Harvard Business School **5-895-053**
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Freemark Abbey Winery

Teaching Note

This classic case describes a problem facing William Jaeger whose vineyard is in the path of a possible oncoming storm. Should he harvest some rain-sensitive Riesling grapes before their prime, or risk having them spoiled by over watering. In an interesting twist, the grapes might actually benefit from the rain, if it happens to be of the right type. The case has been used, successfully, to introduce decision trees to a wide range of audiences.

Possible Assignment (The questions should be tailored, in difficulty, and in number, to suit the audience).

1. Assuming Mr. Jaeger chooses to harvest the Riesling grapes before the storm arrives, how much money will he make?

2. Assuming Mr. Jaeger chooses to leave the grapes on the vine, what is the probability that the grapes will end up with *botrytis*, and how much money will he make if that occurs?

3. Taking account of all the various possibilities, what should Mr. Jaeger do?

4. (optional) How much should Mr. Jaeger be willing to pay to learn whether the storm really will hit the Napa Valley?

5. (optional) How much should Mr. Jaeger be willing to pay to learn whether *botrytis* would form *if* the storm were to hit the Napa Valley?

Teaching Plan and Analysis

It is possible, in this day and age, that somewhere, even in a relatively novice group, there is someone who understands enough about decision trees, especially if they have read a note on the subject, to draw a correct tree for this case fairly easily. It is a good idea to avoid such a person if possible in the early stage of the discussion. If you take a vote early on, you should be able to ask someone who prefers to harvest now to explain their position (including describing how much money they expect to make). This person, or another, should then be asked to explain what happens if the

Professor David E. Bell prepared this teaching note as an aid to instructors in the classroom use of the case, Freemark Abbey Winery, HBS No. 181-027.

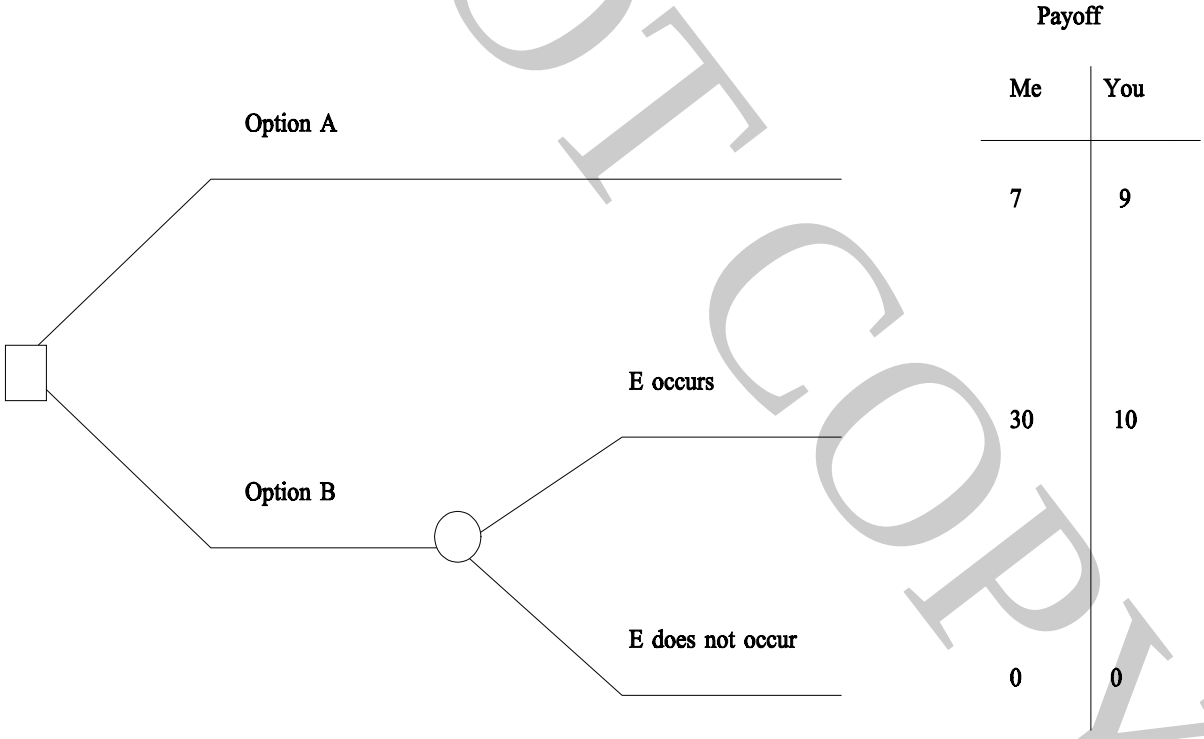
grapes are to be left on the vine. "So, if we leave the grapes on the vine, what happens next?" The answer you're looking for is "It either rains or it doesn't." If you get an answer like "You either did the right thing or you didn't," try the making-a-movie tactic: "Mr. Jaeger has decided to leave the grapes where they are - in the movie version of this case, what do the cameras film next?" The idea is that the next thing that happens is that the storm clouds appear on the horizon - or not.

