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Optimal Decision in Turkey Marketing: A Bayesian Approach

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KEYWORDS Production; marketing, turkey enterprises; Bayesian model

ABSTRACT This paper analyses production marketing decision in turkey enterprise in South- western Nigeria in the context of Bayesian decision model so that economically rational decisions can be adopted by the entrepreneurs in live turkey business. The data used to achieve the objective of the study were obtained from a cross- sectional survey of forty turkey producers in eight local government areas of south-western Nigeria. The study revealed that turkey enterprise in the study area was a profitable venture. However, to guarantee this profitability, decision makers must take into account (i) the ruling price at the time of making such decision, (ii) extra cost of keeping their birds, (iii) price movements and (iv) likely losses that might result from theft, death, disease outbreak etc when deciding to delay sales to a future date.

INTRODUCTION

Nigeria's livestock industry (both commercial and backyard type) constitutes an important sub sector of the nation's agricultural economy- the industry provides employment and income for a fair proportion of our rural population and it is an important source of protein for the populace at large. Protein of animal origin contains the important amino-acid needed for growth and they are richer in quantity and quality than vegetable proteins which are far less assimilable by the human body.

The nation's livestock industry was credited with providing about 36.5% of total protein intake of Nigerians (Balogun and Alawa, 1989), hence improving productivity in the sub-sector improves the nutritional status of the populace. The Central Bank of Nigeria (CBN 1994) in its annual report indicated that the sub-sector contributed about N522m (i.e. 5.9%) of Nigeria's gross domestic product for that year. It may also be indicated that the industry enhances proper land use and the maintenance of the ecosystem. Despite the foregoing and other contributions (not mentioned) of the livestock sub-sector, the industry still falls short of playing its primary role of providing Nigerians with protein cheaply. This paper focuses attention on a unit- the poultry unit of the livestock sub-sector of our agricultural economy. Poultry enterprise has the advantage of comparatively short generation (gestation) interval, low capital investment, quick returns and wide acceptability among all sections of the populace compared with other livestock. However, as an agricultural undertaking, it has its own fair share of risks

Important sources of risk in agricultural production (poultry inclusive) include price and yield fluctuations, diseases, availability and quality of inputs, hereditary characteristics of plants and animals, mortality rate (of plants and animals) changes in weather conditions, technology, government policies, land tenure arrangements etc. Also time is itself a source of risk in production and marketing- the production period varies for various types of product. In agriculture the time- lag inherent in production creates an atmosphere of imperfect knowledge which is the basis for uncertainty in respect of harvesting, processing and marketing. However the degree of risk reduces with increased knowledge of efficient utilization of natural and economic factors in production and marketing while the ability to manage risk influences the efficiency of resource use. Nigeria's agricultural industry is characterized by a myriad of independent small producers who are essentially price takers in both factor and product markets. The market for most farm inputs and output is exposed to an unregulated climate of fluctuating prices which makes it difficult to predict reasonably for planning purposes.

Rational decision is that choice of action which is preferred above all others and it is the product of the planning process. Decision making in agricultural processes is never a choice amongst delimited and prescribed moves in a game with fixed rules and a known list of possible outcomes of any move or sequence of moves. The farmer does not know precisely, completely and for certain what other farmers would do in response to any given action of his own or that of nature; he is also ignorant about what nature

would do by way of weather, technology, government policies, market conditions etc. The ability to perfectly formulate expectations and choose the most efficient course of action is undoubtedly the sole determinant of success in any production system and hence a strong and resilient growth in the economy.

Turkey production and marketing like any other business venture faces many situations which indicates risks of various degrees; these include changing weather conditions, poisoning through ingestion of toxic materials, cannibalism and feather picking among growing poults, seasonal variations, competition from substitute meat forms etc. Thus a producer-marketer needs to plan well and execute such plans properly so as to optimize his returns over his costs. This paper analyses production-marketing decision-making in turkey enterprise in south-western Nigeria in the context of Bayesian theory so that economically rational decision can be adopted by the entrepreneurs in live turkey business

The paper is in five parts. The next section reviews relevant literature while the third section analyses costs and returns in turkey production. Section four presents the marketing decision model employed and the results derived there from; while the last section summarizes and concludes.

