ECO2030: Microeconomic Theory II, module 1

Lecture 3

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2018.10.30

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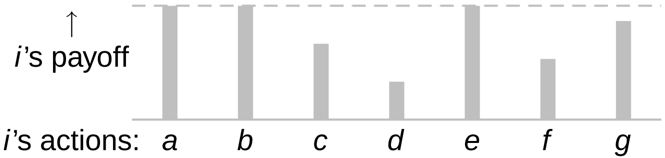
Characterization of mixed strategy Nash equilibrium

- α^* is a mixed strategy Nash equilibrium $\Leftrightarrow$ α_i^* is a best response to α_{-i}^* for all i
- When is a mixed strategy α_i a best response to α_{-i}^*?
- Suppose expected payoffs to player i's actions, given α_{-i}^*, are:



- What mixed strategies of player i are best responses to α_{-i}^*?
- Mixed strategy α_i is a best response to α_{-i}^* if and only if it assigns probability zero to c, d, and f; all probability must be assigned to actions that are best responses to α_{-i}^*

Characterization of mixed strategy Nash equilibrium

Definition

Support of mixed strategy $=$ set of actions to which strategy assigns positive probability

Proposition (*Lemma 33.2*)

α^* is a mixed strategy Nash equilibrium

$\Leftrightarrow$

for every player *i*, α_i^* is a best response to α_{-i}^*

$\Leftrightarrow$

for every player *i*, every action in support of α_i^* is a best response to α_{-i}^*.

Characterization of mixed strategy Nash equilibrium

- Consider two-player game
- Actions $1, \ldots, k$ for player 1 and $1, \ldots, m$ for player 2
- Mixed strategy pair $((p_1, \ldots, p_k), (q_1, \ldots, q_m))$ is mixed strategy Nash equilibrium if and only if there exist numbers π_1 and π_2 such that

$$E(u_1(j,q)) \begin{cases} = \pi_1 & \text{for every action } j \text{ with } p_j > 0 \\ \leq \pi_1 & \text{for every action } j \text{ with } p_j = 0 \end{cases}$$

and

$$E(u_2(p,j)) \begin{cases} = \pi_2 & \text{for every action } j \text{ with } q_j > 0 \\ \leq \pi_2 & \text{for every action } j \text{ with } q_j = 0 \end{cases}$$

Example

Is strategy pair a mixed strategy Nash equilibrium?

	L (0)	C ($\frac{1}{3}$)	R ($\frac{2}{3}$)	
T ($\frac{3}{4}$)	$\cdot, 2$	$3, 3$	$1, 1$	$\frac{5}{3}$
M (0)	$\cdot, \cdot$	$0, \cdot$	$2, \cdot$	$\frac{4}{3}$
B ($\frac{1}{4}$)	$\cdot, 4$	$5, 1$	$0, 7$	$\frac{5}{3}$
	$\frac{5}{2}$	$\frac{5}{2}$	$\frac{5}{2}$	

(Unspecified payoffs are irrelevant.)

- Compute expected payoff of each action, given other player's actions
- If every action in support of each player's mixed strategy yields same payoff *and* actions outside support yield at most this payoff *then* strategy pair is mixed strategy Nash equilibrium

Finding mixed strategy Nash equilibria

Finding mixed strategy equilibrium in which each player's strategy has given support, if one exists:

- For each player $i = 1, \ldots, n$, let $S_i \subseteq A_i$
- To find mixed strategy equilibrium $(p_1, \ldots, p_n)$ in which support of p_i is S_i for each player i,
  - find solution of system of equations

$$\begin{aligned} E(u_1(j, p_{-1})) &= \pi_1 \quad \text{for every } j \in S_i \\ &\vdots \\ E(u_n(j, p_{-n})) &= \pi_n \quad \text{for every } j \in S_n \end{aligned}$$

    (if one exists)
  - Check, for each player i, whether $E(u_i(j, p_{-i})) \leq \pi_i$ for every action j of player i

Example

	L	C	R
T	$1,2$	$3,3$	$1,1$
M	$1,0$	$0,2$	$2,1$
B	$3,4$	$2,1$	$0,7$

Equilibrium in which support of player 1's strategy is $\{T,M\}$ and support of player 2's strategy is $\{L,C\}$?

