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THE USE OF THE PARTIAL LEAST SQUARES REGRESSION PROCEDURE TO PREDICT THE NET PROFIT IN PRODUCTION OF EGG-TYPE PULLETS

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SUMMARY

Data on the financial variables of 43 cycles of Lohman Brown commercial egg-type pullets production were collected for 15 years (1990-2005) from Al-Nahda farm at Nubaria region in the north western part of Egypt. The flock size per cycle ranged between 25700 to 79500 birds, with a mean of 39600 birds, during the data collection period.

The data were analyzed by the Partial Least Squares Regression (PLS) procedure using the XLSTAT 1.01, 2009 software. The objective of the study was to find out the possibility of projecting the net profit per-cycle (NP) as a dependent (response) variable from information on five independent (explanatory) cost variables. The cost variables included feed cost (FC), purchased chicks price (CP), veterinary cost (VC), cost of depreciation of the buildings and equipment (DC), and other cost (OC). These five variables were assembled in a principal component which was used in building the projection model (equation).

Mean NP was L.E 62973, and the highest cost variable was FC (L.E 156182) representing about 46 % of the total cost. The correlation matrix between all variables showed significant correlation coefficients ($P<0.05$) between the independent variables and between each of them and the dependent variable (NP).

The model quality index showed high explanatory power of the generated component for NP. An equation for the projection model of NP was built, and the goodness of fit statistics for NP showed high accuracy ($R^2 = 0.90$). The model can be used for prediction and simulation purposes.

Keywords: Egg-type pullets, partial least squares (PLS) regression procedure, projection of net profit

INTRODUCTION

The production of ready-to-lay pullets represents one of the good investment opportunities in the poultry business. This is particularly suited to the producers who have mastered the growing of chicks from the day they are hatched up to the time they are about to lay. These pullets are 100-days old female egg-type birds which are preferred by some producers over the day-old chicks.

There is a demand for pullets because many producers want birds that produce cash flow almost immediately by the time they receive the birds. By this time, the birds are already vaccinated against major diseases and are no longer as delicate to be taken care of as the young chicks (Hofstad *et al*., 1984). In other words, the risk is much less in this type of operations.

Egg-type pullets' production has been managed successfully under a wide range of feeding quality and disease challenge situations. The goal of the brooding and grow-up systems of production is to provide pullets of ideal weight, condition, and stage of sexual maturity as they enter the laying house. It is production inputs which make the variation between birds; performance, and consequently profit.

Cost of production and returns are the major concerns in poultry production, provided other production parameters are within the normal range as suggested for good performance (Farooq *et al.*, 2002). Cost items, in particular, determine to a considerable extent the net profit per cycle.

The present work is, therefore, an effort to study the cost variables which have major effects on the net profit per cycle in an egg-type replacement pullets farm. Also, to find out the possibility of predicting the net profit from such variables. The partial least squares (PLS) regression procedure was applied to determine the variable importance for projection (VIP), and the principal components which can be used in constructing an equation for projection of the net profit per cycle.

MATERIAL AND METHODS

1. Source of Data:

Data on 43 cycles of egg-type Lohman Brown pullets production during the period from 1990-2005 were collected from the egg production project at Noubaria in the north eastern region of Egypt. This project belongs to the Central Fund for livestock development in the reclaimed land (CFLD).The project was established in (1986) to provide small farmers with a good source of egg-type pullets at the age of 100 days. The flock size per cycle ranged between 25700 to 79500 birds, with a mean of 39600 birds, during the data collection period.

At the end of each cycle the 100-day old pullets were sold at market price, and cash values of cost and revenue items were recorded. The net profit was calculated, defined as the difference between the total revenues and the total costs. All variables are expressed in Egyptian Pounds (L.E).

The data were pertaining to the price of the purchased day-old chicks (CP), feed cost (FC), veterinary cost (VC), depreciation cost of buildings and equipment (DC), and other cost of production (OC). The other cost included fuel, water and electricity, maintenance, rent of land, and miscellaneous expenses.

2. Flock Management:

Lohman Brown chicks were raised in a closed house with pad-cooling system from one day until 100 days of age. Chicks were placed in wire cages (100 cm width by 50 cm depth and 40 cm height) at 14 chicks per cage, with two water nipples and automatic chain feeder. Chicks received continuous illumination during the first two days post-hatch, and were transferred gradually to 8-hr photoperiod daily at 14 days of age, and this continues until 100 days of age. The average of light intensity was about 10 lx.

Brooding temperature of 33 ^{O}C was maintained for the first three days then decreased to 30 ^{O}C for the rest of the first week. The temperature was reduced gradually to 22 ^{O}C by the end of the second week until the fourth week. From the beginning of the fifth week to the end of the cycle when chicks reach 100 days of age, the birds were exposed to 22 ^{O}C. Electric fan heaters were used to provide and maintain the required temperature. Relative humidity was set at 50-60%.

