Decision Making Analysis for Supply Chain Planning

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Abstract:

This paper will present several approaches to making supply chain decisions utilizing both left-brain (quantitative) and right brain (qualitative) approaches. The three major challenges addressed are: (1) a calculation or estimation of expected values; (2) the use of an alternative/attribute matrix; (3) decision-making under scenarios of uncertainty, risk and certainty. These tools will prove to be useful in improving both the efficiency and effectiveness of decision-makers, and hence improve operational performance.

I. Introduction

Business organizations employ persons who routinely make decisions on a host of issues, some relatively inconsequential, or ones with much more dramatic and expensive (or profitable) results. Everyone from the CEO to business unit manager to shop floor supervisor to the empowered machine operator does this, and it is beneficial to utilize tips, tools and techniques that make for more effective decision-making.

A significant truism of the modern world is that we find ourselves buried within and among an overload of data, which supposedly is to our benefit. The contradiction is that while we have too much data, we often are lacking information. The distinction between data and information is that data could represent meaningless numbers aligned in rows and columns in spreadsheets or databases, whereas information is useful, it is actionable, it provides a clue as to what to do next. There is of course the question of whether the user has the knowledge of how best to use it.

II. Expected Values

An expected value can be thought of as what we expect a result to be, for example, what the temperature will be tomorrow. Businesspersons will appreciate the comparison to demand forecasting, as the result is just as likely to be correct (meaning: all forecasts are wrong!). Although all forecasts may be wrong, we should at least aspire to be “less wrong” than yesterday, or “less wrong” than competitors, and a “less than perfect” plan is better than no plan at all.

How can one determine a future value? This can be either calculated statistically or estimated via judgment. An example of a statistical calculation is the flip of a fair coin, with equal probability (50%) of heads or tails. If we assign a value of +1 to heads, and -1 to tails, then the expected value of a coin flip is:

$$EV = (.5)(+1) + (.5)(-1) = .5 + (-.5) = 0$$

Let us put this another way. Say we are offered the opportunity of betting one rand with the potential to make one rand if the result is heads, thus profiting 1R, and losing our rand if the result is tails, thus losing 1R. The expected result of this, again assuming a fair coin, would

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be no net gain or loss, a neutral proposition. In fact we may suggest this is a wasted effort, as there is certainly a cost of our time to engage in this challenge.

Where there are statistical based calculations it becomes very important to understand the probability distribution and parameters. An example is identifying the mean and standard deviation of a normal distribution, or the minimum and maximum values of a uniform distribution. Statisticians would be familiar with the concepts of hypothesis testing and more detailed analysis than is required here. Suffice to say that mathematics is our friend.

In the absence of statistical expertise, or without knowledge of a population sample, the determination of an expected value becomes an estimation or judgment call. While some may refer to this as the "seat of the pants guesstimate", it has been shown over time that there are visionaries who are able to see the next big thing. Steve Jobs' tenure at Apple is a great example of a man who foresaw demand for products that did not yet exist. The book "Megatrends" predicted in 1982 that there would be an explosion in the use of what was then known as the "information superhighway" (later, the internet). We would be remiss if we suggested that there are some people who just have luck, or a sixth sense, or as though this might be genetic, a result of having the right DNA. It is more appropriate to conclude that some people know what to look for and have a fundamental understanding of people, processes, society, system dynamics and motivations. They can "see" the invisible connections that exist and trigger cause-and-effect reactions.

III. Alternate/Attribute Analysis

Alternate/Attribute Analysis is also known as Qualitative Factor Analysis, or Weighted Factor Analysis. It is appropriate when considering a finite set of alternatives or options available to the decision maker. These options are characterized by criteria known as attributes, which have some value. For example, let us say a carpenter wishes to purchase a heavy-duty pickup truck for use with work, and also for hunting and fishing. They may desire horsepower, towing capacity, cargo space and four-wheel drive capability. Further, these factors may be of varying importance. Let us say the carpenter has created the following chart representing their choices, the important factors with weights assigned to them (totalling 100%), and entered scores for how each vehicle does on a scale of 0-100 under each criteria.