For player 1 to get same payoff from T and B need

$$\begin{aligned} q_1 + 3q_2 &= \pi_1 \\ q_1 &= \pi_1 \end{aligned}$$

which obviously has no solution with $q_2 > 0$

So no equilibrium with these supports

Example

	L	C	R
T	$1, 2$	$3, 3$	$1, 1$
M	$1, 0$	$0, 2$	$2, 1$
B	$3, 4$	$2, 1$	$0, 7$

Equilibrium in which support of player 1's strategy is $\{T, B\}$ and support of player 2's strategy is $\{L, C\}$?

For player 1 to get same payoff from T and B need

$$\begin{aligned} q_1 + 3q_2 &= \pi_1 \\ 3q_1 + 2q_2 &= \pi_1 \end{aligned} \qquad \Rightarrow q_1 = \tfrac{1}{3}, q_2 = \tfrac{2}{3}, \pi_1 = \tfrac{7}{3} \quad (q_1 + q_2 = 1)$$

For player 2 to get same payoff from L and C need

$$\begin{aligned} 2p_1 + 4p_3 &= \pi_2 \\ 3p_1 + p_3 &= \pi_2 \end{aligned} \qquad \Rightarrow p_1 = \tfrac{3}{4}, p_3 = \tfrac{1}{4}, \pi_2 = \tfrac{10}{4} \quad (p_1 + p_3 = 1)$$

Example

	L	C	R
T	$1,2$	$3,3$	$1,1$
M	$1,0$	$0,2$	$2,1$
B	$3,4$	$2,1$	$0,7$

Equilibrium in which support of player 1's strategy is $\{T, B\}$ and support of player 2's strategy is $\{L, C\}$?

$$q_1 = \frac{1}{3}, q_2 = \frac{2}{3}, \pi_1 = \frac{7}{3}; p_1 = \frac{3}{4}, p_3 = \frac{1}{4}, \pi_2 = \frac{10}{4}$$

For an equilibrium, need also

$$\text{1's payoff to } M \leq \pi_1 \quad \Rightarrow q_1 \leq \frac{7}{3}, \text{which is true}$$

and

$$\text{2's payoff to } R \leq \pi_2 \quad \Rightarrow p_1 + 7p_3 \leq \frac{10}{4}, \text{which is true}$$

So equilibrium exists with these supports

Finding all mixed strategy equilibria

Procedure

- For each player i, choose a set $S_i \subseteq A_i$
- Find all the mixed strategy equilibria of the game in which the support of the strategy of each player i is S_i
- Repeat for all possible profiles $(S_i)_{i \in N}$ of such subsets

Example

	L	R
T	$1,1$	$2,0$
B	$1,0$	$0,2$

- Subsets of A_1: $\{T\}$, $\{B\}$, $\{T,B\}$
- Subsets of A_2: $\{L\}$, $\{R\}$, $\{L,R\}$

Pairs of subsets:

P1	P2	NE?
$\{T\}$	$\{L\}$	Yes
$\{T\}$	$\{R\}$	No: R is not best response
$\{T\}$	$\{L,R\}$	No: P2 not indifferent between L, R
$\{B\}$	$\{L\}$	No: L is not best response
$\{B\}$	$\{R\}$	No: B is not best response
$\{B\}$	$\{L,R\}$	No: P2 not indifferent between L, R
$\{T,B\}$	$\{L\}$	L is best response $\Leftrightarrow p \geq 2(1-p) \Leftrightarrow p \geq \frac{2}{3}$
$\{T,B\}$	$\{R\}$	No: P1 not indifferent between T, B
$\{T,B\}$	$\{L,R\}$	No: B not best response if $q < 1$

