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A mathematical model for estimation of optimum broiler production period under the economic conditions of Turkey

C. Oğuz[1] and S.S. Parlat[2]

[1]*Department of Agricultural Economics,*
[2]*Department of Animal Science,*
Agricultural Faculty, Selçuk University
42031 Konya,Turkey

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ABSTRACT

Using mathematical methods and statistical techniques, the present paper explains the current economic characterization of broiler meat production under the economic conditions of Turkey. State of the art of econometrical modelling and the classic method currently used for regulatory decision-making in the world are described. Based on this evaluation, needs for future research are defined. It is concluded from our work that mathematical modelling of economically optimal production time would improve economic profitability. The classical method of economic optimization in animal production would not be suitable for all kinds of economic assessments, and that a range of different approaches is necessary so that the method used is the most appropriate for the data available and for the economic risk characterization issue. Future refinements to classical evaluation should incorporate more clearly the extent of uncertainity and variability in the resulting output. In this study, the basic data used for evaluation were food intake, weight gain, food cost, cumulative weight gain, cumulative chicken cost and marginal net income (MNI). After the mathematical function between production period and MNI was calculated, the optimum production period was predicted. Then, total MNI was estimated by integration of the calculated mathematical function.

KEY WORDS: mathematical method, broiler production

INTRODUCTİON

In animal production farms, estimation of optimum production time is very important in respect to economic production (Scott et al., 1982). A classic calculation method would not be suitable for economic optimization assessments or for all databases. Mathematical modelling of the production time-net income relationship would improve the economic assessment process (Parlat et al., 1999). The optimal production period depends on the realization of maximal income from a unit production factor (Doll et al., 1984). It could be calculated realistically by a mathematical function between dependent and independent variables (Debertin, 1986). Therefore, determination of the optimum production period for maximization of total net income is of major importance. Also, functional analysis of production gives information about maximization of net income (Connor, 1973). Groen (1989) indicated that optimal production time influences relative contributions of improvements of animal traits to economic efficiency of production. Uncertainity over future production time is an important factor and must be considered when deriving economic values. Hirooka and Sasaki (1988) found that, for some animal products, there are significant time to time variations in economic values. In addition, optimal production time and prices of animal products are seldom known for certain at the time that a producer must make decisions about how much and when to produce animal products. Increasingly, animal producers are exposed to unpredictable competitive markets for inputs and outputs, so that economic production time risk is often significant and may increase over time (Hardaker et al., 1997). Various mathematical models have been used by animal producers to estimate optimal economic production time. Profit econometrical models assume perfect knowledge of all relevant parameters. Ideally, animal producers should use economic models that take into account the fact that knowledge is imperfect and economic circumstances are dynamic in time. The aim of the present study was to consider an optimal production time for broiler producers by using an econometrical model. Optimum production time for animal production systems could be estimated by a mathematical relationship between production period and net income.

This function makes possible to estimate optimum production time, namely, time of minimum movement variation for net income. According to Gossen's law of diminishing returns, an optimum economic production level could be reached when marginal cost is equal to marginal income (Heady, 1968).

This article was prepared for given the need for a new approach to calculation of optimum broiler production time with regard to compensation of various deficiencies.

MATERIAL AND METHODS

Theory

The most basic assumption of a production function is that a mathematical relationship exists between production time and net income

$$y=f\{x\}$$

where y is net income and x a vector of production time.

In general, for econometrical models, the optimal value of y depends on prices and costs of animal products. Net income and time equations give the profit or risk-rated profit function. This function reflects the solution to the firm's optimization problems.

Application example

Production data of a commercial broiler producer farm having a total of 10,000 broiler chickens (Ross genotype) capacity were used for this study. In this research, broiler chicken cost (BCC) was \$0.40/chicken and total BCC was \$4,000. Also, food price was \$0.25/kg and, broiler meat price was \$1.75/kg. In the present study, the main expenses were BCC and food cost as these expenses were at least 90% of total expenses. Therefore, other expenses (about 10%) could not be inluded in the calculations. The specification of the equation in our example reflects the fact that data are available for many livestock production processes. In our example we model elements of the production function for the equation in order to best use the data available on weight gain and production time.

