**Decision Analysis**

**Decision Rules**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | 🡪MaxiMax  🡪MaxiMin  🡪Regret  🡪MiniMaxRegret |
|  |  | States of Nature | |  |  |
|  | Alternatives | 1 | 2 |  |  |
|  | A | Information | |  |  |
|  | B |  |  |
|  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | 🡪Expected Value  🡪Expected Regret (Opportunity Loss)  🡪Decision Trees  🡪Expected Value of Perfect Information  🡪Expected Value of Sample Information  Bayesian Analysis  Utility Theory |
|  |  | States of Nature | |  |  |  |
|  | Alternatives | 1 | 2 | Expected Values |  |  |
|  | A | Information | | E[A] |  |  |
|  | B | E[B] |  |  |
|  | Probability | P(1) | P(2) |  |  |  |
|  |  |  |  |  |  |  |

**Decision Rules – Without Probability**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | MaxiMax  MaxiMin  Regret  MiniMaxRegret |
|  |  | States of Nature | |  |  |
|  | Alternatives | 1 | 2 |  |  |
|  | A | Information | |  |  |
|  | B |  |  |
|  |  |  |  |  |  |

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.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Example |  |  |  |  |  |  | Decision Rules |  |
|  |  |  | States of Nature | |  |  |  |  |  |
|  |  | Profit | Good Market | Bad Market |  |  |  | MaxiMax | Optimistic |
|  | Alternatives | SiteA | $300K | $100K |  |  |  | MaxiMin | Pessimistic |
|  | SiteB | $400K | $50K |  |  |  | MiniMaxRegret | Opportunity Loss |
|  |  |  |  |  |  |  |  |  |  |

Now consider the Decision Rules.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Example1 |  |  |  |  |  |  | Decision Rule |  |
|  |  |  | States of Nature | |  |  |  |  |  |
|  |  | Profit | Good Market | Bad Market | Max |  | 🡪 | MaxiMax | Optimistic |
|  | Max 🡪 | SiteA | $300K | $100K | $300K |  |  | MaxiMin | Pessimistic |
|  | SiteB | $400K | $50K | $400K |  |  | MiniMaxRegret | Opportunity Loss |
|  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Example2 |  |  |  |  |  |  | Decision Rule |  |
|  |  |  | States of Nature | |  |  |  |  |  |
|  |  | Profit | Good Market | Bad Market | Min |  |  | MaxiMax | Optimistic |
|  | Max 🡪 | SiteA | $300K | $100K | $100K |  | 🡪 | MaxiMin | Pessimistic |
|  | SiteB | $400K | $50K | $50K |  |  | MiniMaxRegret | Opportunity Loss |
|  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Example3 |  |  |  |  |  |  | Decision Rule |  |
|  |  |  | States of Nature | |  |  |  |  |  |
|  |  | Regret | Good Market | Bad Market | Max |  |  | MaxiMax | Optimistic |
|  | Min 🡪 | SiteA | $100K | 0 | $100K |  |  | MaxiMin | Pessimistic |
|  | SiteB | 0 | $50K | $50K |  | 🡪 | MiniMaxRegret | Opportunity Loss |
|  |  |  |  |  |  |  |  |  |  |

**Decision Rules – With Probability**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | 🡪Expected Value  Expected Regret  Decision Trees  Expected 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 sites like the sites under consideration are reported by a marketing research company. Assume the market will be either good or bad and the market analysis will result in either a positive or negative recommendation.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Historical Data: |  | Good Market | Bad Market | Sum |
|  | Positive Recommendation | 6 | 4 | 10 |
|  | Negative Recommendation | 2 | 8 | 10 |
|  | Sum | 8 | 12 | 20 |

From this table of historical data, we can divide through by the total sum to obtain probabilities.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Probabilities: |  | Good Market | Bad Market | Sum |
|  | Positive Recommendation | 6/20=0.3 | 4/20=0.2 | 10/20=0.5 |
|  | Negative Recommendation | 2/20=0.1 | 8/20=0.4 | 10/20=0.5 |
|  | Sum | 8/20=0.4 | 12/20=0.6 | 20/20=1.0 |

Consider the terminology of the probabilities.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | M=Market (Good,Bad) | |  |
|  |  | Good Market | Bad Market |  |
| R=Recommendations  (Positive,Negative) | Positive Recommendation | Joint Probabilities  P[M,R] | | Marginal Probabilities,  P[R] |
| Negative Recommendation |
|  |  | Marginal Probabilities, P[M] | |  |

We can estimate the probability of a “Good Market” to be 0.4 (P[M=Good]=0.4) and a “Bad Market” to be 0.6 (P[M=Bad]=0.6). We can estimate the probability of a “Positive Recommendation” to be 0.5 (P[R=Positive]=0.5) and a “Negative Recommendation” to be 0.5 (P[R=Negative]=0.5).

