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https://doi.org/10.5281/zenodo.1273307 **Research Article**

Business Decision Making and Forecasting According to Probability Principles Convergences Between Historical and Empirical Research Methods

Economics

Keywords: Calculations, forecasting, probability, Bayes's method, business decisions.

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Abstract

The object of this paper is to describe and investigate mathematical models of random phenomena, primarily from a theoretical point of view. Statistics is concerned with creating principles, methods, and criteria to treat data pertaining to such (random) phenomena or to data from experiments and other observations of the real world, by using, for example, the theories and knowledge available from the theory of probability. We can express economic and other analysis more precisely when we use mathematics. The application of mathematics has allowed economic theory to advance and provides the basis for computer models of the economy that have been developed. As we progress in economics we will find mathematics is used in various ways in textbooks and in journal articles.

1. Introduction

It would be unwise to assume that decision makers in organizations attempt to maximize their decisions in the interests of the organization, or that they are likely to follow an 'objectively' rational model. Individuals (and groups) 'satisfe' in their decision processes, identifying problems and opportunities within a limited perceptual framework, usually leading to the acceptance of 'goog enough' solutions which meet minimum-acceptance criteria. The title used for this paper is Decision Making according to probability principle. However, many other terms are also used for the concepts and techniques described in the paper. These include-Mathematical and Quantitative Methods-Operational Research or OR-Quantitative Analysis-Business Mathematics, Statistics and Management Science. Regardless of the name used, it is important to realise that the same approach is employed.

Quantitative methods are especially helpful with large, complex problems. If the manager has had little experience with similar problems, or if the problem is sufficiently complex, then a quantitative analysis of the problem can be an especially important consideration in the manager's final decision.

2. Main characteristics of decision making and forecasting techniques

Life is a constant sequence of decision-making situations. Statistical decision theory exhibit that most decision are made intuitively without even thinking about them. Other decision may require some thought, but can still be made intuitively. But, some decisions are not easy to make. Complex decisions faced by organizations, such as whether or not to build a new plant or how many units of a given item to produce, are also difficult decisions. Applying the formal models of decision theory may not always be easy, but for the important decisions it should prove

worthwhile. As with any statistical procedure, applying decision theory is a modeling problem in which the statistician attempts to build a model that is a reasonable approximation to the real-world decision-making problem of interest. The research concept is the central function of the market business. The firm must forecast how and when each and every one of its competitors will add capacity[81]. The other key input to problems of decision making involves the *potential consequences* of the various actions that are being considered. Once all of the inputs have been determined, the decision-making problem can be solved by using the adequate techniques that will be developed in this paper. We should keep in mind, however, that the initial modeling of a problem is also very important. Often this modeling process is iterative, since the model-building process may lead to the consideration of new actions or ecents that had previously been ignored.

When testing the relationship between two variables, a specific explanatory model is used. But, when testing the hypothesis empiricaly and quantitatively the variables must be calculated and measured. The asumed independent variable is established by calculations and measuring the relative strength of the functions of the respondents. By measuring the functions of the respondents one assumes that it is likely that the respondents will behave in a particular way when solving problems and making decisions (which is the research phenomenon). The assumed dependent variable is measured by using secondary data. Economic analysis can be expressed precisely when we use adequate techniques. The implementation of some adequate techniques has allowed economic theory to advance and provide the basis for computer models of the economy that have been developed. As we progress in economics we will find many statistics that are used in various ways in textbooks and in journal articles.

When faced with a business decision, business managers are usually confronted with an array of possible actions, a variety of economic environments, and corporate gains (or losses) the dependent on manager's chosen action and the state of nature that occurs. Similarly, business decisions are made regurlarly in an environment where decision makers cannot be certain of the future behavior of those factors that will eventually affect the outcome resulting from various options under consideration[82]. Managers must apply adequate techniques for specific problems. We will try to present an introduction to business decision theory, a systematic procedure for analyzing a decision problem and arriving at an appropriate action. Perhaps, the simplest procedure is graphical solution of Linear Programming.

3. Data, Methodology and Results

Graphical methods of solving Linear Programming problems can only be used for problems with two decision variables. Problems with three or more unknowns must be solved by techniques such as the simplex method. Graphical methods are the simplest to use and should be

[81] Source: Porter E. M. (1980). *Competitive Strategy-techniques for analyzing industries and competitors.* The Free Press. New York, NY 10020. Page 234.

