OPTIMIZATIONS IN NEW PRODUCTS ASSIMILATION MARKETING IN UNCERTAINTY DECISION MAKING CONDITIONS – MATHEMATICAL MODELS

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Abstract:
When the decident is in a state of uncertainty, based on the lack of enough data for establishing the real terms probability of manifestation, and the variables are partial, than the decision process takes place accordingly to the nature of the game and the chooser's state of mind, by using different rules such as: min-max criterion, max-min criterion, max-max criterion. We gave as example for these rules a wine company manager who has to decide the type of wrap for a certain type of frothy wine from three possibilities.

Key words: *optimum, pessimistic, regrets, realism, rationality criteria*

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When all necessary elements are known for certain, the modeling of decisions taken in sure circumstances doesn't imply major problems, and the mathematical programming, the critical path method, and number analysis are successfully used. But most marketing decisions are taken in aleatory, undetermined circumstances or even in circumstances of competitional universes.

The decision process complicates in these cases, the optimum, real or realistic decision can be obtained only by using different probabilistic methods: traditional statistical methods for estimating and testing possible variants, Markov chains, methods based on waiting theory, on simulation methods and especially on Bayesian analysis.

When the decident is in a state of uncertainty, based on the lack of enough data for establishing the real terms probability of manifestation, and the variables are partial, than the decision process takes place accordingly to the nature of the game and the chooser's state of mind, by using different rules such as: min-max criterion, max-min criterion, max-max criterion etc.

A wine company manager has to decide the type of wrap for a certain type of frothy wine from three possibilities. For selling the product in each wrap, he estimates different profit levels, as follows:

Table 1. Profit for all wrap types and various quantities of frothy wine sold in one month

Wrap type (monetary units)	Product quantity (bottles / month)					
	10.000	12.000	14.000	16.000	18.000	20.000
V1	50 m.u.	200 m.u.	410 m.u.	650 m.u.	910 m.u.	1.280 m.u.
V2	0 m.u.	180 m.u.	390 m.u.	690 m.u.	890 m.u.	1.210 m.u.
V3	100 m.u.	220 m.u.	430 m.u.	710 m.u.	1.050 m.u.	1.250 m.u.

Which is the most profitable wrap type?

This is a problem of decision in state of uncertainty, with only one decident participating to single decision criterion. For solving such a type of problem there can be used the following:

a) Optimum criterion (max-max): In this case, the decident has an optimum way of choosing the optimum variant. This way of choosing the optimum variant is possible when the real terms seem more favorable. According to this criterion, the variant with the most profitable results in a favorable state of nature is the optimum variant. In other words, the decident assumes that the best state of nature will appear, and that he will choose the variant that maximizes his profit. In order to elaborate the decision, the decident will first select the maximum possible profit for each alternative and then he will pick up the maximum profit alternative. The following situations are possible:

- only one decisional criterion optimizes through maximum (profit, productivity) – is applying the next relation $V_{opt} = \max_{a} \max_{n}(x_{an})$ (1)

where x_{an} represents the consequence of using variant V_a in the $S_{n.}$ state of nature;

- only one decisional criterion optimizes through minimum (cost) – is applying the next relation $V_{opt} = \min_{a} \min_{n}(x_{an})$ (2)

In the example above, profit represents only one decisional criterion that optimizes through maximum.

The following relation applies $V_{opt} = \max_{a} \max_{n}(x_{an})$ and it obtains:

- for V1, max = $\max_{n}$ (50, 200, 410, 650, 910, 1.280) = 1.280
- for V2, max = $\max_{n}$ (0, 180, 390, 690, 890, 1.210) = 1.210
- for V3, max = $\max_{n}$ (100, 220, 430, 710, 1.050, 1.250) = 1.250

By comparing the values obtained for the three decisional variants, that means max(1.280, 1.210, 1.250), it identifies the fact that the wrapping optimum variant is V1, because in this situation the maximum profit is obtained, that means 1.280 monetary units/month.

b) Pessimistic criterion (max-min): The criterion was first introduced by Abraham Wald, being also known as "the pessimist's" criterion. The max-min criterion is based on the principle that the decident, within each strategy, will first choose the less effects alternative, and from these, will choose the variant that leads to the highest effect, eventually. Accordingly to this criterion, the variant with the most favorable consequence in the unfavorable state of nature is the optimum variant. In other words, in this case the decident assumes that the worst state of nature will take place and will try to maximize the minimum possible profit. To elaborate the decision, the decident will first select the minimum possible profit for each alternative, and then he will pick up the maximum profit alternative. The following situations are possible:

- only one decisional criterion optimizes through maximum (profit, productivity) – is applying the next relation $V_{opt} = \max_{a} \min_{n}(x_{an})$ (3)

- only one decisional criterion optimizes through minimum (cost) is applying the next relation $V_{opt} = \min_{a} \max_{n}(x_{an})$ (4)

In the example above, profit represents only one decisional criterion that optimizes through minimum.

