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VECTOR ERROR CORRECTION MODEL FOR FORECASTING SHEEP NUMBERS IN BULGARIA

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Abstract

The aim of this study was to forecast sheep numbers in Bulgaria on 01.11.2016 and on 01.11.2017, using a vector error correction model (VECM). A vector error correction model was constructed to forecast sheep numbers in Bulgaria for 2016 and 2017. The model was developed on the basis of 3 time series for the period 2000 – 2015 year. The time series were: Sheep numbers in Bulgaria on 01 November, Number of sheep farms on 01 November and Consumption of lamb and goat meat for 1 year per member of household (kg). Sources of information were annual data from the Ministry of agriculture and food, Republic of Bulgaria and the data from the National Statistical Institute. The stationarity of the variables was tested with Augmented Dickey-Fuller Unit Root Test. The cointegration of the three variables was estimated with Johansen Cointegration Test. VECM was constructed with lag length 1 and 1 cointegrated vector. An intercept was included in the model. Granger causality test was performed with the help of Wald Test in order to check the short-run causal relationship, running from the independent variables to the dependent variable. In order to forecast the number of sheep on 01 November 2016 and on 01 November 2017, one of the equations of the VECM was estimated with the method of least squares. The standard error of the regression, the coefficient of determination, the Adjusted R-squared of regression, F-statistic of regression, Jarque – Bera Test of Normality, Breusch-Godfrey Serial Correlation LM Test and Autoregressive Conditional Heteroscedasticity Test of Residuals were calculated. To check the stability of the model, the cumulative sum and cumulative sum of square had been represented. The forecasted sheep numbers in Bulgaria on 01.11.2016 are 1,313,796; and on 01.11.2017 are 1,306,403.

Key words: *Vector error correction model, sheep numbers, forecast*

INTRODUCTION

In 2015 Bulgaria produced 74,324 tons of sheep milk, which accounted for 6.4% of total milk production. There were 1,117 thousand sheep mothers on 01.11.2015, which was 19.6% less than in 2014. The number of sheep was 1,331.9 thousand heads. Sheep farms were 37.7 thousand, which was with 19.4% less than in 2014 [4].

Sheep breeding in Bulgaria is characterized by extensive farming, low average milk yield, low average number of animals on a farms level. However, there is a process of consolidation of flocks: the average number of sheep in a farm on 01 November 2015 was 35.3 head numbers, which was with 23.8% more, compared to 01 November 2014; the average number of sheep - mothers on 01 November 2015 was 29.9 head numbers, which was with 25.3% more, compared to 01 November 2014 [4].

For the proper and effective development of sheep farming, labour is of a great importance: according to some authors [6], the relative share of labour costs from the total, varied from 28% to 37% for a sheep flock of Bulgarian Synthetic population. Other factors, influencing the economic efficiency of sheep breeding, are milk productivity and protection of the new-born lambs [5].

MATERIALS AND METHODS

The aim of this study was to forecast sheep numbers in Bulgaria on 01.11.2016 and on 01.11.2017, using a vector error correction model.

A vector error correction model (VECM) [1] was constructed to forecast sheep numbers in Bulgaria for 2016 and 2017. The model was developed on the basis of 3 time series for the period 2000 – 2015 years.

The time series were: Sheep numbers in Bulgaria on 01 November (ShN), Number of sheep farms on 01 November (FN) and Consumption of lamb and goat meat for 1 year per member of household (kg) (Cons). Sources of information on which the model was constructed were annual data from the Ministry of agriculture and food, Republic of Bulgaria for the period 01.11.2000 – 01.11.2015 year [7] and the data from the National Statistical Institute [8].

The stationarity of the variables was tested with Augmented Dickey-Fuller Unit Root Test. Stationary time series have mean and variance, which are constant over time [3].

A nonstationary time series will have a time-varying mean or a time-varying variance or both [3].

The next step was to check for cointegration of the three variables with Johansen Cointegration Test [2].

VECM was constructed with lag length 1 and 1 cointegrated vector. An intercept was included in the model.

In order to forecast the number of sheep on 01 November 2016 and on 01 November 2017, one of the equations of the VECM was estimated with the method of least squares. The standard error of the regression, the coefficient of determination (R-squared), the Adjusted R-squared of regression, F-statistic of regression, Jarque – Bera Test of Normality, Breusch-Godfrey Serial Correlation LM Test and Autoregressive Conditional Heteroscedasticity Test of Residuals (ARCH Test) were calculated.

