Skyrms: *Evolution of the Social Contract*

1. Introduction

Two traditions for applying game theory/decision theory to the social contract

1) Normative tradition:

Key question: What would a rational decision-maker agree to?

Example: Rawls-Harsanyi debate. Rawls' Difference Principle.

Main tools:

i) *Decision theory principles*: Dominance, EU maximization, Rules for Decision under Ignorance

ii) *Game theory principles*: Dominance, Nash equilibrium

2) Descriptive/Explanatory tradition:

Key question: Why did, or how could, the existing social contract (or more generally, existing social practices and conventions) evolve as it did?

Examples: our conception of distributive justice as requiring equal division of resources; altruistic behaviour.

A variety of puzzling social phenomena **not** solved by the normative approach, or where the two approaches even appear to diverge:

Main tools:

i) *Analogy* between biological evolution and cultural evolution. The analogy is formally developed in…

ii) *Evolutionary game theory*

- Agents
- Strategies
- Differential outcomes (payoffs) that influence population levels

Cf. iterated PD examples. You can find out what happens to the population over time, and what strategy mixes constitute stable equilibria.

iii) *Additional explanatory resources*

Detection of strategies, correlation, variation, etc.

Contents of the book

Chapter 1: Sex and Justice

A. Parallel puzzles

B. Solution for birth rate case

C. Parallel solution for justice

D. Complications: polymorphic traps

A. Parallel Puzzles

<u>I. Birth Rate</u>

1. *Two puzzling phenomena:*

(a) **Rough equality.** Approximately equal numbers of males and females at birth (all mammal species).
(b) **Male excess.** Regular elevation of human male birth rate: slightly over 50%.

How can we explain (a) and (b)?

2. *Arbuthnot* (1710)

Starting point: the phenomena are too stable to be attributed to chance

Explanation for (a): the Creator favours monogamy
Explanation for (b): due to the higher mortality of males, excess at birth ensures equal numbers at reproductive age

Objections:

(1) Supernatural explanation
(2) Even in polygamous species, the sex ratio is close to 50%

3. *Is there an alternative explanation?*

Natural selection:

Genetically-linked traits that confer an advantage over other traits (higher probability of survival to reproduction) tend to increase in a population.

Example: Evolution of taller molars in horses.

Difficulty:

Suppose tendency to produce offspring in equal numbers, or to produce one sex in excess, is genetically linked.
None of these tendencies should become predominant, since none confers any advantage for survival or number of offspring.

II. **Distributive Justice**

1. *A puzzle about justice*.

Set-up: Two people dividing a chocolate cake.

Procedure:

- Each writes down a claim to a percentage
- If the total is ≤ 100%, each gets the claimed amount
- If the total exceeds 100%, neither gets anything.

The puzzle:

Everyone agrees that you should ask for an even split. *WHY?*

From the *normative* point of view, all strategies (x, 100 – x) with 0 < x < 100 are Nash equilibria and hence count as equally good solutions.

[With each such pair, both agents are giving their best response and have no incentive to change.]

Upshot: Nash equilibrium does not explain our conception of justice.
Rational self-interest does not appear to explain our conception of justice.

Attempted solutions from the normative side: Rawls, Harsanyi.

- Harsanyi is unable to avoid the multitude of equilibria
- Rawls is unable to justify use of Maximin.

B. Evolutionary explanation of birth rates

(a) Rough equality.

An evolutionary explanation is available.

Assume that the tendency to produce both sexes in equal numbers, or one sex in excess, is indeed genetically linked, and thus heritable.

Key Insight: Although this tendency does not affect the expected number of children, it affects the expected number of grandchildren.

In more detail:

Suppose there were an excess of females in the population.
Then males would have more children on average than females, and contribute more genes to the next generation.
So a person with a tendency to produce an excess of males would have more grandchildren than average, and the tendency would spread.

Stability: 50/50 is a stable evolutionary equilibrium. Imbalance in either direction will produce counter-pressures.

A simple example:

1) 100 individuals: 60 F, 40 M.
2) Males and females pair off until all of one gender are gone.
3) Within each gender, everyone has an equal probability of pairing off.

F – 2/3
M – 1

4) Each individual has the same expected number of offspring (say 2).

