Milk Production -Forecasting In Khartoum State, Sudan

Safa Abdelgadier Hassan [a], Hag Hamad Abdelaziz [b], Abdelateif Hassan Ibrahim[c] , Khalid Salih Mohamed Musa [d]

[a] *Department of Economics, Faculty of Economics and Social Studies, Bahr El-Ghazal, Wau, South, Sudan*
[b] *Department of Agricultural Economics, Faculty of Agricultural Studies, Sudan University of Science and Technology, Shambat , Sudan.*
[c] *Department of Agric-Economics, Faculty of Agriculture, University of Khartoum*
[d] *Department of Agricultural Economics and Agribusiness College of Agriculture, University of Bahri*

Abstract
The objective of this study was forecast milk production of Khartoum State, during (2018-2030), different techniques used for the prediction of total year milk yield. Auto-Regressive Integrated Moving Average (ARIMA) Model with statistical time –series modeling technique was used to develop using 29 yr. of historical milk-production data. The models predicted the total annual milk production, as performance measures, ARIMA analysis of the Mean Absolute Percentage Error (MAPE) was found to be 1.611. So, the ARIMA (1.0.0) model obtained accurate results regarding the performance to forecasting the dairy production.

Key words: *Milk-Production Forecasting, ARIMA Model.*
*Corresponding author. Email: safsaf dewa@ gmail.com

1. Introduction

Dairy production is one of the most important sectors in Sudan as it plays a big role in achieving food security. It also considered as one of the main pillars of the country's development. Dairy products are among the most important products of livestock sector (FAO, 2006). The total figure of milk produced in Sudan is increasing consistently over time with cattle milk constituting the lion share.

The up- grading of milk production during the 2006-2016 was attributed to the increment of cattle numbers, improvement of veterinary cares and increasing percentage of foreign bloods in the local breeds cross(MEF, 2016).

But it seemed that the dairy producers aren't commercially oriented as only 50% of the total milk produced in the country is available for human consumption (MAR.2017).

On the other hand, milk demand is in a continuous increase. It increased from 3.1 million tons in 2000 to about 35.7 million tons in 2002 (MEF, 2008). Forecasting of milk production help producers, extension works, planners and policy maker to estimate The supply requirement of milk in future and but appropriate plans to face growing demand of milk.in this study, an attempt has been made to forecast dairy production using statistical time-series modeling techniques and Auto-Regressive Integrated moving Average(ARIMA).

From the Annual Report "Ministry of Agriculture and Animal Resource and irrigation, Khartoum State (2018)", the data on milk production in Khartoum for period 1989 to 2017 was utilized for model fitting and data for subsequent periods from2017-2030(table 1and 2) were used for validation. The analysis was carried out by using SPSS package.

2. Methodology

2.1Auto-Regressive Integrated Moving Average (ARIMA) Model, (ARIMA Model for Time Series Data), the regression model takes the form:

2.1.1 Model Identification

At the outset, the stationary of the series is examined. In case the data is found to be non-stationary, stationarity is achieved by differencing technique. For instance, the differencing of first order is

Z= y_t - y_{t-1}

The next step in the identification process is to find the initial values for the orders of non-seasonal parameters p and q, which are obtained by looking for significant correlations in the auto correlation function (ACF) and partial autocorrelation function (PACF) plots.

For identifying the orders of AR component, a common practice is to see for significant spikes in the first few lags of the PACF graph and for, MA component, that of ACF graph,(Box, Jenkins;1994).

2.1.2 Estimation

The parameters are estimated by modified least squares technique appropriate to time series data.

2.1.3 Diagnostic checking

For the adequacy of the model, the residual are examined from the fitted model and alternative models are considered, if necessary- if the first identified model appears to be inadequate then other ARIMA models are tried until satisfactory model fits to the data.

The ARIMA model is given by (taken $z_t$as the already first differenced series, in our case d=1

$(z_t$-μ)- $α_1$ (z_{t-1}-μ)-………-$α_p$ (z_{t-p} -μ)

= e_t-$β_1 e_{t-1}$-…….- $β_q e_{t-q}$

Is called ARIMA (p, 1, q) of order (p.q),

Different model are obtained for various combination of AR and MA individually and collectively (Makridakisetal.1998).the best model is obtained on the basis of minimum value of Akaike information criteria (AIC) given by.

