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Articles in the field of agricultural economics, suitable for publication in the journal, will be welcomed.

Articles should have a maximum length of 10 folio pages (including tables, graphs, etc.) typed in double spacing. Contributions, in the language preferred by the writer, should be submitted in triplicate to the Editor, c/o Department of Agricultural Economics and Marketing, Private Bag X250, Pretoria, 0001, and should reach him at least one month prior to date of publication.

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Contents

EXPECTATION MODELS IN FARM BUSINESS MANAGEMENT*

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INTRODUCTION

It is generally accepted that co-ordination and supervision are important elements in the management of any enterprise, including the agricultural enterprise.[1]

The importance of co-ordination is explained by Heady[2] as follows: "The fundamental role of the coordinating unit, management in its true sense, is this: First: it must formulate expectations of the conditions which will prevail in the future. This task ordinarily is encountered before investment is made or production plans are ready to be committed. It involves the anticipation of future prices and production rates. Second: ... a plan of production (investment) must be formulated which is logical and consistent with expectations. Decisions must be made. Third, the production plan must be put into action. An auxiliary responsibility of management is the acceptance of the economic consequences of plans. In summary then, the important steps in co-ordination include expectations, plans action and acceptance of consequences." According to this approach, co-ordination consist partly of formulating expectations and drawing up production plans.

Profitability rests partly on realistic decision-making, which in its turn is based on realistic estimates of relevant natural, social and economic parameters.

In this article certain methods of making estimates are discussed, with examples where such methods have been used successfully.

EXPECTATION MODELS

A great variety of models can be applied to formulate expectations for purposes of decision-making and planning. These models vary from simple to sophisticated econometric models. However, a model should not be judged on how complicated it is, but rather according to how reliably it describes the future reality. For example, if two models were equally accurate and reliable, it would be only logical to use the simpler of the two.

The importance of this part of the management function is obvious. The more accurately, precisely and reliably expectations can be determined, the better can be the planning and execution.

The following models are among those sometimes applied to formulate expectations.[3]

Arithmetical means

Underlying this method is the assumption that as the universe becomes larger, the statistical scatter of the data assumes the normal distribution. The arithmetical mean is consequently the best criterion for estimating the most general value of the universe.

According to McMillan and Gonzalez[4], a set of data would follow the normal distribution and the mean would be a reliable criterion of the most general value if the ratio of the standard deviation (σ) to the mean ($\bar{X}$) is smaller than one third ($\sigma/\bar{X} < 1/3$). Where this ratio is greater than one third, the universe cannot be normally distributed and the mean consequently should not be used as the expected value.

Judgement forecasts

In any prediction sound judgement is a requirement. The alternative production possibilities in an established region are often determined on grounds of judgement, based on knowledge and experience of the situation in the region.

Functional models

In the case of these models a functional relationship between different variables is derived mathematically or statistically. The expectations are then formulated with the help of predetermined values of certain independent variables in the derived equations. Examples of this method are the fitting of functions by regression or similar statistical techniques.

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* Based on an M.Sc.(Agric.) thesis by C.J. van Rooyen at the University of Pretoria and internal project No. 6 of 1975 of the Department of Agricultural Economics and Marketing which dealt with systems analysis of certain aspects of the harvesting and delivery of maize.

Stochastic expectation models

It is sometimes necessary to determine the most probable expectation of an eventuality. For this purpose probabilism may be used with statistically compiled probability distribution. The most probable value of a set of data may, for example, be indicated by the density function of the appropriate probability distribution.

Mechanical rectilinear extrapolation

Expectations based on these models cannot be regarded as very reliable. However, in the absence of sufficient information to produce a more reliable model, these models sometimes have to be used.

THE APPLICATION OF CERTAIN EXPECTATION MODELS

Functional expectation models

The application of some functional models is illustrated by producing regression equations from agricultural data. An example that is applicable in irrigation farming will be used from here onwards to illustrate this type of model.

The relationship between the level of the Hartbeespoort Dam and the gross margins[5] of alternative production activities

In irrigation farming it may be expected that there is a meaningful relationship between the gross margins of production activities and the quantity of irrigation water applied.

At the Hartbeespoort Irrigation Scheme the available irrigation water for the production season is determined according to the quantity of water in the dam on the first day of the October preceding the production season - in other words, the level of the dam on 1 October. For planning purposes this means that a farmer knows how much irrigation water is going to be available during the production year ahead. If a functional relationship can then be identified between the dam level and the gross margins of the alternative production activities, a meaningful expectation model can be construed and applied for the planning of optimal farm production.