Granger causality test was performed with the help of Wald Test in order to check the short-run causal relationship, running from the independent variables to the dependent variable.

To check the stability of the model, the cumulative sum (CUSUM) and cumulative sum of square (CUSUMSQ) had been represented.

RESULTS AND DISCUSSIONS

The three time series appeared not to be stationary according to the graphical analysis and the Augmented Dickey-Fuller Unit Root Test (Fig.1, Fig. 2 and Fig. 3).

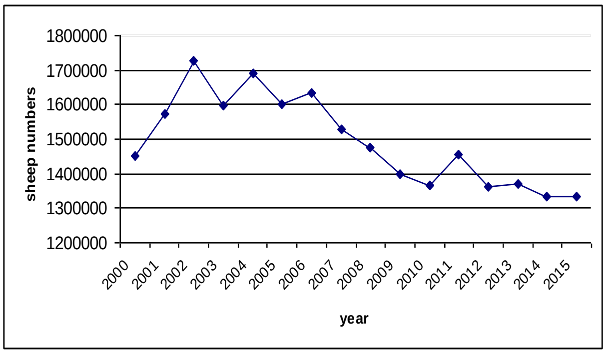

Fig. 1. Sheep numbers in Bulgaria on 01 November
*Note: Augmented Dickey-Fuller Test Statistic: -0.432409; 5% Critical Value: -3.1003

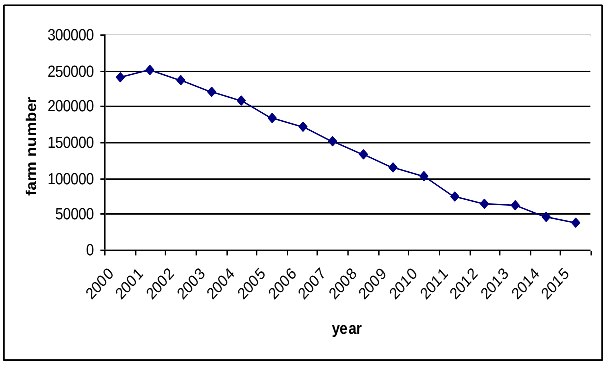

Fig. 2. Number of sheep farms on 01 November
*Note: Augmented Dickey-Fuller Test Statistic: -0.8555; 5% Critical Value: -3.1003

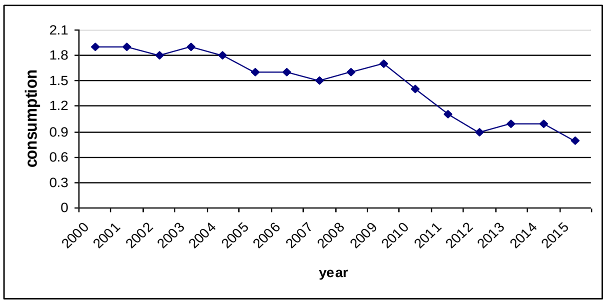

Fig. 3. Consumption of lamb and goat meat for 1 year per member of household (kg)
*Note: Augmented Dickey-Fuller Test Statistic: -0.2968; 5% Critical Value: -3.1003

During the studied period (2000 – 2015) the three variables showed a decreasing trend.

The Augmented Dickey-Fuller Unit Root Test showed that ShN was stationary at second difference (lag 1); FN and Cons were stationary at first difference (lag 1) (Fig. 4, Fig. 5 and Fig. 6).

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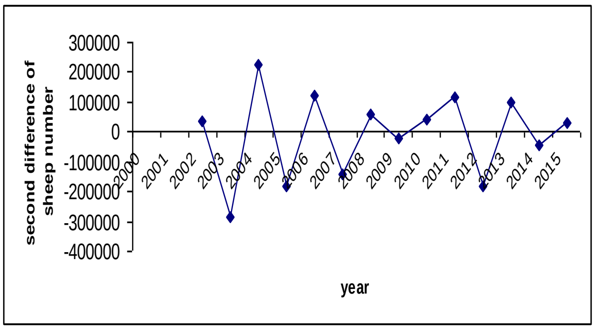

Fig. 4. Second difference of Sheep numbers in Bulgaria on 01 November
*Note: Augmented Dickey-Fuller Test Statistic: -5.01834; 5% Critical Value: -3.1483