[82] Source: Newbold,P., Carlson,W., and Thorne,B. (2007). *Statistics for Business and Economics.* Prentice Hall. N.Yersey. Page 2.

used wherever possible. Its component elements are limitations, types of problems and limitations, and graphical example. There[83]:

1. A line is plotted to represent the equality limit of each constraint.
2. The set of feasible solutions is where all the constraint are satisfied.
3. The optimal solution occurs where a line representing the objective function just touches the feasible set.

The PL form is written as: Max (min) $Z = aX + bY$

Most linear programming are too large to be solved graphically, and an algebric solution procedure must be employed. The most widely used algebraic procedure for solving linear programming is called the simplex method[84]. The mathematics behind the Simplex method are complex and this paper does not try to explain why the method works but it does describe how to use the technique. A step by step arithmetic method of solving LP problems whereby one moves progressively from a position of, say, zero production, and therefore zero contribution, until no further contribution can be made. Each step procedures a feasible solution and each step produces an answer better than the one before, i.e. either greater contribution in maximising problems, or less cost in minimising problems[85].

Recall that the theory of LP states the optimal solution will lie at a corner point of the feasible region. In large LP problems, the feasible region cannot be graphed because it has many dimensions, but the concept is the same. The simplex method systematicaly examines corner points, using algebric steps, until an optimal solution is found[86]. It is important to understand the ideas to produce solution. The simplex approach yields not only the optimal solution to the decision variables and the maximum profit (or minimum cost), but valuable economic information as well. To be able to use computers successfully and to interpret LP computer printous, we need to know what the simplex method is doing and why[87].

We give solving a minimization problem using the simplex method.
Solve the following LP:

Minimize cost $f = Ax_1 + Bx_2$

subject to $A1x_1 + A2x_2 \leq C$

$A3x_1 - A4x_2 \leq D$

$A5x_1 - A6x_2 \leq E$

[83] Source: Soper, J. (2004). *Mathematics for Economics and Business.* Blackwell Publishing Ltd. UK. Page 340.
[84] Several computer codes also employ what are called interior point solution procedures. These work well on many large problems, but the simplex method is still the most widety used solution procedure. Source: Anderson, Sweeney, Williams. (2003). *An Introduction to Management Science-Quantitative Approaches to Decision Makimg.* Thompson. USA. Page 225.
[85] Source: Lucey,T. (2002). *Quantitative Techniques.* Thompson. UK. Page 313.
[86] Source: Render, Stair, Hanna. (2009). *Quantitative Analysis Management.* Pearson. USA. Page 372.
[87] There are a lot of softwares for solving LP: Management Scientist, LINDO, Excel Solver, MathEcon, QM…

Linear programming can be applied to the two-person, zero-sum game to solve for the probabilities associated with mixed strategies. The major advantage of linear programming is that it can be applied to games with more than two strategies per player. To ilustrate the linear programming formulation of a game situation, we will consider the sample pay off matrix for a 2-by-4 game in the following table:

		Player B strategies			
		w	x	y	z
Player A strategies	1	/	/	/	/
	2	/	/	/	/

Now we will try to apply some other techniques which are adequate for the prognoses of the different social and economical features such as**:** Moving Average, Exponential Smoothing, Trend and Seasonality etj. These are hipotetical information,which are more usefull the results and the expected values for the future issues with a smaller standard mistake.We can give some information for an issue for the and we try to implement the technique 12 period of time and we try to implement Moving Average technic.

Moving Average

t	1	2	3	4	5	6	7	8	9	10	11	12	13	14
$\mathbf{Z_t}$	15	12	11	18	21	16	14	17	20	18	21	16	14	19
MA			15.4	15.6	16.0	17.2	17.6	17.0	18.0	18.4	17.8	17.6		

Author's calculations

The results of Moving Average are calculated till the 10th period whereas with the prognosis formula of" Moving Average',we can calculate its values of the 11th and 12th period (17.8 and 17.6) whereas they will forecast the accounts of the 13th and 14th period. (14 and 19). Similar we apply the technique Exponential Smoothing for some perod of times:

		MAE	**MAPE**	**MSE**	
w	0.4		11.3034	1.20%	216.931
t	$\mathbf{Z_t}$	$\mathbf{Z_t}$ **hat**	**|Error|**	**%Error**	**Error^2**
1	924	931	7	0.76%	49
2	925	928.2	3.2	0.35%	10.24
3	912	926.92	14.92	1.64%	222.606
4	908	920.952	12.952	1.43%	167.754
5	910	915.7712	5.7712	0.63%	33.3067

