Signaling

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Applying for Economics Graduate School

An Example of Signaling

Questions

- What should I apply? MBA or Econ PhD?
- What's the most important factor if I apply?
- Are foreigners/females discriminated against?
- Is mathematics needed in graduate school?
- Is MA (at NTU) required before I enter PhD?
- How should I prepare myself now?

What Program Should I Apply?

- MBA or Econ PhD?
- This depends on Your Career Interest
- However, MBA is NOT for "newly graduates"
  - MBA is designed for people who have worked for years and are heading for top management
- They teach undergraduate level Economics, but
  - tie it with actual working experience
  - Socializing with other CEO-to-be's is a bonus

What Program Should I Apply?

- Econ PhD provides you the rigorous training to modern "economic analysis" techniques
- This is used by
  - Academics (Economics, Public Policy, Law, etc.)
  - Economics Consulting Firms
  - Public Policy Evaluation
  - Financial Companies (like Investment Banking)
  - International Organizations (APEC, IMF, etc.)

Most Important Factor

- What is the Most Important Factor when I Apply for Graduate School?
- Petersons Guide surveyed both students and admission committee members (faculty)
- They find that both agree No.1 factor is:
  - Letter from someone the committee knows
- Why is this No.1?
- Credible Signaling!

Most Important Factor

- No.1:
  - Letter from someone the committee knows
- Who are the people committees know?
- What if I cannot find someone to write?
- Find Other "Credible Signals"!
  - GPA?
  - GRE or TOEFL?
  - Other Distinct Features such as AWA 5.0 or higher?

Discrimination and Gender

- Are Foreigners or Females Discriminated Against?
- Foreigners:
  - Different Programs have different policy
  - UCLA (8/35) vs. MIT (25/30)
- Women: Only 16% of the Faculty are Female
  - Does the market favor women? Maybe...
  - Comparison: 33% Math Professors are Female

Is Mathematics Needed?

- Advice for Econ PhD Applicants:
  - Take a heavy dose of mathematics during undergraduate. ~ Peterson's Guide
- So, the answer is generally "yes."
  - There is a "gap" between undergrad & graduate...
- However, the ability to find economic intuition behind the math is even more essential
  - My first year micro comp. experience...
- They need Bilingual People!

Is Mathematics Needed?

- What Kind of Math is Needed?
- Advanced Calculus – Score 80 or higher (A/A+)
  - The thinking process required for you to score A/A+ is what's important
- Linear Algebra – Basic Tool for Econometrics
- Advance Statistical Inference (Mathematical Statistics) – Basic Tool for Econometrics
- The more the better, but mastering these three is better than being a jack of all traits...

Is MA required before I enter PhD?

- No. Top-10 schools admit only PhD students.
  - Chicago: We'll give you a master if you can't finish.
- However, you might not be able to survive studying both math & economics in English...
- Hence, a MA might help since
  - MA classes are similar to PhD classes
  - You might not be sure if you want to go for PhD
- Condition on passing 1st year comp's, MA is unnecessary, but you may want to hedge...

How Should I Prepare Myself Now?

- Create Credible Signals!
- Such As:
- GPA 4.0, ranked 1/160
- Good References
- A Published Research Paper
- Take a Heavy Dose of Mathematics
- Take Graduate Level Courses in Economics
- Take Economics Courses Taught in English

Signaling

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What Makes a Signal Work?

- A Signal must be affordable by certain types of people
  - Cost $<$ Benefit (if receivers "decodes" it)
- A signal must be too expensive for players of the wrong type to afford
  - Cost $>$ Benefit (even if receivers "decodes" it)
- Separating Equilibrium: Those who buy and those who don't are of different types

What Makes a Signal Work?

- Separating Equilibrium consists of a circular argument:
  - Signal senders buy the signal anticipating receivers decode it
  - Receivers get assurance about sender types from the signal and act different with/without it
  - This is a self-fulfilling prophecy
- Spence (Dissertation 1974)

What Makes a Signal Work?

