L_B - H_B} - \xi > \frac{cH_B}{L_B - H_B}$ as case 1_B and $\frac{cL_B}{L_B - H_B} - \xi < \frac{cH_B}{L_B - H_B}$ as case 2_B.

At this time,

Case 1_B:



Case 2_B:



In the case of H_A

$$U_{A-Seek} - U_{A-Not\ seek}$$

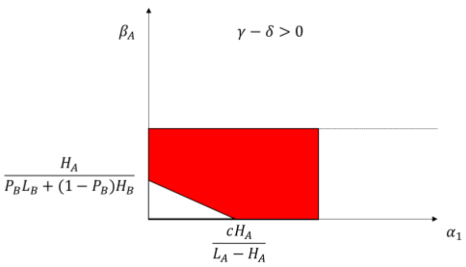
$$= -\alpha_{A1}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B r' - P_B r\right) c(H_A - \beta_A a_B)$$

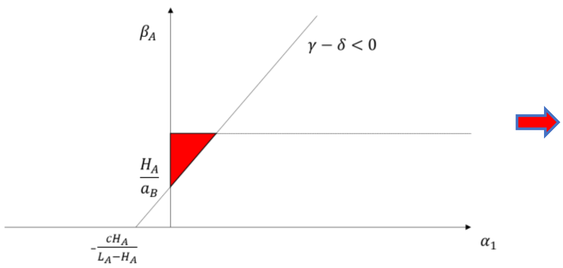
$$= -\alpha_{A1}(\gamma - P_A)\left(L_A - H_A\right) + c\{H_A - \beta_A\left[P_B L_B + \left(1 - P_B\right) H_B\right]\}$$

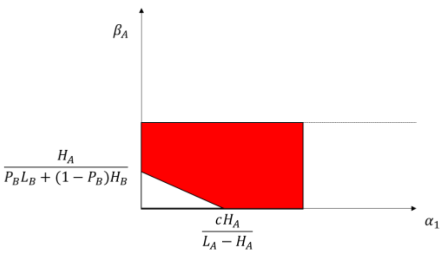
Therefore, In order to meet the condition $U_{A-\text{seek}} - U_{A-not\ seek} < 0$, there must be:

$$\beta_A > -\alpha_{A1}\frac{(\gamma - P_A)\left(L_A - H_A\right)}{c\left[P_B L_B + \left(1 - P_B\right) H_B\right]} + \frac{H_A}{[P_B L_B + \left(1 - P_B\right) H_B]}$$

When $(\gamma - \delta) > 0$ and $(\gamma - \delta) < 0$, the relationship between β_A and α_{A1} is shown in the following figure:







In the case of L_A

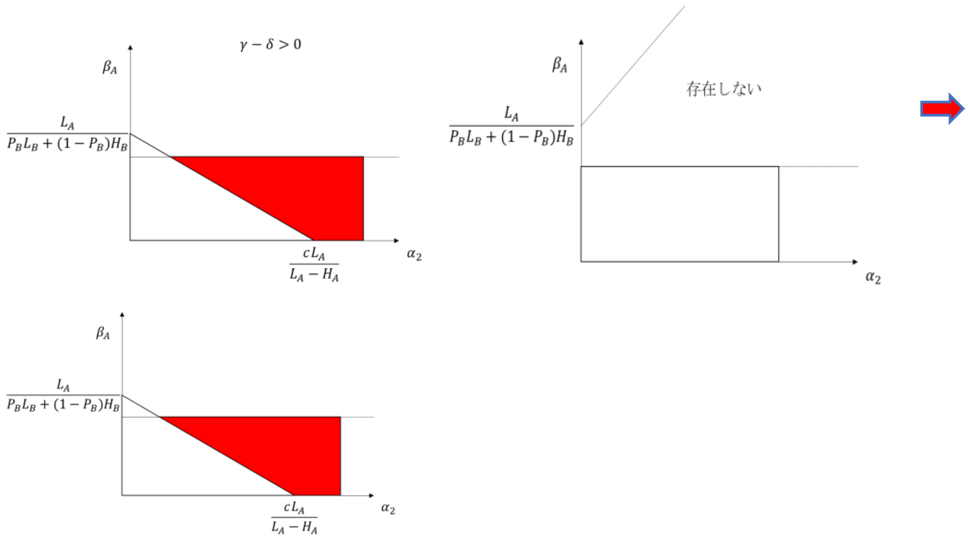
$$U_{A-Seek} - U_{A-Not\ seek} = -\alpha_{A2}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B r' - P_B r\right) c(L_A - \beta_A a_B)$$

$$= -\alpha_{A2}(\gamma - P_A)\left(L_A - H_A\right) + \left(r + P_B r' - P_B r\right) c\{L_A - \beta_A\left[P_B L_B + \left(1 - P_B\right) H_B\right]\}$$

Therefore, in order to meet the condition $U_{A-\mathrm{seek}} - U_{A-not\ seek} < 0$, there must be:

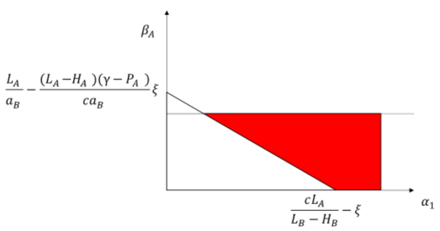
$$\beta_A > -\alpha_{A2} \frac{(\gamma - P_A)\left(L_A - H_A\right)}{c\left[P_B L_B + \left(1 - P_B\right) H_B\right]} + \frac{L_A}{\left[P_B L_B + \left(1 - P_B\right) H_B\right]}$$

When $(\gamma - \delta) > 0$ and $(\gamma - \delta) < 0$, the relationship between β_A and α_{A2} is shown in the following figure:

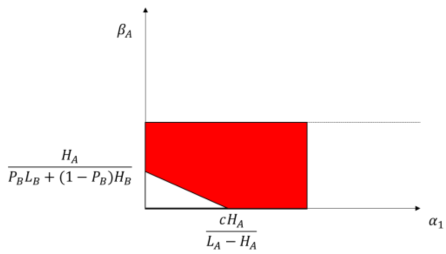


Owing to $\alpha_2 - \alpha_1 = \xi$, there is $\frac{cL_A}{L_A - H_A} - \xi > \frac{cH_A}{L_A - H_A}$ as case 1_A, $\frac{cL_A}{L_A - H_A} - \xi < \frac{cH_A}{L_A - H_A}$ as case2_A. At this time,

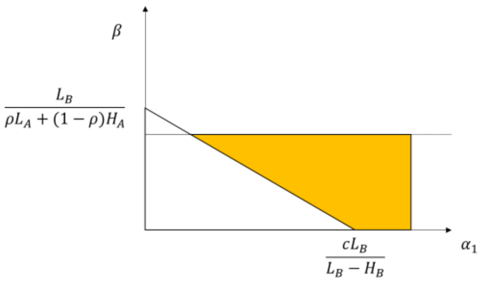
Case 1_A:



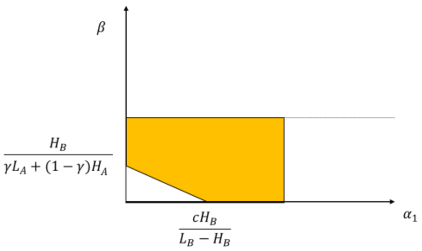
Case 2_A:



Player A must satisfy all of the conditions of game equilibrium case1_A and 2_A. Player B must satisfy all of the conditions of game equilibrium case1_B and 2_B. Thus, the result of the union set of case1_B and case1_A is 0<ξ<c. It is shown in the following figure:



Since the results of the union set of case 1_B and case 2_A are $\xi < c$, $\xi > c$, ξ does not exist. Since the results of the union set of case 2_B and case 1_A are $\xi > c$、$\xi < c$, ξ does not exist. The result of the union set of case 2_B and case 2_A is $\xi > c$. The figure is shown as follows:



⑦ $r = 1, r' = 1, q = 1, q' = 1$

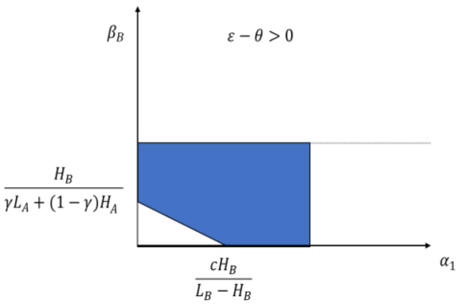
In the case of H_B

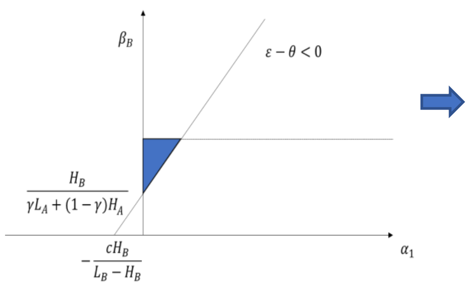
$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B1}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - H_B)$$
$$= \alpha_{B1}(L_B - H_B)[\left(1 - P_B\right) - \theta] + c(\beta_B[\gamma L_A + (1-\gamma)H_A] - H_B)$$

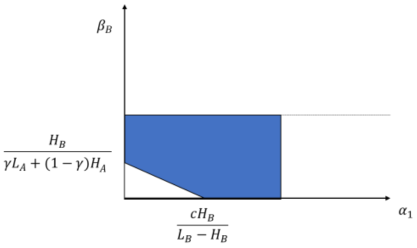
Therefore, in order to meet the condition $U_{B-help} - U_{B-not\ help} > 0$, there must be:

$$\beta_B < -\alpha_{B1}\frac{\left(L_B - H_B\right)[\left(1 - P_B\right) - \theta]}{c[\gamma L_A + (1-\gamma)H_A]} + \frac{H_B}{[\gamma L_A + (1-\gamma)H_A]}$$

When $\left(\varepsilon - \theta\right) > 0$ and $\left(\varepsilon - \theta\right) < 0$, the relationship between、$\beta_B$and$\alpha_{B1}$is shown in the following figure:







In the case of L_B

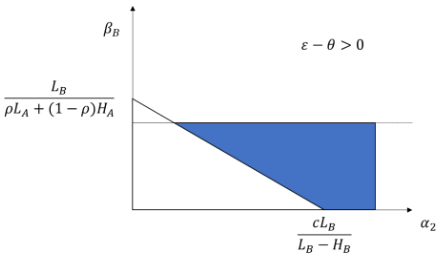
$$U_{B-Help}-U_{B-Not\ help}=\alpha_{B2}(L_B-H_B)(\varepsilon-\theta)+c(\beta_B a_A-L_B)$$

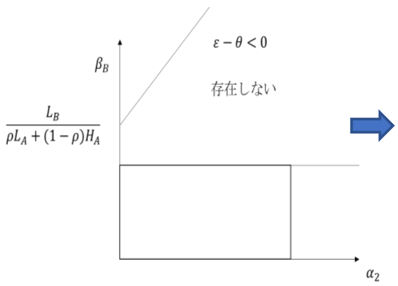
$$=\alpha_{B2}(L_B-H_B)[\left(1-P_B\right)-\theta]+c\{\beta_B[\rho L_A+(1-\rho)H_A]-L_B\}$$

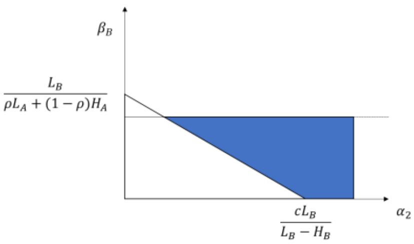
Therefore, in order to meet the condition $U_{B-help}-U_{B-not\ help}>0$, there must be:

$$\beta_B<-\alpha_{B2}\frac{\left(L_B-H_B\right)[\left(1-P_B\right)-\theta]}{c[\rho L_A+(1-\rho)H_A]}+\frac{L_B}{[\rho L_A+(1-\rho)H_A]}$$

When $\left(\varepsilon-\theta\right)>0$ and $\left(\varepsilon-\theta\right)<0$, the relationship between, β_B and α_{B2} is shown in the following figure:

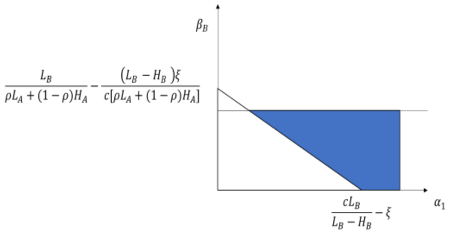




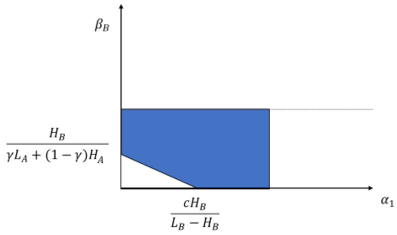


To put the two figures above together, we must distinguish between occasions between $\frac{cL_B}{L_B-H_B}-\xi>\frac{cH_B}{L_B-H_B}$ as case 1_B and $\frac{cL_B}{L_B-H_B}-\xi<\frac{cH_B}{L_B-H_B}$ as case 2_B. At this point:

Case 1_B:



Case 2_B:



In the case of H_A

$$U_{A-Seek} - U_{A-Not\ seek}$$

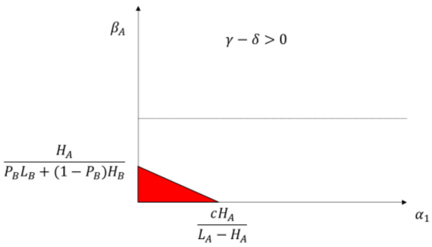
$$= -\alpha_{A1}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B r' - P_B r\right) c(H_A - \beta_A a_B)$$

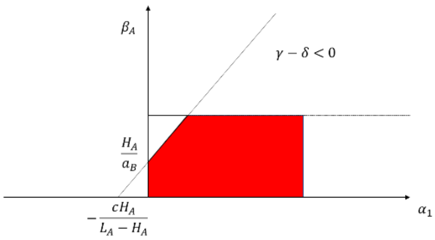
$$= -\alpha_{A1}(P_A - \delta)\left(L_A - H_A\right) + c\{H_A - \beta_A\left[P_B L_B + \left(1 - P_B\right) H_B\right]\}$$

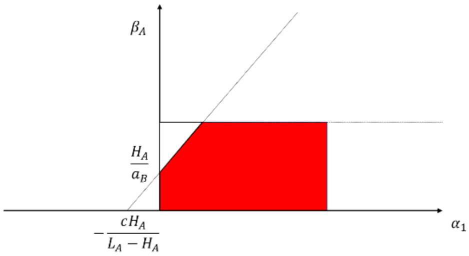
Therefore, in order to meet the condition $U_{A-seek} - U_{A-not\ seek} > 0$, there must be:

$$\beta_A > -\alpha_{A1}\frac{(P_A - \delta)\left(L_A - H_A\right)}{c\left[P_B L_B + \left(1 - P_B\right) H_B\right]} + \frac{H_A}{\left[P_B L_B + \left(1 - P_B\right) H_B\right]}$$

When $(\gamma - \delta) > 0$ and $(\gamma - \delta) < 0$, the relationship between β_A and α_{A1} is shown in the following figure:







In the case of L_A

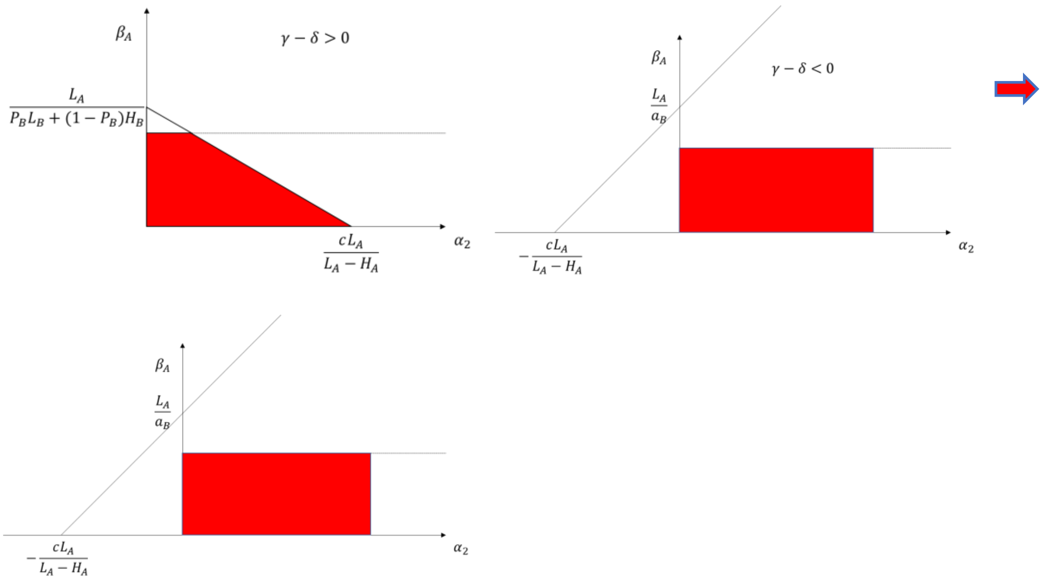
$$U_{A-Seek} - U_{A-Not\ seek} = -\alpha_{A2}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B r' - P_B r\right) c(L_A - \beta_A a_B)$$

$$= -\alpha_{A2}(P_A - \delta)\left(L_A - H_A\right) + c\{L_A - \beta_A\left[P_B L_B + \left(1 - P_B\right) H_B\right]\}$$

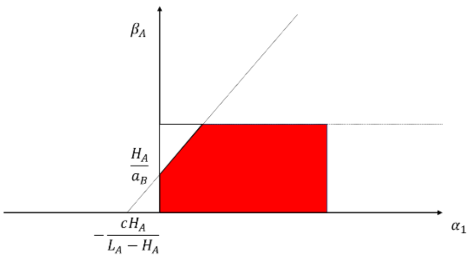
Therefore, in order to meet the condition $U_{A-seek} - U_{A-not\ seek} > 0$, there must be:

$$\beta_A < -\alpha_{A2}\frac{(P_A - \delta)\left(L_A - H_A\right)}{c\left[P_B L_B + \left(1 - P_B\right)H_B\right]} + \frac{L_A}{\left[P_B L_B + \left(1 - P_B\right)H_B\right]}$$

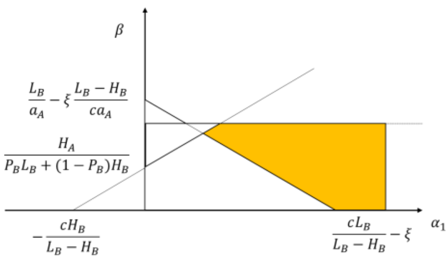
When $\left(\gamma - \delta\right) > 0$ and $\left(\gamma - \delta\right) < 0$, the relationship between β_A and α_{A2} is shown in the following figure:



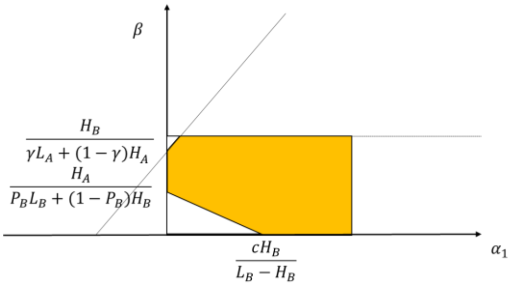
Since $\xi > 0$, $-\frac{cL_A}{L_A - H_A} - \xi$ is always smaller than $-\frac{cH_A}{L_A - H_A}$. Thus, the union set is:



Player B must satisfy all of the conditions of game equilibrium case 1_B or case2_B, so does player A. Thus, the result that satisfies the conditions of player A and B is$0 < \xi < \mathrm{c}$. The figure is



To satisfy Case 2_B and player A's conditions, the result is $1 > \xi > c$. The figure is as follows:



⑧ $r = 1, r' = 1, q = 1, q' = 0$

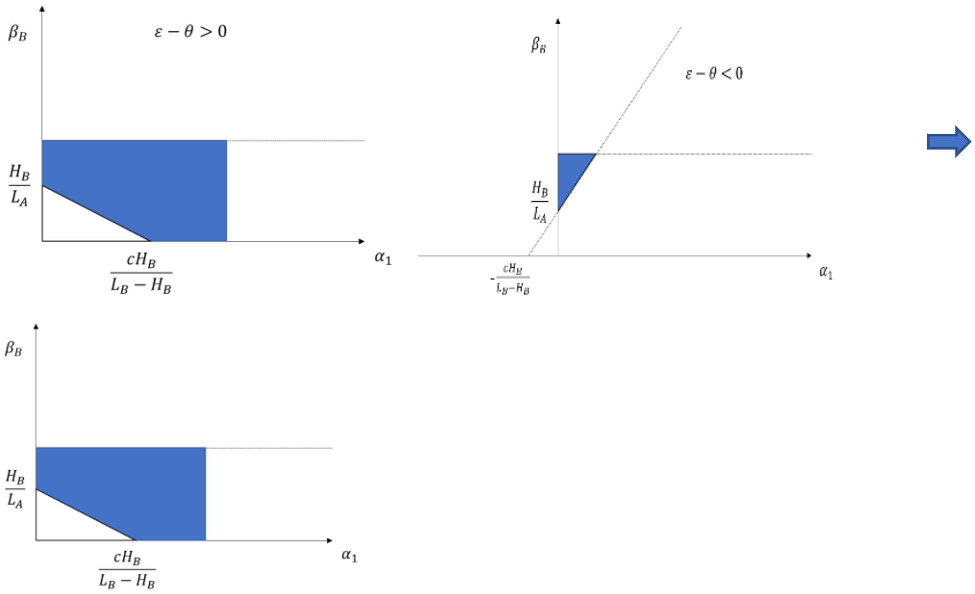
In the case of H_B

$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B1}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - H_B)$$
$$= \alpha_{B1}(L_B - H_B)[\left(1 - P_B\right) - \theta] + c(\beta_B L_A - H_B)$$

Therefore, in order to meet the condition $U_{B-Help} - U_{B-Not\ help} > 0$, there must be:

$$\beta_B > -\alpha_{B1}\frac{\left(L_B - H_B\right)[\left(1 - P_B\right) - \theta]}{cL_A} + \frac{H_B}{L_A}$$

The relationship between β_B and α_{B1} is shown in the following figure:



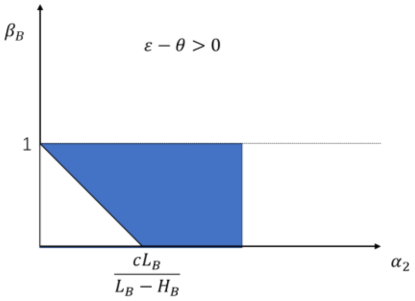
In the case of L_B

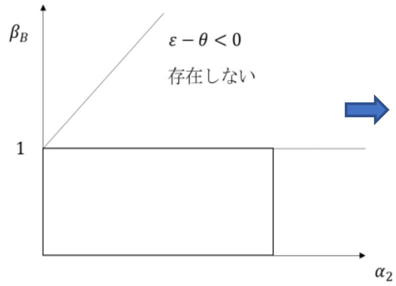
$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B2}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - L_B)$$
$$= \alpha_{B2}(L_B - H_B)[\left(1 - P_B\right) - \theta] + c(\beta_B L_A - L_B)$$

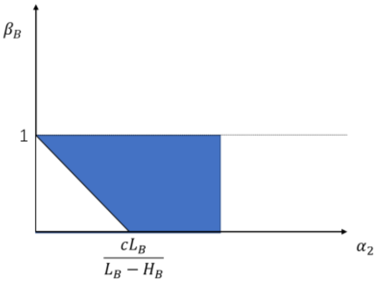
Therefore, in order to meet the condition $U_{B-Help} - U_{B-Not\ help} > 0$, there must be:

$$\beta_B > -\alpha_{B2}\frac{\left(L_B - H_B\right)[\left(1-P_B\right)-\theta]}{cL_A} + \frac{L_B}{L_A}$$

The relationship between β_B and α_{B1} is shown in the following figure:



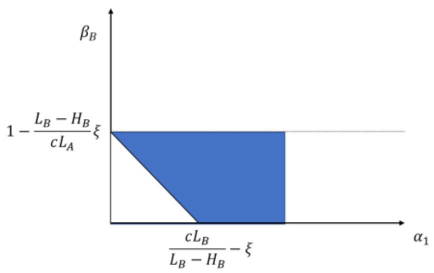




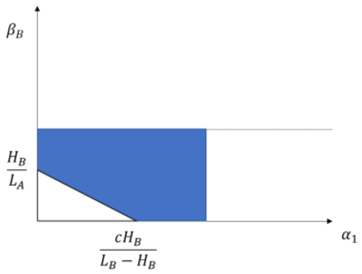
To combine the two figures above together, we must distinguish between occasions between $\frac{cL_B}{L_B-H_B} - \xi > \frac{cH_B}{L_B-H_B}$ as case 1_B and $\frac{cL_B}{L_B-H_B} - \xi < \frac{cH_B}{L_B-H_B}$ as case 2_B.