In an attempt to obtain such a functional relationship linear least square regression equations were applied to the relevant data. The October level of the dam was introduced into the expectation model as an independent variable and the gross margins of the production activities as dependent variables.

The information used in the analysis was gathered at the experimental farm at Losperfontein during the years 1958 to 1971. In order to make the data for different years comparable, prices were deflated according to the relevant indices of prices of farm requisites as taken from the Short Abstract

The functional relationship was hypothesised as follows:

$$Y = A + BX$$

Where
- Y = gross margin per hectare or per livestock unit
- A = absolute term (intercept at Y axis)
- X = October dam level
- B = regression coefficent $\left(\frac{d \text{ gross margin}}{d \text{ dam level}}\right)$

of Agricultural Statistics. In Table 1 the results of the regression analysis are given.

The statistical significance of the hypothesised relationship was measured against the correlation coefficient, the Student's t test and the F test. In terms of all three of these statistical criteria there is a significant rectilinear relationship in the observations made between the October level of the dam and the gross margins of tobacco, wheat and dairy production. The gross margins of pig production are not significantly influenced.

From these results the gross margins of the enterprises at different dam levels can therefore be determined. Tobacco is used as an example. If the October level of the dam is 3 metres, the gross margin of tobacco will be the following:

$Y = 266{,}20 + 41{,}7X$

Therefore gross margin = R391,30

In Table 2 the gross margins for the various products at a few different dam levels are indicated.

This expectation model therefore makes it possible to forecast the unit incomes of the different enterprises before the beginning of the season. These expected incomes can be put to use in the planning process, particularly to establish the optimal enterprise combination for the production season concerned.

So this model makes it possible to integrate relationships that occur in nature in a meaningful way into the decision-making action in order to put farm enterprise planning on a more scientific and objective basis and in so doing to maximise the probability of an optimal farm income.

Stochastic expectation models

Stochastic processes arise if natural uncertainties within which the manager must make decisions occur with such regularity that the variance can be described by means of a probability distribution.

Often certain criteria are applied for calculation procedures in spite of the fact that the probability distribution of such data has not been identified. If, for example, the data are not distributed according to the normal distribution, it would be theoretically incorrect to accept the arithmetical mean as the most general value - the value with the greatest probability of occurring. McMillan and Gonzalez maintain that the arithmetical mean is acceptable and the data therefore normally distributed only if the ratio of the standard deviation (σ) to the average (X) is less than one third ($\sigma/\bar{x} < 1/3$).

If, however, this ratio is greater than one

TABLE 1 - Relationship between October dam level and gross margins

Production activity	Absolute term	Regression coefficient	Correlation coefficient	t value	n - 1 degrees of freedom	f value	n - k - 1 - degrees of freedom
Tobacco	266,20	41,70	0,79	3,92**	10	15,38***	9
Wheat	12,20	9,30	0,73	3,16**	10	9,99***	9
Dairy produce	60,38	9,55	0,62	2,37*	10	5,61**	9
Pigs	185,47	7,60	0,35	0,83a	6	0,69a	5

***: significant at p = 0,005
**: significant at p = 0,01
*: significant at p = 0,05
a: not significant

TABLE 2 - Gross margins at different dam levels

Dam level m	Tobacco R/ha	Wheat R/ha	Dairy R/cow	Pigs R/sow
3	391,30	40,10	76,26	178,39
6	513,86	67,46	101,00	178,39
12	766,74	123,88	151,33	178,39
18	1 016,83	179,69	201,99	178,39

third, the gamma distribution[6] is approached and the gamma density function would therefore indicate the most probable value.

According to McMillan and Gonzalez[7], the gamma density function indicates the most probable value if the probability distribution includes the following forms:

The probability density function of the gamma distribution is as follows:

$$F(x) = \frac{Lx^{r-1} e^{-Lx}}{(r-1)!}$$

$$r = \frac{(\text{Mean})^2}{(\text{Standard deviation})^2}$$

e = Naperian logarithm

$L = \sqrt{r}$

x = the value of which the probability is being determined

! = $(r-1)(r-2)(r-3)(r-4) \ldots [r-(r-1)]$

A number of applications will be discussed next:

Rainfall data

Green, Barger *et al*, Barger and Thom, Shaw *et al* and Thom[8] found that the distribution of rainfall in the same month over a number of years is mainly skew and deviates from the normal distribution. It could therefore give rise to incorrect decision-making if the arithmetical mean was applied to determine the expected rainfall. On the grounds of these observations Green used an adapted gamma distribution and Barger *et al*, Barger and Thom, Shaw *et al* and Thom the gamma distribution to describe the distribution of the rainfall and determine the expected rainfall. In pursuance of the above-mentioned references the possibility of determining the most probable rainfall in the Hartbeespoort irrigation area was investigated with the help of the gamma probability density function.