First, food intake (FI), weight gain (WG) and food cost (FC) per chicken for each period (7 weeks) were calculated. Then, cumulative weight gain (CWG) and cumulative chicken cost (CCC) per chicken for each period. Also, marginal income (MI), marginal food plus chicken costs (MFCC) and marginal net income (MNI) *per* chicken for each period. After this step, the mathematical function between the production period and (x) and MNI (y) was calculated. Finally, the optimum production time was estimated *via* the calculated mathematical function. In this model, production period (x) and MNI (y) were used as independent and dependent variables, respectively. Then, the derivatived function was calculated by using this model and equalized to zero.

That is: $f'(x)=dy/dx=0$

The calculated x value *via* derivatived function is the mathematically optimum production time (Abromowitz and Stegun, 1972). By using the calculated x value for the $f(x)$ function, the marginal NI value for optimum production time could be estimated. Also, total NI values could be calculated by integration of the $f(x)$ function from beginning to maximum production time.

The data were subjected to regression analysis (Steel and Torrie, 1980) by using SPSS (1988) and MINITAB (1995) softwares.

RESULTS AND DISCUSSION

Food intake(FI), weight gain (WG), food cost (FC), cumulative weight gain (CWG), and cumulative chicken cost (CCC) per chicken for each period are shown in Table 1. CCC per chicken for each period was calculated as follows:

CCC of 1stperiod (CCC_1) = Chicken cost / CWG x CWG of 1stperiod (CWG_1)

Marginal income (MI), marginal FC plus chicken coast (MFCC) and marginal net income (MNI) per chicken for each period are shown in Table 2.

MNI *per* chicken for each period was calculated with the figures from Tables 1 and 2. MNI *per* chicken for each period was calculated as:

MNI *per* chicken of 1stperiod (MNI_1) = MI per chicken of 1stperiod (I_1) - MFCC *per* chicken of 1stperiod ($MFCC_1$).

The mathematical function was calculated to determine the relationship between x and y. The relationship between x and y is shown in Figure 1. The estimated regression equation, coefficient of determination and variance analysis of the relationship between x and y are shown in Table 3. The mathematical function between x and y is as follows:

$$y=f(x)= -0.524474+0.340693x-0.029073x^2$$

where: y is MNI (dependent variable)
x is the production period (independent variable).

As seen, there is a quadratic polynomial relationship between the dependent and independent variables. In this equation, if the function is derived and then equalized to zero, the optimum production period can be calculated. That is:

$$y'=f'(x)=dy/dx=0.340693-0.058146x=0$$

When this function is solved, x equals 5.86 week. That is, the optimal production period is 41.02 days for the present study. By using the calculated x value in the $f(x)$ function, the maximum MNI value during the production period was obtained as:

$$f(5.86) = 0.47363 \text{ (maximum MNI value)}$$

As seen from Table 2, MNI for 6th weeks was the maximum. Also, total NI *per* chicken could be calculated by integration of $f(x)$ function from beginning to 5.86 weeks. That is:

TABLE 1

Food intake, weight gain, food cost, cumulative weight gain and cumulative chicken cost *per* chicken for each period

Period week	Food intake g/ period	Weight gain g/ period	Food cost $/period	Cumulative weight gain, g/period	Cumulative chicken cost, $/period
1	131	114	0.033	114	0.40
2	297	234	0.074	348	0.27
3	428	304	0.107	652	0.19
4	643	384	0.161	1036	0.15
5	871	449	0.218	1485	0.12
6	1055	472	0.264	1957	0.09
7	1230	472	0.308	2429	0.08

