Chapter 15.
Application to Biology: Evolutionarily Stable Strategies

- Evolution and Rationality
- Trust in Networks

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Evolutionary Game Theory

- Players evolve strategy
- Originally proposed by Maynard Smith (1973) for use in evolutionary biology
- Payoffs interpreted in terms of reproductive success
- Animals not rational – instead evolutionary pressure drives selection

Evolution and Rationality

- Evolution and rationality result in similar equilibria
- Why? Are they in some manner the same?
- Nobel Prize winner Robert Aumann says they are two different things with a superficial similarity
- Nonetheless, evolution has informed a lot of thinking even about science, technology, economics and industry
- Evolutionary economics

Players and Populations

- Players become populations
- Better than average payoffs for strategies allow them to “invade”
- Key insight that certain strategies are necessary to maintain an evolutionary equilibrium
- Mixed strategies become variations in strategies adopted by individuals
- Evolutionary stable strategy is a mixture which persists over time

Replicator Equation

- System dynamic

$$dx/dt = x\,(\,\psi_x - \overline{\psi})$$

- Populations grow proportionally; this prevents negative units
- Populations grow in proportion to their success
- Success is measured relative to the population average of other strategies which are present in the system

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Trust in Networks Game

- Consider a network of many traders who are randomly paired to play a one shot prisoner’s dilemma
- Evaluate two strategies: *trust* and *defect*
- Pay-offs are
    - Cheating > trading > no trading > cheating a cheater > being cheated

“>” is the “greater than”-sign, indicating that cheating is more desirable than trading, etc.

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Trust in Networks Game

- Suppose there was a costly and noisy signal p, which could be used to identify defectors
- The signal correctly identifies a defector with probability of $p > 1/2$
- Is there a third strategy possible of *inspecting?*
- The inspector refuses to trade with defectors, but cooperates with trusters and inspectors

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Pay-Off Matrix for the Trust in Networks Game

	Inspect	Trust	Defect
Inspect	p^2 p^2	p p	$-2(1-p)$ $2(1-p)$
Trust	p p	1 1	-2 2
Defect	$2(1-p)$ $-2(1-p)$	2 -2	-1 -1

Pay-Off Matrix for the Trust in Networks Game

	Inspect	Trust	Defect
Inspect	p^2 p^2	p p	$-2(1-p)$ $2(1-p)$

Either inspector may veto the trade

inspectors will forgo desirable trades

Inspectors will be fooled (1-p) percent of the time

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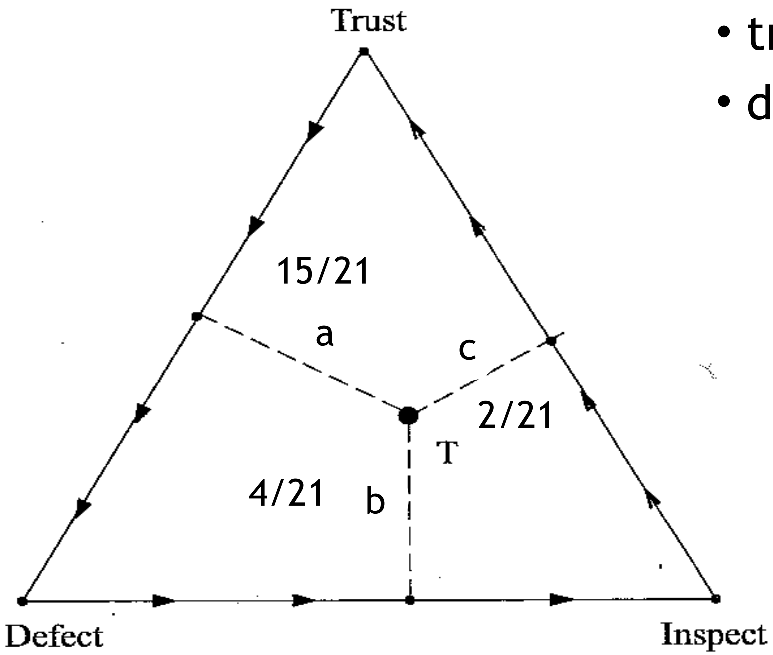
Two Player, Symmetric Game