- Exercise: Show which types of people can afford the following signals:
  - GPA 4.0, ranked 1/160
  - Good References
  - A Published Research Paper
  - Take a Heavy Dose of Mathematics
  - Take Graduate Level Courses in Economics
  - Take Economics Courses Taught in English
  - AWA 5.0

Theory of Signaling

- Harsanyi (MS 1967-68)
  - Types: Privately observe a move of "Nature"
- Bayesian-Nash Equilibrium (simultaneous) or Perfect-Bayesian Equilibrium (sequential)
  - Separating Equilibrium
  - Pooling Equilibrium
  - Semi-pooling Equilibrium
- Refinements: Sequential, Intuitive, Divine, Universal Divine, Never-Weak-BR, Stable

Simple Signaling Game

- Brandts and Holt (AER 1992)
- Worker Types are H or L with (2/3, 1/3)
- Seeing own type, Workers can choose to S (skip) or I (invest in education)
- Seeing this action, Employer assign the worker to a D (dull) or C (chanlenging) job
- Employer payoffs are 125 if she assigns D to L types and C to H types

Simple Signaling Game

- Workers get 100 doing C and 20 doing D
- L types get additional 40 for taking action S
- H types get 40 for taking action I, 20 for taking S

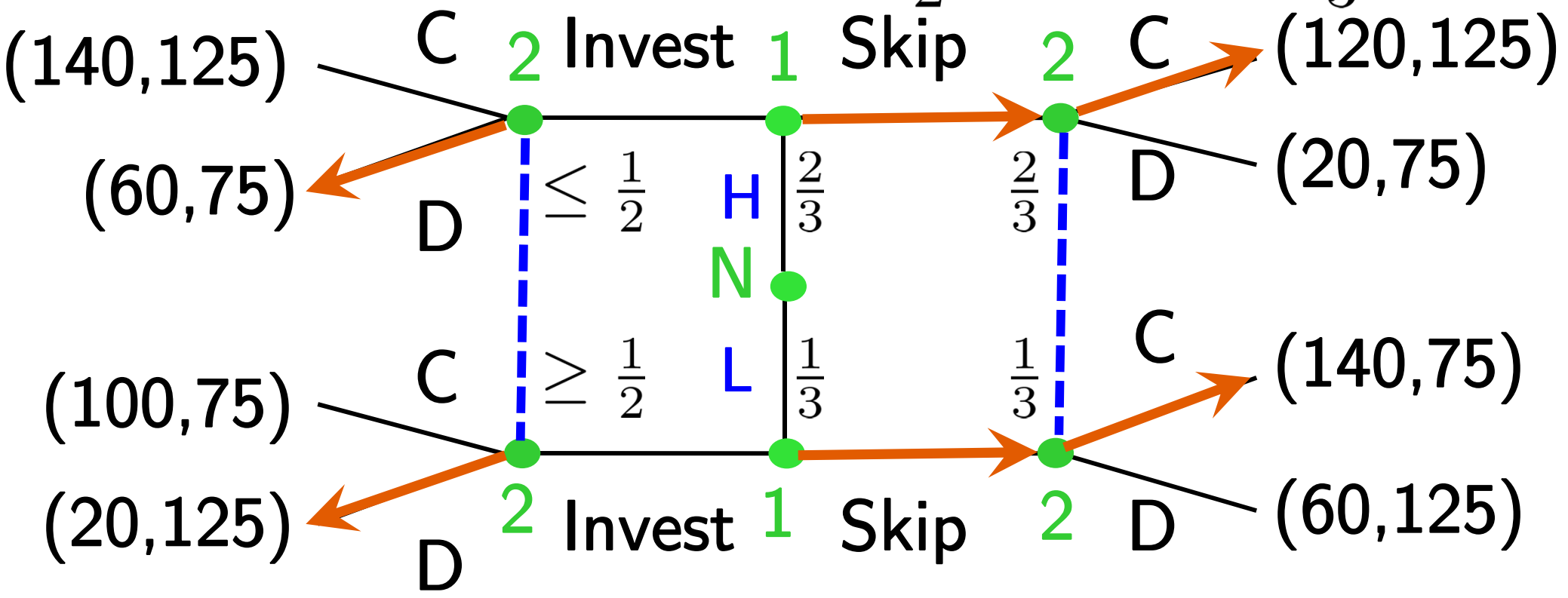
	Action seeing S		Action seeing I	
	C^S	D^S	C^I	D^I
Type L	140, 75	60, 125	100, 75	20, 125
Type H	120, 125	20, 75	140, 125	60,75