TABLE 2

Marginal income, marginal food *plus* chicken costs and marginal net income *per* chicken for each period

Period week	Marginal income $/period	Marginal food plus chicken costs $/period	Marginal net income $/period
1	0.200	0.429	-0.230
2	0.410	0.342	0.067
3	0.532	0.292	0.240
4	0.672	0.310	0.362
5	0.786	0.339	0.447
6	0.826	0.358	0.468
7	0.826	0.383	0.443

TABLE 3

Estimated regression equation, coefficient of determination and variance analysis of relationship between production period and marginal net income

Source	SS	df	MS	F	P
Regression	0.39824363	2	0.19912182	638.94895	0.000
Residuals	0.00124656	4	0.00031164		

Estimated regression equation[a] : $\hat{Y} = -0.524474 + 0.340693\,x - 0.029073x^2$

Determination of coefficient : $R^2 = 0.99537 \pm 0.01756$

x - production period

y - marginal net income

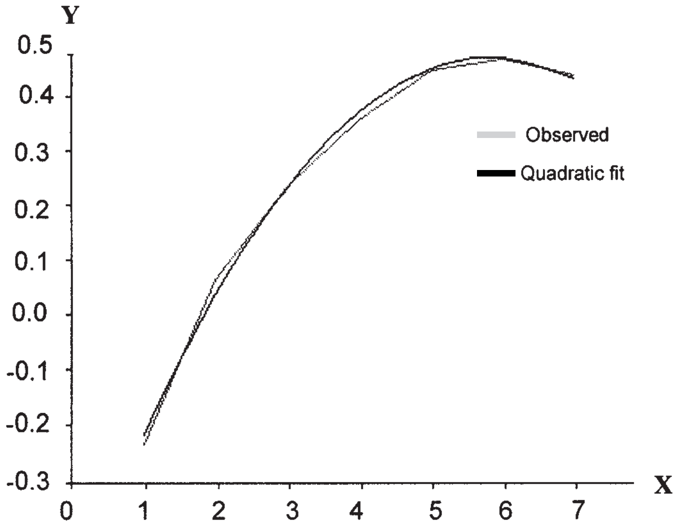

Figure 1. Graph of relationship between production period (X) and net income (Y)

$$\int_a^b f(x) = \int_0^{5.86} -0.524474+0.340693x-0.029073x^2=0.826093$$

Greater differences in economic values were observed when they were compared based on the econometric optimization model. Generally, differences in optimal values of the management variable depend on market, economic and environmental conditions in specific commercial broiler operations. This example is very simplified, with only one output and one input variable, but does illustrate that econometrical models can have a large important impact on economic profitability. Great differences exist between traditional calculations and econometrical functions. From the economic point of view, production functions represents a better model of the real economic situation and the producer's choices. Marginal economic production of any factor could be realized, when the cost factor is equal to product price. The results of this research are compatible with explanations about functional analysis of production given by other researchers (Doll et al., 1968; Heady, 1968; Cramer et al., 1979).

Profitability defined in this study consisted of a quadratic function. A number of different approaches have been developed to elicit the required information from decision makers to be able to encode their preferences into a suitable utility function (Hardaker et al., 1997). Estimating the variance of economic profitability is a complex issue because it depends on production functions and economic parameters. Some of these calculation methods and parameters are needed for concerning variations in economic values are often made implicitly.

CONCLUSIONS

A classic calculation method would not be suitable for economic optimization assessment, or for all databases. Mathematical modelling of the production time-net income relationship would improve the economic assessment process. Future refinements to the production time-net income characterization should incorporate more clearly the extent of uncertainity and variability in the resulting output. It is apparent that optimum production period for this study is 5.86 weeks. The method economically makes it possible to calculate the optimum production period in broiler farms. This model should be evaluated as a universal calculation method, whereas the optimum production period may differ according to the economic conditions of any country. The manner of calculating the optimum production period is important. The advatages of this model will appear when it is used more frequently in experimental studies and the results applied in practice.