From this table of probabilities, we can divide through by the marginal probabilities to obtain conditional probabilities. For example, dividing the joint probabilities, P[M,R], by the marginal probabilities, P[R], will yield the conditional probabilities, P[M|R]=P[M,R]/P[R].

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Conditional Probabilities: | P[Market|Recommendation] | Good Market | Bad Market | Sum |
|  | Positive Recommendation | 0.3/0.5=0.6 | 0.2/0.5=0.4 | 1 |
|  | Negative Recommendation | 0.1/0.5=0.2 | 0.4/0.5=0.8 | 1 |

We can estimate the probability of a “Good Market” and a “Bad Market” given a “Positive Recommendation” to be 0.6 and 0.4, respectively, (P[M=Good|R=Positive]=0.6 and P[M=Bad|R=Positive]=0.4).

Similarly, we can estimate the probability of a “Good Market” and a “Bad Market” given a “Negative Recommendation” to be 0.2 and 0.8, respectively, (P[M=Good|R=Negative]=0.2 and P[M=Bad|R=Negative]=0.8).

|  |  |
| --- | --- |
| Summary | |
| 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]=0.4  P[M=Bad|R=Positive]=0.2 and P[M=Bad|R=Negative]=0.8 |

**Decision Rules – With Probability, EMV**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | 🡪Expected Value  Expected Regret  Decision Trees  Expected 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 sites like the sites under consideration are reported by a marketing research company. 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 |

Now consider the EMV Decision Rule.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Example4 |  |  |  |  |  |  | Decision Rule |
|  |  |  | States of Nature | | EMV |  |  |  |
|  |  | Profit | Good Market | Bad Market | E[$] |  |  | 🡪Expected Value |
|  | Max 🡪 | SiteA | $300K | $100K | $180K |  |  | (Expected Monetary Value, EMV) |
|  | SiteB | $400K | $50K | $190K |  |  |  |
|  |  | Probability | 0.4 | 0.6 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

|  |  |
| --- | --- |
| Example 4 Calculations. | For SiteA: $300K\*0.4+$100K\*0.6=$180K |
|  | For SiteB: $400K\*0.4+$50K\*0.6=$190K |

**Decision Rules – With Probability, EOL**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | 🡪Expected Value  🡪Expected Regret  Decision Trees  Expected 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 a market research company for similar stores in the area provided probabilities of future market conditions.

|  |  |
| --- | --- |
| Marginal Probabilities: | |
|  | P[M=Good]=0.4; P[M=Bad]=0.6 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Example4 |  |  |  |  |  |  | Decision Rule |
|  |  |  | States of Nature | | EMV |  |  |  |
|  |  | Profit | Good Market | Bad Market | E[$] |  |  | 🡪Expected Monetary Value, EMV |
|  | Max 🡪 | SiteA | $300K | $100K | $180K |  |  | Expected Regret |
|  | SiteB | $400K | $50K | $190K |  |  | (Expected Opportunity Loss, EOL) |
|  |  | Probability | 0.4 | 0.6 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

|  |  |
| --- | --- |
| Example 4 Calculations. | For SiteA: $300K\*0.4+$100K\*0.6=$180K |
|  | For SiteB: $400K\*0.4+$50K\*0.6=$190K |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Example5 |  |  |  |  |  |  | Decision Rule |
|  |  |  | States of Nature | | EOL |  |  |  |
|  |  | Regret | Good Market | Bad Market | E[Regret] |  |  | Expected MonetaryValue, EMV |
|  | Min 🡪 | SiteA | $100K | 0 | $40K |  |  | 🡪Expected Regret |
|  | SiteB | 0 | $50K | $30K |  |  | (Expected Opportunity Loss, EOL) |
|  |  | Probability | 0.4 | 0.6 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

|  |  |
| --- | --- |
| Example 5 Calculations. | For SiteA: $100K\*0.4+0\*0.6=$40K |
|  | For SiteB: 0\*0.4+$50K\*0.6=$30K |
|  | Regret = Opportunity Loss = OL |