6	912	913.4627	1.46272	0.16%	2.13955
7	915	912.8776	2.12237	0.23%	4.50445
8	924	913.7266	10.2734	1.11%	105.543
9	943	917.8359	25.1641	2.67%	633.23
10	962	927.9016	34.0984	3.54%	1162.7
11	960	941.5409	18.4591	1.92%	340.737
12	958	948.9246	9.07544	0.95%	82.3635
13	955	952.5547	2.44526	0.26%	5.9793
14		953.5328			

Author's calculations

And we can read the value 953.5328 for the last period, predicted from the previous techique. From the information for the average payment of the subsidies for the farmers in the rural places in Macedonia in the last three years, with the imlementation of the techique Forecasting with 'Trend and Seasonality, we have the following results:

Forecasting with Trend and Seasonality

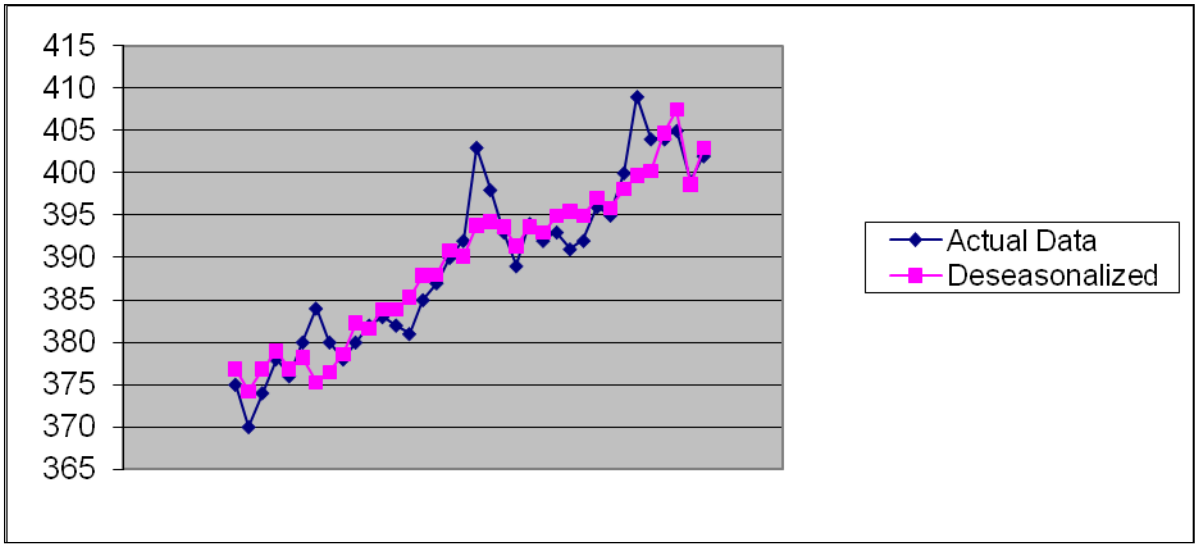
Month	**Avg. Pay**						**SI**	**Deseason**
Jun-2013	375						99.52	376.83
Jul-13	370						98.87	374.22
Aug-13	374						99.25	376.82
Sep-13	378						99.74	378.97
Oct-13	376						99.78	376.82
Nov-13	380	**MA**	**CMA**	**SI-raw**	**SI-avg.**	**SI**	100.48	378.20
Dec-13	384	378.33	378.63	101.42	102.25	102.33	102.33	375.26
Jan-13	380	378.92	379.38	100.16	100.87	100.95	100.95	376.43
Feb-13	378	379.83	380.29	99.40	99.76	99.84	99.84	378.62
Mar-13	380	380.75	381.13	99.70	99.32	99.39	99.39	382.31
Apr-13	382	381.50	382.08	99.98	100.02	100.09	100.09	381.64
May-13	383	382.67	383.17	99.96	99.68	99.76	99.76	383.92
Jun-13	382	383.67	384.46	99.36	99.44	99.52	99.52	383.86
Jul-13	381	385.25	386.00	98.70	98.79	98.87	98.87	385.35
Aug-13	385	386.75	387.38	99.39	99.17	99.25	99.25	387.91
Sep-13	387	388.00	388.38	99.65	99.67	99.74	99.74	387.99
Oct-13	390	388.75	389.25	100.19	99.70	99.78	99.78	390.85
Nov-13	392	389.75	390.13	100.48	100.40	100.48	100.48	390.14
Dec-13	403	390.50	390.96	103.08	***1199***	***1200***	102.33	393.82
Jan-2014	398	391.42	391.83	101.57			100.95	394.26
Feb-14	393	392.25	392.54	100.12			99.84	393.65