REFERENCES

Abramowitz M., Stegun I.A., 1972. Handbook of Mathematical Functions. Dover Publ., New York, NY 10014

Connor O.R., 1973. Principles of Farm Business Analysis and Management. Irish University Press, Shannon (Ireland)

Cramer G.L., Clarence W.J., 1979. Agricultural Economics and Agribusiness. John Wiley Publ., New York

Debertin D.L., 1986. Agricultural Production Economics. Macmillan Publishing Company, New York

Doll J.P., Rhodes J.V., West G.J., 1968. Economics of Agricultural Production. Irwin Publ. Illinois

Doll J.P., Orazem F., 1984. Productions Economics. John Wiley Publ., New York

Groen A., 1989. Cattle breeding goals and production circumstances. PhD Thesis, Department of Management of Animal Breeding, WageningenAgricultural University, Wageningen (The Netherlands)

Hardaker J.B., Huirne R.B.M., Anderson J.R., 1997. Coping with Risk in Agriculture. CAB International, Biddles Ltd, Guilford (UK)

Heady E.O., 1968. Economics of Agricultural Production Resource Use. Prentice-Hall Publ., New Delhi (India)

Hirooka H., Sasaki Y., 1998. Derivation of economic weights for carcass traits in Japanese Black cattle from field records. J. Anim. Breed. Genet. 115, 27-37

Minitab, 1995. Minitab Inc., State Coll. PA, 16801 (USA)

Parlat S.S., Yildiz A.O., Yildirim İ., 1999. A mathematical model for estimation of fattening period by coefficient of fattening efficiency in meat type Pekin ducks. 12th European Symposium on Waterfowl, Adana (Turkey), p. 165

Scott M.L., Nesheim M.C., Young R.J., 1982. Nutrition of the Chicken. M.L.Scott and Associates Publ., Ithaca, New York

SPSS, 1988. SPSS/PC+V.2.0. Base Manuel for the IBM PC/XT/AT and PS/2. Marija and Morusis, SPSS Inc.

Steel R.G.D., Torrie J.H., 1980. Principles and Procedures of Statistics. A Biometrical Approach. McGraww-Hill Book Co., New York

Wilton J.W., Goddard M.F., 1996. Selection for carcass and feedlot traits considering alternative slaughter end points and optimised management. J. Anim. Sci. 74, 37-45

STRESZCZENIE

Matematyczny model do szacowania optymalnego okresu produkcji brojlerów w ekonomicznych warunkach Turcji

Przedstawiona praca objaśnia matematyczne metody i techniki statystyczne obecnie dostępne dla ekonomicznej oceny produkcji mięsa brojlerów w Turcji. Opisano matematyczne modelowanie oraz klasyczne metody stosowane w świecie i używane obecnie przy podejmowaniu decyzji ekonomicznych.

W oparciu o wyniki tych ocen zdefiniowano kierunki do dalszych badań, na podstawie których powinna poprawić się skuteczność doboru warunków produkcji i jej rentowność. Klasyczna metoda ekonomicznej optymalizacji produkcji zwierzęcej nie jest uniwersalna i często nie może być stosowana do wszystkich rodzajów ekonomicznych ocen. W modelach winien być brany pod uwagę zakres oceny tak, aby przyjęta metoda była najwłaściwsza w odniesieniu do danych dostępnych do oceny warunków ekonomicznych. Dalsze udoskonalenia klasycznej oceny powinny uwzględniać wyraźniej zakres ryzyka i zmienności. W przedstawionych badaniach do oceny przyjęto następujące podstawowe dane: pobranie paszy, przyrost m.c., całkowity koszt kurczęcia oraz marginalny przychód netto (MM). Na podstawie obliczonej matematycznej funkcji pomiędzy okresem produkcji a MNI oszacowano optymalny okres produkcji, a zatem MNI określono przez obliczenie funkcji matematycznej.