Accounting is an Information System Choice

That accounting systems provide information is frequently accepted by laymen as a given. However, careful thinking about accounting suggests that we consider this more fully. Why does one care about information when making business decisions? The presumption is that information improves decisions. In what sense? In any interesting setting, one cannot guarantee that information always improves decisions. Rather, there are a few important considerations that should be made explicit. These things include: uncertainty & probability, probability beliefs, probability belief revisions, expected value, and variance. In this note, we'll try to discuss and illustrate each of these.

Uncertainty

Uncertainty occurs naturally in accounting. The transactions amounts include predictable components and unpredictable or random components. For instance, a firm expects to invest $3,000 in equipment. The equipment cost may deviate from this predictable amount due perhaps to shortness or excess of supply and deviations in other costs including freight and installation (perhaps also driven by changes in the supply of these factor inputs).

In thinking about information choice problems it is useful to think more carefully about the nature of these unpredictable or random components. While unpredictable, that doesn't necessarily mean that there is no structure. In fact, it is extremely helpful to provide some structure. This formal structure is referred to as **probability** and the unpredictable or random components are said to follow a **probability distribution**. A probability distribution simply indicates the likelihood of various possible outcomes associated with the random component. Further, a well-defined probability distribution is one in which the sum of probabilities over all possible outcomes is equal to one (i.e., the distribution covers all possible outcomes; this of course may mean that all real numbers from minus infinity to infinity are admissible outcomes). Unpredictable or random components associated with a probability distribution are referred to as **random variables**.

Since a probability distribution identifies the likelihood over all possible outcomes, the probability distribution provides the weights that one might attach to the outcomes when evaluating uncertainty in the outcomes. This is precisely the calculus employed to evaluate **expected value** or **mean** and **variance** of random variables. It is convenient to think of expected value as the predictable component. The expected value of a random variable is the "probability-weighted" sum of outcomes over all possible outcomes.

$E[x] = \sum_{j=1}^{n} p_j x_j$ where p_j = the probability associated with outcome j, x_j = the value associated with random variable x for outcome j, and there are n distinct outcomes associated with x.[1]

Consider the following example. The random variable x takes on possible values equal to 1, 2, and 3 with respective probabilities 1/4, 5/8, and 1/8 (note that the probabilities sum to one). The expected value or mean of x is E[x] = 1/4(1) + 5/8(2) + 1/8(3) = 15/8 = 1.875.

The mean or expected value indicates what value one can expect for x, on average. The average of course is a weighted average where the weights are determined by the probabilities associated with each outcome. Obviously it doesn't mean that it will always take on that value; in our example above the mean value is not even equal to any of the possible values for x.

[1] If x is a continuous rather than a discrete random variable (i.e., it takes on all real values over some interval rather than involving only a finite number of values), then expected value is still the weighted sum but the weighted sum is found via integration $E[x] = \int_a^b x f(x) dx$ where x takes on all values over the interval (a,b) and f(x) is the probability distribution for x over the interval (a,b).

Accordingly, it seems sensible that one would like to have a measure of how variable or widely dispersed that possible outcomes of x are around this mean. This measure is referred to as the **variance** and it's a measure of "probability-weighted average" dispersion about the mean. The variance of a random variable x (denoted Var[x]) is the probability-weighted average squared deviations of the outcomes from the mean.[2]

$$\mathrm{Var}[x] = E[(x - E[x])^2] = E[x^2] - E[x]^2 = \sum_{j=1}^{n} p_j(x_j - \sum_{j=1}^{n} p_j x_j)^2 = \sum_{j=1}^{n} p_j x_j^2 - \left(\sum_{j=1}^{n} p_j x_j\right)^2$$

Return to the earlier example and compute the variance for the discrete random variable x. $\mathrm{Var}[x]=1/4(1-1.875)^2 + 5/8(2-1.875)^2 + 1/8(3-1.875)^2$, or $1/4(1^2) + 5/8(2^2) + 1/8(3^2) - (1.875)^2 = 0.359375$.

<u>Decision making and information system choice</u>

When making decisions, one is usually concerned with making choices that make the most of available opportunities, or equivalently, minimizing opportunities foregone or opportunity costs. When making decisions under uncertainty, minimizing expected value of opportunity costs is equivalent to making the "best" decision, on average.[3] In other words, if the same decision is confronted repeatedly then the decision that produces the "best" average outcome is the decision that minimizes the expected opportunity cost.

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[2] If x is a continuous rather than a discrete random variable, then variance is still the weighted sum of the squared deviations from the mean but the weighted sum is found via integration $\mathrm{Var}[x] = \int_a^b (x - E[x])^2 f(x)dx$ where x takes on all values over the interval (a,b) and f(x) is the probability distribution for x over the interval (a,b).

[3] "Best" requires a caveat here. This statement should be about how well-off the decision maker feels about the outcome or, in other words, the decision maker's utility for the outcome. An implication of the above is that a risk neutral decision maker maximizes his/her expected value of utility when expected opportunity cost is minimized. For risk averse decision makers, we would need to work with the decision maker's expected value of utility for opportunity cost outcomes to properly capture the spirit of "best". In this note, we'll assume risk neutrality for simplicity.

Consider the following example. If action a is pursued the opportunity cost is 1,2,3 with respective probabilities 1/4,5/8,1/8. On the other hand, if action b is pursued the opportunity cost is 1,2,3 with respective probabilities 1/8,1/2,3/8. The expected opportunity cost if action a is pursued is 1.875; while if action b is pursued the expected opportunity cost is 18/8 = 2.25. Action a produces the "best" outcome on average. The decision problem is tabulated below.