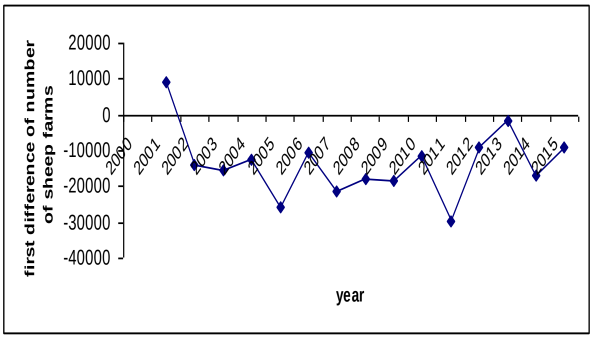

Fig. 5. First difference of Number of sheep farms on 01 November
*Note: Augmented Dickey-Fuller Test Statistic: -3.15363; 5% Critical Value: -3.1222

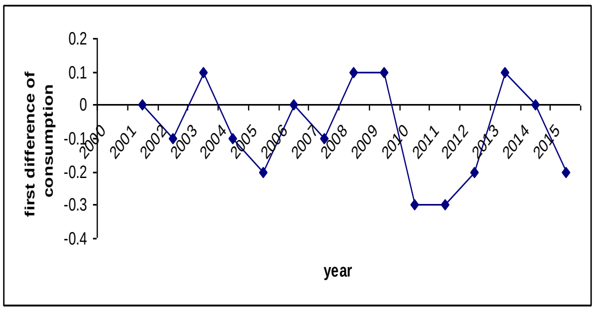

Fig. 6. First difference of Consumption of lamb and goat meat for 1 year per member of household (kg)
*Note: Augmented Dickey-Fuller Test Statistic: -3.3872; 5% Critical Value: -3.1222

According to the results of the Johansen Cointegration Test, the variables were cointegrated at 5% significance level and there were long-run relation (equilibrium) between them. The Likelihood Ratio indicates 3 cointegrating equation at 5% significance level (Table 1).

Table 1. Cointegration test results including intercept and no trend

Series: ShN, FN and Cons Lags interval: 1 to 1				
Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.937024	54.68531	29.68	35.65	None **
0.556846	15.97540	15.41	20.04	At most 1 *
0.279105	4.581666	3.76	6.65	At most 2 *
*(**) denotes rejection of the hypothesis at 5%(1%) significance level				
L.R. test indicates 3 cointegrating equation(s) at 5% significance level				

The three system equations of the VECM were:

(1.) D(ShN,2) = C(1)*(D(ShN(-1)) + 2634.864* Cons(-1) + 0.147* FN(-1) - 5736.906) + C(2)*D(ShN(-1),2) + C(3)*D(Cons(-1)) + C(4)*D(FN(-1)) + C(5)

(2.)D(Cons) = C(6)*(D(ShN(-1)) + 2634.864* Cons (-1) + 0.147* FN(-1) - 5736.906) C(7)*D(ShN(-1),2) + C(8)*D(Cons(-1)) + C(9)*D(FN(-1)) + C(10)

(3.)D(FN) = C(11)*(D(ShN(-1)) + 2634.864*Cons(-1) + 0.147*FN(-1) - 5736.906) + C(12)*D(ShN(-1),2) + C(13)*D(Cons(-1)) + C(14)*D(FN(-1)) + C(15)

Where:
D(ShN,2) - Second difference of Sheep numbers in Bulgaria on 01 November;
D(ShN(-1)) – First difference of Sheep numbers in Bulgaria on 01 November for the previous time period;
Cons(-1) - Consumption of lamb and goat meat for 1 year per member of household for the previous time period;
FN(-1) - Number of sheep farms on 01 November for the previous time period;
D(ShN(-1),2) - Second difference of Sheep numbers in Bulgaria on 01 November for the previous time period;
D(Cons(-1)) – First difference of Consumption of lamb and goat meat for 1 year per member of household for the previous time period;
D(FN(-1)) - First difference of Number of sheep farms on 01 November for the previous

time period;
D(Cons) - First difference of Consumption of lamb and goat meat for 1 year per member of household;
D(FN) - First difference of Number of sheep farms on 01 November;
C(1), C(2), C(3), C(4), C(6), C(7), C(8), C(9), C(11), C(12), C(13), C(14) - coefficients of the independent variables
C(5), C(10), C(15) – Intercepts.

Table 2 represented the estimation of the parameters of the first equation of the VECM. The method of least squares was used. The standard error of the regression, the coefficient of determination (R-squared), the Adjusted R-squared of regression, F-statistic of regression, Jarque – Bera Test of Normality, Breusch-Godfrey Serial Correlation LM Test and Autoregressive Conditional Heteroscedasticity Test of Residuals (ARCH Test) were represented.