Feed and water were available *ad libitum* to meet the requirements set by the National Research Council (NRC, 1994). The birds were subjected to vaccination program according to that outlined by Hofstad *et al.* (1984). The cycles continue all over the year with two - four weeks elapsing between every two consecutive cycles to allow for taking sanitary measures. The produced 100-day old pullets were sold to the farmers at market price.

3. Statistical analysis:

The Partial Least Squares (PLS) regression procedure as in XLSTAT (2009).1.01 software was applied to the data. The data included one dependent (response) variable, net profit (NP), and five independent (explanatory) variables: feed cost (FC), chick price (CP), veterinary cost (VC), depreciation cost (DP), and other cost (OC).

After selecting the variables which are relevant to NP, the analysis proceeded for seven steps to end up with a prediction equation for NP: 1) computing the basic statistics (means, standard deviations and minimum and maximum values), 2) constructing the correlation matrix among variables, 3) testing the model quality by number of components, 4) estimating model parameters, 5) testing goodness of fit for the dependent variable (NP), 6) identifying the variable importance in the projection (VIP), and finally, 7) estimating the model parameters of predicting NP.

4. The Partial least squares (PLS) regression:

The PLS regression procedure is efficient and optimal for the criterion based on covariances. It is recommended in cases where the number of variables is high, The method used in this study (referred to by XLSTAT software as PLS1) corresponds to the case where there is only one dependent variable, which is net profit (NP) in our case. The idea of the PLS regression is to generate a set of components out of the studied independent variables so that they explain as well as possible the dependant variable (NP), and have the characteristic of producing a model that involves linear combinations of explanatory variables. The model can be used for projection of NP or for simulation.

RESULTS AND DISCUSSION

Our aim in the present work was to assemble together information on the cost of raising egg-type pullets obtained from a large size-operation for an extended period of production (1990-2005). The analysis of the available data would be used in projecting net profit.

1. Summery statistics:

Variability in cost variables is mainly attributable to management conditions (Farooq *et al*., 2001; Zahir-ud- Din *et al*., 2001), size of operation (Ames and Negmba, 1986; Kumar and Mahalati, 1998; Ascard *et al*.,1995), mortality rate (North, 2001; Kitsopanidis and Manes, 1991; Asghar *et al*., 2000; Zahir- ud -Din *et* *al.,* 2001, Abdel-Aziz *et al*., 2008), and feed efficiency (Elwardany *et al*., 1998; Abdel-Aziz *et al*., 2008).

Table 1 shows the means and standard deviations of the six studied variables, the dependent variable (NP) and the five selected explanatory cost variables: OC, DC, CP, FC, and VC. The highest mean value was that of FC, which was about (L.E 156182) per cycle, followed by the price of the purchased chicks (PC), which amounted to about L.E 78847 per cycle, representing about 46 % and 23 % of the total cost respectively. These results were supported by Abdel-Aziz *et al*. (2009); Farooq *et al*. (2002). Abdel-Aziz *et al*. (2009) reported values of 37 % - 46 % for FC, and 16 % - 21 % for CP.

Table 1. Summery Statistics

Variables	Observations	Mean (LE)	Standard deviation (LE)
Net Profit(NP)	43	62873	42208
Other Cost (OC)	43	49342	38057
Depreciation Cost (DC)	43	31911	19881
Chick Price (CP)	43	78847	58280
Feed Cost (FC)	43	156182	133189
Veterinary Cost (VC)	43	21570	22754

Cost of feed is the major input variable, accounting for up to 70% of the total poultry production cost (Qunaibet *et al*., 1992; Zahid,1994;Leeson and Summers , 1997; Farooq *et al*.,2002). The contribution of day-old chick price to the total cost in table-egg production farms was 4 to 5 % (Zahid, 1994; Farooq *et al*., 2002) and 9 % in broiler breeders' farms (Abdel-Aziz, 2003; Abdel-Aziz *et al*., 2007). Whereas, Vaccination and medication cost contribute a portion which ranged between 3 and 5 % (Zahid, 1994; Farooq *et al*., 2002; Abdel-Aziz, *et al*., 2008).

The large estimates of the standard deviations for all means reflected the wide range of values. For example NP ranged from L.E 20396 to, L.E 179064, and FC ranged from L.E 241865 to L.E 521673. This may be due to the long period of data collection (1990-2005) and to the wide differences of flock size in the production cycles which ranged from 25700 to 79500 birds (CFLD, 2009).

2.The correlation matrix

The correlations between all the selected independent variables and between each of them and the dependent variable (NP) are given in Table 2.

All correlation coefficients (r), including those between NP and other variables were high (over 0.90 in most cases), and significantly different from zero ($P < 5\%$). The estimates ranged from 0.61 up to 0.96. The lowest correlations were found between OC and each of the other variables.

