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## **DECISION MAKING AND AN INTRODUCTION TO SURPRISE VIA COMMANDER BAYES, AN INTUITIVE EXPLANATION**

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### **INTRODUCTION**

Executives are constantly involved in making decisions. In many instances, they don't have all the facts, but have strong clues that will influence their decisions. A key management mantra is – I don't want to be surprised or miss anything important. What might be surprising is that using mathematics we can estimate the chance of missed issues or surprises.

### **IMPORTANT COMMENT**

How can a good decision become great the easy way? The foremost impediment to greatness is that issues are missed or surprises occur. Indeed, research shows that most people seriously underestimate the chance of unknown or surprising events to occur. The ominous impact is extra costs, sometimes painfully extra. However, these additional costs can be drastically slashed and the decision moved closer to great with the Bayesian approach we developed. And let us now explore how Bayesian better masters those costs, uncertainties and surprises.

### **EXAMPLE**

An example from the world of mergers and acquisitions is particularly revealing.

Your company has benefitted from the tax law revision and has received a windfall that it would now like to invest. Venture capital folks have advised that there are two companies available, Company A and Company B, that meet the criteria you have set forth. Those two are immediately considered by the venture capitalists. But, the lead venture capitalist consultant, being highly expert and not wanting to be surprised, knows that there might be another unknown company that might be an even more perfect fit. We'll call it Company S for Surprise, since the identity of the unknown company would be a surprise.

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## FACTS

Since there is no other information to start, the venture capitalists must assume that each is just as likely as the other so they each have a probability of 1/3 of being the likely acquisition candidate.

$$P(A)=1/3, P(B)=1/3, P(S)=1/3$$

Venture Capitalist 1 (VC1), who has studied Company A carefully, has found some heretofore unpublished information pertaining to the market served by Company A. He knows that Company A will benefit significantly from this new intelligence and assigns an 80% probability to Company A as the potential acquisition candidate. Thus,

$$P(I|A)=0.8=\text{there is an 80\% match between the intelligence found and its impact on Company A.}$$

VC1 is about to wrap things up, when, just then, VC2 exclaims that she has come across some different information that would benefit Company B. VC2 is expert on Company B and says that to her, the probability that the information will benefit Company B is 60%. She says that she has analyzed the information and is 60% confident that it will be a benefit to Company B.

$$P(I|B)=0.6=\text{there is a 60\% match between the information and Company B.}$$

Adding to the confusion, the lead VC Consultant then chimes in and says to wait a minute, let us not miss anything and regret it later. What if a surprise company (Company S) could also benefit from this heretofore unpublished information? To the lead VC Consultant, the chance Company S could so benefit is 60%. Thus,

$$P(I|S)=0.6=\text{probability that Company S could benefit from that information.}$$

These numbers do not add up to 1 since humans are making judgments. The evidence is fuzzy, and the situation is not clear, just as in real life. What can be done to straighten out this confusion? Right at that moment someone has a great idea. Let us call upon Commander Bayes.

Commander Bayes immediately produces his famous formula which he says has served him well for over 200 years – so he has great faith in it. He says,

$$P(A|I)=\text{probability that Company A could benefit most significantly from the information}$$

Then,

$$P(A|I)=[P(I|A)P(A)]/[P(I|A)P(A)+ P(I|B)P(B)+ P(I|S)P(S)] \text{ which can also be written as } \\ P(A|I)=[P(I|A)P(A)]/[1/3[P(I|A)+ P(I|B)+P(I|S)]=0.8/[0.8+0.6+0.6]=0.4$$

$$\text{Similarly, } P(B|I)=0.3 \text{ and } P(S|I)=0.3$$

We have derived the chance that Company A or Company B would be the best candidate. But also, and this is an important advancement, we included the chance that some unknown company, some surprise company, might be the best alternative. We have, in effect, calculated the chance of surprise.

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## EXPLORE

What if our numbers are in error? Would this confuse things or not? What might that mean to us? Suppose,

$P(I|S)=0.8$  while the other probabilities were unchanged. That is,  $P(I|A)=0.8$  and  $P(I|B)=0.6$ . Then, recalculating,

$$P(A|I)=36\% \quad P(B|I)=27\% \quad P(S|I)=36\%$$

Thus, the chance there was some surprise Company S, rose, while the other two fell somewhat. Given the inherent uncertainty of the information, the changes were not dramatic, but the numbers were relatively stable, despite the changes. We deliberately increased  $P(I|S)$  and checked to see what happened to the other numbers. The other probabilities, including the important ones,  $P(A|I)$  and  $P(B|I)$ , changed slightly. This relative stability in the numbers is an inherent property of the methodology.

Commander Bayes smiled as he again helped identify the best acquisition candidate.

## CONCLUSION ABOUT SURPRISE

This quick example illustrates how Bayesian math can estimate not just the chance of various events, but also the chance of some missed or surprise issue even though we may know essentially nothing about that possible surprise. Conceptually, we included it in the calculations and let Bayes do the work. It might be surprising, but we have estimated the chance of a surprise. As noted, the chance of unknown or surprising events tends to be dramatically higher than we tend to believe. Hence, the need for our approach. Again, Commander Bayes smiled.

*Want to meet Commander Bayes? Should you have an interest in the software that utilizes this technology in your decision making, please contact the authors at Willard Zangwill ([Willard.Zangwill@chicagobooth.edu](mailto:Willard.Zangwill@chicagobooth.edu)) or Jerry Scherer ([januerry@comcast.net](mailto:januerry@comcast.net)).*