Simple Signaling Game

- Two Pooling Equilibria:
- Sequential Equilibrium
  - Both Types choose S, Employers assign C
  - Out-of-equilibrium Belief: choosing I means L
  - Hence, Employers assign D if they see I
- Intuitive Equilibrium
  - Both Types choose I, Employers assign C
  - Out-of-equilibrium Belief: choosing S means L
  - Hence, Employers assign D if they see S

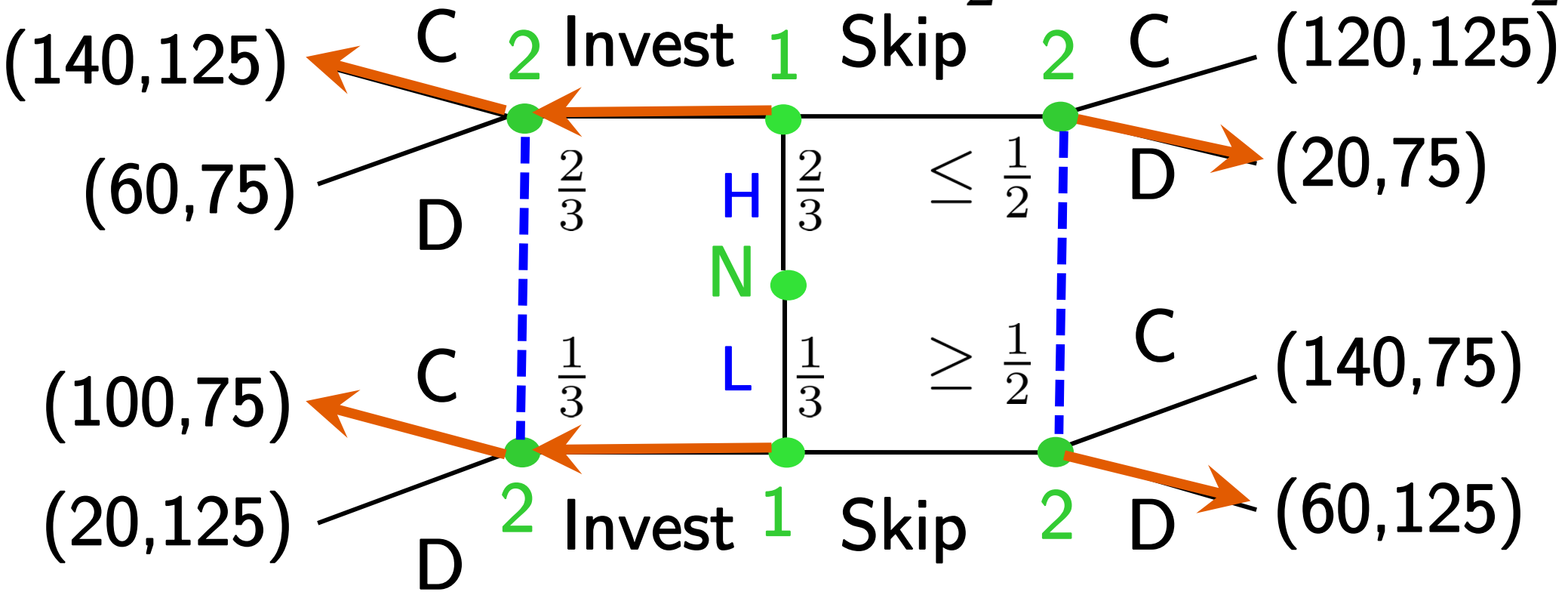
Simple Signaling Game: Extensive Form

- Sequential Equilibrium: $\Big((S|H, S|L), (D|I, C|S)\Big)$
- Beliefs: $\Pr(H|I) \leq p_1 = \frac{1}{2}, \Pr(H|S) = \frac{2}{3}$



