

Cooperation in Conflict Games

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- “World War I was an unwanted spiral of hostility” ... “World War II was not an unwanted spiral of hostility-it was a failure to deter Hitler’s planned aggression.” (Joseph Nye (2007)).
- Stag hunt and chicken have multiple Nash equilibria. Jervis (*spiral model*), Schelling (*reciprocal fear of surprise attack*): mutual fear and uncertainty determine the outcome.

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- Are long-run relationships more peaceful? Is democracy good for peace? (Other issues: communication? mediation? signalling?)

The one-shot game

- Payoffs for player i (row-chooser)

$$\begin{array}{cc} & H & D \\ H & h_i - c & h_i \\ D & -d & 0 \end{array} \quad (1)$$

- Strategic complements (Stag Hunt): $(0 <) c < d$. Strategic substitutes (Chicken): $c > d (> 0)$. We allow h_i to be negative or positive (more soon).
- Player i 's *hostility type* h_i is made up of a known publicly known component k_i and a private idiosyncratic component $\eta_i \in [\underline{\eta}, \bar{\eta}]$. So, $h_i = k_i + \eta_i$. Distribution of η_j conditional on $\eta_i = y$ is $F(\cdot|y)$.

Assumption 1. (i) $F_1(x|y) > 0$ (ii) $F_2(x|y) \leq 0$ (a more hostile player i is more pessimistic about j 's hostility).

Notice this allows for both independent and positively correlated types.

Strategic Complements

- *Strategic complements*: H more appealing if the opponent is expected to choose H ($c < d$)
- Player i is a *dominant strategy hawk* if $h_i \geq 0$. Player i is a *dominant strategy dove* if $h_i - c \leq -d$ or $h_i \leq c - d$. In between, we have *coordination types*.

Theorem

Suppose both players have dominant strategy hawks and doves. If $d > c$ and $F_1(s|t) + F_2(s|t) < \frac{1}{d-c}$ then the game has a unique BNE. This BNE is in cut-off strategies.

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- Independence: “Large idiosyncratic uncertainty” implies uniqueness. This is our formalization of Schelling’s “reciprocal fear of surprise attack”. Positive correlation helps uniqueness here.
- Unique equilibrium $(\tilde{h}_i, \tilde{h}_j)$ is interior:

$$\tilde{h}_i + (d - c) (1 - F(\tilde{h}_j - k_j | \tilde{h}_i - k_i)) = 0$$

- If player j uses a “cutoff strategy” with cutoff hostility type $h_j = x$, then for player i with hostility type $h_i = y$, the probability player j plays D is $\delta_j(y) = F(x - k_j | y - k_i)$

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- Player i 's net gain from choosing H instead of D when his type is $h_i = y$ is

$$\Psi^i(x, y) \equiv y + (d - c) (1 - F(x - k_j | y - k_i)). \quad (2)$$

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- For a cutoff strategy to be a best response, player i should be more inclined to choose H the more hostile he is:

$$\Psi_2^i(x, y) = 1 - (d - c)F_2(x - k_j | y - k_i) > 0 \quad (3)$$

In view of Assumption 1, (3) holds if $d > c$. (It also holds if $d < c$ and types are not too strongly correlated.)

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- If condition (3) holds then player i 's best response to player j 's cutoff x is to use a cutoff point denoted $\beta_i(x)$.

- The slope of the best response function is obtained by totally differentiating $\Psi^i(x, \beta_i(x)) = 0$,

$$\beta'_i(x) = -\frac{\Psi_1^i(x, \beta_i(x))}{\Psi_2^i(x, \beta_i(x))} = -\frac{(c-d)F_1(x - k_j | \beta_i(x) - k_i)}{1 - (d-c)F_2(x - k_j | \beta_i(x) - k_i)}. \quad (4)$$

Notice that $\beta'_i(x) > 0$ if $d > c$ (and $\beta'_i(x) < 0$ if $d < c$).

