**Decision Tables & Bayesian Analysis**

Michael D. Harper, Ph.D.

Two sites are under consideration for a new retail store. The success of each site is dependent on the market demand. The estimated profit (x$1000) from a good or bad market is presented below for each site.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  |  | States of Nature |  |
|  | Payoff | Good Market | Bad Market |  |
|  | SiteA | $300K | $100K |  |
|  | SiteB | $400K | $50K |  |
|  |  |  |  |  |

To aid in the decision process, historical data from 20 similar sites from a marketing research company are presented below. Assume the market will be either good or bad and the market analysis will result in either a positive or negative recommendation.

|  |
| --- |
| M=Market (Good , Bad)R=Recommendation (Positive , Negative) |

Historical Data

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  | Frequency | Good Market | Bad Market |  |
|  | Positive Recommendation | 6 | 4 |  |
|  | Negative Recommendation | 2 | 8 |  |
|  |  |  |  |  |

Bayesian Probabilities

|  |  |  |
| --- | --- | --- |
| Prior: | P[Good]= | 8/20 = 2/5 = 0.4 |
| False Negative: | P[Negative|Good]= | 2/8 = 1/4 = 0.25 |
| False Positive: | P[Positive|Bad]= | 4/12 = 1/3 = 0.333 |

Bayesian Table

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|   RM  | Prior  | Conditional | P[R|M] | Joint | P[R,M] | Posterior | P[M|R] |
| P[M] | Positive | Negative | Positive | Negative | Positive | Negative |
| Good | 0.4 | 0.75 | 0.25 | 0.3 | 0.1 | 0.6 | 0.2 |
| Bad | 0.6 | 1/3 | 2/3 | 0.2 | 0.4 | 0.4 | 0.8 |
|   |  |  |  | 0.5 | 0.5 |  |   |
|   |   |   |   | Marginal | P[T] |   |   |

Bayesian Table

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|   RM  | Prior  | Conditional | P[R|M] | Joint | P[R,M] | Posterior | P[M|R] |
| P[M] | Positive | Negative | Positive | Negative | Positive | Negative |
| Good | 0.4 | 0.75 | 0.25 | 0.3 | 0.1 | 0.6 | 0.2 |
| Bad | 0.6 | 1/3 | 2/3 | 0.2 | 0.4 | 0.4 | 0.8 |
|   | ↑ |  |  | 0.5 | 0.5 | ↑ |  ↑ |
|   |   |   |   | Marginal | P[T] |   |   |

Decision Analysis, EVSI

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | EMV | EMV | EMV |  |  |
|  | Payoff | Good | Bad | Prior | Positive | Negative |  |  |
|  | SiteA | 300 | 100 | 180 | 220 | 140←Max |  |  |
|  | SiteB | 400 | 50 | 190←Max | 260←Max | 120 |  |  |
| → | Prior= | 0.4 | 0.6 |  ↑ |  ↑ |  ↑ |  |  |
| → | Posterior|Positive= | 0.6 | 0.4 | → |  ↑ |  ↑ |  |  |
| → | Posterior|Negative= | 0.2 | 0.8 | → | → |  ↑ | EPSI |  |
|  |  | Max(EMV)= | 190 | 260 | 140 | 200 |  |
|  |  |  |  | Marginal= | 0.5 | 0.5 | ↑ |  |
|  |  |  |  |  |  |  |  |  |
|  |  | EPSI= | 200 |  |  |  |  |
|  |  | EMV Prior= | 190 |  |  |  |  |
|  |  | EVSI= | 10 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

**Decision Rules – With Probability, EVSI**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | Expected ValueExpected Regret Decision TreesExpected Value of Perfect Information🡪Expected Value of Sample Information |
|  |  | States of Nature |  |  |  |
|  | Alternatives | 1 | 2 | Expected Values |  |  |
|  | A | Information | E[A] |  |  |
|  | B | E[B] |  |  |
|  | Probability | P(1) | P(2) |  |  |  |
|  |  |  |  |  |  |  |

Two sites are under consideration for a new retail store. The success of each site is dependent on the market demand. The estimated profit (x$1000) from a good or bad market is presented below for each site.

To aid in the decision process, historical data from 20 similar sites from a marketing research company are presented below. Assume the market will be either good or bad and the market analysis will result in either a positive or negative recommendation.

|  |
| --- |
| Marginal Probabilities: |
|  | P[M=Good]=0.4; P[M=Bad]=0.6; P[R=Positive]=0.5; P[R=Negative]=0.5 |
| Conditional Probabilities: |
|  | P[M=Good|R=Positive]=0.6 and P[M=Good|R=Negative]=0.4P[M=Bad|R=Positive]=0.2 and P[M=Bad|R=Negative]=0.8 |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Example7 |  |  |  |  |  |  |  |  |  |  |
|  |  | States of Nature |  |  |  |  |  |  |  |  |
|  | No Information | Good Market | Bad Market | EMV |  |  |  |  |  |  |  |
|  | SiteA | $300K | $100K | $180K |  |  |  |  |  |  |  |
| SiteB | $400K | $50K | $190K | =Max |  |  | Positive | Negative |  |  |
|  | P[M] | 0.4 | 0.6 |  |  |  | EMV | $260K | $140K | EPSI |  |
|  |  |  |  |  |  |  | P[R] | 0.5 | 0.5 | $200K |  |
|  | Positive | Good Market | Bad Market | EMV |  |  |  |  |  | ↓ |  |
|  | SiteA | $300K | $100K | $220K |  |  |  |  |  | EMV |  |
|  | SiteB | $400K | $50K | $260K | =Max |  |  |  |  | $190K |  |
|  | P[M|Positive] | 0.6 | 0.4 |  |  |  |  |  |  | ↓ |  |
|  |  |  |  |  |  |  |  |  |  | EVSI |  |
|  | Negative | Good Market | Bad Market | EMV |  |  |  |  |  | $10K |  |
|  | SiteA | $300K | $100K | $140K | =Max |  |  |  |  |  |  |
|  | SiteB | $400K | $50K | $120K |  |  |  |  |  |  |  |
|  | P[M|Negative] | 0.2 | 0.8 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |
| --- | --- |
| Example 7 Calculations. | E[$|+]: $300K\*0.6+$100K\*0.4=$220K & $400K\*0.6+$50K\*0.4=$260K |
|  | E[$|-]: $300K\*0.2+$100K\*0.8=$140K & $400K\*0.2+$50K\*0.8=$120K |
|  | E[$|+/-]: $260K\*0.5+$140K\*0.5=$200K 🡨EPSI |
|  | EPSI=Expected Profit from Sample Information=$200K |
|  | EVSI=Expected Value from Sample Information: EVSI=EPSI – MaxEMV = $200K - $190K = $10K  |