Simple Signaling Game: Extensive Form

- Intuitive Equilibrium: $\Big((I|H, I|L), (C|I, D|S)\Big)$
- Beliefs: $\Pr(H|I) =\leq p_1 = \frac{1}{2}, \Pr(H|S) \leq p_1 = \frac{1}{2}$



Simple Signaling Game

Periods	Message | Type		Action | Type		Equilibrium Predictions	
	I | H	I | L	C | I	D | S	Intuit.	Seq.
1-4	100	25	100	74	100	0
5-8	100	58	100	100	100	0
9-12	100	75	98	60	100	0
Suggest Actions: "C | S, D | I"						
1-4	50	13	60	46	100	0
5-8	75	33	33	67	100	0

Follow-up Studies

- Banks, Camerer and Porter (GEB 1994)
- Design 7 games, separating:
  - Nash vs. non-Nash
  - Sequential vs. Nash
  - Intuitive vs. Sequential
  - Divine vs. Intuitive
  - Universal Divine vs. Divine
  - NWBR vs. Universal Divine
  - Stable vs. NWBR

Follow-up Studies

- Results show that subjects do converge to the more refined equilibrium up to intuitive
- After that, subjects conform to neither
  - Except for possibly Stable vs. NWBR
- Is this a test of refinements, or a test of equilibrium selection?
- Exercise: Show how equilibria in Table 8.3 (BCP94') satisfy corresponding refinements

Follow-up Studies

- In game 2-6, different types send different messages
  - No simple decision rule explains this
  - But weak dominance and 1 round IEDS hold
- Are people just level-1?
- Also, how does the convergence work?

Follow-up Studies

- More studies on learning:
- Brands and Holt (IJGT 1993)
  - Subjects lead to play less refined equilibrium
  - Why? Initial random play produces history that supports the non-intuitive equilibrium
- Anderson and Camerer (ET 2000)
  - EWA yields $\delta{=}0.54$ (0.05);
  - Does better than choice reinforcement $(\delta{=}0)$ and weighted fictitious play $(\delta{=}1)$

Specialized Signaling Games

- Potters and van Winden (IJGT 1996)
  - Lobbying
- Cadsby, Frank & Maksimovic (RFS 1990)
  - Corporate Finance
- Cooper, Kagel, Lo and Gu (AER 1999)
  - Ratchet Effect
- Cooper, Garvin and Kagel (Rand/EJ 1997)
  - Belief Learning in Limit Pricing Signaling Games

Lobbying: Potters & van Winden (IJGT96)

- Lobby group is type t_1 or t_2 with (1-p, p)
- Lobby group can send a signal (cost c)
- Politician chooses action x_1 or x_2 (match type)

