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ORIGINAL RESEARCH ARTICLE

Statistical Analysis of Long and Short-run Equilibrium of Egg Hatchability in Two commercial hatcheries in Ibadan Metropolis

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ABSTRACT

The challenge of dearth of information on egg hatchability variables (EHV) for strategic planning can sufficiently be met using a statistical tool like cointegration which establish relationships between such egg hatchability variables (EHV) and considers the time series nature of the data. We conducted this study to evaluate the cointegration of EHV (egg set, fertile egg and total chicks hatched) in 2 selected commercial hatcheries in Ibadan Metropolis and to compare the results of the co- analysis from the 2 hatcheries. We adopted Engle and Granger co-integration tests method to assess long and short run equilibrium using data from two commercial hatcheries - Bronco and Foresight hatcheries at Oluyole Estate (Latitude 7º 23′ N and Longitude 3º 82′ E) in Ibadan. The mean egg hatchability variables were 5118.421, 4396.653, and 3796.335 for egg sets, fertile eggs and total chicks for farm 1. These were relatively lesser than 13076.160, 11717.280 and 10462.050 returned for egg set, fertile egg and total chicks for farm II. It was obtained that for each of the variable at both farm, the ADF is significant at 0.01, 0.05 and 0.1 level of significant. This implied that the egg hatchability variables (EHV) data and for both farms were non stationary. Similarly, they were non-random walk process because the data were still non-stationary after the first and second differencing. It was also observed that the unit root for the EHV, since the absolute values of EHV is greater than unity (- /B/>1), hence the non- stationarity of the EHV could be described as explosive. Three types of causality direction can be identified in this study – Unidirectional causality running from total chicks to egg set (at Farm II), bidirectional causality running from egg set to fertile egg (at both farm) and no causality between the 2 EHV as egg fertile and total chicks (at Farm II). Sum of square of residuals of VECM for total chick was the least while the adjusted R^2 for the VECM ranged from 0.362 for fertile egg to 0.456 for egg set for farm I and for farm II, it ranged between 0.311 for total chicks and 0.449 for fertile egg. The implications of these results were that long run equilibrium could be established between all EHV. We conclude from our study that relationship between EHV in this study is a genuine relationship arising from the cointegration of the EHV and not a spurious regression.

Keywords - Equilibrium, long-run, causality, Spurious, hatching, Akaike.

INTRODUCTION

Obtaining information on egg available for hatching might not be feasible at all times hence, strategic planning of hatching programme which require egg hatchability variable data might suffer a hitch. The challenge of dearth of information on egg hatchability variables (EHV) for strategic planning can sufficiently be met using a statistical tool which establish relationships between the egg hatchability variables (EHV) like cointegration and as well considers the time series nature of the data. Relationships between egg variables have been established in the past (Dauda et al. 2006; Dumman et al. 2016). The persistence of these relationships over time constitute a challenge for adequate strategic planning in egg and hatchery industries. Cointegration is one of the recent advances in time series analysis. Some of these advances have focused on market related phenomenon as it relates to egg and chicken (Faminow and Benson, 1990; Saran and Gagwan, 2008; Tang, 2013; Konstantinos et al., 2013). Other concerted efforts at annexing cointegration tools in agricultural research include, estimating the degree of conformity of egg markets in India to the law of one price (Sendhil et al., 2013), analysis of spatial cointegration amongst major wholesale egg markets in India (Saran and Gangwar, 2008) and a cointegration approach analysis of the effects of boiling and cooling on some physical properties of luffa sponge seed (Ilori et al., 2016). These works notwithstanding regular update of cointegration study is required for its plausibility in different fields (Tsay, 2001). There is dearth of studies on the application of cointegration analysis to the production aspect of animal production especially poultry. This study thus aim at annexing the tools of long and short run equilibra in the assesment of the causal direction of EHV. This would be found useful in the strategic planning of hatching activities of both breeder farms and commercial hatcheries. The objectives are thus to evaluate the cointegration of egg hatchability variables (EHV) - egg set, fertile egg and total chicks hatched in 2 selected farms in Ibadan Metropolis and to compare the results of the co-integration analysis from the two commercial hatcheries.