AIC=-2logL+2m

Where:

M=p+q and L is likelihood function.

The performances of different approaches have been evaluated on the basis of Mean Absolute percentage Error [MAPE] and Root Mean Square Error [RMSE].

Which are given by:

$$MAPE=\frac{1}{n}\sum_{t-1}^{n} \left| \frac{yt-ft}{yt} \right| *100$$

$$RMSE=\sqrt{\frac{1}{n}\sum_{t-1}^{n}(yt-ft)2}$$

Where:

yt: is the original milk yield in different years and

ft: is the forecasted milk yield in the corresponding years and

n: is the number of years used as forecasting period

3. Result and discussion

3.1. ARIMA model

Table 1 shows the yearly milk production for the period 1989-1990 to 2017-2018 time plot (figure A) of milk production data revealed that there is increasing trend in the data. For a precise performance of a forecasting model, it is necessary to make adjustments to the parameters for each technique. Within this context, for the application of ARIMA model (Box, Jenkins; 1994) the data adjustments were generated by SPSS statistical software for 13 periods, in defining the components of level, trend, and a tool contained in the Excel software. As demonstrated in Table 2, the ARIMA model, due to the lower value of MAPE, the following adjustment parameters (p, d, q) were considered, shown in Table 2.

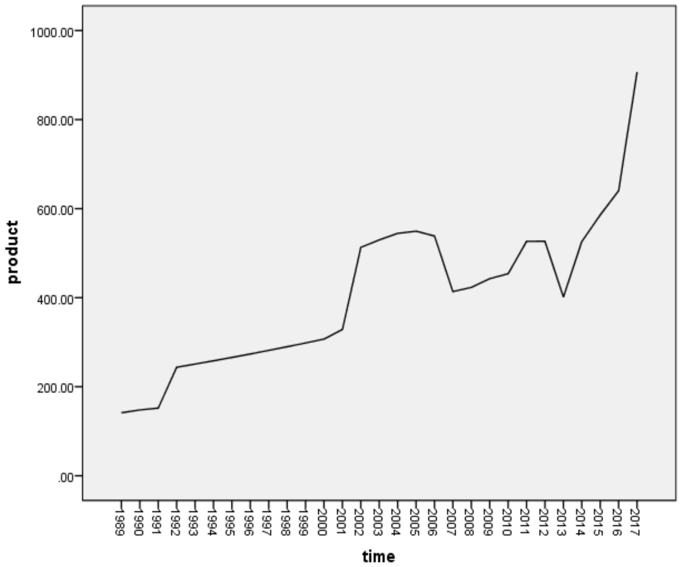
ARIMA model the stationary check of the series revealed that it was non-stationary. Merely by using the first differencing technique, it was made stationary (Fig. B) and thus the value of d was 1. The graphs of sample ACFs and PACFs Were plotted (Fig. C and D). On matching plots with the theoretical ones of various ARIMA processes, the PACF of AR (1) compared well with the sample PACF as spikes cut off after lag 1. Hence the order of AR component P was taken as 1.Plot of differenced series over years (Figure B). The forecast adjustments were made from 1989 to 2018 in order to project future forecast for the year 2030, in the 13 period to, as shown in table 2.

Table 1: Milk production in Sudan for the period 1989to 2017.

s.n	Year	Observed milk production(million ton)
1	1989	4. 95
2	1990	4.99
3	1991	5.02
4	1992	5.49
5	1993	5.52
6	1994	5.55
7	1995	5.58
8	1996	5.61
9	1997	5.64
10	1998	5. 67
11	1999	5. 70
12	2000	5.73
13	2001	5.79
14	2002	6.24
15	2003	6.27
16	2004	6.30
17	2005	6.31
18	2006	6.29
19	2007	6.02
20	2008	6.05
21	2009	6.09
22	2010	6.12
23	2011	6.27
24	2012	6.27
25	2013	5.99
26	2014	6.27
27	2015	6.37
28	2016	6.46
29	2017	6.81