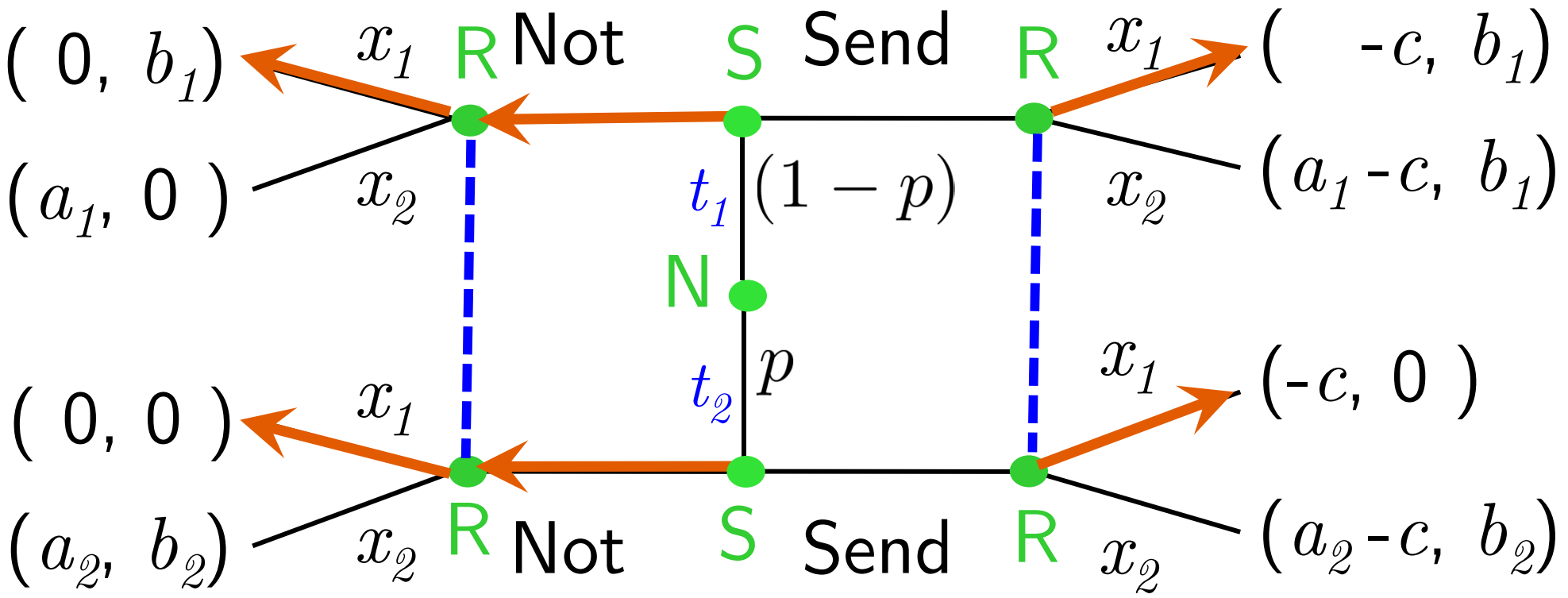
Type	No signal		Costly Signal	
	x_1	x_2	x_1	x_2
t_1 (1-p)	0, b_1	a_1, 0	-c, b_1	a_1 - c, 0
t_2 (p)	0, 0	a_2, b_2	-c, 0	a_1 - c, b_2

Lobbying

- For $\beta = \dfrac{pb_2}{(1-p)b_1} < 1$; there are 2 equilibrium:
- Pooling: Lobby groups both don't send signal
- Politician ignores signal and chooses x_1
  - Intuitive, divine, but not universally divine
- Semi-pooling: type t_2 always send signal
- Politicians mix x_1, x_2 with $(1\text{-}c/a_1,\ c/a_1)$ if signal
- type t_1 mixes by sending signal with prob. β
  - Universally divine