MATERIALS AND METHODS

Engle and Granger (1987) co-integration tests method was adopted to assess long and short run equilibrium and it involves - tests for the order of integration of the variables (that is the number of times each of the EHV is differenced before becoming stationary). The variables entering the co-integrating equation should be integrated of the same order and this was confirmed using Augmented Dickey – Fuller test. These unit root tests provide evidence on whether the EHV rates follow random walks or otherwise. According to Engle and Granger (1987), if two variables are cointegrated, there exists a long-run equilibrium relationship between them. In the Engle and Granger (1987) otherwise tagged "EG method", cointegration is tested by regressing one variable on the other and testing whether the residuals of the estimated regression equation are stationary. There are two test statistics in the Johansen co-integration test - the trace statistics and the maximum eigenvalue statistic (Johansen, 1991). The trace statistic test has the null hypothesis:

H_o: there exist at most r co-integrating relations against the alternative of m co-integrating relations (*Where* $r = 0, 1, m - 1$).

The maximum eigen-value statistic on the other hand test the null hypothesis - there are r co-integrating relations against the alternative hypothesis - there are $r+1$ co-integrating relations.

Sources of sample data and Analysis – The sources of sample data for this research were two commercial hatcheries - Bronco and Foresight hatcheries and are located at Oluyole Estate (Latitude 7º 23′ N and Longitude 3º 82′ E) in Ibadan. The 2 hatcheries receive hatching eggs from different breeder farms within and outside Ibadan environs for hatching. Data of the two commercial hatcheries were collected. The data includes hatchability records for the period of 10 years (2006-2016) and N - total number of 961 data. This is tantamount to 481weeks (twice weekly data collection) and the remaining 79weeks represent the missing data and the remaining part of 2016. Data on egg set (total number of eggs presented for incubation), egg transferred (total number of fertile eggs transferred from the setter to the hatcher) and the hatchability (total number of egg hatched or total chicks hatched) were collected twice (Tuesday and Thursday) per week. The data were analyzed using descriptive statistics (mean, variance and skewness), cointegration analysis (including test of the Unit root, Granger causality analysis and Vector error correction Model). The best short and long run equilibrium model was chosen using Akaike Information Criteria (AIC). AIC is one of the 2 Information Criteria adopted for model diagnosis. Akaike Information Criterion (AIC) suggested by Akaike (1973) is a model selection tool which gives an estimate of the model performance on a new or fresh data set. AIC is given by the expression

AIC = -2 * loglikelihood + 2 * d (d is the total number of parameters)

The smaller the AIC value the better the model (Breiman *et al*. 1984).

The statistical packages used for this work were SAS (version 8) for descriptive analysis and E-View (version 9) for cointegration analysis.

RESULTS

Summary statistics of the Egg Hatchability Variables (EHV)

The mean egg hatchability variables were 5118.421, 4396.653, and 3796.335 for egg sets, fertile eggs and total chicks for farm 1. These were relatively less than 13076.160, 11717.280 and 10462.050 returned for egg set, fertile egg and total chicks for farm II. However, the reverse trends of the means were obtained for the variance obtained for both farms. The variance 35013421.522, 25527463.206 and 8130845.029 obtained for egg set, fertile egg and total chicks for farm 1 were greater than 30755320.880, 2486.5002.736 and 21526370.681 for egg set, fertile egg and total chicks for farm 2 (Table 1). The skewness of the egg hatchability variables -0.386(egg set), 0.390(fertile egg) and 0.478(total chicks) for farm 2 tends to zero than those of farm 1 (Table 1). All the EHV in both farms have equal number (N = 961) of observations (Table 1). All the variance-covariance values were positive values ranging from 18111980.932 (variance for total chicks) to 34976985.320 (variance for egg set) for farm 1 (Table 2) while the variance-covariance matrix of egg hatchability variable of farm 2 ranged between 30723312.000 (variance for egg set) and 9757371.000 (covariance of fertile egg and total chicks). However unlike in egg hatchability variables of farm 1, no 2 variance-covariance values were the same (Table 2). The obtained variance for fertile egg and covariance for fertile egg and total chicks were the same. Similarly, none of the variance-covariance values were zero or near zero. We could thus conclude that the covariance off egg hatchability variable were non-orthogonal as well as not independent. In addition, standardizing these covariances by the square roots of the constituents' variable variances, we have highly correlated variables. This implied substantial multi co-linearity.