At this point,

Case 1_B:



Case 2_B:



In the case of H_A

$$U_{A-Seek} - U_{A-Not\ seek}$$

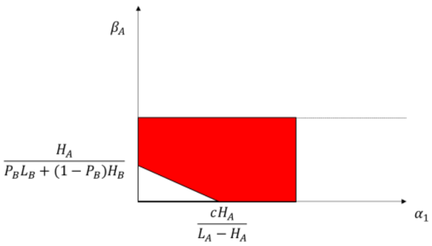
$$= -\alpha_{A1}(\gamma-\delta)\left(L_A - H_A\right) + \left(r + P_B r' - P_B r\right)c(H_A - \beta_A a_B)$$

$$= -\alpha_{A1}\left(L_A - H_A\right) + c\{H_A - \beta_A\left[P_B L_B + \left(1 - P_B\right)H_B\right]\}$$

Therefore, in order to meet the condition $U_{A-Seek} - U_{A-Not\ seek} < 0$, there must be:

$$\beta_A > -\alpha_{A1}\frac{\left(L_A - H_A\right)}{c\left[P_B L_B + \left(1 - P_B\right)H_B\right]} + \frac{H_A}{[P_B L_B + \left(1 - P_B\right)H_B]}$$

The relationship between β_A and α_{A1} is shown in the following figure:



In the case of L_A

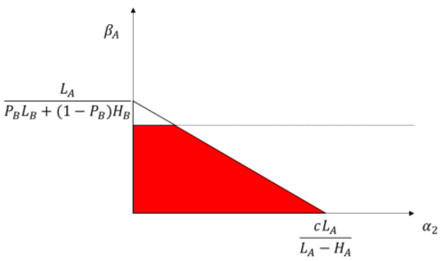
$$U_{A-Seek} - U_{A-Not\ seek} = -\alpha_{A2}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B r' - P_B r\right)c(L_A - \beta_A a_B)$$

$$= -\alpha_{A2}\left(L_A - H_A\right) + c\{L_A - \beta_A\left[P_B L_B + \left(1 - P_B\right)H_B\right]\}$$

Therefore, in order to meet the condition $U_{A-Seek} - U_{A-Not\ seek} > 0$, there must be:

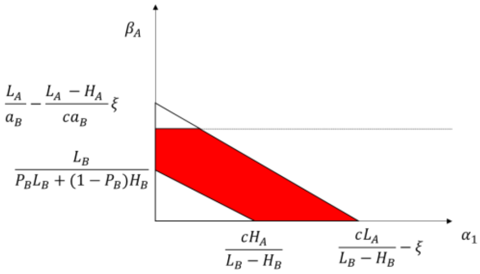
$$\beta_A < -\alpha_{A2}\frac{\left(L_A - H_A\right)}{c\left[P_B L_B + \left(1 - P_B\right)H_B\right]} + \frac{L_A}{\left[P_B L_B + \left(1 - P_B\right)H_B\right]}$$

The relationship between β_A and α_{A2} is shown in the following figure:

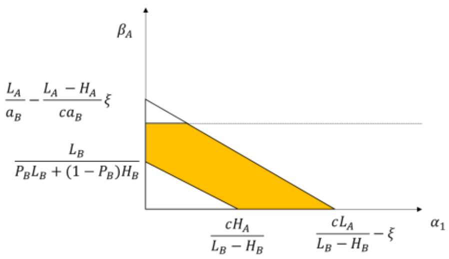


Since $\alpha_2 - \alpha_1 = \xi$, there are

$\frac{cL_A}{L_A - H_A} - \xi > \frac{cH_A}{L_A - H_A}$ as case 1_A and $\frac{cL_A}{L_A - H_A} - \xi < \frac{cH_A}{L_A - H_A}$ as case 2_A. At this point, Case 1_A: Case 2_A: ∅



Player B must satisfy all of the conditions of game equilibrium case1_B or case2_B, Player A must satisfy all of the conditions of game equilibrium case1_A or case2_A, Because case 2_A is an empty set, the union set of case 1_B and case 2_B is also an empty set. Thus, the result that satisfies both case1_B and case1_A is $0 < \xi < \mathrm{c}$. The figure is as follows:



Since the result of the union set of case 2_B and case 1_A is $\xi > \mathrm{c}$, $\xi < \mathrm{c}$, ξ does not exist.

The above section discusses the 8 equilibriums. The next section will discuss why the following 8 situations are not equilibrium:

⑨ $r = 0, r' = 0, q = 1, q' = 0$

In the case of L_A

$$U_{A-Seek} - U_{A-Not\ seek}$$

$$= [P_B r' + \left(1 - P_B\right) r]\{-\alpha_{A2}\left[\left[L_A \gamma + H_A \left(1-\gamma\right)\right] - L_A\right] - \beta_A c a_B\} + [P_B \left(1 - r'\right)$$

$$+ \left(1 - P_B\right)\left(1 - r\right)]\left\{-cL_A - \alpha_{A2}\left[\left[L_A \gamma + H_A \left(1-\gamma\right)\right] - L_A\right]\right\}$$

$$+ L_A c + \alpha_{A2}\left[\left[L_A \delta + H_A \left(1-\delta\right)\right] - L_A\right]$$

$$= -\alpha_{A2}\left(L_A - H_A\right) + \left(r + P_B\, r' - P_B\, r\right)c(L_A - \beta_A a_B)$$
$$= -\alpha_{A2}\left(L_A - H_A\right)$$

Owing to $U_{A-Seek} - U_{A-Not\,seek} > 0$ must be satisfied, $U_{A-Seek} - U_{A-Not\,seek}$ must be less than 0. This contradicts $q = 1$.