Draw out the tree in this way without worrying about probabilities.

If the storm arrives, but is cold and not conducive to *botrytis*, we must decide what to do with the grapes. Since the way the case describes it, bottling gets $2/bottle compared to $1/bottle for other possibilities, the decision seems open and shut. "Everyone agree with that?" Someone will worry that by selling weak wine we will be harming the brand name of the vineyard. The question becomes, is the damage done greater than the $12,000 we make by bottling? It would seem fairly clear that it is. Next someone will suggest bottling the grapes, but under a different label. This is a good idea and one that we assume in the completed decision tree shown in **Exhibit 1**.

Note that this debate was an instructive one. Had we merely "taken a vote" about what to do if the grapes were weak, the "sell in bulk" group might have held the day without realizing that there were other options. The big idea is that by explaining *how* you reach a decision, that is, the *assumptions* that are involved, you may possibly reach a better solution that is agreed upon by all.

As a trivial example, suppose we have a problem as follows, where all gains are to be shared by you and I.



I believe the probability of E occurring is 0.2, so I prefer option A to B. You believe the probability of E occurring is 0.8 but still prefer Option A. If we take a vote, we do A. If we discuss our assumptions, however, we may agree that prob(E) = 0.5 (the average of our two beliefs), that option A will pay off $8 and that B, if E occurs, will be worth $20. Now we should pick B!

The only other controversial matter in the analysis is what happens if Jaeger does not harvest and the storm never arrives. The case is written a little obliquely, but what is intended is that there is

a 40% chance of 25% sugar, a 40% chance of 20-25% sugar and a 20% chance of a low acid wine. A debate on this interpretation may be regarded as a simulated disagreement over likelihoods as in my example above.

There are other matters that might be put on the tree. The most appropriate is again about branding. If the *botrytis* does form, won't this be a big plus for the vineyard? How much is it worth to have produced a *botrytis* Riesling? This issue is best left to a sensitivity analysis after we are done. Other issues that are legitimate but should be ignored on the tree include:

- will the vines be damaged by the storm? (Mr. Jaeger can't do anything about that, unless having grapes on the vines increases the chance of damage).
- what about all the other grapes being grown at Freemark Abbey? (They aren't affected by *botrytis*).
- what about harvesting only *some* of the Riesling grapes as a diversification move?[1] (The Riesling grapes are already a fairly small part of the operation and, as we shall see, the goodwill value of having *botrytis* wine dominates any diversification benefits).
- could there be a second storm? (No doubt the answer is yes!)

The dollar amounts at the endpoints of the tree are fairly routine. If we harvest now we will end up with 12,000 bottles at $2.85 each or $34,200. Some decision should be made about how much wine we get in the cold storm scenario. The tree assumes a 7% increase in wine volume.[2] The *botrytis* endpoint recognizes a 30% reduction in wine volume.

Placing probabilities on the tree is usually non controversial. If you have time you could discuss how Mr. Jaeger could come up with a probability of 0.4 for the possibility of *botrytis* given a storm. (One possibility is historical records. Another is that we make such judgements informally all the time - uncertainties aren't always 50-50).

Now to fold back the tree. "We agree that if the storm comes, and if the *botrytis* forms, we earn $67,200. If the storm comes but the *botrytis* does not, we earn $25,680. Now tell me this, as Mr. Jaeger looks across the fields and sees the storm clouds heading his way, but *before* he knows whether they will lead to *botrytis*, how much are the Riesling grapes worth to him?". The answer, of course, is 0.4 x 67,200 + 0.6 x 25,680 = $42,288. But this should be accompanied by some discussion. Despite any philosophical reservations the instructor may have, the best argument is that if Mr. Jaeger makes decisions using expected values (in this way) he will almost surely make more money (over time) than if he uses any other system.

In this way the tree is completed as in **Exhibit 1**. Except for the 7% issue, you are urged not to compromise on the structure of the tree.