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- A well-known condition for uniqueness is that the slope is *less than one*. Mathematically, this condition turns out to be $F_1(s|t) + F_2(s|t) < \frac{1}{d-c}$:

$$\begin{aligned} \beta'_i(x) &= \frac{(d-c)F_1}{1-(d-c)F_2} = 1 - \frac{1-(d-c)(F_1+F_2)}{1-(d-c)F_2} \\ &= 1 - \frac{1-(d-c)(F_1+F_2)}{\Psi_2^i(x, \beta(x))} \end{aligned}$$

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- We separately show that there are no non-cut-off equilibria

Strategic Substitutes

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- Player i is a *dominant strategy dove* if $h_i \leq 0$. Player i is a *dominant strategy hawk* if $h_i - c \geq -d$ or $h_i \geq c - d$. Types in between are *opportunistic types*.

Theorem

Suppose both players have dominant strategy hawks and doves. If $c > d$ and for all $x, s, t \in (\underline{\eta}, \bar{\eta})$:

$$F_1(s|t) - F_2(s|t) < \frac{1}{c-d} \quad \text{and} \quad F_1(s|x) - F_2(x|t) < \frac{1}{c-d} \quad (5)$$

then there is a unique BNE. This BNE is a cutoff equilibrium.

- Independence: “Large idiosyncratic uncertainty” implies uniqueness. This is a formalization of “escalating fear of conflict” or “deterrence by fear”. *Negative* correlation helps uniqueness here.

Example

- The players' types are generated from an underlying parameter θ as follows. First, θ is drawn from a uniform distribution on $\Theta \equiv [\underline{\theta}, \bar{\theta}] \subset \mathbb{R}$. Then, η_1 and η_2 are independently drawn from a uniform distribution on $[\theta - \varepsilon, \theta + \varepsilon]$. We assume support of θ is large enough that dominant strategy hawks and doves are feasible. *Neither player can observe θ .*
- If player i draws $\eta_i \in [\underline{\theta} + \varepsilon, \bar{\theta} - \varepsilon]$, then his posterior beliefs about θ are given by a uniform distribution on $[\eta_i - \varepsilon, \eta_i + \varepsilon]$. Therefore, player i 's beliefs about η_j are given by a symmetric, triangular distribution around η_i with support $[\eta_i - 2\varepsilon, \eta_i + 2\varepsilon]$.
- You can show

$$F_2(t|s) = F_2(s|t) = -F_1(t|s) = -F_1(s|t).$$

- For strategic complements, sufficient condition for uniqueness is *always* satisfied:

$$0 = F_1(s|t) + F_2(s|t) < \frac{1}{d - c}$$

- For $|s - t| < 2\varepsilon$ we have

$$F_1(s|t) - F_2(s|t) = \frac{1}{2\varepsilon^2} (|s - t| + 2\varepsilon)$$

which reaches a maximum $2/\varepsilon$ when $|s - t| = 2\varepsilon$.

- Also,

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which also reaches a maximum $2/\varepsilon$. Therefore, our uniqueness condition for strategic substitutes (5) is $\varepsilon > 2(c - d)$.

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- **Proposition** *If $\varepsilon < k/2$ then there is a unique BNE. In this BNE, player 1 plays H iff $h_1 \geq c - d$ and player 2 plays H iff $h_2 \geq 0$.*

- For intermediate ε , multiple equilibria can exist. Suppose $2\varepsilon > k$. First, there is the above equilibrium where player 2 plays H unless he is a dominant strategy dove and player 1 plays D unless he is a dominant strategy hawk.
- Let $h^* = \frac{(c-d)(2\varepsilon-k)^2}{8\varepsilon^2}$ (and there are some conditions on how high ε can be). Players' strategies are as follows: player 1 plays D iff $h_1 \leq h^*$; player 2 plays D iff $h_2 \leq 0$ or $h_2 \in [h^*, c-d]$.
- Consider player 1 first. For player 1 of type h^* , the probability that player 2 plays H is $F(h^* - k|h^*) = \frac{(2\varepsilon-k)^2}{8\varepsilon^2}$ and he is indifferent between H and D . Higher types are more aggressive and assess a lower probability that player 2 plays H . These types strictly prefer to play H and, by a symmetric argument, lower types prefer to play D .