The following relation applies $V_{opt} = \max_{a} \min_{n}(x_{an})$ and it obtains:

- for V1, min= $\min_{n}$ (50, 200, 410, 650, 910, 1.280) = 50
- for V2, min = $\min_{n}$ (0, 180, 390, 690, 890, 1.210) = 0
- for V3, min = $\min_{n}$ (100, 220, 430, 710, 1.050, 1.250) = 100

By comparing the values obtained for the three decisional variants, that means max(50, 0, 100), it identifies the fact that the wrapping optimum variant is V3, because in this situation the maximum profit is obtained, that means 100 monetary units /month.

c) Criterion of regrets (min-max): The criterion was stated by L.J. Savage, and it is based on similar to maximum criterion principles, but the choice is between alternatives with results expressed in regrets. For determining the optimum variant, within each strategy will first choose the highest regret alternative, and from these will choose the less regret alternative, eventually. According to this criterion, the variant that leads to minimizing decident's regrets is the optimum variant.

In the example above, profit represents only one decisional criterion that optimizes through maximum.

Table 2. Regrets matrix on selecting a new wrap for frothy wine

Wrap type	Product quantity (bottles / month)					
	10.000	12.000	14.000	16.000	18.000	20.000
V1	50	20	20	60	140	0
V2	100	40	40	20	160	70
V3	0	0	0	0	0	30

The following relation applies $V_{opt} = \min_a \max_n (R_{an})$ (5)

R_{ik} represents regret of V_a variant from the S_n state of nature, determined as follows:

$$R_{an} = \max_a(x_{an}) - x_{an} \quad (6)$$

The regrets matrix is built using the relation above:

- for R_{11}, max = $\max_a$ (50, 0, 100) - 50 = 50
- for R_{21}, max = $\max_a$ (50, 0, 100) - 0 = 100
- for R_{31}, max = $\max_a$ (50, 0, 100) -100 = 0

The others values from regrets matrix are calculated the same way (Table 2).

After that $\max_a$ (R_{an}) is calculated, as follows:

- for V1, max = $\max_a$ (50, 20, 20, 60, 140, 0) = 140
- for V2, max = $\max_a$ (100, 40, 40, 20, 160, 70) = 160
- for V3, max = $\max_a$ (0, 0, 0, 0, 0, 30) = 30

The optimum variant V_{opt} = min (140, 160, 30) = 30 is identified from these values. The V3 wrap variant is recommended (it suites the minimum regret).

d) Optimality, realism or Hurwicz criterion: According to this criterion, the favorable and unfavorable states of nature are identified from the multitude of nature states. It associates a coefficient of $\alpha \in (0, 1)$ to the favorable state of nature. That is in fact the decident's estimation for the probability of that state of nature to happen. If the multitude of states of nature reduces to two (the favorable and the unfavorable), and the probability of the favorable state of nature to happen is α, that means that the probability of the unfavorable state of nature to happen is the difference to one – meaning (1 - α). In this situation, where the probabilities of the states of nature to happen are estimated, the problem becomes one of risk decision. It is solved by applying one of the bellow relations, according to the criterion that is optimized:

- only one decisional criterion optimizes through maximum (profit, productivity): is applying the next relation $V_{opt} = \max_a[\alpha \cdot x_{an}^1 + (1-\alpha) \cdot x_{an}^0]$ (7)

- only one decisional criterion optimizes through minimum (cost):

is applying the next relation $V_{opt} = \min_a[\alpha \cdot x_{an}^1 + (1-\alpha) \cdot x_{an}^0]$ (8)

where x_{an}^1 represents consequence of using the V_a variant in the most favorable state of nature and x_{an}^0 represents consequence of using the V_a variant in the most unfavorable state of nature.

In the example above, profit represents only one decisional criterion that optimizes through maximum. Now we apply relation (7).

The decident considers the optimism coefficient α = 0,7. From the relation (7), it results:

- for V1 = 0,7 · 1.280 + (1 – 0,7) · 50 = 896 + 15 = 911
- for V2 = 0,7 · 1.210 + (1 – 0,7) · 0 = 847
- for V3 = 0,7 · 1.250 + (1 – 0,7) · 100 = 905

V1 is chosen as the optimum variant, because according to this criterion it has the highest profit.

e) Proportionality or rationality criterion (Bayes-Laplace): Bayes-Laplace's criterion starts from the premise that each state of objective conditions has the same probability to happen, and the variant with the arithmetic average of the results for the states considered is the optimum variant. Mathematically, the determination formula for the optimum variant is $V_{optim} = \max_a \frac{1}{n}\sum_{i=1}^{n} X_{ai}$. In the example above, there is

-only one decision criterion that optimizes through maximum (profit, productivity):

the following relation applies $V_{opt} = \max_a \left(\sum_{n=1}^{N} \frac{x_{an}}{N} \right)$ (9)

where N represents the number of states of nature.

- only one decisional criterion optimizes through minimum (cost):

is applying the next relation $V_{opt} = \min_a \left(\sum_{n=1}^{N} \frac{x_{an}}{N} \right)$ (10)

In the example above profit represents only one decision criterion that optimizes through maximum. It gets:

- for V1 = (50 + 200 + 410 + 650 + 910 + 1 280)/6 = 583,33
- for V2 = (0 + 180 + 390 + 690 + 890 + 1.210)/6 = 560
- for V3 = (100 + 220 + 430 + 710 + 1.050 + 1 250)/6 = 626,67

V3 is chosen as the optimum wrap variant, because according to this criterion it has the highest profit.

Although this criterion has many advantages, using it in the decision marketing process is restricted, because in this area there are no equal probabilities for different alternatives to accomplish.

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