Compare three individuals:

	Children	Grandchildren	
A	2M	$2 \cdot 2$	$= 4$
B	1M, 1F	$2 + (2/3)2$	$= 3\frac{1}{3}$
C	2F	$(2/3)4$	$= 2\frac{2}{3}$

Each of A's grandchildren carries the tendency to produce an excess of males, so this tendency has spread.

Polygamous mammals: If only 1 in 10 males has offspring, then breeding males become 10 times as valuable. The expected reproductive value of a single male is unchanged.

Note: Tendencies function like strategies, even though they are not intentional.

(b) Male excess.

Key insight: Develop a more complex model in which the *parental cost* of producing and rearing males and females need not be the same.
The argument above yields an equilibrium with *equal parental investment* in each gender.

Argument. Males and females produce the same average number of children at maturity.
But due to higher mortality, males are 'cheaper' to produce.
[If 50 in 100 males reach maturity, and 75 in 100 females, then on average 3 males will take as much investment as 2 females]

At 50/50, the tendency of producing males will start to spread. If the difference in 'cost' is slight, this spread will be checked once there are slightly more males.

Expected parental expenditure for a male at birth is lower than for females because of high mortality.
But average parental expenditure for a male at the end of parental care is higher than for a female.

C. Solution for Justice

Evolutionary model:

- cake portions represent fitness
- strategies are inherited/replicated in accordance with payoffs
- random pairings
- identity of individuals in the interactions is unimportant
  [only the pair of strategies determines the overall outcome, and the relative proportions determine the frequency of each type of pairing]

Observations:

- all interactions are dyadic (two-person)
- but these dyadic interactions will "solve" the co-operation problem by convergence to a dynamic equilibrium
- cf. Hardin: in rational choice theory, rational choices in dyadic interactions don't generalize to multi-agent case

Solution to the problem:

Special case: all adopt the same pure strategy.

Case i: Everyone demands more than 50% (but less than 100%).

Then nobody gets anything.
Anybody who demands a modest positive amount will do better.

Case ii: Everyone demands less than 50%.

Then anybody who demands a modest amount more than 50% will do better.

The only equilibria are: all demand 50%, and all demand 100%. Only the first is a *stable* equilibrium.

D. Polymorphic traps

Polymorphic state: different strategies played by different proportions of the population.

Could evolution lead to equilibria involving polymorphic states?

Birth rate case:

Fisher's arguments show only that *average* birth rate must be near 50%.
But it does not rule out, e.g.,

30% → produce 90 percent males
30% → produce 90 percent females
40% → produce 50% of each.

Yet such equilibria are not found.

Cake division:

All the Nash equilibria are there. Ex:

75% Greedy: Demand 80%
25% Modest: Demand 20%.

Both expect, on average, 20% of the cake, and no other demand does better. So we have a stable evolutionary equilibrium.

For **any** proportion p between 0 and 1, (Demand p, Demand 1-p) will be a stable equilibrium with a proportion demanding p and a proportion demanding 1-p.

Trap: 60% of the cake is wasted on average, each time. No way the agents can do better.

Problem: Which initial proportions of these different populations lead to the fair division equilibrium, and which to polymorphic traps?

Replicator diagrams: illustrate the relative size of "sinks" leading to fair division or a polymorphic trap.

Show that justice will evolve from a larger set of initial conditions than will injustice.

How to avoid the traps

1. **Granularity**

   More slices of cake (approaching continuous divisibility) → higher proportion evolve to fair division.

2. **Detection and correlation.**

   - Drop assumption of random pairing off from sex ratio case, the polymorphisms disappear
   - If we assume positive correlation between like strategies – so like are most likely to meet like – then polymorphisms start to disappear.

   Extreme case: like only meet like. Then only “Demand ½” survives.

   Result: a modest amount of correlation has a huge influence in favour of the “fair division” equilibrium.

SUMMARY

1. Number of pure equilibria

Rational choice theory:

Multiple pure equilibrium strategies: (p, 1-p)

Evolutionary approach:

Only one evolutionarily stable pure strategy: share equally

2. Avoiding polymorphic traps

a) Variation: even if caught, might bounce out
b) Finer grained division
c) Correlation/tendency to pair off with the like-minded

Since all of these tendencies are realized, we have a high probability for justice to evolve – and this may be the best explanation for the conception we have.