Literature review

A welter of applications of Bayesian theory exists in the literature. Eidman et al. (1967) applied the technique to the problem of choice between contract and independent production of turkeys under the uncertainties of product price and mortality rate. Bullock and Logan (1970) combined *a priori* information about the historical pattern of month-to-month price changes with information provided by a price-forecasting model to develop monthly feed or sell decision criteria in Californian commercial cattle enterprises. Carlson (1970) determined optimum methods of controlling brown-rot in peaches; employing marginal probabilities to estimate expected gains to individual farmers from the use of optimum strategies based on three returns with a minimum income side condition. Olayide (1968) studied fodder supply problem in Nigeria in which he derived an optimal strategy as that which minimized expected cost of fodder supply. Commenting on this study, Adamu (1976) indicated that the no-data strategy could be improved by incorporating a posterior probability distribution of weighted averages of rainfall and humidity in the study (i.e. to correct for the "no data" strategy employed). Olayemi (1982) determined optimal storage decisions for maize farmers operating under conditions of price uncertainty based on conditional probabilities estimated from a combination of actual price changes and predicted price changes whereby prior probabilities were revised to obtain posterior probabilities through an application of Bayes' theorem. Ajobo (1996) determined optimal marketing strategies for a group of farmers who had the advantage of contact with an extension research organization.

MATERIALS AND METHOD

The data for this study came from a cross-sectional survey of forty (40) turkey producers in eight (8) local government areas in south-western Nigeria. The data collected are analysed using budgetary method and Bayesian decision model was therefore ₦ 218788 while net returns per turkey was ₦ 2,188. Hence the enterprise indicates a benefit-cost ratio of 3.01:1 per turkey and 2.11:1 per enterprise. The flexibility index is 1.4% which indicates relatively easy entry and exit into the enterprise.

RESULTS AND DISCUSSION

The average number of birds raised was 100 (in a range of 10 to 300); mean price per turkey was ₦3225 (in a range of ₦ 500 to ₦ 1000) resulting in mean gross revenue of ₦322500 per enterprise. Mean total variable costs were ₦102, 200 while mean total fixed ₦1490 and hence mean total of ₦103,712; mean returns to managements.

The Marketing Decision

Over 90 percent of the turkey producers prefer to sell their birds in December when it is believed that demand is high thereby commands high prices. The economic rationality of this decision is tested within a Bayesian model in which price uncertainty is accommodated. November unit price is ₦3,250.00 (in the range of ₦2500.00 to ₦4000).

This is assumed to be known with certainty as the decision to sell in November or December is taken with full knowledge of the unit price in

November. The lowest, the most likely and the highest unit price expected in December are, on the average ₦2750, ₦3500 and ₦4500.00 respectively. The estimated cost of keeping a bird for an additional month ranges from N60 to ₦300.00 with an average of ₦150.00. The economic rationally of this decision is being tested.

The Decision Model

Bayesian decision model which involves enumerating all the possible pay offs and selecting the action that provides the highest pay off is used to set marketing decision criteria.

Given that the decision maker could not obtain additional information from experiments or price forecast, he (turkey producer) could then use information from a prior probability distribution p (θ) derived from past experience and monetary pay offs (λ_{ij}) (if the utility function is assumed to be linear over the relevant range) associated with each action-state of nature combination to make the desired decision. The optimal Bayes strategy which is generally defined as one which maximizes expected utility under this situation may be presented as

$$E(U) = \text{Max}(\lambda_{ij})/(P\theta)$$

Where:

E (U) = expected utility

(λ_{ij}) = Net payoff (utility) derived from action-state of nature pair and

(P) = decision maker's subjective (prior) probability distribution for the random variable (i.e. unit of turkey in December).

In other words, under this strategy, the decision maker estimates all possible payoffs from action-state of nature pairs and uses his prior (subjective) probabilities as weights in deriving expected payoffs and then chooses the strategy with the highest payoff in this study,

λ_{ij} = GV- (CV+C)

= (P_1 +Ä P) – P_t – C

= ÄP – C

Where GV = expected unit price of turkey in December (Naira per head)

CV = current unit price of turkey in November (Naira per head)

C = expected cost per head of feeding for another month (Naira per head)

P_t = price per turkey in November (Naira)

P = price change that occurs over the next one month (Naira)

The subjective or judgemental probability [P (θ)] of an event is the degree of belief that an individual has in the occurrence of that event (Karmel and Polasek. 1977). These subjective probabilities may be gained from so-called objectives evidence (historical data), plus less formal sources such as advisers, past/personal experience, the media and even gossip. The major criticism of subjective probabilities is that they are vague and imprecise.

