Uptake of a diagnostic blood test for sheep scab: a game theoretic approach

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Background: the need for a blood test

- Sheep scab is a serious and economically important disease that is emerging in the UK
- Currently, treatment is based on clinical signs and subsequent diagnosis via skin scrapings.
- A promising alternative is a diagnostic blood test developed by Moredun which can reliably detect *P. ovis* on sheep even before clinical signs of disease are evident.

Will farmers adopt the test?

- We assume a farmer will weigh the benefits of testing and early treatment against the cost of unnecessarily paying to test an uninfected flock. We also assume a farmer's assessment of whether his flock might be infected and need testing will depend on his neighbour's decisions and infection state.
- **Game theory** is designed to capture these **strategic interactions** between individuals in their decision making process.
- Here, we use a **stochastic game** which allows farmer to move between high, medium and low risk states depending on their infection status and actions.

A stochastic game for sheep scab test adoption

- Our baseline economic and epidemiological data define a stochastic game (example below) with high, medium and low risk states.
- The **payoffs** for each combination of decisions are shown above the diagonal (with the payoff for farmer 1 first, and the payoff for farmer 2 second).
- The **probabilities** of moving between states (shown below the diagonal) assume that farms
  - move to the high risk state if either farm had clinical infection last year
  - move to the medium risk state if subclinical infection was detected using the new test
  - move to the low risk state if both farms were uninfected.

High risk state

Farmer 1 \ Farmer 2	test	adopt
Adopt test	5,5 / 0.6,0.2,0.2	5,6 / 0.8,0.1,0.1
Don't adopt	6,5 / 0.8,0.1,0.1	6,6 / 0.9,0.1,0.0

Medium risk state

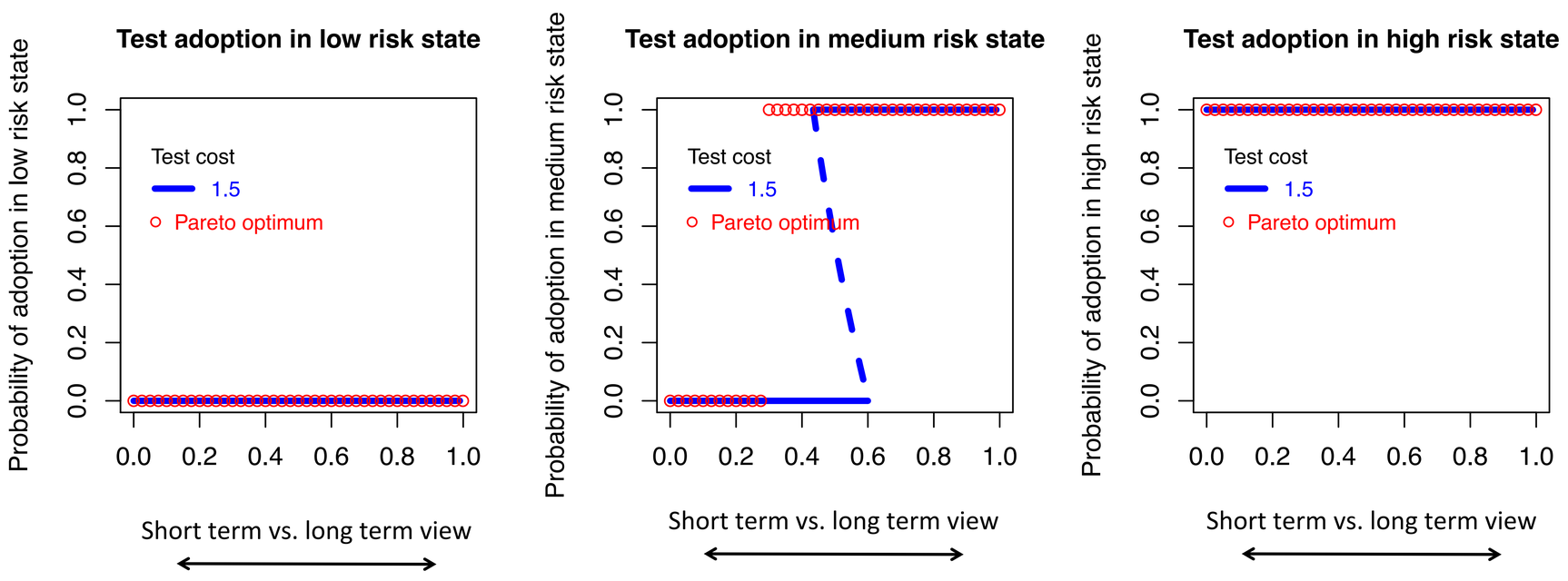
Farmer 1 \ Farmer 2	test	adopt
Adopt test	8,8 / 0.5,0.3,0.2	8,9 / 0.6,0.3,0.1
Don't adopt	9,8 / 0.6,0.3,0.1	9,9 / 0.7,0.2,0.1

Low risk state

Farmer 1 \ Farmer 2	test	adopt
Adopt test	10,10 / 0.1,0.1,0.8	10,11 / 0.4,0.2,0.4
Don't adopt	11,10 / 0.4,0.2,0.4	11,11 / 0.3,0.3,0.5

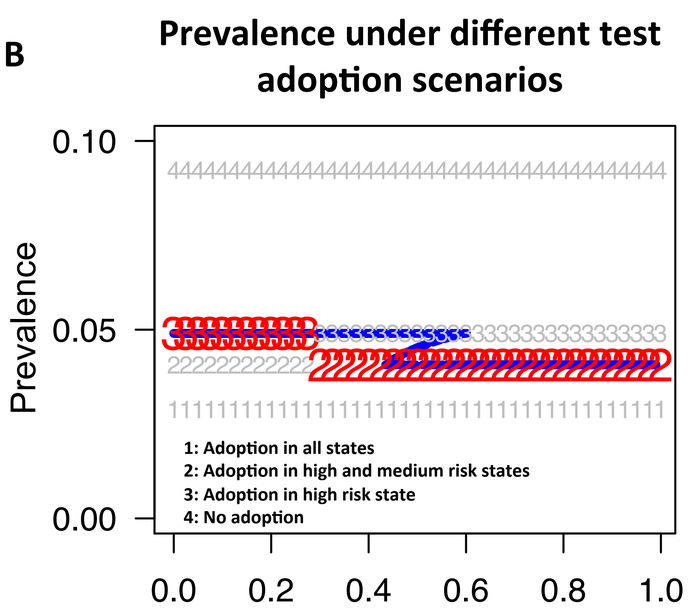
Model outputs and interpretation

A



- The solution, **the Nash equilibrium,** (blue) is shown (**A**) for an expected test cost of **1.5** times the current cost of diagnosis via skin scraping.
- The solution depends on whether farmers take a short term or long term view of their investments.
- The Nash equilibrium does not always match the **Pareto optimum (red circles)** which is the best strategy for all.
- Under this test adoption scenario, we expect a reduction in prevalence of around 50% (see **B**).

B



Key observations

- Test adoption depends on whether farmers take a short or long term view of their investments.
- For expected current expected costs of the new blood test we expect test adoption in the high risk state but not necessarily in the medium risk.
- Under this adoption scenario, we would expect to see a **reduction in prevalence of infected farms of just over 50%**.
- The solution does not always match the Patero optimum which would be the best solution for all if farmers chose to cooperate.
- Also, there may be multiple solutions. This is important as solutions are not equally profitable; therefore, strategic decision making may result in non-adoption, when adoption would be better.
- These results provide support for **herd health schemes which encourage and facilitate cooperation between farmers**.