⑩ $r = 0, r' = 0, q = 0, q' = 1$

In the case of L_A

$$U_{A-Seek} - U_{A-Not\,seek} = -\alpha_{A2}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B\, r' - P_B\, r\right)c(L_A - \beta_A a_B)$$
$$= -\alpha_{A2}(-1)\left(L_A - H_A\right)$$

Owing to $-\alpha_{A2}(-1)\left(L_A - H_A\right)$ is always positive, $U_{A-Seek} - U_{A-Not\,seek}$ must be greater than 0. This contradicts $q = 0$.

⑪ $r = 1, r' = 0, q = 0, q' = 1$

In the case of L_A

$$U_{A-Seek} - U_{A-Not\,seek} = -\alpha_{A2}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B\, r' - P_B\, r\right)c(L_A - \beta_A a_B)$$
$$= -\alpha_{A2}(-1)\left(L_A - H_A\right) + \left(1 - P_B\right)c\{L_A - \beta_A\left[P_B L_B + \left(1 - P_B\right)H_B\right]\}$$

Owing to $-\alpha_{A2}(-1)\left(L_A - H_A\right)$ and $\left(1 - P_B\right)c\{L_A - \beta_A\left[P_B L_B + \left(1 - P_B\right)H_B\right]\}$ are always positive, $U_{A-Seek} - U_{A-Not\,seek}$ must be greater than 0. This contradicts $q = 0$.

⑫ $r = 0, r' = 1, q = 1, q' = 0$

In the case of L_B

$$U_{B-Help} - U_{B-Not\,help} = \alpha_{B2}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - L_B)$$
$$= \alpha_{B2}(L_B - H_B)\left(-1\right) + c(\beta_B L_A - L_B)$$

Owing to $\alpha_{B2}(L_B - H_B)(-1)$ and $c\left(\beta_B L_A - L_B\right)$ are always negative, $U_{B-Help} - U_{B-Not\,help}$ must be less than 0. This contradicts $r' = 1$.

⑬ $r = 1, r' = 1, q = 0, q' = 1$

In the case of L_A

$$U_{A-Seek} - U_{A-Not\,seek} = -\alpha_{A2}(\gamma - \delta)\left(L_A - H_A\right) + \left(r + P_B\, r' - P_B\, r\right)c(L_A - \beta_A a_B)$$
$$= -\alpha_{A2}(-1)\left(L_A - H_A\right) + c\{L_A - \beta_A\left[P_B L_B + \left(1 - P_B\right)H_B\right]\}$$

Owing to $-\alpha_{A2}(-1)\left(L_A - H_A\right)$ and $c\{L_A - \beta_A\left[P_B L_B + \left(1 - P_B\right)H_B\right]\}$ are always positive, $U_{A-\mathrm{Seek}} - U_{A-\mathrm{Not\,seek}}$ must be greater than 0. This contradicts $q = 0$.

⑭ $r = 0, r' = 1, q = 1, q' = 1$

In the case of L_B

$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B2}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - L_B)$$
$$= \alpha_{B2}(L_B - H_B)(-1) + c(\beta_B L_A - L_B)$$

Owing to $\alpha_{B2}(L_B - H_B)(-1)$ and $c(\beta_B L_A - L_B)$ are always negative, $U_{B-Help} - U_{B-Not\ he\ \ p}$ must be less than 0. This contradicts $r' = 1$.

⑮ $r = 0, r' = 1, q = 0, q' = 0$

In the case of L_B

$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B2}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - L_B)$$
$$= \alpha_{B2}(L_B - H_B)(-1) + c(\beta_B L_A - L_B)$$

Owing to $\alpha_{B2}(L_B - H_B)(-1)$ and $c(\beta_B L_A - L_B)$ are always negative, $U_{B-Help} - U_{B-Not\ help}$ must be less than 0. This contradicts $r' = 1$.

⑯ $r = 0, r' = 1, q = 0, q' = 1$

In the case of L_B

$$U_{B-Help} - U_{B-Not\ help} = \alpha_{B2}(L_B - H_B)(\varepsilon - \theta) + c(\beta_B a_A - L_B)$$
$$= \alpha_{B2}(L_B - H_B)(-1) + c(\beta_B H_A - L_B)$$

Owing to $\alpha_{B2}(L_B - H_B)(-1)$ and $c(\beta_B H_A - L_B)$ are always negative, $U_{B-Help} - U_{B-Not\ help}$ must be less than 0. This contradicts $r' = 1$.

4. Discussion

Based on the above equilibrium analysis results, the difference in self-awareness ξ is greatest when it is larger than c, it becomes equilibrium⑥ and equilibrium⑦. In other words, when the degree of loss avoidance of the player is the highest, there are equilibrium⑥ and equilibrium⑦. At this time, the helper always helps, regardless of help-seekers' ability. When ξ is small, there are equilibrium①, equilibrium②, equilibrium③, equilibrium⑥, equilibrium⑦ and equilibrium⑧. At this time, player B with high ability would help. α_1 is the largest in equilibrium ④, equilibrium ⑤, equilibrium ⑥ and equilibrium ⑦. At this time, we concluded that helpers and help-seekers behave similarly, regardless of ability.