This value is of great practical importance because available irrigation water is a scarce resource[9] and must therefore be applied as economically as possible. Under these circumstances the rainfall can be an important source of supplementary water supply and consequently the correct expected rainfall can play

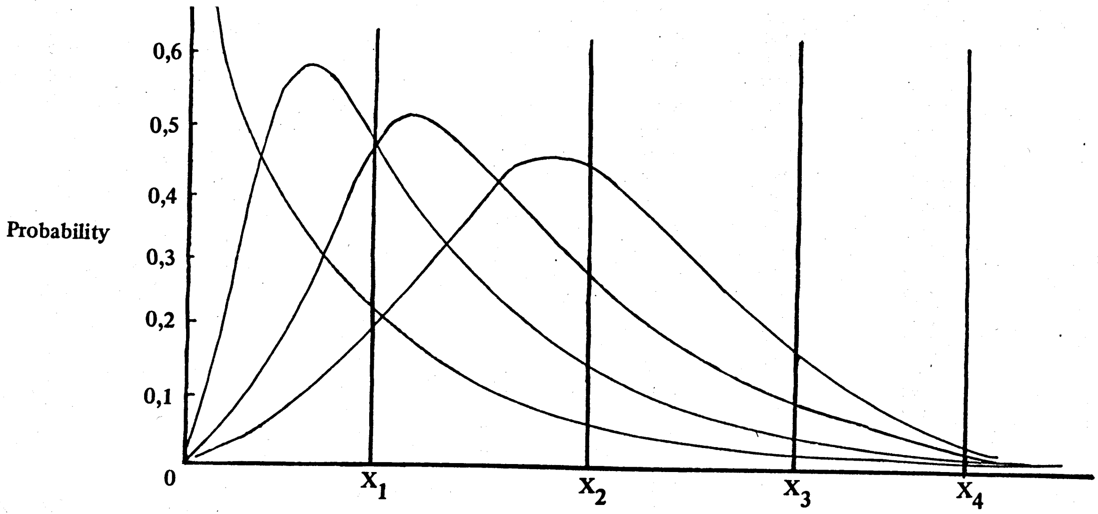

FIG. 1

an important part in establishing the optimum production combination and profitability.

The standard deviation and the mean of the monthly rainfall figures over a period of 42 years were determined and for twelve months the ratio of the above statistical criteria was greater than one third ($\sigma/\bar{x} > 1/3$). The gamma distribution was consequently suitable and the most probable rainfall for each month was calculated with the help of the gamma probability density function.[10]

Tables 3 and 4 show the average and standard deviations, the intervals and the probability that a certain quantity of rain will fall and also the most probable rainfall for each month. During the winter months smaller intervals are used to obtain a more accurate probability distribution.

According to Tables 3 and 4, the probability that there will be between 100 and 119 mm of rain during January is 0,129 or 12,9 per cent and the probability that there will be between 0 and 1,9 mm of rain during July is 0,2 or 20 per cent. The rainfall with the highest probability in each month indicates the expected rainfall for that month.

From this analysis it may be deduced that the application of the arithmetical mean would result in a significant overestimation of the expected rainfall, particularly for the winter months. It is also particularly during this period of the year that the available irrigation water from the dam becomes scarce. A more accurate determination of the expected rainfall is consequently of decisive importance in the choice of winter production activities which would achieve an optimal farming pattern.

The application of the gamma distribution to some aspects of the delivery of maize

In a research project[11] in which the economic aspects of the harvesting and delivery of maize were investigated with the help of a systems analysis approach, the ratio of the standard deviation to the arithmetical mean was determined for all sets of data. On the basis of this it was decided whether the most general values, as used in the "systems analysis", would be determined by using the arithmetical mean or the density function of the gamma distribution.