Example

	L	C	R
T	$1, 2$	$3, 3$	$1, 1$
M	$1, 0$	$0, 2$	$2, 1$
B	$3, 4$	$2, 1$	$0, 7$

P1	P2	NE?
$\{T\}$	$\{L\}$	No: L is not BR
$\{T\}$	$\{C\}$	Yes
Other singleton pairs		No: ...
$\{T\}$	$\{L, C\}$	No: P2 not indifferent between L, C
Other pairs w/ 1 action in support for one player		Only one with indifference: $(\{T, M\}, \{L\})$. Not NE, because B is better than T, M.
$\{T, M\}$	$\{L, C\}$	No: L is not BR to any strategy with support $\{T, M\}$

Example

	L	C	R
T	$1,2$	$3,3$	$1,1$
M	$1,0$	$0,2$	$2,1$
B	$3,4$	$2,1$	$0,7$

P1	P2	NE?
$\{T,B\}$	$\{L,C\}$	Find q s.t. P1 indifferent between T and B: $q=\frac{1}{3}$. Find p s.t. P2 indifferent between L and C: $p=\frac{3}{4}$. Now check payoffs to M and R: payoff to $M \leq$ payoff to T, B; payoff to $R \leq$ payoff to L, C $\Rightarrow$ Nash equilibrium.
Other pairs w/ 2 actions in each support		$\ldots$

Example

	L	C	R
T	$1,2$	$3,3$	$1,1$
M	$1,0$	$0,2$	$2,1$
B	$3,4$	$2,1$	$0,7$

P1	P2	NE?
Pairs w/ 2 actions in support for 1 player, 3 actions in support for other		...
$\{T, M, B\}$	$\{L, C, R\}$	For each player, three equations in three unknowns.

Finding all mixed strategy equilibria

- Method is exhaustive
- ... and exhausting for even moderate sized games
- Number of possible supports for mixed strategy of player with k actions: $2^k - 1$
- So n players each with k actions $\Rightarrow (2^k - 1)^n$ possible pairs of supports
- 4 players, 4 actions each $\Rightarrow (15)^4 \approx 50{,}000$ possible pairs
- 2 players, 10 actions each $\Rightarrow (1{,}023)^2 \approx 1{,}000{,}000$ possible pairs
- Computationally efficient methods exist to find *an* equilibrium
- See `http://www.gambit-project.org/` and Chapter 4 of *Multiagent Systems* by Shoham and Leyton-Brown

Strict Nash equilibrium

Definition

A Nash equilibrium is strict if, for every player, the payoff to every nonequilibrium strategy is *less than* the payoff to her equilibrium strategy, given the other players' strategies

Examples

- Nash equilibrium of *Prisoner's Dilemma* is strict
- Pure strategy Nash equilibria of *BoS* are strict
- Nash equilibrium of Bertrand's duopoly game is not strict
- Mixed strategy Nash equilibrium in which some player's strategy is not pure is not strict (all actions in support of strategy yield same payoff)

Incentives in mixed strategy Nash equilibrium

- *Every* mixed strategy with the same support as equilibrium mixed strategy is best response to other players' strategies
- So no player has a positive incentive to choose equilibrium strategy
- What determines her equilibrium strategy?
- Strategy is determined by requirement that *other* players' strategies be optimal
- Specifically, in *two-player* game, one player's equilibrium mixed strategy keeps *other* player indifferent between a set of her actions, so that *she* is willing to randomize

	L $(\frac{2}{3})$	R $(\frac{1}{3})$
T $(\frac{1}{5})$	$1, 0$	$0, 4$
B $(\frac{4}{5})$	$0, 1$	$2, 0$

Example: reporting a crime (“volunteer’s dilemma”)

- Many people witness a crime
- One person’s reporting crime to police suffices
- When deciding whether to report, each person doesn’t know whether anyone else has reported
- A person who reports bears a cost c
- If the crime is reported, everyone obtains the benefit $v > c$