Table 1. Summary Statistics for the Egg Hatchability variable

	Farm I			**Farm II**		
Statistics	**Egg Set**	**Fertile Egg**	**Total Chicks**	**Egg Set**	**Fertile Egg**	**Total Chicks**
Mean	5118.421	4396.653	3796.335	13076.160	11717.280	10462.050
Variance	35013421.522	25527463.206	18130845.029	30755320.880	24865002.736	21526370.681
Skewness	1.880	1.650	1.154	0.386	0.390	0.478
Kurtosis	8.214	6.791	3.770	2.825	2.742	2.770
Jarque-Bera	1654.919	1011.459	236.897	25.038	27.006	38.721
Sum	4918803	4225184	3648278	12566193	11260305	10054031
Observations	961	961	961	961	961	961

Table 2. Variance - Covariance analysis of the egg Hatchability variable

		EGGST	**EGFRTILE**	**TCHICKS**
	EGGST	34976985.320		
	EGFRTILE	29470865.295	25500896.474	
Farm I	**TCHICKS**	23750727.730	25500896.474	18111980.932
	EGGST	30723312.000		
	EGFRTILE	26704773.000	24839126.000	
Farm II	**TCHICKS**	20078676.000	19757371.000	21503969.000

Unit Root Test for the Egg Hatchability Variables (EHV)

The null hypothesis of our Augmented Dickey-fuller test (ADF) which indicates the presence of unit root returned significant results -3.577,-3.0667 and -3.221 for egg set, fertile egg and total chicks for farm 1. Similarly, the ADF of - 4.409, - 5.529 and - 9.585 returned for egg set, fertile egg and total chicks at farm 2 were significant (p<0.01). It was obtained that for each of the variable at both farms, the ADF is significant at 0.01, 0.05 and 0.1 level of significant (Table 3). This implied that the EHV data and for both farms were non-stationary. Similarly, they were non-random walk process because the data were still non-stationary after the first and second differencing. In addition, it was observed that the unit root for the EHV, the absolute values of the EHV is greater than 1(- /B/>1), hence the non- stationarity of the EHV could be described as explosive. It means the shock to the system would become more pronounced and influential as time proceeds on.

Table 3. Unit Root Test using Augmented Dickey-Fuller Test.

		Farm I		Farm II	
		t-Statistic	Prob.*	t-Statistic	Prob.*
Egg set	ADF test statistic	-3.57679	0.0064	-4.40894	0.0003
	1% level	-3.43704		-3.43699	
	5% level	-2.86438		-2.86436	
	10% level	-2.56834		-2.56832	
Egg Fertile	ADF test statistic	-3.06665	0.0295	-5.52869	0
	1% level	-3.43704		-3.43699	
	5% level	-2.86438		-2.86436	
	10% level	-2.56834		-2.56832	
Total Chicks	ADF test statistic	-3.22135	0.0191	-9.58473	0
	1% level	-3.43702		-3.43696	
	5% level	-2.86437		-2.86435	
	10% level	-2.56833		-2.56832	

The results of further test of unit root using AR (p) model $Y_t = \theta_0 + \phi Y_{t-1} + a_t$ (where a_t ~ Normal WN $(0, \sigma_a^2)$ showed that the system, EHV has no unit root. This is because δ <0 (Table 4 and 5). Hence we reject the null hypothesis: $H_0 : \delta = 0$ and accept $H_1 : \delta = 0$ $Y_t =$ the value of any of the EHV at current time t, $\theta_0 =$ initial value of the EHV, Y_{t-1} = The value of Y_t at preceding period, ϕ = autoregressive coefficient and a_t is error term at period t.

