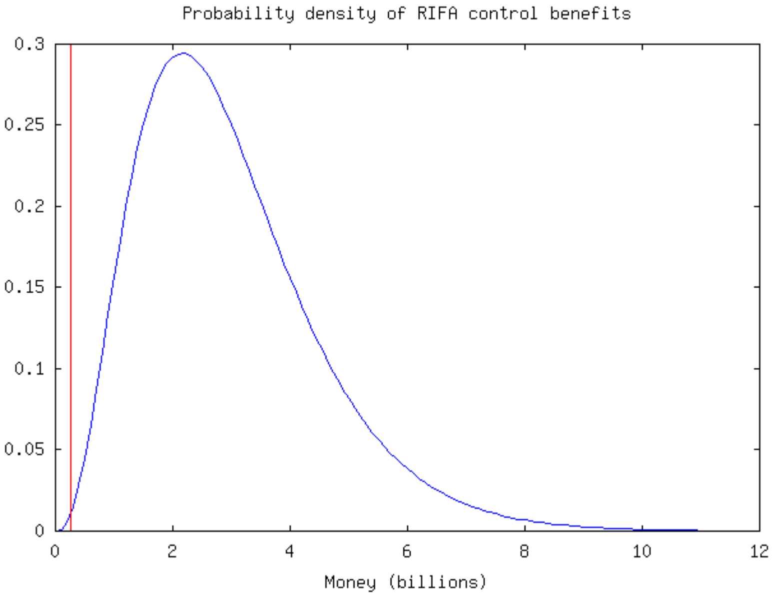
Value of information in risk-return analysis

- Uncertainty is a fundamental feature of biosecurity decisions.
- Reducing uncertainty has value because it may allow better decisions.
- How large is that value?

Example: RIFA benefits distribution



Mathematics

- Value of policy based on existing information depends on expected benefits EB and cost C:

$$\max(EB - C, 0)$$

- *Ex ante* Value of policy based on perfect information depends on the full distribution of possible benefits:

$$E \max(B - C, 0)$$

- *Ex ante* Value is equivalently

$$\int_C^\infty (B - C) f(B) dB,$$

where f is the probability density of benefits.

Mathematics

- Value of information is the expected gain from improved information :

$$E \max(B - C, 0) - \max(EB - C, 0)$$

- Equivalently, the probability of a changed optimal decision times the expected savings conditional on a changed decision.
- Only the tails of the distribution matter. When $EB > C$, value of information

$$\int_0^C (B - C) f(B) dB$$

RIFA results

- Probability of Benefits less than \$250 Million is less than one-tenth of one per-cent: 0.0007.
- Conditional on $B < 250$, Benefits average about 80% of Cost.
- Sounds like a no-brainer. But the value of information is about $35,000$ dollars.

Intuition

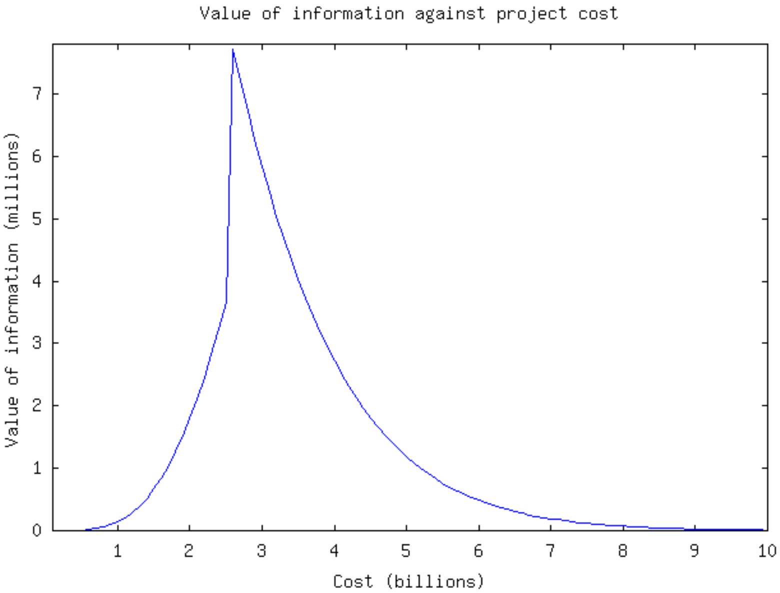
- Value comes from small chance (0.0007) of saving about 50 million on average.
- A trivial chance of being wrong does not necessarily imply a trivial value of information.
- The value scales linearly: 30 million benefit with a 2.5 million cost would have only about $350 value of information.
- Higher cost raises value. $500 million cost — increases information value from $35 K to $800 K. Still less than 1% chance of error, but average loss when error occurs is $100 million.

Simple experiments

Consider scaling the benefits distribution down by 100 fold, so $EB = 30$ million.

- 2:1 benefit cost ratio ($C = 15$ million) gives 650 K value of information.
- 1:2 benefit cost ratio ($C = 60$ million) gives 490 K value of information.
- Note that there is value even if the default is to take no action.

Value of information as cost varies



Two intuitive theorems

- Value of information is greatest when project has zero expected net benefit $C = EB$.
- Value of information is increased by a mean-preserving spread in benefit distribution.

Use of theorems

- What if density is hard to quantify, for example from benefits transfer with one obervation?
- Suppose you can specify basic information such as upper and lower bounds on benefits.
- Can use those two theorems to derive simple upper bounds on value of information.

A simple bound

- The value of information is always less than

$$\frac{(\overline{B} - C) * (C - \underline{B})}{(\overline{B} - \underline{B})}.$$

- In turn, this is always less than C (the bound is tight).
- Bound can be tightened by specifing EB.
- Bound can be tightened by specifing single peaked density (cuts bound by about half).

Can handle greater realism

- More general types of uncertainty, and correlations between B and C.
- Continuous choices.
- Project ranking by benefit-cost ratio (just reinterpret C).
- Whether to acquire information before an incursion, given time constraints.