However, special procedures for evoking and measuring decision makers subjective probabilities (such as the method used in this study) can overcome the vagueness problem.

The triangular-distribution method suggested by Robison et al. (1984) is used to estimate the subjective probability distribution of possible unit prices of turkey in December (State of nature) because of its ease of use both in elicitation and in computing parameters (Pingali and Carlson, 1985). The use of the method requires three items from the decision maker: (i) the most likely unit price (Naira) in December, (M) (ii) the lowest possible unit price (Naira) in December (L), and (iii) the highest possible unit price (Naira) in December (H).

Based on these values and requiring that all probabilities sum to 1, 0 the following formulae were used to compute a cumulative distribution that is used for decision making

1. For a unit price Xi ≤ Mi, Pi = $(Xi - L)^2/(H-L)(M-L)$
2. For a unit price Xi ≤ Mi, Pi = $1.0- (Xi-H)^2/(H-L)(H-M)$

Specifically, the representation of the marketing decision problem facing turkey producers is as shown in Table 1.

The Bayesian approach to turkey marketing decision making can be stated as follows: given the 2 possible actions, the 3 alternative prices in December and the marginal profits (net payoff) from delaying sale for one month (i.e. from November to December) Table 1 along with a vector of *a priori* information about the relative frequency of ϕ we have

$$P(\phi) = \begin{matrix} (p(\phi_1)) \\ (P(\phi_2)) \\ (P(\phi_3)) \end{matrix}$$

where ($P(\phi_j)$) is the a prior probability that state ϕ_j will occur, then action A_i for which expected profit $U_i = \Sigma_j \lambda_{ij} P(\phi_j)$ is a maximum should be selected.

Using the triangular distribution method, the

Table 1: Representation of the decision problem

Action	*States of nature*		
	ϕ_1 *(High price in December)*	ϕ_2 *(Average prices in December)*	ϕ_3 *(Low prices in December)*
A1 (sell in November)	λ 11	λ 12	13
A2 (sell in December)	λ 21	λ 22	23

probability that December average unit price will be less than 3,250 naira (the average price for November) is 0.19. The probabilities that the December unit price will be less than 2,750 naira, 3,500 naira and 4,500 naira are, respectively, 0.375,0.250 and 0.50.

Given that these are the possible states of nature in December and requiring that the probabilities sum to 1.0, the triangular method is used to calculate the probabilities P(ϕ) as 33.33 percent, 40 percent and 26.67 percent respectively.

Using the same method, the chances that December prices are less than the November prices as calculated for the respondents ranges from 0 to 33.33 percent. 60 percent of the cases indicate 0 percent, wile the remainder ranges from 7 to 33 percent

The fact that the probabilities that the December price will be less than November price is low cannot be taken to mean that the decision to market the turkeys in December is correct in the economic sense. This is because account has not been taken of such factors as cost of keeping the turkeys for one more month, price uncertainty, as well as possible theft and death of turkeys.

To take account of price uncertainty in December and the cost of keeping the turkeys for one more month, relevant Bayesian probabilities are calculated. Thus, the marketing decision problem of the producers is as contained in Table 2 CV is constant at 3,250 naira per turkey.

This result (Table 2) shows that an average turkey producer who aims at maximizing expected net profit must market his live turkeys in December so as to gain 122.50 naira per turkey.

Table 3 shows that it is rational to sell in December as long as the expected price in December is at least 3,500 naira (given that the November price is 3,250 naira). It is also rational to sell in December, if the states of nature (possible prices in December) are equally likely. This implies that an average producer can sell in December, if the expected price is at least 3,500 naira when November price is 3,250 naira.

The relative profits based on *a priori* information for actions a_1 (sell in December) and a_2 (sell in November) for turkeys at alternative price levels are shown in Table 4. The "no data" strategy for keeping turkey for one more month can be summarized as follows: delay sales period if P < 3,000 naira, sell if P> 3,000 naira, where P is the November price of turkey.