The unit root models adopted in the present study compose of the constant, the random walk and the drift as follows;

$$\Delta Y_t = \theta_0 + \delta Y_{t-1} + a_t$$

$\Delta Y_t =$ Change in the value of any of the EHV at current time t, δY_{t-1} is the random walk and other components are as defined earlier.

The shocks of the EHV system die away based on the θ^T obtained for the EHV (Table 4 and 5) which was less than 1. The restricted ADF model for EHV for farm I revealed that it is advisable that the null hypothesis $(H_0 : x_t = x_{t-1} + \varepsilon_t)$ should be rejected. Where $x_t =$ value of the egg variable at period *t*, $x_{t-1} =$ value of the same egg variable at preceding period and $\varepsilon_t =$ the error term. This was due to the fact that $x_t \neq x_{t-1} \neq x_{t-2} \ldots x_{t-14}$ for both egg set and fertile egg (Table 4). The $x_t, x_{t-1}, x_{t-2} \ldots x_{t-12}$ of the total chicks also followed the same trend of

$x_t \neq x_{t-1} \neq x_{t-2} \ldots x_{t-12}$. This implies that no 2 values of the EHV were the same for egg sets, fertile egg and total chicks. The adjusted R^2 were 0.52, 0.521 and 0.518 for egg set, fertile egg and total chicks. The correspondent Akaike Information Criteria were 20.077(egg set), 19.701(fertile egg) and 19.241(Total chicks – Table 4). Similarly, the restricted ADF model for EHV of farm II had coefficient of $x_t > x_{t-1} < x_{t-2} < x_{t-3} \ldots < x_{t-7}$. This indicates that $x_t \neq x_{t-1} \neq x_{t-2} \ldots \neq x_{t-7}$ hence, it is advisable we reject the null hypothesis of $x_t = x_{t-1} = x_{t-2} \ldots = x_{t-7}$ for egg set and fertile egg (Table 5). For total chicks at Farm II however, $x_t > x_{t-1} < x_{t-2} < x_{t-3}$ showing similar trend with both egg set and fertile egg, it is advisable we reject the null hypothesis of $x_t = x_{t-1} = x_{t-2} = x_{t-3}$ (That is equality of the value of any given EHV at all time). From these results, we can deduce that;

a). The differencing time - $d(x_t)$ for both egg set and fertile egg were equal for EHV at both farms.

b). The differencing time of total chicks for both farms were less than their corresponding egg set and fertile egg.

Long and short – run Equilibrium of the Egg Hatchability Variables.

Granger causality analysis showed that it is advisable we reject the null hypothesis for all the causality instances for farm I (Table 6). This is due to the fact that the F statistics obtained for the causality- egg set does not granger cause total chicks (12.560) and *vice versa* (11.123); fertile egg does not granger cause total chicks (8.376) and *vice versa* (10.529) as well as egg set does not granger cause fertile egg (9.786) and *vice versa* (8.320) were significant ($P < 0.01$ – Table 6). Since all these P-values were significant, we cannot accept the null hypothesis meaning that there is short causality running from independent variables to dependent variables. However, the trend of causality for EHV for farm II was different. The F statistics returned for egg set does not granger cause fertile egg (6.546) and *vice versa* (8.790) were significant ($P<0.01$).

The granger causality analysis showed that the F-statistics obtained for fertile egg does not granger cause total chicks (1.883) and *vice versa* (2.698) were not significant. It is thus advisable to accept the null hypothesis. The F statistics of 5.678 returned for total chicks does not granger cause egg set was significant while the *vice versa* (1.706) were not significant ($P < 0.01$- Table 6). From these results, it is apparent that taken any of the 3 EHV as independent variable, short run equilibrium can be caused to another dependent variable at farm I. For farm II however, both egg set and fertile egg alone can cause short run equilibrium from the EHV taken as independent variable to another dependent variable.