With respect to the helper, by equilibrium ④ and equilibrium ⑤, if the self-awareness α is large but the politeness β is very small, neither player B with high ability nor with low ability would help. By equilibrium ①, equilibrium ② and equilibrium ③, if self-awareness α and politeness β are within a certain range, player B with high ability would help, player B with low ability would not. In equilibrium ⑥, equilibrium ⑦ and equilibrium ⑧, when self-awareness α and politeness β are all large, either player B with the high ability or low ability would help.

With respect to the help-seeker, in equilibrium⑦, If politeness β is small when seeking help, either player A with low ability and with high ability would seek help. In equilibrium ② and equilibrium ⑧, if self-awareness α and politeness β are within a certain range, player A with high ability would not seek help, however, player A with low ability would seek help. In equilibrium ③ and equilibrium ⑥, when self-awareness α and politeness β are both large, either player B with the high ability or low ability would not seek help.

In situation⑫, situation⑭, situation⑮ and situation⑯ where there is no equilibrium, it is impossible that player B with high ability does not help but help with low ability. While the psychological effect of self-awareness α and politeness β affect human behavior, it is impossible to force others to do things beyond your abilities.

In situation⑩, situation⑪, situation⑬ and situation⑯, it is unlikely that player with low abilities would not seek help and player with high abilities would seek help.

5. Implications

This paper studies human irrational behavior from the perspective of behavioral economics. Through the establishment of a game model, we can understand why people do not seek help when they are clearly in trouble. Because people have the nature of politeness, it is difficult to ask for help from others if they are excessively polite, and help others if they are excessively polite. Besides, people with strong self-awareness are easy to care about what others think of themselves. In order to build a good impression, they may not ask others for help, but they may help others although it is not their original intention. Specifically speaking, from the perspective of the help seeker, it is difficult to make clear what kind of people are likely to seek help and what kind of people are unlikely to seek help. On the other hand, from the perspective of helpers, what kind of people are likely to help and what kind of people are unlikely to help.

Consequently, this study found that when the loss avoidance degree of players is the largest, the helper will help others. Besides, when the loss avoidance degree of players is small, people with high ability would help. In addition, people with higher self-awareness would take the same action. If self-awareness is great, but the degree of politeness is relatively small, no matter the ability is high or low, they will not help each other. If the level of politeness is very low, people with the low ability or high ability would seek help. When politeness and self-awareness are within a certain range, neither big nor small, people with high ability would help, people with low ability would not help; people with low ability would seek help, but people with high ability would not seek help. When politeness and self-awareness are both great, people with the high ability or low ability would not seek help.

6. Conclusion

This study analyzes whether people would seek help or help others from two basic human characteristics of self-awareness and politeness. We found that, first, the more polite the helper is to the help seeker, the easier to help. Second, helper with a higher level of self-awareness and wish to keep a better impression from the help seekers would help. However, helper with low ability would not grudgingly help others. Help seeker with higher the degree of politeness would be less likely to seek help; Besides, help seeker with a higher degree of self-awareness and care more about other people's impression would not seek help.

7. Limitations and Future Directions

To simplify the model, the study has limitations. First, this study does not consider the repaying, in other words, whether the help will be repaid in the future. Second, this study only considered two psychological factors, politeness and self-awareness; however, there could be other psychological factors which would influence human behavior in this situation.

Future studies can consider the act of repaying; the game model can be set as a repeated game. In addition, other psychological factors can be considered in the game model for a better understanding of human help-seeking and help-giving behavior.

References

Barbee, A. P., Rowatt, T. L., & Cunningham, M. R. (1996). Chapter 10 - when a friend is in need: feelings about seeking, giving, and receiving social support. *Handbook of Communication & Emotion,* 281-301.

Bendixsen, S. K. N. & Wyller, T. (2019). *Contested Hospitalities in a Time of Migration: Religious and Secular Counterspaces in the Nordic Region* London: Routledge

Bohns, V. K. , & Flynn, F. J. . (2015). Empathy Gaps Between Helpers and Help-Seekers: Implications for Cooperation. Emerging Trends in the Social and Behavioral Sciences.. John Wiley & Sons, Inc.

Harsanyi, J. C. (1967). Games with Incomplete Information Played by “Bayesian” Players, I–III Part I. The Basic Model. *Management Science,* 14(3), 159–182. doi:10.1287/mnsc.14.3.159

Hashimoto,T. (2015). Amplification of reciprocity norms between sense of contribution and request for assistance. *Social psychology research,* 31(1), 35-45.

Huang, L., & Zhu, Q. (2020). A dynamic games approach to proactive defense strategies against Advanced Persistent Threats in cyber-physical systems. *Computers & Security,* 89, 101660.

Martochhio, J. J. (2005). Research in personnel and human resources management (vol. 25). *, 30*, 217-271.

Myatt, D. P. , & Wallace, C. C. . (2004). Adaptive play by idiosyncratic agents. *Games & Economic Behavior, 48*(1), 0-138.