CENTER FOR AGRICULTURAL PROFITABILITY
Institute of Agriculture and Natural Resources

Branching Out: Harnessing the Power of Decision Trees

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In today's world, full of risk and uncertainty, agricultural producers face a very challenging decision-making environment. Their decisions are often a complex sequence of choices made over time, during which uncertainties are revealed and additional information is gathered. A decision tree or decision flow diagram can aid in the decision-making process by providing a clear graphical representation of the sequence of events and relevant information.

A decision tree contains the relevant courses of action, event uncertainties, and potential outcomes in the order they are expected to occur through time. Like the decisions they are meant to represent, decision trees can become very complex, very quickly. However, constructing a decision tree forces the decision-maker to think through a road map that summarizes future decision points where they can exercise control and future uncertainties where chance determines the direction taken.

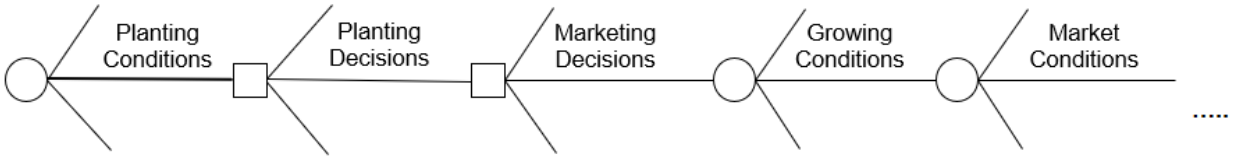
Constructing a Decision Tree

Let's start with an idea of chance controlling the direction in the context of two of the biggest risks in agriculture: market prices and weather. Decision trees use a small circle to designate a chance event node where uncertainty can lead to different outcomes. A small square or rectangle is used to designate a decision node where the decision-maker is in control.

For illustration, consider a situation where a corn producer is contemplating a forward contract marketing decision for an expected crop of 200,000 bushels. Figure 1 presents a decision tree outline for the corn farmer, beginning with the planting conditions that influence planting decisions. The farmer must decide whether to forward contract some of the expected crop for delivery at the local elevator. The two significant uncertainties yet to come include growing conditions (weather), which will impact yield, and market conditions, whch will determine price. Since the crop will be delivered to the local market, weather conditions will also influence the

market prices available. Therefore, the growing conditions uncertainty is placed before market conditions uncertainty in the chain of events.

Figure 1: Example Decision Tree Outline for Corn Farmer



Including Additional Details

Figure 2 expands this example into a decision tree with the crop marketing decision depicted as a single choice between entering a forward contract for half of the expected production or not. This splits the decision tree into two major branches. The top half of the tree represents not entering the forward contract, implying the crop will be sold on the cash market. The bottom half represents entering the forward contract to deliver half of the expected production, 100,000 bushels, to the local elevator for a sale price of $4.30 per bushel.

The marketing decision is followed by two uncertainties, weather and market conditions, each with three possible outcomes. The result is nine possible outcomes for each marketing choice. This is a simplified description of what most farmers experience throughout the year as many weather events unfold alongside changing market conditions and opportunities. One of the best outcomes of constructing a decision tree is the framework that it provides for updating through time to reframe repetitive decisions with the most current information.

Growing conditions uncertainty is depicted as a 30% chance of good weather, a 50% chance of average weather, and a 20% chance of bad weather. Good weather results in a 10% yield increase, while bad weather results in a 10% yield decrease.

Market conditions uncertainty is depicted as a 20% chance of good markets, a 50% chance of average markets, and a 30% chance of bad markets if weather is average or better. With bad weather, the farmer expects a 30% chance of good markets and a 20% chance of bad markets. As with yields, good markets result in a 10% increase in price, and bad markets result in a 10% decrease in price.

Estimating a Distribution of Possible Outcomes

The probabilities can be multiplied and combined with the marketing revenue for each path in the decision tree to produce a distribution of outcomes. For example, if the producer decides to cash market the crop, the best-case scenario is good weather followed by good market conditions. A yield of 220,000 bushels sold at $4.73 per bushel would net the highest revenue at $1,040,600. However, this only has a 6% chance of occurring.