Lobbying: Pooling Equilibrium

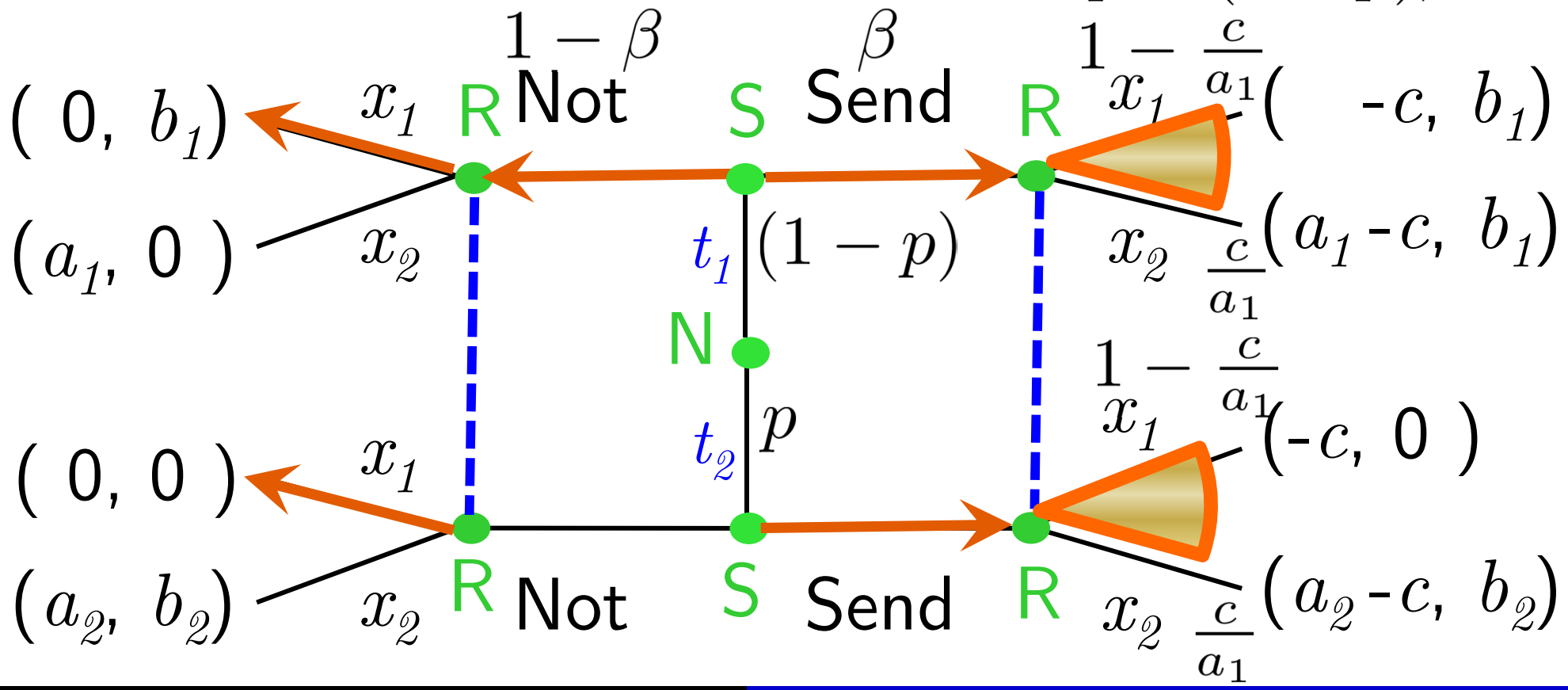
- Equilibrium: $\Big((Not|t_1, Not|t_2), (x_1|Send, x_1|Not)\Big)$
- Beliefs: $\Pr(t_2|Not) = p = \Pr(t_2|Send)$



Lobbying: Semi-Pooling Equilibrium

$$\Big((\beta S+(1-\beta)N|t_1, S|t_2), ((1-\alpha)x_1+\alpha x_2|S, x_1|N)\Big)$$

- Beliefs: $\Pr(t_2|N)=1; \Pr(t_2|S)=\dfrac{p}{p+(1-p)\beta}$



Lobbying

Treatment	Signal Freq. (t_1, t_2)			x_2 Freq. (no sig., sig)		
	β	Actual	Pred.	c/a_1	Actual	Pred.
1	0.25	38, 76	25,100	0.25	2, 5	0,25
2(2c)	0.75	46,100	75,100	0.25	3, 79	0,25
2a(6c)	0.75	83, 93	75,100	0.25	11, 54	0,25
3	0.25	16, 85	25,100	0.75	0, 53	0,75
4	0.75	22, 83	75,100	0.75	5, 80	0,75
Aver.	0.25	27, 81	25,100	0.25	5, 46	0,25
	0.75	50, 92	75,100	0.75	2, 66	0,75

Lobbying

- Supporting universally divine equilibrium
- Fictitious Play Learning:
  - Past frequency of x_2 after signal is $r(m)_{t\text{-}1}$
- Should signal if $r(m)_{t\text{-}1}\ a_1$ - c >0
  - Subjects signal 46% if >0, 28% if <0
  - Politicians choose x_2 77% if >0, 37% if <0
- Potters and van Winden (JEBO 2000)
  - Similar results; little difference between students and professionals

Corporate Finance

- Cadsby, Frank & Maksimovic (RFS 1990)
- Firms are either H or L with (50%, 50%)
  - Worth B_H, B_L if carry project; worth A_H, A_L if pass
- Need capital I to finance the project
- Investors can put up I and get S shares
- Exercise: When will there be pooling, separating, and semi-separating equilibria?

- Example:
- L types worth 375, 50 (with/without project)
- H types worth 625, 200 (with/without project)
- Capital $I = 300$
- Separating equilibrium: S=0.80
- Pooling equilibrium: S=0.60
- Semi-pooling equilibrium: S=0.68
- Exercise: Show that these are equilibria!