Mar-14	389	392.83	393.21	98.93		99.39	391.37
Apr-14	394	393.58	393.79	100.05		100.09	393.63
May-14	392	394.00	394.33	99.41		99.76	392.94
Jun-14	393	394.67	394.92	99.51		99.52	394.91
Jul-14	391	395.17	395.42	98.88		98.87	395.46
Aug-14	392	395.67	396.13	98.96		99.25	394.96
Sep-14	396	396.58	397.25	99.69		99.74	397.02
Oct-14	395	397.92	398.13	99.22		99.78	395.86
Nov-14	400	398.33	398.75	100.31		100.48	398.11
Dec-14	409	399.17				102.33	399.69
Jan-2015	404					100.95	400.21
Feb-15	404					99.84	404.67
Mar-15	405					99.39	407.47
Apr-15	399					100.09	398.63
May-15	402					99.76	402.97
Jun-2017	**403.25**	<- Forecast				**99.52**	405.22

Author's calculations

We trust the prognosis value of the mentioned technique, for the amount of the subsidies in the rural places for June 2017[88] (403.25).

The graphical delivered issues of the mentioned technique



As long as we want to do some research we question whether to contiunue or no as a consequence of uncertainity for the economic benefits, nevertheles without research we deal with

[88]The valuesare expectant to change owing to the evetual global economical crises.

uncertainity in decision making. In addition to new qualitative research tools, marketers have developed new methodologies to help them understand target consumers[89]. Accordinely we ask wehter we should do market research or not? We can clarify the dilemma applying a synthesis based on principle od the theory of Thomas Bayes (1763). Bayes theory may help us answear wether we should do market research or if the information that we have are suffiecent for decision making.

Quantitative methods are an appreciation of the methods which can be used to quantify a market opportunity[90]. Expected value is one of the determinants that compares the decision of the potential value, based on market research, with the decision of potencial value that is not based on market research. The expected value of an event contains two parts: "redemption" that results from an event (the market situation, low demand, middle demand, high demand) and the probability that the event will materialize. That is a random variable for an experiment containing vaules S from R. If x has discrete distribution with distribution function f, than the expected value of x is defined as:

$$E(X) = \sum_{x \in S} xf(x)$$

If X has continous distribution with distribution function f, than the expected value of x is defined as:

$$E(X) = \int_{S} xf(x)dx$$

Lastly we assume that X has mixed distribution. In specific way we assume that S is union of set D and C, so that the conditional distribution of X in D is discrete with distribution fd and with conditional distribution of X in C is continous, with distribution fc. Let p=P (X in D). The expected value is:

$$E(X) = p\sum_{x \in D} xf_D(x) + (1-p)\int_{C} xf_C(x)dx$$

In order to understand the expected value in probabilistic way and with statistic terms we assume that we form sequences of random independent variables. The avearge (the expected value) after n distributions is:

$$\overline{X}_n = \frac{1}{n}\sum_{i=1}^{n} X_i$$

As a consequence the average will convert in the expected value as n growth. Precize explanation is the law of big numbers. So the expected value is average of different flows (the market

[89] Source: www.prenhall.com/kotler or www.prenhall.com/custombusiness
[90] Source: Wickam A. Ph. (2004). *Strategic Entrepreneurship.* Prentice Hall. Great Britain. Page 394.

circumstances) in the result table where are the ponders of the probability that will materialize, the situation S, S', S" (low, middle, high demand).

4. Some conclusion

From this modest paper and general affirmation of quantitative analysis, we can give some concusion, such us:

- Empirical and quantitative evidences increase credibility of concrete results.
- Despite of the problem that is studied, in the same time is possible to choose the adecuate statistical methods, despite of procedurals and tecnical methods that can appear. This is antedate to obtain more precise results. Today this issue is most easiest due to the computing aplicative programme.
- Optimal Decision making is achieveable if the number of variable is enlarged, number of observation and questionaires due to occurate.
- We can take decisions for the whole phenomenon through sample.
- Research expenses must be reasonable.
- The rezults that we have, according to statistical trend, matrix and stochastic, they have express main elements for quantification parametres, according to theoritical expectation and experiences that we have used in literature.