The worst-case scenario is bad weather followed by bad markets, which has a 4% chance of occurring. In this case, the decision to sell on the cash market results in the lowest revenue at $696,600. The most likely outcomes, each with a 25% chance are average weather and average markets, resulting in a revenue of $860,000; good weather and average markets, or average weather and good markets, resulting in $946,000; and bad weather and average markets, or average weather and bad markets, resulting in $774,000.

Calculating Expected Values

One of the interesting aspects of decision trees is that they can easily be used to calculate an expected value (or weighted average) for the outcomes by multiplying the probabilities by the respective values. In this case, that calculation results in an expected value of $863,010. This is slightly above the $860,000 outcome using original price and yield expectations because of the slightly positive probabilities for better outcomes. Often, uncertainties involve more possible outcomes and less symmetry in impacts and probabilities than depicted in this example, resulting in a more significant difference between these two values.

Similar calculations can be made for the decision to forward contract 100,000 bushels at $4.30 per bushel. Because some sales are locked in, the range of outcomes is tighter, ranging from a low of $739,600 to a high of $997,600. The $860,000 outcome remains a most likely scenario at 25% probability, but it is the only outcome occurring that often due to the contracting. Forward contracting controls some of the downside risk, resulting in the weighted average of the outcomes being slightly higher at $865,590.

Making a Decision

Based on the weighted average, the farmer may decide to forward contract the 100,000 bushels. However, a good decision considers the entire distribution of outcomes for each choice. Figure 3 takes the outcomes enumerated in Figure 2 and creates a distribution chart for each choice. The blue bars in Figure 3 represent the cash market outcomes, showing the more extreme high and low outcomes, as well as the three revenue outcomes that each have 25% chance of occurring. The orange bars represent the forward contracting outcomes, which have a tighter range with more intermediate values occurring at lower probabilities.

Constructing a decision tree forces the decision-maker to think through the implications of management decisions and the inherent risk. While they can be complicated, the process of putting together a decision tree helps the decision-maker to consider important elements, including chance events, decision points, and outcomes. Once constructed, a decision tree also provides a valuable decision aid by illustrating a distribution of outcomes for each decision choice. The decision tree template can be updated for future decisions or expanded to capture further elements of the decision problem.

