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Quantitative Methods to Determine Factors Affecting Productivity and Profitability of Beef Fattening Enterprises in Egypt

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Abstract: This study was carried out during the period extended from 2011 to 2013 on standardized records of fattening beef enterprises to demonstrate the use of productive and profit regression models as a possible method to determine factors affecting productivity and profitability of beef fattening enterprises. The production function revealed that about 95% from the changes in beef meat production were attributed to the changes in fattening period, initial weight and daily weight gain. The beef meat production was positively affected by initial weight and daily growth of animal, where increasing initial weight and daily growth of animal by 1% resulted in increase of beef meat production by 0.475% and 0.455%, respectively. The results of profit function indicated that the most important factor affecting beef enterprises profitability is selling price of animal, while the factors having the second and third highest effect were purchasing price of animal and feed cost; respectively. The live animal selling price was positively related to beef profitability, where increasing selling price by 1% would increase profit by 7.52%. The influence of feed cost and live animal purchasing price on beef profitability was significantly negative, where increasing purchasing price and feed cost by 1% would decrease beef profitability by 3.71% and 2.91%, respectively. Also, the logistic regression function revealed a significant association between beef breed and some predictors such as Initial weight and weight gain.

Key words: Logistic Regression · Meat Production · Production Function · Profit Function

INTRODUCTION

Beef cattle production is an important branch of animal production sector as it occupies a special place in countries economy with its employment rate and values of products produced. Beef is the culinary name for meat from bovine especially domestic cattle and is the third most widely consumed meat in the world, accounting for about 25% of meat production worldwide, after pork and poultry at 38% and 30% respectively [1]. The problems of beef production are complex and include multiple biological, economic and social factors, so, the examination of all factors and problems following this sort of production is requested. The emphasis is to know the individual (marginal) effects of each of the factors affecting the beef enterprise in order to achieve the maximal production and to realize the maximal economic effects. Regression models (production and profit regression models) were used to determine the sources of efficiencies (inefficiencies) and to identify the relationships between efficiency measures and profitability for beef cow producers [2]. Also, Logistic regression, or logit regression, is a type of probabilistic statistical classification model [3], used for predicting the outcome of a categorical dependent variable based on number of independent variables.

Production regression function precisely define the factor-product and factor-factor relationships and enable the managers to control the factors affecting the economy of beef meat production and these measures which should be taken to reach certain goals [4]. Profit regression function also was used with the aim of selection in dairy [5], commercial layer and breeding layer enterprises [6, 7]. It seems possible to use this functional approach as a

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decision support tool in beef fattening enterprise. From this point of view, this research was performed to use productive and profit function models to estimate some factors affecting productivity and profitability of beef fattening enterprises and exploring its possible use as a practical decision support tool in the field by producers.

MATERIALS AND METHODS

Material and Data Source: During the period extended from 2011 to 2013 a standardized data of 464 fattening cows were collected depending on random samples of beef production sectors in different regions of El-Menofia, Kaliobia and 6 October province. The data were collected from the farm records available in the investigated beef farms or from the structured questionnaires established by the researcher in accordance with objectives of this study and were admitted to the dairy holders and managers during the time of interview. The records included two beef breeds, Balady breed (local breed) which represented 25.3% of the sample and Cross-bred cattle (Balady x Friesian) which represented 74.7% of the sample.

Methods: Information has been obtained regarding the production factors and prices used in the production process in the beef fattening enterprises. The data obtained through interview survey were manipulated using SPSS (16.0) software to create input data for the regression analysis.

Procedures Followed in Regression Analysis:

Testing Normality, Linearity and Homogeneity of the Data: Both dependent and independent variables were tested for normality by using (histogram and normal p-p plot method) to determine if these variables are normally distributed or not, also the residual of the regression function were tested for normality and it showed nearly normally distributed residual. Data were also tested for linearity (linear relationship) between dependent and independent variables and it showed significant linear relationship between variable at $P<0.05$. Moreover, the relation between dependent variable (Y) and each independent variable (X_i) was inspected by examining the scatter graphics according to Utts [8] and it was observed that Y and Xi has linear relationship. Finally, homogeneity test were done by using Hartly's test according to Bliss *et al.* [9] to test homogeneity of the data.