Table 5 shows that if the expected price in

Table 2: A priori expected net profit (₦) of the decision problem

Action	*States of nature* S_1 *₦ 2750*	*Expected net* S_2 *₦ 3500*	*Optimal* S_3 *₦ 4500*	*Profit (₦)*	*Decision*
A1 = sell in November	0	0	0	0	
A2 = sell in December	-650	100	1100	₦ 122.5	
P(S_i)	0.33	0.40	0.27		sell in December

Source: Data Analysis

Element of this matrix are calculated as follows

λ_{ij} = GV – CV- V

= $P_{t+1} - P_t - C$

=ΔP- C

Where GV = expected gross value of turkey in December (Naira per turkey)

CV = current value of turkey in November (3, 250 naira per turkey)

C = expected cost per head for keeping for one more month

Table 3: Sensitivity of optimal decision to changes in probabilities distribution

P(₦ 2750) P(S1)	*P(₦ 3500) P(S2)*	*P(₦ 4500) P(S3)*	*₦*	
			Expected Net profit	*Optimal decision*
1.00	0	0	-650	sell in November
0	1.00	0	100	sell in December
0	0	1.00	1100	sell in December
1/3	1/3	1/3	183	sell in December

Source: Data Analysis.

Table 4: Relative a prior expected profits for action a^1 and a^2 at alternative price levels (Expected price in December (EDP) = ₦3522.5).

Current price (₦) Per turkey	*Expected profit*		
	a_1 = sell in Dec. ₦ per head	*a_2 = sell in Nov.*	*Optimal action*
2,500	872.5	0	Sell in Dec.
2,800	572.5	0	Sell in Dec.
3,000	327.5	0	Sell in Dec.
3,500	-127.5	0	Sell in Nov.
4,000	-627.5	0	Sell in Nov.

Source: Data Analysis.

December is 2,750 naira, an average producer should sell in November as long as P > 2,500 naira. If however, p < 2,500 naira, he should sell in December.

Table 6 shows that it is not rational to sell in December, if p> 3,000 naira but sell if P < 3,000 naira, given that the expected price in December is 3,500 naira. Table 7 shows that the decision to sell in December will be rational, if P <4,000 naira as long as the expected price in December is 4,500 naira.

The foregoing analysis ignores the uncertain events that could result form possible theft, death, disease incidence etc. but assumes that the decision maker is operating under price uncertainty only.

Table 5: Relative *a priori* expected profits for action a_1 and a_2 at alternative price levels Expected Price in December (EPD) = ₦ 2750.

Current price (₦) Per turkey	*Expected profit*		
	a_1 = sell in Dec (₦) per head	*a_2 = sell in Nov.*	*Optimal action*
2,500	100	0	sell in Dec.
2,800	-200	0	sell in Nov.
3,000	-400	0	sell in Nov.
3,500	-900	0	sell in Nov.
4,000	-1400	0	sell in Nov.

Source: Data analysis

We now relax the assumption that the number of turkeys at the initials stage (i.e. in November) is equal to that at the final stage (December). In other words, introducing another uncertain event that might confront turkey producers in the course of making their decisions i.e. introducing the element of theft, disease incidence, poisoning and death that can reduce the size of the producer's stock.

Table 8 shows that regardless of the size of the enterprise, a 7% loss of birds due to any of the afore-mentioned random factors will not change the decision of the average turkey

Table 6: Relative *a priori* expected profits for action a_1 and a_2 at alternative price levels (Expected Price in December (EPD)= ₦ 3500)

Current price (₦) Per turkey	*Expected profit*		
	a_1 = sell in Dec (₦) per head	*a_2 = sell in Nov.*	*Optimal action*
2,500	850	0	sell in Dec
2,800	550	0	sell in Dec.
3,000	350	0	sell in Dec.
3,500	-150	0	sell in Nov.
4,000	-650	0	sell in Nov.