At this point, it may be useful to perform a sensitivity analysis on the probability of a storm arriving, or on the probability of *botrytis* forming if it does. Note that the question of valuing the good will should *botrytis* form is moot, unless we consider the possibility that the probability of *botrytis* is overstated.

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[1]An idea first suggested by my colleague, Prof. Richard Meyer.

[2]Why 7%? This was a foible of Bill Krasker who wrote the case and the original teaching note. It had an interesting aftermath when a student, opening the case after it had been used for a number of years, made the same assumption.

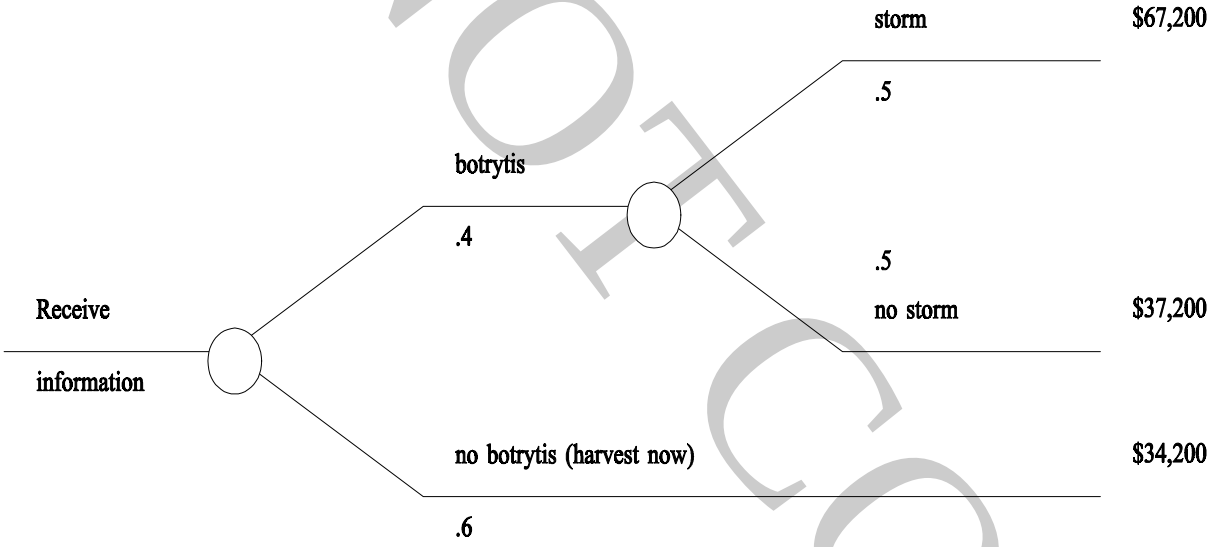
The assignment describes, two "value of information" questions that should probably not be assigned at all (since they may be too hard, or you may not have time to get to them). They are best used as extra material if time allows. Note that we do not formally cover value of information until later in the course.

"What is the most that Mr. Jaeger should be willing to pay to know in advance whether the storm will come to the Napa Valley?"

I ask individuals in the class and record their "bids". A typical range is $1,000 to $5,000. Yet, as can be seen from the tree, even if Mr. Jaeger *knew* the storm would not arrive, he would leave the grapes where they are, (as common sense dictates). Thus the information has no value whatsoever.

"Suppose Mr. Jaeger has a cousin in San Diego (or wherever this storm is coming from). This cousin could easily tell whether the storm is warm and gentle (and therefore *botrytis* bearing) or cold and hard (leading to weak grapes). However, the cousin would not be able to tell whether the storm would actually hit the Napa Valley. What is the most you'd be prepared to pay for this information?"

The bids plummet precipitously based on the students' recent experience in these matters. However, *this* information turns out to be of considerable value. The tree should be redrawn to reflect the new situation:



The expected value of this tree is 0.4 ($52,200) + 0.6 ($34,200) = $41,400. The information is thus worth $41,400 - $39,744 = $1,656.

If you have students who get this one right, especially if the problem was given orally, in class, they are *very* strong.

Finally, one may ask,[3] why Freemark Abbey is bothering to grow 1,000 cases of Riesling at all? (especially if they are so sensitive to climate.) The answer is that the whole thing is driven by the *possibility* of *botrytis* and the fame that accompanies a producer of such wine. Thus, in truth Mr. Jaeger couldn't have been happier at the prospect of the storm. And as it happens, he was in luck. In the year that the case was written, Freemark Abbey produced a *botrytis* Riesling.

[3]Again, following Richard Meyer.

Exhibit 1