- We must also show player 2's strategy is at a best-response. Assume $k < 2\varepsilon \left(1 - \frac{2\varepsilon}{c-d}\right)$. For $h_2 \in [h^* + k - 2\varepsilon, h^*]$, $\Pr\{h_1 > h^* | h_2\} = \frac{1}{8\varepsilon^2} ((h_2 - k + 2\varepsilon) - h^*)^2$. The net gain from playing H rather than D becomes

$$h_2 + \frac{(d-c)}{8\varepsilon^2} (h_2 - h^* - k + 2\varepsilon)^2. \quad (6)$$

This is quadratic in h_2 and equals zero when $h_2 = h^*$. It reaches a maximum at

$$\hat{h} = h^* + k - 2\varepsilon + \frac{4\varepsilon^2}{c-d}$$

which is interior to the interval $[h^* + k - 2\varepsilon, h^*]$ as long as $k < 2\varepsilon \left(1 - \frac{2\varepsilon}{c-d}\right)$. In fact, (6) is strictly positive for $h_2 \in [h^* + k - 2\varepsilon, h^*]$. For $h_2 \in [0, h^* + k - 2\varepsilon]$, player 2 knows his opponent plays D and then it is optimal to play H . There is a similar argument for $h_2 \in [h^*, c-d]$.

- We can reverse roles of players and find a third equilibrium.

Repeated Stag Hunt

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- **Theorem** *The twice repeated stag hunt has a PBE where in each round the probability of conflict is strictly lower than in the unique equilibrium of the one-shot game.*
- Long-run stag hunt relationships are more peaceful as players can “build trust”.

- Let \tilde{h} be cutoff in one-shot game. There are two cutoff \hat{h} and h^* such that :

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- Consider the following strategies. In period 1, player i chooses H iff $h_i \geq \hat{h}$. If both choose H in period 1, then in period 2, player i chooses H iff $h_i \geq c - d$. If both choose D in period 1, then in period 2, player i chooses H iff $h_i \geq 0$. If player i chooses H and player j chooses D in period 1, then in period 2, player i chooses H iff $h_i \geq h^*$, and player j chooses H iff $h_j \geq c - d$.

Repeated Chicken

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- **Theorem** *The twice repeated chicken game has a unique symmetric cut-off PBE, where in round 1 the probability of conflict is strictly greater than in the unique equilibrium of the one-shot game.*
- Long-run chicken relationships are hostile, because neither party wants to be perceived as weak.
- “If we had bent our back, they would immediately have thrown a saddle on us, and then they would have sat themselves on top of us and begun to drive on us.” Khrushchev

- There are three cutoffs $h^*(\hat{h}), \hat{h}, h^{**}(\hat{h})$ such that

$$\begin{aligned} 0 &< h^*(\hat{h}) < \hat{h} < h^{**}(\hat{h}) < c - d \\ \hat{h} &< \tilde{h} \end{aligned}$$

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$$\hat{h} < \tilde{h}$$

- Consider the following strategies. In period 1, player i chooses H iff $h_i \geq \hat{h}$. If both choose H in period 1, then in period 2, player i chooses H iff $h_i \geq h^{**}(\hat{h})$. If both choose D in period 1, then in period 2, player i chooses H iff $h_i \geq h^*(\hat{h})$. If player i chooses H and player j chooses D in period 1, then in period 2, player i chooses H iff $h_i \geq 0$, and player j chooses H iff $h_j \geq c - d$.

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- Two opposite effects. First, if leaders who choose H are replaced, the cost of a “bad reputation” can be avoided. This *increases* the incentive to choose H in round 1. Second, if the leader who chooses H in round 1 is replaced, he loses the “rents from office”, which *reduces* the incentive to choose H in round 1. The second effect is small if rents are small. Thus, if rents from office are small, democracy is bad for peace.

Is democracy good for peace in chicken games?

- If leader i chooses D in round 1 then he reveals that he is dovish. If he stays in power, leader j will be very likely to choose H in round 2 by strategic substitutes. To avoid this, the median voter of country i will prefer to elect a new leader.
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