Figure 2: Example Decision Tree for Corn Farmer Marketing Decision

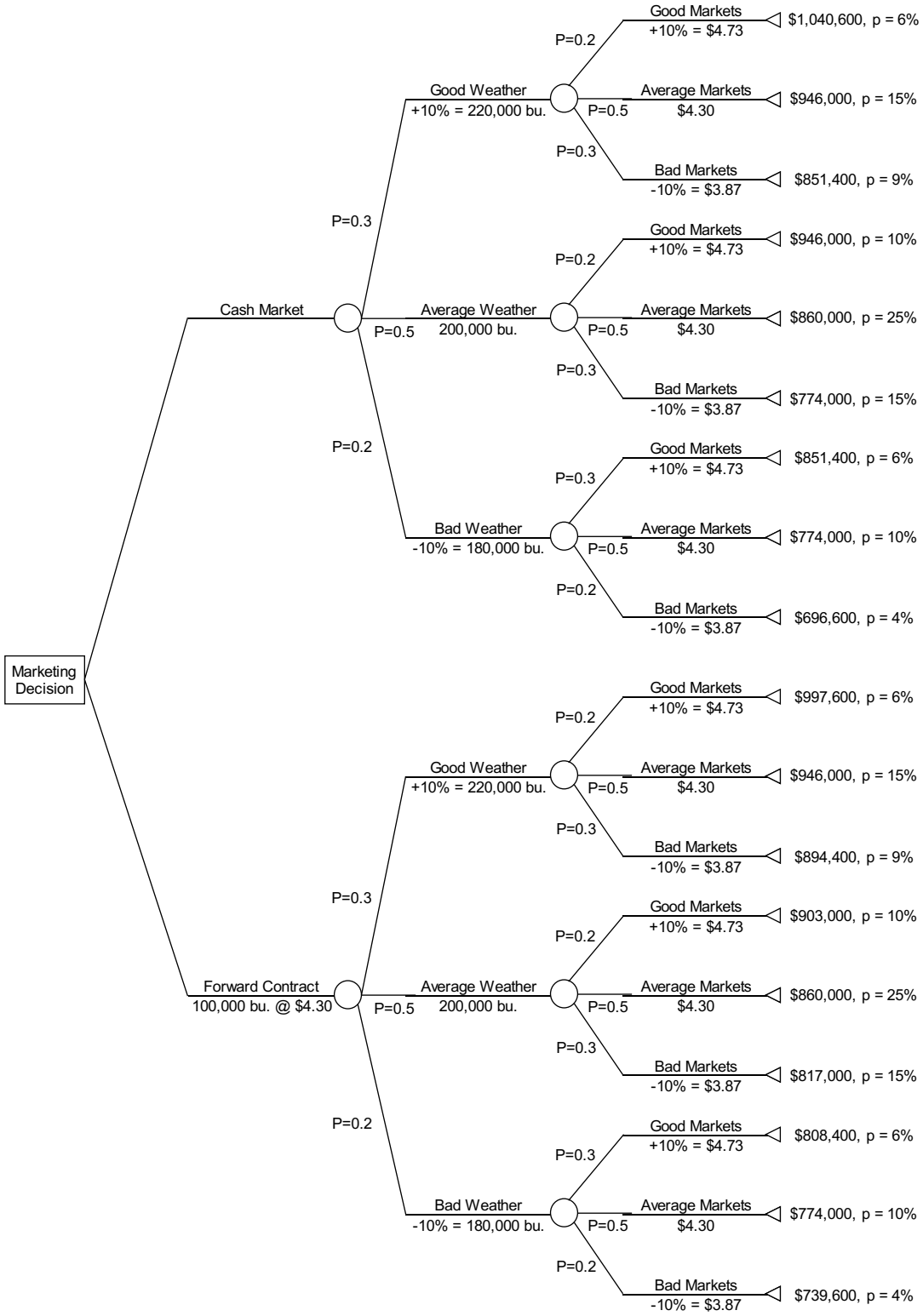
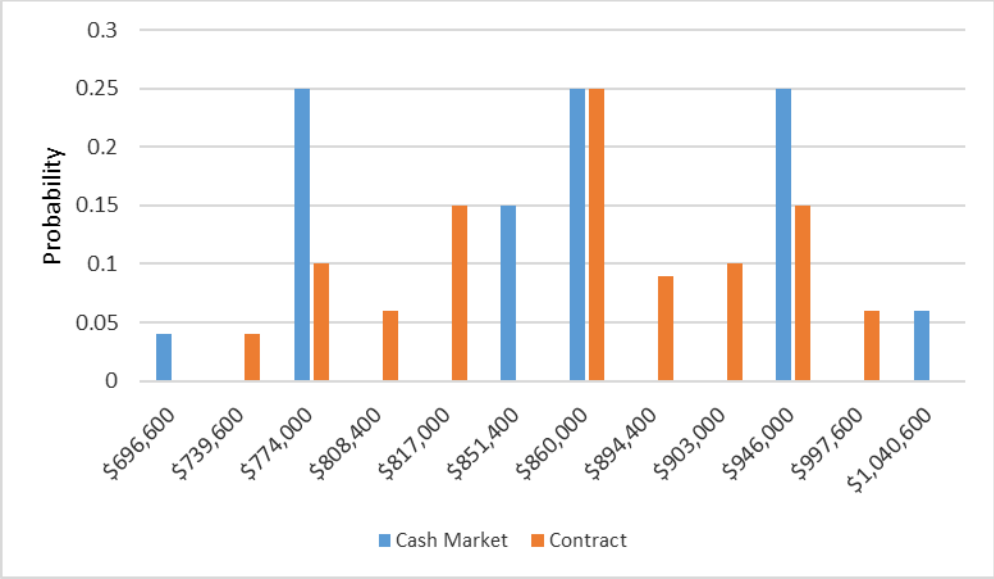


Figure 3: Distribution of Outcomes for Example Decision Tree Marketing Decision



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