Table 2. Estimation of the parameters of the equation. Dependent Variable D(ShN,2), N= 13

Variable	Coefficient	Standard error	t-Statistic (Probability)
C(1)	-1.344	0.27	-5.01 (0.001)
C(2)	-0.198	0.16	-1.21 (0.261)
C(3)	-128635.31	113926.70	-1.13 (0.292)
C(4)	2.561	2.32	1.11 (0.301)
C(5)	16683.00	37169.89	0.45 (0.666)
R-squared of regression			0.91
Adjusted R-squared of regression			0.87
Standard error of the regression			53416.81
F-statistic of regression (Probability)			21.20 (0.0003)
Jarque – Bera Test of Normality (Probability)			0.17 (0.92)
F-statistic of Breusch-Godfrey Serial Correlation LM Test - lag 1 (Probability)			0.59 (0.47)
F-statistic of ARCH Test - lag 1 (Probability)			3.65 (0.09)

The equation could be written with the substituted coefficients as follows:

D(ShN,2) = -1.344*(D(ShN(-1)) + 2634.864* Cons(-1) + 0.147* FN(-1) - 5736.906) -0.198*D(ShN(-1),2)) - 128635.31*D(Cons(-1)) + 2.561*D(FN(-1)) + 16683

Since the C(1) coefficient is a negative number with a probability less than 0.05, there is long-run causality, running from the independent variables to the dependent variable.

Table 3. Wald Test

Null Hypothesis: C(2)=0	
Chi-square (Probability)	1.462 (0.227)
Null Hypothesis: C(3)=0	
Chi-square (Probability)	1.275 (0.259)
Null Hypothesis: C(4)=0	
Chi-square (Probability)	1.222 (0.269)

The results from the Table 3 (p-values>0.05) showed that there is no short-run causality. The same conclusion can be made from the p-values of the coefficients C(2), C(3) and C(4) from the Table 2.
The plots of CUSUM and CUSUMSQ fall within the critical bounds of 5% which shows that the model was stable (Fig. 7 and Fig. 8).

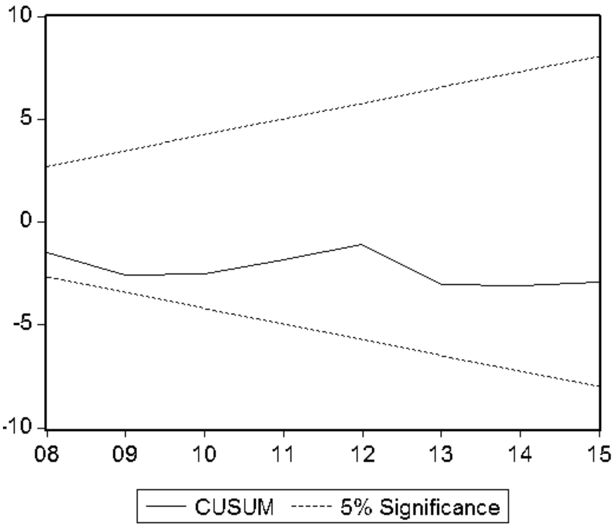

Fig.7. Plot of CUSUM

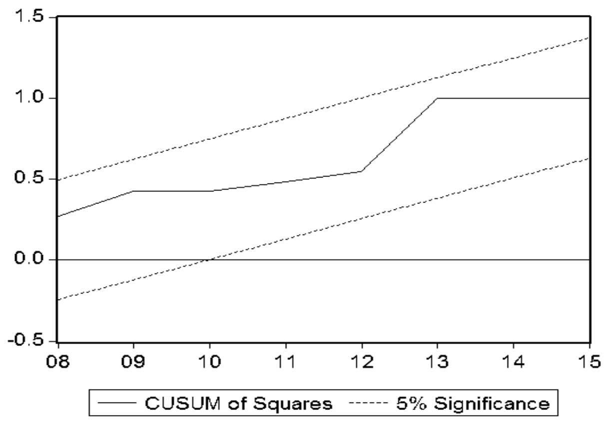

Fig. 8. Plot of CUSUMQ

With the help of the system equations, the forecasted sheep numbers in Bulgaria on

01.11.2016 and on 01.11.2017 were found. Dynamic solution was applied. The forecasted sheep numbers in Bulgaria on 01.11.2016 are 1,313,796; and on 01.11.2017 are 1,306,403.

CONCLUSIONS

The forecasted sheep numbers in Bulgaria on 01.11.2016 are 1,313,796; and on 01.11.2017 are 1,306,403.

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