Application: reporting a crime ("volunteer's dilemma")

Strategic game

Players n individuals

Actions For each player, $\{Call, Don't\ call\}$

Payoffs For each player i,

$$u_i(a) = \begin{cases} v - c & \text{if } a_i = Call \\ v & \text{if } a_i = Don't\ call \text{ and} \\ & \quad a_j = Call \text{ for some } j \neq i \\ 0 & \text{if } a_j = Don't\ call \text{ for all } j \end{cases}$$

Application: reporting a crime ("volunteer's dilemma")

Nash equilibria

- Equilibria in pure strategies? n pure Nash equilibria, in each of which exactly one player calls
- How can these equilibria be realized? For an equilibrium in which player 1 calls, who is player 1?
- Look for symmetric equilibrium, in mixed strategies

Application: reporting a crime ("volunteer's dilemma")

Mixed strategy Nash equilibrium

In mixed strategy equilibrium in which every player calls with same probability p with $0 < p < 1$,

$$\text{payoff if player calls} = \text{payoff if player doesn't call}$$

$\Rightarrow$

$$v - c = 0 \cdot \Pr\{\text{no one else calls}\} + v \cdot \Pr\{\geq \text{one other person calls}\}$$

$\Rightarrow$

$$v - c = v \cdot (1 - \Pr\{\text{no one else calls}\})$$

$\Rightarrow$

$$c/v = \Pr\{\text{No one else calls}\} = (1-p)^{n-1}$$

$\Rightarrow$

$$p = 1 - (c/v)^{1/(n-1)}$$

Application: reporting a crime (“volunteer’s dilemma”)

Mixed strategy Nash equilibrium

- Conclusion: in a symmetric mixed strategy Nash equilibrium, every player calls with probability

$$p = 1 - (c/v)^{1/(n-1)}$$

(Note: this number is between 0 and 1.)

Application: reporting a crime ("volunteer's dilemma")

Mixed strategy Nash equilibrium: comparative statics

$$p = 1 - (c/v)^{1/(n-1)}$$

- $n \uparrow \Rightarrow p \downarrow$: more people $\Rightarrow$ each is less likely to call
- Probability that at least one person calls:

$$\begin{aligned} &\Pr\{\text{at least one person calls}\} \\ &\qquad = 1 - \Pr\{\text{no one calls}\} \\ &\qquad = 1 - \Pr\{i \text{ does not call}\} \Pr\{\text{no one else calls}\} \\ &\qquad = 1 - (1-p)(c/v) \end{aligned}$$

Because $n \uparrow \Rightarrow p \downarrow$,

$$n \uparrow \Rightarrow \Pr\{\text{at least one person calls}\} \downarrow$$

$\Rightarrow$ the more people, the *less* likely the police are informed

Domination by a mixed strategy

An action may be dominated by a *mixed strategy* even if it is not dominated by a pure strategy

Example

	L	R
T	1	1
M	0	4
B	4	0

(where the payoffs are those of player 1)

- $\frac{1}{2} \cdot M \oplus \frac{1}{2} \cdot B$ strictly dominates T

An action strictly dominated by a mixed strategy is not used with positive probability in a mixed strategy equilibrium, and hence can be eliminated when looking for Nash equilibria

Mixed strategy equilibrium

- Interpretation: Read Section 3.2 of book
- Omit Section 3.3 (correlated equilibrium)
- Omit Section 3.4 (evolutionary equilibrium)