**Decision Rules – With Probability, Decision Trees**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | 🡪Expected Value  Expected Regret  🡪Decision Trees  Expected 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 a market research company for similar stores in the area provided probabilities of future market conditions.

|  |  |
| --- | --- |
| Marginal Probabilities: | |
|  | P[M=Good]=0.4; P[M=Bad]=0.6 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Example4 |  |  |  |  |  |  | Decision Rule |
|  |  |  | States of Nature | | EMV |  |  |  |
|  |  | Profit | Good Market | Bad Market | E[$] |  |  | 🡪Expected MonetaryValue, EMV |
|  | Max 🡪 | SiteA | $300K | $100K | $180K |  |  | Decision Trees |
|  | SiteB | $400K | $50K | $190K |  |  |  |
|  |  | Probability | 0.4 | 0.6 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

|  |  |
| --- | --- |
| Example 4 Calculations. | For SiteA: $300K\*0.4+$100K\*0.6=$180K |
|  | For SiteB: $400K\*0.4+$50K\*0.6=$190K |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  | Decision Rule |
|  |  |  |  |  | 0.4 | Good | $300K |  |  |  |
|  |  |  | SiteA | $180K |  |  |  |  |  | Expected MonetaryValue, EMV |
|  |  |  |  |  |  |  |  |  |  | 🡪Decision Trees |
|  |  |  |  |  | 0.6 | Bad | $100K |  |  |  |
|  |  | SiteA. $190K |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | 0.4 | Good | $400K |  |  |  |
|  |  |  | SiteB | $190K |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | 0.6 | Bad | $50K |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |

**Decision Rules – With Probability, EVPI**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | 🡪Expected Value  Expected Regret  Decision Trees  🡪Expected 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 a market research company for similar stores in the area provided probabilities of future market conditions.

|  |  |
| --- | --- |
| Marginal Probabilities: | |
|  | P[M=Good]=0.4; P[M=Bad]=0.6 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Example4 |  |  |  |  |  |  | Decision Rule |
|  |  |  | States of Nature | | EMV |  |  |  |
|  |  | Profit | Good Market | Bad Market | E[$] |  |  | 🡪Expected Monetary Value, EMV |
|  | Max 🡪 | SiteA | $300K | $100K | $180K |  |  | EVPI |
|  | SiteB | $400K | $50K | $190K |  |  |  |
|  |  | Probability | 0.4 | 0.6 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

|  |  |
| --- | --- |
| Example 4 Calculations. | For SiteA: $300K\*0.4+$100K\*0.6=$180K |
|  | For SiteB: $400K\*0.4+$50K\*0.6=$190K |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Example6 |  |  |  |  |  |  | Decision Rule |
|  |  |  | States of Nature | | EMV |  |  |  |
|  |  | Profit | Good Market | Bad Market | E[$] |  |  | Expected Monetary Value, EMV |
|  | Max 🡪 | SiteA | $300K | $100K | $180K |  |  | 🡪EVPI |
|  | SiteB | $400K | $50K | $190K |  |  |  |
|  |  | Probability | 0.4 | 0.6 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  | Perfect |  |  | EPPI |  |  |  |
|  |  | Information | Good | Bad | E[$] |  |  |  |
|  |  | Sites AorB | $400K | $100K | $220K |  |  |  |
|  |  | Probability | 0.4 | 0.6 |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

|  |  |
| --- | --- |
| Example 6 Calculations. | For EPPI=Expected Profit of Perfect Information: $400K\*0.4+$100K\*0.6=$220K |
|  | For EVPI=Expected Value of Perfect Information:    Expected Profit with Perfect Information: EPPI = $220K  Expected Profit without Perfect Information: MaxEMV = $190K  Expected Value of Perfect Information: EVPI = $ 30K  [ EVPI = EPPI – MaxEMV = $220K – $190K = $30K ]  . . . |

**Decision Rules – With Probability, EVSI**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | Expected Value  Expected Regret  Decision Trees  Expected 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]=0.4  P[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 | 0.2 |  |  |  |  |  |  | ↓ |  |
|  |  |  |  |  |  |  |  |  |  | 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 |