Source: Ministry of Agriculture and Animal wealth and irrigation, 2018

Figure A: Khartoum milk production in (million tons) over years



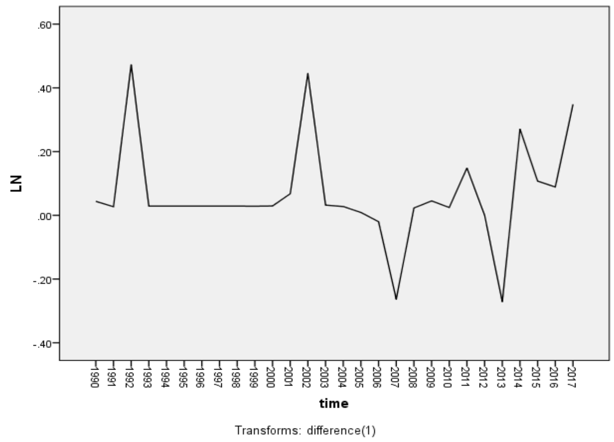
Source: Data Analysis –SPSS

Table 2: ARIMA parameter (Adjustment parameters) Forecasts of Milk Production in Khartoum State- Sudan using ARIMA parameter (p,d,q) models.

s.n	Year	Lcl	Ucl	ARIMA(1.0.0)
1	2018- 2019	6.50	7.18	6.84
2	2019- 2020	6.46	7.30	6.87
3	2020- 2021	6.47	7.38	6.92
4	2021- 2022	6.50	7.44	6.97
5	2022- 2023	6.54	7.50	7.02
6	2023- 2024	6.59	7.56	7.07
7	2024- 2025	6.64	7.63	7.13
8	2025- 2026	6.70	7.69	7.19
9	2026- 2027	6.76	7.75	7.27
10	2027- 2028	6.81	7.81	7.31
11	2028- 2029	6.87	7.87	7.35
12	2029- 2030	6.93	7.94	7.43
13	2030-2031	6.99	8.00	7.49
	MAPE			1. 611
	RMSE			0.156

Source: Data Analysis –SPSS

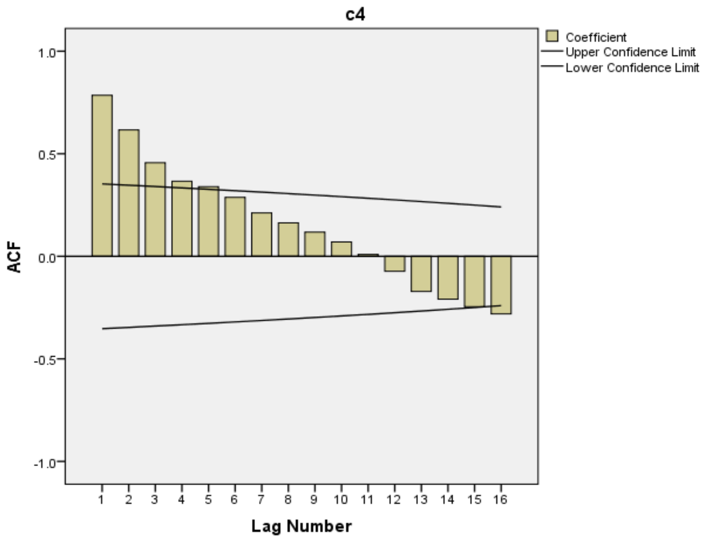
Figure B: Difference Series over the Year



Source: Data Analysis -SPSS

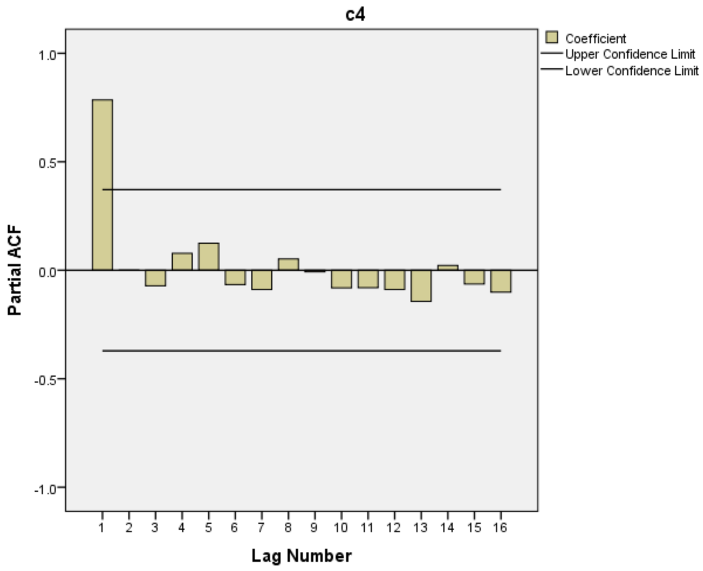
Also, in order that the proposed model adequately represents the data and at the same time have lesser number of parameters an MA component of order 1 was also added to the Model. In addition, using SPSS package for different values of p and q (0.1 or2), in this study ARIMA (1.0.0) model was found to be the best model (table 2).