Forming Productive Regression Equation: Multiple regression method were used to estimate the direction and magnitudes of the relation between the meat production (kg live-weight/head) (Y) and the variables that are considered to have effect on the production (independent variables) as fattening period (X_1), initial weight at the beginning of fattening period (X_2) and daily average weight gain (X_3).The initial regression equation was:

$$Y = \alpha + B_1X_1 + B_2 X_2 + B_3 X_3$$

Where:

Y = Meat production (kg/head) & α = *constant*

X_1 = Fattening period (day)

X_2 = Initial weight at the beginning of fattening period (kg/head)

X_3 = Daily average live-weight gain (kg/head)

Forming Economic Regression Equation: Multiple regression method also was used to estimate the direction and magnitudes of the relation between the profit (Y) and the variables that are considered to have effect on the profit as (total feed cost, depreciation cost, total veterinary management cost, live animal purchase price, live animal selling price, fattening period, initial weight and daily average weight gain). The initial regression equation was:

$$Y = \alpha + B_1X_1 + B_2 X_2 + B_3 X_3 + B_4X_4 + B_5 X_5 + B_6 X_6 + B_7 X_7 + B_8 X_8$$

Where:

Y = profit (EGP/head = Egyptian pound/head) & α = *constant*

X_1 = Total feed cost (EGP/head)

X_2 = Depreciation cost (EGP/head)

X_3 = Total veterinary cost (veterinary supervision + drug + vaccine + disinfectant) (EGP/head)

X_4 = Live animal purchase price (EGP/head)

X_5 = Live animal selling price (EGP/head)

X_6 = Fattening period (day)

X_7 = Initial weight at the beginning of fattening period (kg/head)

X_8 = Daily average live-weight gain (kg / head).

Forming Logistic Regression Equation: Multivariate logistic regression was used according to Petrie and Watson [10] to elucidate the association between the beef breeds (Y) and the other explanatory variables as (fattening period, initial weight and daily average weight gain). The beef breeds were considered a binary outcome variable that was coded as 1 in case of Cross-bred animal and 0 in case of Balady breed. The explanatory variables were selected through stepwise method to avoid multi-colonarity and out-correlation. The initial regression equation was:

$$\text{In (odds)} = b_0 + B_1X_1 + B_2 X_2 + B_3 X_3$$

$$\text{Log } (p/1-p) = b0 + b1*x1 + b2*x2 + b3*x3$$

In (odds) = odds of beef breeds & b_0 = *constant*

X_1 = fattening period (day)

X_2 = initial weight at the beginning of fattening period (kg/head)

X_3 = daily average live-weight gain (kg/head)

Regression equation was estimated by using Stepwise Regression Analysis Procedure in the SPSS for Windows 7.0 statistic software. In the stepwise procedure, independent variables are included in the equation respectively starting from a variable having the highest correlation with a dependent variable and the ones that are deemed to be statistically insignificant at $P<0.05$ are automatically dropped from the equation. Thus, the best model explaining the dependent variable can be without a need of trial and error of several models. Regression analysis was estimated in two forms; linear and logarithmic form. But, the logarithmic function was more common and accurate as R^2 was higher in logarithmic form than linear function. Comparison between the outputs of the logarithmic functions was done to determine the best accurate function, which used to describe the relationship between dependent variables and independent indices.

RESULTS

Productive Regression Model: The model results estimated with stepwise regression method (logarithmic form) and the relevant statistical tests are present in Table 1. The R^2 of the model was 95% (column 5) which means that the independent variables included in the model explains 95% of the variation occurring in meat production per kg in beef fattening enterprises in Egypt.

The beta values (β) in the table are the coefficient estimates of the equation and they indicate how much change shall realize in dependent variable (meat production) against a 1 unit change in each X_i. As seen from table1, fattening period (X_1) was found to be statistically insignificant at $P<0.05$. While, the increase of 1 unit in the initial live-weight (X_2) and daily average weight gain (X_3) causes an increase of about 0.475 and 0.455, respectively in meat production per kg live-weight. The estimated equation was as follows:

$$Y = 0.493 + 0.003X_1 + 0.475 X_2 + 0.455 X_3$$

Profit Regression Model: The results of regression model used to estimate the influence of economic indices on beef enterprises profitability are reported in Table 2. These results revealed that the logarithmic profit function was highly significant ($P<0.05$) and about 82% from the changes in profitability were attributed to the changes in economic indices studied. As seen from table2, depreciation cost (X_2), veterinary management cost (X_3), fattening period (X_6) and initial weight (X_7) were found to be insignificant at $P<0.05$. While, feed cost (X_1) and live animal purchase price (X4) had a negatively relationship with beef enterprises profitability; and live animal selling price (X_5) had a positive relationship with profit. The estimated equation was as follows:

$$Y = -5.079 - 2.912X_1 - 0.017 X_2 - 0.035 X_3 - 3.717X_4 + 7.529 X_5 + 0.153 X_6 + 0.106 X_7 + 0.526 X_8$$

Logistic Regression Equation: Logistic function used to elucidate the relation between the beef breeds (Y) and some predictors as (initial weight, fattening period and daily average weight gain). Value of Negelker R^2 (0.607) showed in Table 3 indicates moderate strong relation between predictors and grouping variable (beef breed). Also, the test of full model against a constant (Table 4) was statistically significant indicating that the predictors were distinguished between Balady and Crossbred of beef (chi square = 236.9, $P<0.000$ and d.f= 3).

By examining the association between beef breeds and predictor variables (fattening period, initial weight and daily average weight gain) there is the following function:

$$\text{Log } (p/1-p) = 19.27 + 0.037*\text{initial weight} + 0.005*\text{ fattening period} + 0.049*\text{daily weight gain}$$

The results of Exp B (odds ratios for the predictors) are presented in Table 5. The odds ratio for the variable represents the extent to which raising the corresponding measure by one unit influence the odd ratio and we can interpret Exp (B) as change in odds. If the value

Table 1: Estimated regression model of beef productivity

Independent Variables	Beta(β)	T	Sig. t	R Adj	R2	F	Sig.
(Constant)	0.493	21.140	0.000	0.98	0.953	354.0	0.000[a]
Fattening period (day) (x_1)	0.003	0.414	0.679				
Initial weight (kg/head) (x_2)	0.475	84.499	0.000				
Daily weight gain (kg/head) (x_3)	0.455	71.907	0.000				

Table 2: Estimated regression model of beef profitability

Independent Variables	Beta(β)	T	Sig. t	R Adj	R2	F	Sig.
(Constant)	-5.079	-5.600	0.000	0.91	0.82	246.71	0.000[a]
Total feed cost (EGP/head) (x_1)	-2.912	-16.30	0.000				
depreciation cost (EGP/head) (x_2)	-0.017	-0.94	0.925				
total veterinary cost(EGP/head) (x_3)	-0.035	-0.816	0.415				
live animal purchase price (EGP/head) (x_4)	-3.717	-13.85	0.000				
live animal selling price (EGP/head) (x_5)	7.529	21.83	0.000				
Fattening period (day) (x_6)	0.153	0.738	0.461				
Initial weight (kg/head) (x_7)	0.106	0.592	0.554				
Daily weight gain (kg/head) (x_8)	0.526	2.868	0.004				

Table 3: Summary of logistic regression model

Step	-2 Log likelihood	Cox & Snell R Square	Nagelker R Square
1	266.994[a]	.408	0.607

Table 4: Omnibus tests of model coefficient

	Chi-square	df	Sig.
Step	236.915	3	0.000
Block	236.915	*3*	0.000
Model	236.915	*3*	0.000

Table 5: Odds of outcome occurring in the equation

							95.0% C.I. For EXP(B)	
Independent variables	B[a]	SE.	Wald	df	Sig.	Exp(B)	Lower	Upper
Initial weight	.037	.004	73.67	1	.000	1.038	1.03	1.05
Fattening period	.005	.004	1.23	1	.267	1.005	.996	1.01
Weight gain	.049	.006	77.11	1	.000	1.050	1.04	1.06
Constant	19.2	2.00	92.640	1	.000	0.000		

increases 1 the odds of outcome occurring increase, but if the value less than 1 any increase in predictors lead to drop in the odds of outcome.

DISCUSSION

Evaluation of Productive Regression Model Findings: According to the regression findings, the effect of fattening period (X_1) on Y was found insignificant at $P<0.05$. This agreed with Nhiem [11] who reported that the length of fattening period had no significant effect on average daily gain, percentage of lean meat and dressing percentage.

The relationship between meat production and initial weight showed the trend of meat production increased with the initial weight being increased too. This is consistent with Demircan [12] who reported that efficiency of beef cattle became better as initial body weight increased and that to be more sustainable the initial weight should be taken into account. On the contrary Bozkurt and Kaya [13] found that the performance of the animals was not affected by the initial weight. The relative change of initial weight was about 0.475 meaning that the increase in initial weight by 1% resulted in increase of meat production by 0.475%. Similar trend was obtained by Funston *et al*. [14] who pointed out that for every kilogram increase in initial body weight the final weight increased by 1.06 kg, even carcass weight and carcass grade were positively affected by initial body weight.