The use of the gamma distribution is illustrated in calculations to determine the labour utilisation coefficients for the delivery process. For the determination of these coefficients in the delivery process it is important, among other things, to determine the driving time to the granary, the time spent waiting at the granary and off-loading the maize and the time taken to drive back to the place where the maize is loaded. In Table 5 there is an explanation of the results obtained after processing the relevant data.

According to those results it would therefore be correct only in the case of delivery in bulk to a silo in the Highveld region to calculate the time taken by the delivery process and consequently the number of man-hours used with the arithmetical mean.

SHORTCOMING AND LIMITATIONS

In producing expectation models accurate and relevant information is of the greatest importance. Estimates based on inaccurate and incomplete data

TABLE 3 - Gamma distribution of rainfall during summer months (probabilities)

Interval mm	Jan.	Feb.	March	April	Oct.	Nov.	Des.
0 - 9	0,001	0,008	0,029	0,090	0,063	0,007	0,001
10 - 19	0,011	0,032	0,064	0,137	0,123	0,032	0,010
20 - 29	0,027	0,053	0,079	0,135	0,135	0,057	0,027
30 - 39	0,044	0,068	0,084	0,120	0,127	0,073	0,045
40 - 49	0,058	0,079	0,083	0,103	0,111	0,084	0,061
50 - 59	0,069	0,086	0,076	0,085	0,094	0,086	0,072
60 - 69	0,075	0,080	0,074	0,069	0,077	0,085	0,080
70 - 79	0,077	0,076	0,087	0,056	0,061	0,081	0,082
80 - 89	0,076	0,070	0,060	0,045	0,049	0,074	0,080
90 - 99	0,073	0,054	0,054	0,035	0,038	0,066	0,076
100 - 119	0,129	0,104	0,088	0,050	0,052	0,108	0,132
120 - 139	0,104	0,083	0,066	0,031	0,030	0,079	0,103
140 - 159	0,079	0,061	0,049	0,018	0,018	0,056	0,076
160 - 179	0,057	0,044	0,036	0,011	0,010	0,038	0,053
180 - 199	0,040	0,031	0,030	0,006	0,006	0,023	0,036
200 - 219	0,028	0,021	0,018	0,004	0,003	0,017	0,024
220 - 239	0,019	0,014	0,013	0,002	0,002	0,011	0,015
240 - 259	0,012	0,010	0,009	0,001	0,001	0,007	0,010
260 - 279	0,008	0,006	0,006	0,001	0,001	0,004	0,006
280 - 299	0,007	0,005	0,005	0,000	0,000	0,003	0,004
300 - 339	0,005	0,005	0,005	0,000	0,000	0,003	0,004
340 - 379	0,002	0,002	0,003	0,000	0,000	0,001	0,001
380+	0,000	0,000	0,000	0,000	0,000	0,000	0,000
				mm			
Expected rainfall	109,5	109,5	109,5	14,5	24,5	109,5	109,5
Average rainfall	108,2	95,6	68,1	52,0	53,6	89,7	104,5
Standard deviation	59,6	60,6	64,3	42,4	40,1	55,3	55,8

limit the possibilities for application of the models.

A reliable records system is therefore a prerequisite in the application of expectation models.

TABLE 4 - Gamma distribution of rainfall during winter months (probabilities)