Corporate Finance

- Cadsby et al. ran 10 sessions (Table 8.11)
- Results support equilibrium (pooling if multi.)
  - When unique pooling: all firms offer shares
  - When unique separating: Initially, both offer (pool), but H types learn not to offer (separate)
  - When multiple: Converge to pooling equilibrium
- Cadsby, Frank and Maksimovic (RFS 1998)
  - Add costly signals (see Table 8.12 for results)

Ratchet Effect

- Cooper, Kagel, Lo and Gu (AER 1999)
- Firms are either H or L with (50%, 50%)
- Choose output level 1-7
- Planner choose "easy" or "tough" target
  - Set "easy" if Pr(L | output) > 0.325
- Pooling Eq: L chooses 1 or 2; H pools with L
- Myopic K firms: Naively pick 5 (& get "tough")
  - Exercise: Prove these with payoffs in Table 8.13.

Ratchet Effect

- 70-90% L firms choose 2
- Most H firms choose 2 or 5
- Period 1-12: 54-76% myopic →80% tough
- Period 13-36: Convergence to pooling
- Big context effect only for Chinese manager
  - Provides language to folster learning from exp.
- Cooper, Garvin and Kagel (Rand/EJ 1997)
  - Belief Learning in Limit Pricing Signaling Games

Reputation Formation

- Camerer and Weigelt (Econometrica 1988)
- 8 period trust game
- Borrower: "normal" (X) or "nice" (Y)
- (New) Lender each period: Lend or Don't
- Borrower chooses to Default or Repay
  - Normal types default; nice types repay

Reputation Formation

Lender Strategy	Borrower Strategy	Lender Payoff	Borrower Payoff	
			Normal	Nice (Y)
Lend	Default	-100	150	0
	Repay	40	60	60
Don't	-	10	10	10

Reputation Formation

- What does the equilibrium look like?
- Last Period: Lend if $P_8(\text{nice}) > \tau = 0.79$
  - "normal" borrowers default; "nice" ones repay
- Period 7:
  - "normal" borrowers weigh between default now (and reveal) and default later

Conditional Frequency of Lending

Round		1	2	3	4	5	6	7	8
3-5	Predict	100	100	100	100	64	64	64	64
	Actual								
6-8	Predict	100	100	100	64	64	64	64	64
	Actual								
9-10	Predict	100	100	100	64	64	64	64	64
	Actual								

Conditional Frequency of Lending

Round		1	2	3	4	5	6	7	8
3-5	Predict	100	100	100	100	64	64	64	64
	Actual	94	96	96	91	72	59	38*	67
6-8	Predict	100	100	100	64	64	64	64	64
	Actual	96	99	100	95*	85*	72	58	47
9-10	Predict	100	100	100	64	64	64	64	64
	Actual	93	92	83	70	63	72	77	33

Conditional Frequency of Repay (by X)

Round		1	2	3	4	5	6	7	8
3-5	Predict	100	100	100	81	65	59	44	0
	Actual								
6-8	Predict	100	100	73	68	58	53	40	0
	Actual								
9-10	Predict	100	100	73	67	63	56	42	0
	Actual								

Conditional Frequency of Repay (by X)

Round		1	2	3	4	5	6	7	8
3-5	Predict	100	100	100	81	65	59	44	0
	Actual	95	97	98	95*	86*	72	47	14
6-8	Predict	100	100	73	68	58	53	40	0
	Actual	97	95	97*	92*	85*	70*	48	0
9-10	Predict	100	100	73	67	63	56	42	0
	Actual	91	89	80	77	84*	79*	48	29

Follow-up Studies

- Neral and Ochs (Econometrica 1992)
  - Similar repeated trust games
- Jung, Kagel and Levin (Rand 1994)
  - Entry deterrence in "chain-store paradox"
- Camerer, Ho and Chong (JET 2002)
  - Sophisticated EWA (strategic teaching!)

Conclusion

- Cooper, Garvin and Kagel (EJ 1997)
  - "We do not suggest that game theory be abandoned, but rather as a descriptive model that it needs to incorporate more fully how people actually behave."
- Possible improvements:
- QRE, level-k or Cognitive Hierarchy
- Learning (EWA or belief learning)