Truck	Horsepower (30%)	Towing Capacity (15%)	Cargo Space (20%)	4WD (35%)	Total Score
1. Dodge Durango	85	85	80	70	78.75
2. Chevy Silverado	60	75	75	80	72.25
3. Ford F-150	75	80	80	95	83.75

Note that the assignment of weights to each attribute, as well as the scores under each attribute, are not based on numerical values, for example how many pounds of towing

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capacity. It is the estimation, or interpretation of value/importance by the person completing this analysis, hence the term Qualitative Factor Analysis. The total score, however, is a quantitative calculation, based on multiplying each attribute score times the attribute weight, and then aggregating these for a total score. For example:

Dodge Durango: (.3)(85) + (.15)(85) + (.2)(80) + (.35)(70) = 78.75

The "winner" or best alternative using this type of analysis would be the one with the highest score, in this case the Ford F-150 pickup truck. Due to its qualitative nature the Alternative/Attribute Analysis is frequently utilized where one may lack of quantitative values, such as known costs. It can be used to make choices such as which projects to undertake, which employee to hire/promote, or where to locate a new facility.

III. Decision-making Scenarios

Let us say that a CEO is engaged in a decision-making analysis where presented with a number of alternative choices, such as to build a new larger and modernized facility, expand operations at a current facility, or the ever-present do nothing/status quo. These are three possible options that define the decision, and each has a cost associated with it, and perhaps a gain (or loss) depending on whether demand increases or decreases.

The conditions of future demand in this example are known as possible "states of nature." We consider them to be beyond our control or choice, and are left to predict (as with expected values) what will happen. We may utilize detailed statistical analysis or our best judgment to estimate what future demand will be. The following chart has outlined the facility choices and two possible states of nature, which for this example are varying levels of future demand: increasing or staying the same.

Capacity Choice (cost)	**10 Year Demand (sales profit)**	**Net gain/loss**	**Max.**	**Min.**	**Ave.**
New Facility (100M Rand)	Increases and can satisfy (500M Rand)	+400M Rand	+400		+150
New Facility (100M Rand)	Stays the same (no gain in profit)	-100M Rand		-100	
Expansion (10M Rand)	Increases, but only partially able to satisfy (100M Rand)	+90M Rand	+90		+40
Expansion (10M Rand)	Stays the same (no gain in profit)	-10M Rand		-10	
Do Nothing (0 Rand)	Increases, but not able to satisfy (no gain)	0 Rand	0	0	0
Do Nothing (0 Rand)	Stays the same (no gain in profit)	0 Rand			

It should be intuitive that building a new facility is the most expensive option, but could yield the best payoff if there is a significant increase in sales demand over the next ten years. Given three possible options and two possible states of nature, there are then six possible results (3 x 2 = 6), each with an associated payoff listed under the "Net gain/loss"

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column, which represents the increased sales profit minus the cost of capacity. Note that for the “do nothing” alternative there is no associated capacity cost nor an expected gain possible from increased demand.

If we assume that this scenario is operating under conditions of uncertainty, meaning we are unsure what future demand will be, then there are three possible techniques to make this decision, as follows:

1. Maximax: this refers to selecting the option which provides the maximum “maximum” gain. The maximum gain for each option is listed under the “Max.” column, and the largest of these three values is the +400M Rand associated with building the new facility. It represents the greatest profit potential, and would be typical of an aggressive risk-taker.
2. Maximin: this refers to selecting the option which provides the maximum “minimum” gain. The minimum gain for each option is listed under the “Min.” column, and we notice that for two of the options this is a net loss. The maximum of this column is the 0 Rand result from doing nothing. This is typical of a more conservative approach (i.e. “worst case scenario”).
3. Average: this refers to averaging the potential payoffs and essentially treating the states of nature as though they are equally likely. One may say this is applying the expected value calculation, albeit lacking information as to the true future probabilities. The selection in this case would be deciding to build the new facility, as it has the highest average expected result of +150M Rand.

If we were able to assign actual probabilities to the possible states of nature, we could calculate the expected values and then select the capacity option with the highest payout. This is what is known as decision-making under risk.

The final possibility is if we knew with concrete certainty what the future holds. This is known as decision-making under certainty, under which the capacity choice becomes obvious. For example, if we definitely knew sales were projected to increase, then it would make sense to build the new facility and obtain +400M Rand profit. If, however, the demand will remain the same then it makes sense to do nothing, for which we get no gain but also suffer no loss of purchasing capacity that would go unused.

IV. Conclusion

Business leaders have a variety of techniques to help them make more informed decisions. An expected value calculation based on statistics or judgment can help predict future possibilities. The alternate/attribute analysis is appropriate for making a choice considering possible criteria and converting qualitative estimates into a decisive quantitative score. Finally, we make decisions among alternative, considering possible states of nature and the resulting net gains or loss from each possible combination of option/state. This can be done under three scenarios: uncertainty, risk/probability and certainty.

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