		States		
Act	s_1	s_2	s_3	E[x]
a	1;1/4	2;5/8	3;1/8	1.875*
b	1;1/8	2;1/2	3;3/8	2.25

Table. Decision table. Opportunity cost outcomes; probabilities

Now, suppose there is an opportunity to acquire the following information system.

		States		
Signal,Act	s_1	s_2	s_3	E[x]
y_1, a	1;5/8	2;3/8	3;0	1.375*
y_1, b	1;0	2;0	3;1	3
y_2, a	1;1/8	2;17/24	3;1/6	2.04167
y_2, b	1;1/6	2;2/3	3;1/6	2*

Table. Information table. Opportunity cost outcomes; probabilities

If y_1 is observed then action a will be undertaken with expected opportunity cost equal to 1.375. If y_2 is observed then action b will be undertaken with expected opportunity cost equal to 2. The probability of observing y_1 is ¼ and y_2 is ¾. Hence the expected opportunity cost given the information system is (costlessly) available is 1/4(1.375) + 3/4(2) = 1.84375. This is a "better" expected outcome then without the information system (1.875). Therefore, if the information system is not too costly (here it is assumed to involve zero cost) the information system will be acquired. This is the essence of information system choice. The figure below illustrates the information choice problem via a decision tree.

To summarize, information arises in the context of **uncertainty**. Specifically, **information** is data that revises the decision maker's **probability beliefs**. Further, information is **useful** if the **revised probability beliefs** alter the decision maker's preferred action for some possible information signal. And, the information is **valuable** if the information helps identify action choices that improve the expected payoffs to the decision maker (net of the cost of acquiring the information system).

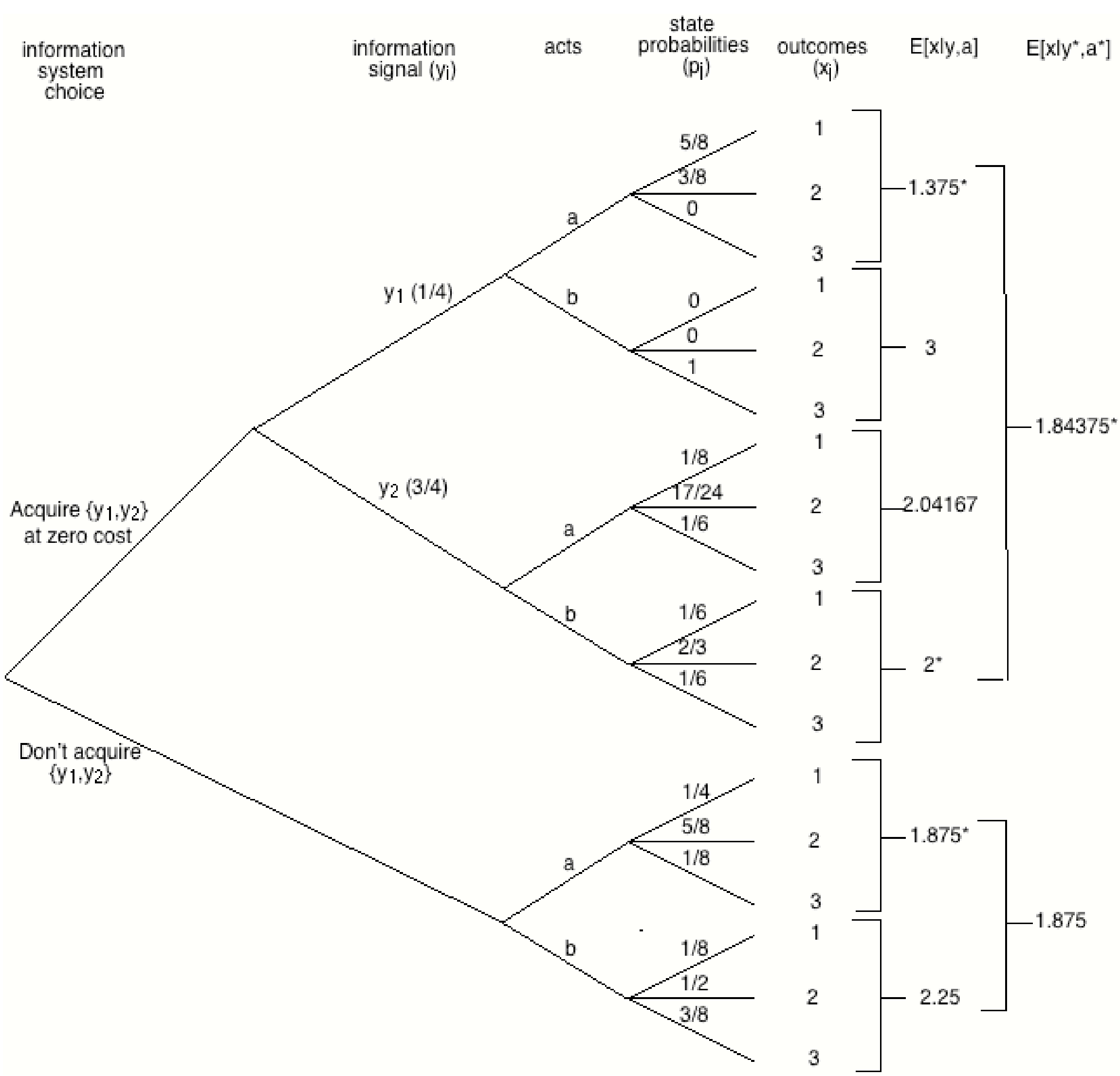

Figure. Decision tree for information system choice (optimal choice is identified by a *)