Source: Data analysis

Table 7: Relative a prior expected profits for action a1 and a2 at alternative price levels (Expected Price in December (EPD) = ₦ 4500)

Current price (₦) Per turkey	*Expected profit*		
	a_1 = sell in Dec (₦) per head	*a_2 = sell in Nov.*	*Optimal action*
2,500	1,850	0	sell in Dec
2,800	1,550	0	sell in Dec.
3,000	1,350	0	sell in Dec.
3,500	850	0	sell in Dec
4,000	350	0	sell in Dec

Source: Data analysis

producer (as contained in Table 2) as long as the November price is not greater than 3,000 naira (see Table 9)

However, a 10 percent reduction in stock will alter that decision, in the sense that he can market in December only, if the November price is not greater than 2,800 naira. Even if the probability that 10% of the bird will be lost is 0.5, it is still not rational to retain that decision unless that chance is not greater that 0.3 (see Tables 10 and 11)

Table 10 shows that an average turkey producer who expects to realize 3,522.50 naira per bird in December given that the November price is 3,250 naira, and that the extra cost of keeping a bird for one more month is 150 naira, should sell his live turkey in November. Table 11 shows that a producer can sell in December, if the probability of a 10 percent loss of his stock is not greater that 0.3.

The implication of the foregoing for turkey business is that a rational decision-making process should take account of; (i) the ruling price at the time of taking marketing decisions (ii) extra cost of keeping their turkeys for given periods of time. (iii) likely price movements (i.e. price risk) and (iv) likely losses that might occur due to theft, death, disease outbreak or adverse weather conditions (yield risk).

Table 8: Relative *a priori* expected profits for action a_1 and a_2 at alternative price levels (7% loss in stock is assumed).

Current price (₦) Per turkey	*Expected profit*		
	a_1 = sell in Dec (₦) per head	*a_2 = sell in Nov.*	*Optimal action*
2,500	621	0	sell in Dec
2,800	321	0	sell in Dec.
3,000	121	0	sell in Dec.
3,500	-379	0	sell in Nov.
4,000	-879	0	sell in Nov.

Source: Data analysis

Table 9: Relative *a priori* expected profits for action a_1 and a_2 at alternative price levels (10% loss in stock is assumed).

Current price (₦) Per turkey	*Expected profit*		
	a_1 = sell in Dec (₦) per head	*a_2 = sell in Nov.*	*Optimal action*
2,500	481.1	0	sell in Dec
2,800	181.1	0	sell in Dec.
3,000	-18.9	0	sell in Nov.
3,500	-518.9	0	sell in Nov.
4,000	-1018.9	0	sell in Nov.

Source: Data analysis

Table 10: *A priori* expected net profit (₦) if the probability of a 10 percent loss in stock (P(10%)) is 0.5

Event	*Probability*	*Sell in November A_1*	*Sell in December A_2*
E_1	0.165	0	-1041.4
E_2	0.165	0	-650.0
E_3	0.200	0	-291.4
E_4	0.200	0	100.0
E_5	0.135	0	708.6
E_6	0.135	0	1100.0
Expected net profit		0	73.2

Source: Data analysis

Table 11: *A priori* expected net profit (₦) if the probability of a 10 percent loss in stock (P(10%)) is 0.3

Event	*Probability*	*Sell in November A_1*	*Sell in December A_2*
E_1	0.099	0	-1041.4
E_2	0.231	0	-650.0
E_3	0.120	0	-291.4
E_4	0.28	0	100.0
E_5	0.081	0	708.6
E_6	0.189	0	1100.0
Expected net profit		0	-73.2

Source: Data analysis

SUMMARY AND CONCLUSION

Decision analysis supports the common practice of an average producer to delay sale by one month in the face of price uncertainty, and possible yield loss in order to make greater profit. The expected net gain is ₦122.50. However, decision analysis does not support the producer's practice of delaying sale by one month (to December in most cases), if 10 percent of his stock can be lost to such factors as theft and death in the course of keeping the birds for one more month. The decision is shown to be rational only if the probability of losing 10 percent of the birds is not greater than 0.3

The budgetary analysis shows that turkey

enterprise in the study area is a profitable venture. However, to guarantee this profitability, decision makers must take into account (i) the ruling price at the time of making such decision (ii) extra cost of keeping their birds, (iii) price movements and (iv) likely losses that might result from theft, death, disease outbreak etc. when deciding to delay sales to a future date

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