The R^2 values (Table 2) allows the visualization of the coefficients of determination of NP and the explanatory variables. With the exception of R^2 between OC and NP ($R^2 = 0.49$), all other coefficients exceeded 0.81.

Table 2. Correlation matrix (Pearson): among all studied variables

Variables	CP	FC	VC	OC	DC	NP*
Chick Price (CP)		0.960	0.949	0.607	0.923	0.909
Feed Cost (FC)	0.921		0.963	0.675	0.930	0.937
Vet. Cost (VC)	0.901	0.928		0.764	0.935	0.929
Other Cost (OC)	0.368	0.456	0.584		0.615	0.699
Depreciation Cost (DC)	0.851	0.865	0.875	0.378		0.928
Net Profit (NP)*	0.827	0.878	0.863	0.489	0.862	

NB: Values above diagonal are correlation coefficients (r) and values below diagonal are coefficients of determination (R^2).

* The dependent (response) variable

All values of (r) are different from 0 at a significant level alpha = 0.05

3. The Model Building

The idea of PLS regression is to generate a set of components (h) starting from a number of variables (p) with h<p. The determination of the number of components to keep is based on a criterion that involves cross-validation, or set by the user. XLSTAT - PLS has automatically selected one component. In our case there was also only one dependent variable (NP).

The obtained component is built to explain as well as possible NP. The PLS regression eventually leads to a linear model for projection of NP.

3.1. The Model quality

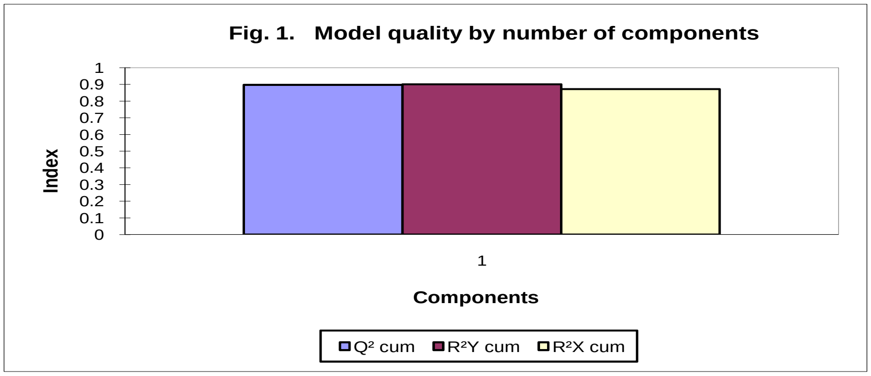
Table 3 and the corresponding chart (Fig.2) allow to visualize the quality of the PLS regression as a function of the generated component.

Table 3. Model Quality

Index	Component
Q^2 Cum	0.897
R^2Y Cum	0.900
R^2X Cum	0.872

Table 3 displays the model quality indexes. The quality corresponds to the contribution of the component to the indexes. The Q^2 cumulated index (Q^2 cum) measures the global contribution of the component to the predictive quality of the model. The Q^2 cum is 0.897, indicating a high degree of stability of the model (ideally it should be close to 1).

The cumulated R^2 y cum and R^2 x cum indexes are measures of the explanatory power of the component for the dependent variable (NP), and the five explanatory variables, respectively. The values of these two indexes correspond to the sum of the coefficients of determination given below the diagonal of Table (2) for the dependent and the explanatory variables. The values of R^2 y cum and R^2 x cum are 0.90 and 0.872, respectively which are very close to 1. This indicates that the component generated by the PLS regression summarizes well both the dependent variable and the explanatory variables. Fig.1 displays the values of the indexes of the single component generated by the PLS regression.



3.2. The variable importance for projection (VIP)

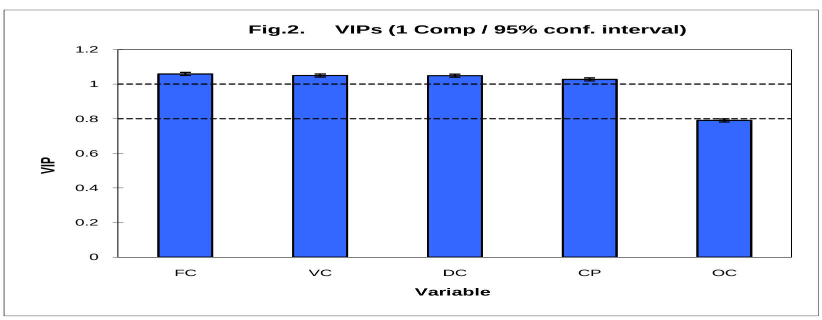
The VIPs are those variables that measure the importance of each of the explanatory variables for the building up of the components. This allows identifying which of the explanatory variables contribute more to the projection model.