Figure c: Auto-correlation function in ARIMA model



Source: data analysis -SPSS

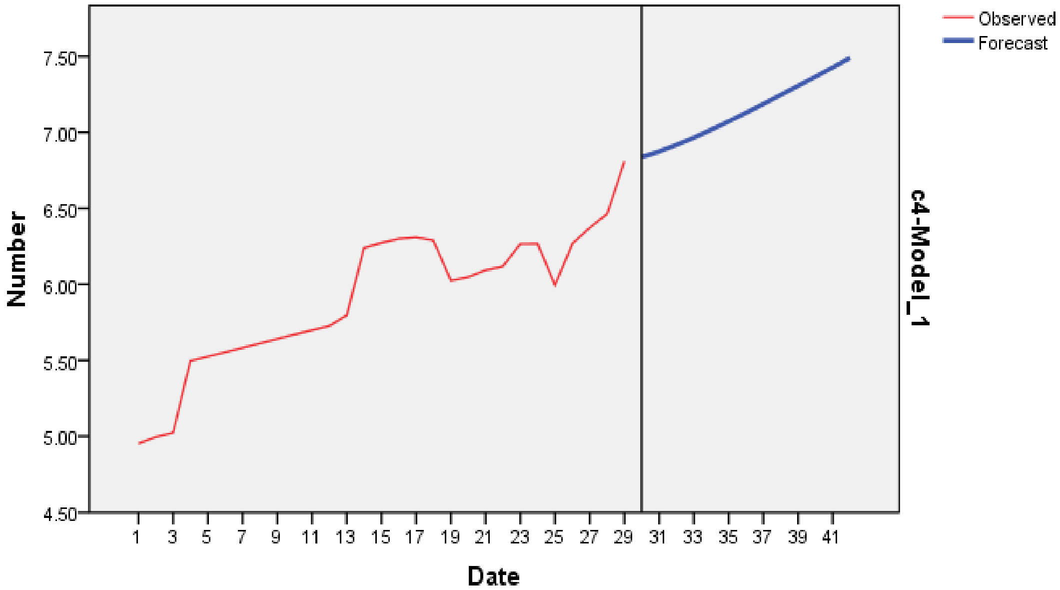
Figure D partial Autocorrelation analyses in the ARIMA model



Source: data analysis -SPSS

For this model the RMSE came out to be 0.156. MAPE and RMSE were computed for the forecasted milk production for the year 201-2030(table 2).the results revealed that; ARIMA (1, 0, and 0) model came out to be performing better when the forecasts were validated.

Figure E actual production and forecast application of ARIMA model



Period: 1989 to 2030
Source: data analysis SPSS.

4. Conclusions

This study aimed to forecasts milk production in Khartoum state using the ARIMA model, The ARIMA forecasting model accuracy for a given range, ARIMA model has many assumptions that can be met. Despite these constraints, scientific evidence shows that

ARIMA methodology is competitive in terms of accuracy (coleth; 2013). Based on Table 2 and on model performances, the (ARIMA) model, according to MAPE was best fitted. The actual production in 2030(Period2018 -2030), according to data shown in Figure1, The ARIMA achieved an accuracy of 1,611% MAPE. Within this context, the model reached a compatible performance for the time series in analysis (Lewis; 1997). For a MAPE below 10% is considered a good forecast, (pankratz; (1983). the figure E shown forecast from 2018 to 2030).

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