The influence of daily growth on meat production showed that the meat production increases with increased daily weight gain and the relative change of daily weight gain was about 0.455 meaning that the increase of daily weight gain by 1 % resulted in increase of meat production by 0.455%.

Evaluation of Profit Regression Model Findings: According to the relationship between feed cost and profit, we can notice that the feed cost increase influences the profit decrease. This conclusion is proved by Ramsey *et al.* [15] who reported that feed costs were expected to have a negative sign in the profitability model, indicating that, as feed costs increase, profit decreases. The relative change of feed costs was about 2.912 meaning that increasing feed costs by 1% would decrease profitability by 2.91%. This also agreed with Hughes [16] who reported that $1.00 increase in feed costs implied a $2.48 reduction in profit. The influence of depreciation cost (X_2) and veterinary management costs (X_3) on profit (Y) was found negatively insignificant ($P <0.05$). Lowering the share of depreciation and veterinary costs per unit in the total unit cost may be considered as the reason for statistically insignificant effect of these factors on profit (Y). The results showed also non-significant relationship between initial weight (X_7) and fattening period (X_6) and profit (Y).

The influence of daily growth on profitability of beef enterprises showed that the profit increases with increased daily weight gain and the relative change of daily weight gain was about 0.526 meaning that the increase of daily weight gain by 1 % resulted in increase of profit by 0.52%. In agreement with our findings [17] asserted that an improvement in average daily weight gain decreased costs of gain and therefore, increased profits.

The relationship between beef enterprises profitability and live animal selling price (X_5) showed that the beef enterprises profitability increased with increasing of the live animal selling price, while live animal purchase price has a negatively relationship with beef enterprises profitability. Results suggested that increasing animal selling price by 1% would increase profit by 7.52%, while increasing animal purchase price by 1% would decrease profit by 3.71%. Finally we can conclude that the most important factor affecting profitability of beef enterprises is live animal selling price (X_5). While the factors having the second and third highest effect were live animal purchase price (X_4) and feed cost (X_1), respectively. Similarly [18] concluded that sale price of cattle had the largest effect on profits per head and Mintert et *al*. [19] reported that feeder cattle purchase price was the most important variable for heavy weight placements and explaining 42% of total profit variability.

Evaluation of Logistic Regression Model Findings: The initial weight and daily weight gain wald value are statistically significant at $P<0.05$, so, daily weight gain and initial weight are predictors for the beef breed and can be used for beef breed discrimination process. But Wald value for fattening period was not significant so, fattening period cannot be used as a predictor for beef breed. The estimate of initial weight (b_1) was (0.037). So, every one unit increase in initial weight score lead to 0.037 increases in log-odd of the breed. The estimate of daily weight gain (b_3) was (0.049). So, every one unit increase in daily weight gain score lead to 0.049 increases in log-odd of the breed. But the estimate of fattening period (b2) was not significantly differing.

The Exp (B) of initial weight is 1.038; means that Crossbred 1.038 time more likely than Balady breed to have high initial weight. The Exp (B) of weight gain is 1.050; means that Crossbred 1.050 time more likely than Balady breed to have height weight gain. While, Exp (B) of fattening period is 1.005; means that Crossbred 1.005 time more likely than Balady breed to have high fattening period. Similarly [20, 21] perceived that crossbred produced better performance and carcass traits compared to the pure breed beef cattle.

CONCLUSION

Calculating the productive function of meat production enabled us to have the best fit function of meat production and its productive indices. The influence of fattening period, initial weight and daily weight gain on the meat production tells us that the meat production increases with increased these factors and about 95 % from the changes in meat production were attributed to the changes in these productive indices.

The profit model estimates indicated that the most important factor affecting profitability of beef enterprise is live animal selling price. While the factors having the second and third highest effect were live animal purchase price and feed cost respectively. The influence of live animal selling price and daily growth on profitability of beef enterprises showed that profit increases with increased daily weight gain and selling price of animal, while live animal purchase price and feed cost have a negatively relationship with beef enterprises profitability. After using an existing set of data to calculate the logistic function and classify beef breed by using initial weight, fattening period and daily weight gain, the logistic regression function revealed a significant association between groups variable (beef breed) and some predictors (Initial weight and weight gain). As the marginal impact of each independent variable on production and profit was the estimated co-efficient value, they could simply be used to evaluate "what-if scenarios" and the risk of investment under changing circumstances in beef meat production. Therefore, the beef meat producers could use such modeling approach as a practical decision support tool.

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