Three types of causality direction can be identified in this study – Unidirectional causality running from total chicks to egg set (at Farm II), bidirectional causality running from egg set to cause short run equilibrium from the EHV taken as independent variable to another dependent variable. fertile egg (at both farm) and no causality between the 2 EHV as egg fertile and total chicks (at Farm II).

The Johansen cointegration test returned trace statistics of 304.978, 152.523 and 22.651 for none, at most 1 and at most 2 cointegration equation. These results are significant at 0.01 (Table 7). Their correspondent eigen values were 0.147, 0.127 and 0.023. Similarly for farm 2, the trace statistics were 168.777 (none) 74.37) (at most 1) and 12.2416 (at most 2 – Table 7) while their corresponding eigen statistics were 0.094, 0.063 and 0.013 and these were significant ($p< 0.01$).

The Johansen cointegration test for maximum eigen test returned same eigen values for the 3 levels of cointegration equation (0, at most 1 and at most 2) for farm 1 (Table 7). The maximum eigen obtained were respectively 152.456, 129.872 and 22.657 with significant F-statistics ($p<0.05$ – Table 7). Similar result of equal eigen values were obtained for the 3 levels of cointegration equation for farm II.

Table 4. Restricted ADF Model for EHV for Farm I

	Egg Set		Fertile Egg		Total Chicks	
	Coefficient	t - statistics	Coefficient	t-Statistic	Coefficient	t-Statistic
X	-0.248913	-3.576792	-0.183007	-3.066652	-0.15358	-3.221352
$D_{(x-1)}$	-0.697574	-9.57296	-0.765596	-11.83971	-0.759204	-13.96432
$D_{(x-2)}$	-0.624733	-8.340802	-0.678959	-9.959618	-0.635057	-10.83562
$D_{(x-3)}$	-0.683725	-8.963385	-0.733058	-10.38496	-0.680148	-11.34017
$D_{(x-4)}$	-0.639435	-8.276333	-0.66917	-9.215458	-0.572603	-9.24382
$D_{(x-5)}$	-0.612728	-7.905975	-0.634155	-8.611809	-0.523262	-8.449796
$D_{(x-6)}$	-0.506849	-6.64614	-0.533793	-7.297564	-0.398863	-6.472943
$D_{(x-7)}$	-0.521815	-7.003119	-0.543936	-7.551996	-0.41502	-7.04424
$D_{(x-8)}$	-0.459672	-6.370821	-0.473989	-6.748911	-0.325335	-5.854898
$D_{(x-9)}$	-0.496275	-7.148988	-0.500528	-7.366073	-0.34104	-6.886066
$D_{(x-10)}$	-0.36403	-5.560717	-0.370683	-5.744043	-0.195935	-4.484851
$D_{(x-11)}$	-0.323991	-5.414285	-0.331295	-5.576465	-0.120092	-3.699928
$D_{(x-12)}$	-0.194986	-3.712116	-0.199939	-3.817398	613.7567	2.849248
$D_{(x-13)}$	-0.2065	-4.640927	-0.204223	-4.58245		
$D_{(x-14)}$	-0.112482	-3.453385	-0.117309	-3.603115		
C	1314.431	3.300281	847.4368	2.817233		
Adjusted R^2	0.520557		0.520683		0.51819	
Mean dependent var	5.731501		6.308668		6.572181	
Akaike info criterion	20.07666		19.70124		19.24072	
Durbin-Watson stat	2.010385		2.009729		2.006789	
F-statistic	69.40244		69.43699		85.96492	