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www.prenhall.com/custombusiness
www.prenhall.com/kotler

Appendix:

Box and Marbles example for Bayes' Rule

Marbles contained

	A	B	C
X	4	52	12
Y	1	45	39
Total	5	97	51

Experiment:

One box is chosen at random.

From the chosen box a marble is drawn at random.

Joint Probability Table

	A	B	C	
X	0.2667	0.1787	0.0784	0.5238
Y	0.0667	0.1546	0.2549	0.4762
Total	0.3333	0.3333	0.3333	1.0000

Revised Probabilities

	A	B	C	
P(. | R)	0.5091	0.3412	0.1497	1.0000
P(. | G)	0.1400	0.3247	0.5353	1.0000

Calculations											**d***	d1	d3	d2	d1	d1	d1
Max	80	85	56	90	11	11	11	11	11	11		58.65	67.71	60.21	67.85	0	0
	s1	**s2**	**s3**	**s4**	**s5**	**s6**	**s7**	**s8**	**s9**	**s10**		**EV**	**EV1**	**EV2**	**EV3**	**EV4**	**EV5**
d1	80	61	50	33	11	11	11	11	11	11		58.65	57.35	47.82	67.85	0	0
d2	12	35	52	90	11	11	11	11	11	11		42.3	42.27	60.21	28.59	0	0
d3	42	85	56	40	11	11	11	11	11	11		55.2	67.71	51.68	49.3	0	0
d4	11	11	11	11	11	11	11	11	11	11		11	11	11	11	0	0
d5	11	11	11	11	11	11	11	11	11	11		11	11	11	11	0	0
d6	11	11	11	11	11	11	11	11	11	11		11	11	11	11	0	0
d7	11	11	11	11	11	11	11	11	11	11		11	11	11	11	0	0
d8	11	11	11	11	11	11	11	11	11	11		11	11	11	11	0	0
d9	11	11	11	11	11	11	11	11	11	11		11	11	11	11	0	0
d10	11	11	11	11	11	11	11	11	11	11		11	11	11	11	0	0
Prob.	0.3	0.2	0.35	0.15	0	0	0	0	0	0			0.28	0.313	0.408	0	0

d2	d3	d1	d3
90	40	56	67

	d3
Min	50

Max	**Min**	**Avg.**	**Hur.**
80	33	56	61.2
90	12	47.3	58.8
85	40	55.8	67
11	11	11	11
11	11	11	11
11	11	11	11
11	11	11	11
11	11	11	11
11	11	11	11
11	11	11	11
		□ =	0.6

Regret Table

										Max
0	24	6	57	0	0	0	0	0	0	57
68	50	4	0	0	0	0	0	0	0	68
38	0	0	50	0	0	0	0	0	0	50
69	74	45	79	0	0	0	0	0	0	79
69	74	45	79	0	0	0	0	0	0	79
69	74	45	79	0	0	0	0	0	0	79
69	74	45	79	0	0	0	0	0	0	79
69	74	45	79	0	0	0	0	0	0	79
69	74	45	79	0	0	0	0	0	0	79
69	74	45	79	0	0	0	0	0	0	79

Revised Probs

P 1	0.1 1	0.5	0.31	0.08	0	0	0	0	0	0
P 2	0.1	0.1	0.45	0.36	0	0	0	0	0	0
P 3	0.5 9	0.0 7	0.3	0.04	0	0	0	0	0	0
P 4	0	0	0	0	0	0	0	0	0	0
P 5	0	0	0	0	0	0	0	0	0	0

	PI	**SI**
EV with	74.1	65.4 3
EV of	15.45	6.77 5
	Efficienc y	44%

Conditional Probs

I1	0.1	0.7	0.25	0.15	1	1	1	1	1	1
I2	0.1	0.1 5	0.4	0.75	0	0	0	0	0	0
I3	0.8	0.1 5	0.35	0.1	0	0	0	0	0	0
I4	0	0	0	0	0	0	0	0	0	0
I5	0	0	0	0	0	0	0	0	0	0

Joint Prob Table

	0.0	0.1								
I1	3	4	0.09	0.02	0	0	0	0	0	0.28
	0.0	0.0								0.31
I2	3	3	0.14	0.11	0	0	0	0	0	3
	0.2	0.0								0.40
I3	4	3	0.12	0.02	0	0	0	0	0	8
I4	0	0	0	0	0	0	0	0	0	0
I5	0	0	0	0	0	0	0	0	0	0
	0.3	0.2	0.35	0.15	0	0	0	0	0	1