Another approach to outcomes in strategic games

Definition

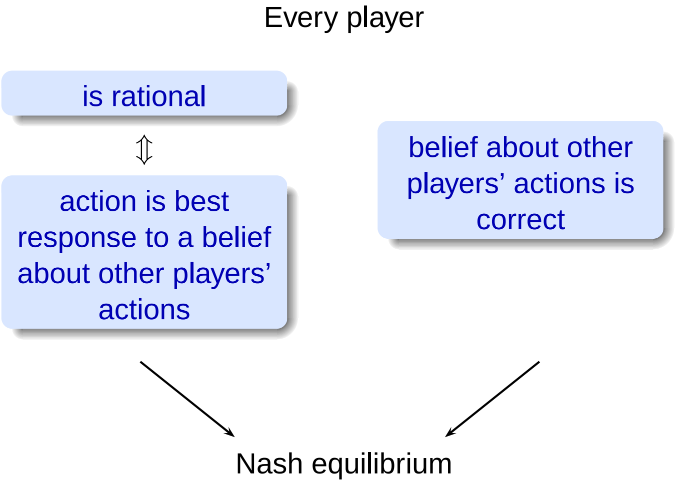
A belief of player i (about the other players' actions) is a probability distribution on $\times_{j \in N \setminus \{i\}} A_j$ (the set of lists of the other players' actions)

Note: a belief may involve correlation between the other players' actions

Definition

A player in a strategic game is rational if her mixed strategy is a best response to some belief

Implications of rationality



Implications of rationality

Every player

is rational

⇕

action is best response to a belief about other players' actions

belief about other players' actions is correct

Implications of rationality

Which actions are best responses to some belief?

Proposition

An action is a best response to some belief if and only if it is not strictly dominated by a mixed strategy.

So every player is rational $\Rightarrow$ no player's strategy is strictly dominated by any mixed strategy

Example: Prisoner's Dilemma

		Player 2: Q	Player 2: F
Player 1	Q	$3,3$	$0,4$
	F	$4,0$	$1,1$

Players are rational $\Rightarrow$ action pair is (F,F)

Implications of rationality

Every player

is rational

⇕

no player's strategy is strictly dominated by a mixed strategy

. . . and believes that other players are rational

. . . and believes that other players believe she is rational

. . . and believes that other players believe she believes they are rational

. . . and so on

↘ ↙

?

Implications of rationality

Example

	L	C	R
T	$0, 4$	$4, 0$	$2, 1$
M	$1, 0$	$3, 1$	$3, 2$
B	$0, 2$	$2, 3$	$1, 1$

- Player 1 is rational $\Rightarrow$ does not choose B (strictly dominated by M)
- Player 2 believes player 1 is rational $\Rightarrow$ player 2 believes player 1 does not choose B
  So player 2 is rational $\Rightarrow$ she does not choose C (strictly dominated by R)
- Player 1 believes that player 2 is rational *and* that player 2 believes player 1 is rational $\Rightarrow$ player 1 believes player 2 believes player 1 does not choose B and that player 2 therefore does not choose C
  So player 1 is rational $\Rightarrow$ she does not choose T
- In one more step . . . player 2 does not choose L

Implications of rationality

Example

	L	C	R
T	$0, 4$	$4, 0$	$2, 1$
M	$1, 0$	$3, 1$	$3, 2$
B	$0, 2$	$2, 3$	$1, 1$

Conclusion

Every player is rational
and believes every other player is rational
and believes every other player believes she is rational
and so on ...

$\Rightarrow$ only action pair that remains is (M, R)

Implications of rationality

- Each player's action in any action profile that survives iterated elimination of strictly dominated actions is rationalizable
  - Note: domination $=$ domination by a mixed strategy
- Any action used with positive probability in a mixed strategy Nash equilibrium is rationalizable
- But in many games other actions also are rationalizable
- If no action of any player is strictly dominated, then all actions of every player are rationalizable

Bayesian games

- Strategic game models situation in which each player knows preferences of other players
- In some situations, players are not certain of other players' preferences
- Model of Bayesian Game allows players to face uncertainty about other players' preferences

Bayesian games: motivational example

Variant of *BoS* with imperfect information

- Player 1 doesn't know whether
  - player 2 prefers to go out with her—player 2 is type m
  - or prefers to avoid her—player 2 is type v
- She thinks probabilities of states are $\frac{1}{2}$–$\frac{1}{2}$
- Player 2 knows player 1's preferences
- Probabilities are involved, so need players' preferences over lotteries, even if interested only in pure strategy equilibria $\Rightarrow$ Bernoulli payoffs