Table 4. Variable Importance in the Projection (VIP)

Variables	VIP*	Standard deviation	Lower bound (95%)	Upper bound (95%)
Feed Cost (FC)	1.059	0.005	1.049	1.068
Vet. Cost (VC)	1.049	0.005	1.040	1.058
Depreciation Cost (DC)	1.049	0.007	1.035	1.063
Chick Price (CP)	1.027	0.002	1.023	1.031
Other Cost (OC)	0.790	0.025	0.741	0.838

* Listed in a descending order.

For the model of one component (Table 4), as it is the case in the present study, it can be seen that feed cost (FC) has the highest VIP value. Veterinary and DC are equally important for the projection. Two border lines for the VIP values are plotted to identify the variables that are highly influential, VIP > 1, (Fig. 2). Four variables (FC, VC, DC, and CP) fell in this category. Only OC fell below 0.80 which marks the lower threshold of the moderately influential variables (0.8 < VIP < 1.0).



3.3 The model parameters

Table 5 contains the parameters (coefficients) of the model for NP projection. The Table is followed by the equation of the model. This equation can be used for prediction or for simulation purposes.

Table 5. Model parameters

Variable	Net Profit (NP)
Intercept	8552.63
Other Cost (OC)	0.178
Depreciation Cost (DC)	0.452
Chick Price (CP)	0.151
Feed Cost (FC)	0.068
Vet. Cost (VC)	0.396

The equation is displayed to facilitate the reuse of the model

$NP = 8552.63 + 0.178 \times OC + 0.452 \times DC + 0.151 \times CP + 0.068 \times FC + 0.396 \times VC$

3.4. Goodness of fit for NP

The goodness of fit statistics of the PLS regression model for NP are given in Table 6.

Table 6. Goodness of fit statistics (Variable NP*)

Observations**	*43*
Sum of weights	43
Degrees of freedom (DF)	41
R square (R^2)	0.900
Std. deviation	13532
Mean square error (MSE)	174603875
Random Mean Square Error (RMSE)	13214

* Net profit ** Cycles

The analysis of the model shows that the model is well fitted ($R^2 = 0.90$). The Table also includes the number of observations (production cycles). The sum of the weights of the observations, the number of degrees of freedom which correspond to the error mean squares (MSE), and the root of the MSE (RMSE).

CONCLUSION

The partial least squares (PLS) regression procedure as described in the XLSTAT 2009 1.01 software is used successfully in developing a projection model for the net profit per cycle. Dependent (response) variable was accurately predicted from five budget independent (explanatory) variables with high accuracy ($R^2 = 0.9$). The analysis of the model shows that the model is well fitted and can be used for prediction or simulation purposes. The procedure can also handle more than one dependent variable and a large number of independent variables.

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إستخدام طريقة الإنحدار الجزئي للحد الأدنى للمربعات للتنبؤ بصافي الربح من بداري إنتاج البيض

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جمعت البيانات المالية لعدد 43 دورة لإنتاج بداري إنتاج البيض اللوهمان البني نفذت على مدار 15 عاما (1990- 2005) في مزرعة النهضة بمنطقة النوباريه.حيث تراوح حجم القطيع فى الدورة الواحدة بين 25700 و 79500 بمتوسط قدره 39600 طائر .
تأسست المزرعة بواسطة الصندوق المركزي لتنمية الثروة الحيوانية بغرض إمداد مزارعي الأراضي المستصلحه بمصدر جيد لهذا النوع من بداري إنتاج البيض على عمر 100 يوم سواء للإحلال أو لإنشاء مزارع صغيرة جديدة.
تم تحليل البيانات بطريقة الإنحدار الجزئي للحد الأدنى للمربعات (PLS) بواسطة برنامج XLSTAT2009 بهدف دراسة إمكانية التنبؤ بفائض الربح للدورة من القيم النقدية للمدخلات (ثمن شراء الكتاكيت عمر يوم، تكلفة التغذية، تكلفة الرعاية البيطرية، تكلفة إهلاك الأصول وتكلفة بنود أخرى للإنفاق).
جمعت قيم المدخلات المختارة في مكون رئيسي وأستعمل هذا المكون في بناء نموذج رياضي للتنبؤ بالقيمة النقدية لصافي الربح.
أظهرت النتائج معاملات ارتباط معنوية بين كل من بنود التكاليف بعضها البعض وبينها وبين صافى الربح.كما أوضحت الدراسة أن صافى الربح يعتمد بدرجة كبيرة على تكاليف التغذية والتي مثلت 46% من التكلفة الكلية وأنه يمكن استعمال نموذج التنبؤ بصافي الربح للدورة الناتج عن هذه الدراسة بدرجة دقة قدرها 90 %.