Interval mm	May	June	July	Aug.	Sept.
0,0 - 1,9	0,080	0,183	0,206	0,220	0,109
2,0 - 2,9	0,060	0,101	0,112	0,124	0,079
3,0 - 3,9	0,050	0,071	0,078	0,087	0,064
4,0 - 4,9	0,040	0,055	0,060	0,966	0,055
5,0 - 5,9	0,040	0,044	0,048	0,054	0,048
6,0 - 6,9	0,036	0,038	0,040	0,045	0,043
7,0 - 7,9	0,033	0,033	0,034	0,038	0,038
8,0 - 8,9	0,030	0,029	0,030	0,033	0,035
9,0 - 9,9	0,029	0,026	0,026	0,029	0,032
10,0 - 10,9	0,025	0,023	0,024	0,025	0,029
11,0 - 11,9	0,023	0,020	0,021	0,023	0,027
12,0 - 12,9	0,022	0,019	0,019	0,020	0,025
13,0 - 13,9	0,021	0,017	0,017	0,018	0,023
14,0 - 14,9	0,020	0,016	0,016	0,016	0,022
15,0 - 15,9	0,019	0,015	0,014	0,013	0,020
16,0 - 16,9	0,018	0,014	0,013	0,013	0,019
17,0 - 17,9	0,017	0,013	0,012	0,012	0,018
18,0 - 18,9	0,016	0,012	0,011	0,011	0,017
19,0 - 19,9	0,015	0,011	0,010	0,010	0,016
20,0 - 20,9	0,015	0,010	0,009	0,009	0,015
21,0 - 21,9	0,014	0,010	0,009	0,009	0,014
22,0 - 22,9	0,014	0,009	0,008	0,008	0,013
23,0 - 23,9	0,013	0,009	0,008	0,007	0,012
24,0 - 24,9	0,013	0,008	0,007	0,007	0,012
25,0 - 25,9	0,012	0,008	0,007	0,007	0,011
26,0 - 26,9	0,012	0,008	0,007	0,006	0,010
27,0 - 27,9	0,011	0,008	0,006	0,005	0,010
28,0 - 28,9	0,011	0,007	0,006	0,005	0,009
29,0 - 29,9	0,010	0,007	0,044	0,005	0,008
30,0 - 39,9	0,061	0,007	0,027	0,003	0,065
40,0 - 49,9	0,055	0,007	0,018	0,017	0,039
50,0 - 59,9	0,038	0,051	0,012	0,009	0,024
60,0 - 69,9	0,026	0,034	0,008	0,005	0,014
70,0 - 79,9	0,019	0,024	0,005	0,003	0,009
80,0 - 89,9	0,013	0,016	0,004	0,002	0,006
90,0 - 99,9	0,009	0,012	0,005	0,001	0,004
100,0 - 119,9	0,011	0,009	0,002	0,000	0,004
120,0 - 139,9	0,001	0,007	0,001	0,000	0,002
140,0 - 159,9	0,003	0,003	0,007	0,000	0,000
160,0 - 179,9	0,002	0,001	0,000	0,000	0,000
180,0+	0,000	0,000	0,000	0,000	0,000
		mm			
Expected rainfall	1,0	1,0	1,0	1,0	1,0
Average rainfall	21,2	8,8	6,1	5,3	14,4
Standard deviation	26,6	21,2	15,2	10,7	19,7

TABLE 5 - Total time to deliver maize* (hours)

	Time to silo			Time to bagging shed		
Region	Western Transvaal	Highveld	N.W. O.F.S.	Western Transvaal	Highveld	N.W. O.F.S.
Arithmetical mean (X)	2,76	2,32	2,29	2,18	2,82	2,29
Standard deviation(σ)	1,94	0,75	1,19	1,05	1,49	1,00
$\sigma/\bar{X}$	0,703	0,323	0,520	0,482	0,528	0,437
Expected value: gamma distribution (γ)	3,8	3,5	3,4	3,3	3,9	3,4
Accepted value	γ	$\bar{X}$	γ	γ	γ	γ
Number of observations	39	80	73	99	51	52

* Total time includes: Driving time to and from, waiting time at granary and off-loading time.

A model's possibilities for application are also limited by the assumptions underlying the model. If the assumptions are not realistic, the model will also not be a realistic reflection of the reality. An assumption that is often made is that events of the past will occur with the same regularity in the future. In some cases such an assumption is realistic, particularly in forecasting weather conditions in cases where the climate is reasonably constant. However, in the case of the economic process, for example farm production, such an assumption is valid only in the short term where technological development and economic conditions may be regarded as constant.

In producing expectation models the functional relationships between the variables are quantified mathematically. The quantification of certain relationships in nature and the economic process by mathematical equations can, however, cause problems because not all such relationships are mathematically quantifiable. By constructing a simpler model, which excludes the non-mathematically quantifiable relationships, the possibility arises that the reality is no longer accurately described by the model and that inaccurate forecasts could therefore result.

CONCLUSION

From the above applications it is evident that functional and stochastic expectation models can be applied practically in the decision-making function of the manager in agriculture. The applicability of these models, however, will depend on how realistic and reliable the quantification of the relationships is. These models do also have many defects and limitations and although the criticism mentioned holds to a greater or lesser degree, models often provide the only scientific basis for the formulation of expectations after intuitive flair and intelligent guesswork. However, in all cases the deficiencies and limitations of these models must be borne in mind in order to interpret the results with the necessary reservations and circumspection and integrate them in decision-making. The models must therefore be applied only as an aid in the decision-making process in order to manage on a more objective and scientific basis.

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