Table 5. Restricted ADF Model for EHV for Farm II

	Egg Set		Fertile Egg		Total Chicks	
	Coefficient	t - statistics	Coefficient	t-Statistic	Coefficient	t-Statistic
X	-0.159777	-4.408935	-0.251053	-5.528694	-0.403911	-9.584726
$D_{(x-1)}$	-0.698634	-15.80462	-0.620124	-12.42381	-0.395636	-9.156973
$D_{(x-2)}$	-0.422096	-8.789006	-0.377454	-7.302206	-0.168369	-4.100962
$D_{(x-3)}$	-0.346792	-7.213491	-0.304499	-5.98638	-0.112081	-3.471582
$D_{(x-4)}$	-0.262195	-5.527399	-0.22394	-4.528053		
$D_{(x-5)}$	-0.256463	-5.662729	-0.219639	-4.713704		
$D_{(x-6)}$	-0.232105	-5.525059	-0.207549	-4.884192		
$D_{(x-7)}$	-0.154666	-4.786774	-0.139168	-4.298441		
C	2090.149	4.213136	2942.584	551.9132	4226.831	9.14755
Adjusted R-squared	0.444751		0.445524		0.399017	
Mean dependent var	-4.435467		-5.288562		-4.185998	
Akaike info criterion	19.62645		19.61235		19.53127	
Durbin-Watson stat	2.002193		2.003074		1.999915	
F-statistic	96.31823		96.61723		159.682	

The corresponding maximum eigen statistics were 94.404, 62.127 and 12.246 (for 0, at most 1 and at most 2 cointegration equations). These results were also significant (P<0.01 – Table 7). The long - run equilibrium return Vector Error Correction Model (VECM) that are indicative of drift from t < t – 1 for both farms (Table 8). Egg set at both farms recorded the highest sum of squares (3.23×10^{10} – Farm I and 2.23×10^{10} - Farm II). The goal of VAR is to determine interrelationships among variables. The simple models of VEC are;

$$\Delta y_{1,t} = \alpha_1(y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{1,t}$$

$$\Delta y_{2,t} = \alpha_2(y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{1,t}$$

The error correction terms are the $\alpha_1(y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{1,t}$ and $\alpha_2(y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{1,t}$. These error term returned for egg set (-0.842), fertile egg (-0.854) and total chicks(-.86) for farm I as well as -0.815, -0.263 and -.755 for egg set, fertile egg and total chicks for farm II were all negative. Sum of square of residuals of VECM for total chick was the least while the adjusted R^2 for the VECM ranged from 0.362 for fertile egg to 0.456 for egg set for farm I and for farm II, it ranged between 0.311 for total chicks and 0.449 for fertile egg (Table 8). The implications of these results were that;

i. Long run equilibrium could be established between all EHV.
ii. Both trace and the maximum eigen statistics gave the same eigen values hence could be said to corroborate each other.

The long run equilibrium models are;

$Y = -0.156x_1 - 0.857x_2$ ---------------(i) and

$Y = 22.295x_1 + 2.628x_2$ -------------- (ii)

Where Y = Egg set, x_1 = Fertile egg and x_2 = Total chick.

Table 6. Granger Causality Tests

	Obs	Farm I		Farm II	
Null Hypothesis:		**F-Statistic**	**Prob.**	**F-Statistic**	**Prob.**
EGGST does not Granger Cause EGFRTILE	956	9.78552	4.00E-09	6.54609	5.00E-06
EGFRTILE does not Granger Cause EGGST		8.32039	1.00E-07	8.79029	4.00E-08
TCHICKS does not Granger Cause EGFRTILE	956	10.5287	7.00E-10	2.69814	0.0198
EGFRTILE does not Granger Cause TCHICKS		8.37626	9.00E-08	1.8833	0.0947
TCHICKS does not Granger Cause EGGST	956	11.1234	2.00E-10	5.67823	4.00E-05
EGGST does not Granger Cause TCHICKS		12.5596	8.00E-12	1.70623	0.1304

Table 7. Long Run Equilibrium (Using Johansen Co-integration test).

	Hypothesized No. of CE(s)	**Farm I**		**Farm II**	
		Eigenvalue	Test Statistic	Eigenvalue	Test Statistic
	None*	0.147	304.978**	0.094	168.777**
	At most 1 *	0.127	152.523**	0.063	74.373**
Trace	At most 2 *	0.023	22.651**	0.013	12.246**
	None *	0.147	152.456**	0.094	94.404**
	At most 1 *	0.127	129.872**	0.063	62.127**
Max-Eigen	At most 2 *	0.023	22.651**	0.013	12.246**

Table 8. Vector Error Correction Model.