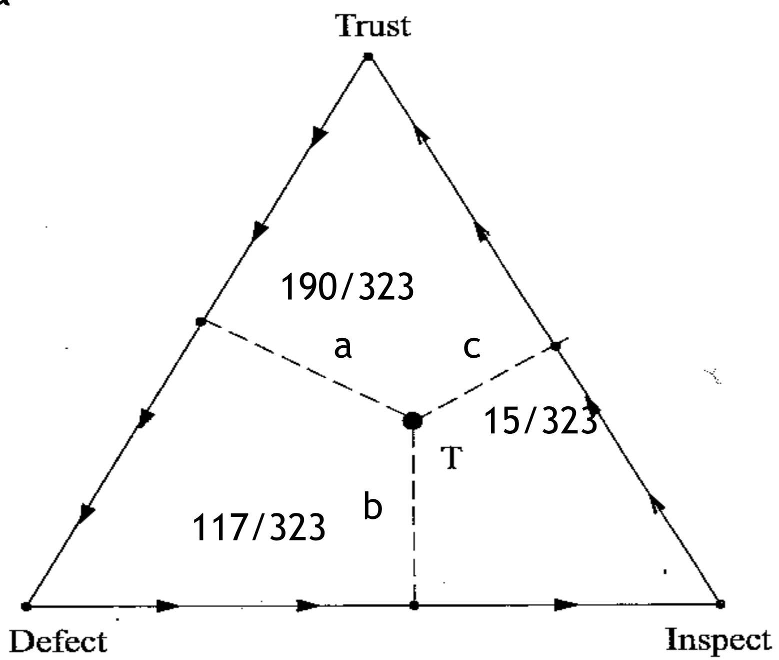
- What combination of strategies does this game permit the population?
- Seek solution in terms of frequencies of
  - inspect a
  - trust b
  - defect c

Phase Diagram

Frequencies of
- inspect a
- trust b
- defect c

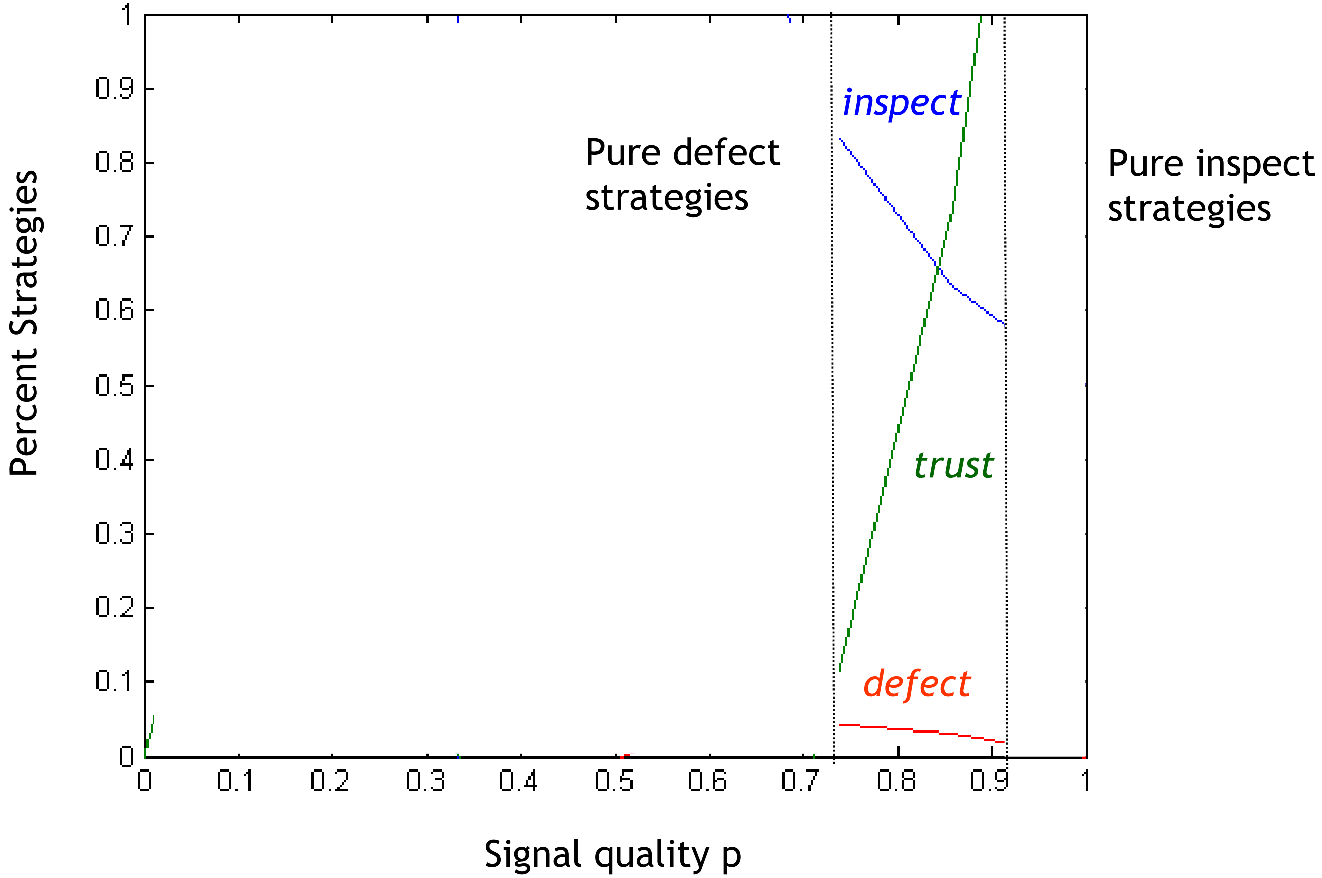


p=0.80
Pay-off 0.47



p=0.90
Pay-off 0.79

Mixed Strategy as a Function of Signal Quality



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