1

2: m

	B	S
B	$2, 1$	$0, 0$
S	$0, 0$	$1, 2$

meet $(\frac{1}{2})$

2: v

	B	S
B	$2, 0$	$0, 2$
S	$0, 1$	$1, 0$

avoid $(\frac{1}{2})$

Bayesian games: motivational example

Variant of *BoS* with imperfect information

1

2: m

	B	S
B	$2, 1$	$0, 0$
S	$0, 0$	$1, 2$

meet $(\frac{1}{2})$

2: v

	B	S
B	$2, 0$	$0, 2$
S	$0, 1$	$1, 0$

avoid $(\frac{1}{2})$

An equilibrium

- Player 1 chooses B
- Type m of player 2 chooses B and type v chooses S
- Argument:
  - P1 chooses $B \Rightarrow$ payoff $\frac{1}{2} \cdot 2 + \frac{1}{2} \cdot 0 = 1$; deviates to $S \Rightarrow$ payoff $\frac{1}{2} \cdot 0 + \frac{1}{2} \cdot 1 = \frac{1}{2}$
  - Type m of player 2: deviate to $S \Rightarrow$ payoff 0
  - Type v of player 2: deviate to $B \Rightarrow$ payoff 0

Bayesian games: motivational example

Another variant of *BoS* with imperfect information

Neither player knows whether other wants to go out with her

1: m_1

	B	S
B	2, 1	0, 0
S	0, 0	1, 2

State mm ($\frac{1}{3}$)

	B	S
B	2, 0	0, 2
S	0, 1	1, 0

State mv ($\frac{1}{3}$)

2: m_2

2: v_2

1: v_1

	B	S
B	0, 1	2, 0
S	1, 0	0, 2

State vm ($\frac{1}{6}$)

	B	S
B	0, 0	2, 2
S	1, 1	0, 0

State vv ($\frac{1}{6}$)

Bayesian games: motivational example

Another variant of *BoS* with imperfect information

- How to model information?
- Each player receives signal about state before choosing action:
  - Player 1 receives same signal, say m_1, in states *mm* and *mv*, and same signal, say $v_1 \neq m_1$, in states *vm* and *vv*
  - Player 2 receives same signal, say m_2, in states *mm* and *vm*, and same signal, say $v_2 \neq m_2$, in states *mv* and *vv*.
- Player i who receives signal t_i is type t_i of player i
- Type m_1 of player 1's posterior belief: state is *mm* with probability $\frac{1}{2}$ and *mv* with probability $\frac{1}{2}$
  Type v_1 of player 1's posterior belief: state is *vm* with probability $\frac{1}{2}$ and *vv* with probability $\frac{1}{2}$
- Type m_2 of player 2's posterior belief: state is *mm* with probability $\frac{2}{3}$ and *vm* with probability $\frac{1}{3}$
  Type v_2 of player 2's posterior belief: state is *mv* with probability $\frac{2}{3}$ and *vv* with probability $\frac{1}{3}$

Bayesian games

Elements new relative to strategic game are indicated in red

A Bayesian game consists of

- a finite set N (*players*)
- a set Ω (*states*)
- for each player $i \in N$
  - a set A_i (*actions*)
  - a set T_i (of *signals* that i may receive) and a function $\tau_i : \Omega \to T_i$ that associates a signal with each state (i's signal function)
  - a probability measure p_i on Ω (i's *prior belief*) with $p_i(\tau_i^{-1}(t_i)) > 0$ for all $t_i \in T_i$
  - a *preference relation* over probability distributions over $A \times \Omega$ (represented by the expected value of a Bernoulli payoff function).