	Farm I			Farm II		
Error Correction:	D (EGG_SET)	D (EGFRTILE)	D (TOTAL)	D (EGG_SET)	D (EGFRTILE)	D (TOTAL)
CointEq1	-1.468	0.253	-0.828	-0.003	-0.028	-0.003
D(EGG_SET)	0.356	-0.267	0.569	-0.806	-0.013	-0.085
D(EGGSET(-2))	0.012	-0.039	0.165	-0.233	-0.065	0.044
D(EGG_TRANS(-1))	-0.227	-0.674	-0.132	0.060	-0.252	0.060
D(EGG_TRANS(-2))	-0.127	-0.240	-0.066	0.045	-0.018	0.049
D(TCHICKS(-1))	-0.862	0.324	-1.146	0.126	0.026	-0.552
D(TCHICKS(-2))	0.006	0.042	-0.250	-0.007	0.059	-0.271
Total	-0.842	-0.854	-0.86	-0.815	-0.263	-0.755
Adj. R-squared	0.456	0.362	0.434	0.364	0.449	0.311
Sum sq. residuals	3.23×10^{10}	2.08×10^{10}	1.46×10^{10}	2.1×10^{10}	2.23×10^{10}	1.92×10^{10}
S.E. equation	5824.651	4678.394	3916.172	4700.204	4861.005	4499.906
F-statistic	134.507	91.446	123.281	79.205	112.311	62.752
Log likelihood	-9661.551	-9451.611	-9281.240	-9455.562	-9487.789	-9413.842
Akaike AIC	20.185	19.747	19.391	19.757	19.824	19.670
Schwarz SC	20.220	19.782	19.426	19.798	19.865	19.710
Akaike information criterion		56.823		57.641		
Schwarz criterion		56.945			57.778	

DISCUSSION

The trend of the mean and variance of the EHV in our study conform with the exponential distribution. For exponential distribution, the relationship between mean and variance is expressed as follows;

$$1/\lambda = 1/\lambda^2 \quad . \; . \; . \; . \; (iii)$$

This implies that the bigger the size of mean, the narrower the variance (Stuart and Ord 1998). The non-orthogonality of the EHV was borne out of the fact that the sum of any 2 combinations of the EHV at any of the farm does not produce zero (Assche, 1988; Doncaster and Davey, 2007). The implications of these findings are that no 2 pairs of EHV are independent of each other though, they might be governed by differing factors. In addition, a number of disparities emerged in our results and are;

i) Disparity in the direction of cointegration of the EHV as afore discussed and
ii) Differences in the order of cointegration of EHV at the 2 farms.

These disparities may be hinged on differences in the sources of eggs presented for hatching as well as handling technique in each hatchery. Four types of causality direction have been identified (Kaleb, 2015) and include – Unidirectional causality running from total chicks to egg set, bidirectional causality running form egg set to fertile egg (at both Farm), between the two variables, Unidirectional causality running from egg set to total chicks and no causality. The first three types were established in our study. The method of cointegration estimation in our work followed Engle and Granger (1987). The negative values of adjustment coefficient α in our study conform with the principle of error correction model (Engle and Granger, 1987). Lastly, the cointegrations of pricing and other economic related variables are usually governed by economic factors such as market forces like demand and supply (Sendhil et al., 2013). The cointegrations of EHV on the other hand are governed by genetic and environmental factors. Some of these factors are peculiar to only few of the variables while some are common to all.

CONCLUSION

It was concluded from the study that relationship between EHV in this study is a genuine relationship arising from the cointegration of the EHV and not a spurious regression. As the main goal of hatchability of eggs is optimum total chicks output, it is therefore imperative to recommend that strategies directed towards achieving the goal should enhanced increase in all the EHV.

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