Notes

- i has no information: $\tau_i(\omega) = \tau_i(\omega')$ for all ω, ω'
- i has perfect information: $\tau_i(\omega) \neq \tau_i(\omega')$ if $\omega \neq \omega'$

First example

Players $N = \{1, 2\}$ (the pair of people)

States $\Omega = \{meet, avoid\}$

Actions $A_1 = A_2 = \{B, S\}$

Signals $T_1 = \{z\}$ and $\tau_1(meet) = \tau_1(avoid) = z$
$T_2 = \{m, v\}$ and $\tau_2(meet) = m$ and $\tau_2(avoid) = v$

Beliefs $p_1(meet) = p_2(meet) = \frac{1}{2}$,
$p_1(avoid) = p_2(avoid) = \frac{1}{2}$

Payoffs The payoffs $u_i(a, meet)$ of each player i for all possible action pairs are given in the left panel of the figure on the earlier slide and the payoffs $u_i(a, avoid)$ are given in the right panel

Second example

Players $N = \{1, 2\}$ (the pair of people)

States $\Omega = \{mm, mv, vm, vv\}$

Actions $A_1 = A_2 = \{B, S\}$

Signals $T_1 = \{m_1, v_1\}$, $\tau_1(mm) = \tau_1(mv) = m_1$, and $\tau_1(vm) = \tau_1(vv) = v_1$
$T_2 = \{m_2, v_2\}$, $\tau_2(mm) = \tau_2(vm) = m_2$, and $\tau_2(mv) = \tau_2(vv) = v_2$

Beliefs $p_i(mm) = p_i(mv) = \frac{1}{3}$ and $p_i(vm) = p_i(vv) = \frac{1}{6}$ for $i = 1, 2$

Payoffs The payoffs $u_i(a, \omega)$ of each player i for all possible action pairs and states are given on the earlier slide

Second example: Nash equilibria

1: m_1

	B	S
B	$2, 1$	$0, 0$
S	$0, 0$	$1, 2$

State mm ($\frac{1}{3}$)

Posterior: $\frac{1}{2}$

	B	S
B	$2, 0$	$0, 2$
S	$0, 1$	$1, 0$

State mv ($\frac{1}{3}$)

Posterior: $\frac{1}{2}$

2: m_2

2: v_2

1: v_1

	B	S
B	$0, 1$	$2, 0$
S	$1, 0$	$0, 2$

State vm ($\frac{1}{6}$)

Posterior: $\frac{1}{2}$

	B	S
B	$0, 0$	$2, 2$
S	$1, 1$	$0, 0$

State vv ($\frac{1}{6}$)

Posterior: $\frac{1}{2}$

Payoffs

$$\frac{1}{2} \cdot 2 + \frac{1}{2} \cdot 0 = 1$$
$$\frac{1}{2} \cdot 0 + \frac{1}{2} \cdot 1 = \frac{1}{2}$$

$$\frac{1}{2} \cdot 0 + \frac{1}{2} \cdot 2 = 1$$
$$\frac{1}{2} \cdot 1 + \frac{1}{2} \cdot 0 = \frac{1}{2}$$

Payoffs: 1 0 0 2

Nash equilibrium: $((B, B), (B, S))$

Second example: Nash equilibria

1: m_1

	B	S
B	$2, 1$	$0, 0$
S	$0, 0$	$1, 2$

State mm ($\frac{1}{3}$)

Posterior: $\frac{2}{3}$

	B	S
B	$2, 0$	$0, 2$
S	$0, 1$	$1, 0$

State mv ($\frac{1}{3}$)

Posterior: $\frac{2}{3}$

2: m_2

2: v_2

1: v_1

	B	S
B	$0, 1$	$2, 0$
S	$1, 0$	$0, 2$

State vm ($\frac{1}{6}$)

Posterior: $\frac{1}{3}$

	B	S
B	$0, 0$	$2, 2$
S	$1, 1$	$0, 0$

State vv ($\frac{1}{6}$)

Posterior: $\frac{1}{3}$

Another Nash equilibrium: $((S, B), (S, S))$