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Forecasting the Contribution Agricultural Sector on the Gross Domestic Product, Sudan

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Abstract

The objective of this study was to forecast the contribution of the Sudanese agricultural sector on the country GDP for the period (2023- 2038). Auto-Regressive Integrated Moving Average (ARIMA) Model with statistical time series modeling technique was used in the analysis. The research depended mainly on secondary data which was collected from different relevant sources. Results showed that ARIMA (1,0,0) was the best model because there is a noticeable agreement between the observed and expected forecasted values and the Mean Absolute Percentage Error (MAPE) was found to be 18.8. Result also revealed that, the forecasted value for the year 2038.

Keywords

Agricultural Sector, Gross Domestic Product, Forecasting, ARIMA Model, Auto-Regressive.

Introduction

After the 2018 revolution, the former Transitional Government of Sudan (TGoS) (2019 – 2021) adopted several macroeconomic measures including removing fuel subsidies unifying exchange rates (February2021) ,and implementing some shock response measures such as the Sudan Family Support Program launched in February 2021 aimed at qualifying for assistance under the Heavily Indebted Poor Countries Initiative in three years . (Abdullah , 2021).

However, when the military over threw the TGoS in October 2021 ,donor supports were immediately suspended or frozen, depriving the country of expected flows of external resources in terms of debt forgiveness, development assistance, and concessional loans because those were tied to realizing a transition to democracy. Despite such challenges, Sudan has great potential, including its considerable agricultural natural resources base. Those resources include around 183.3 million feddan of arable land, representing around 39.3 percent of the country's area. In addition, Sudan has diverse sources of water, including rivers, lakes, seasonal streams, and rainfall. Moreover, the country has diversified climate zone (UNEP and HCENR 2020, 105,135). With those resources and the numbers of people employed in the agricultural sector, the future well-being of the Sudanese people, particularly the poor, will depend on agriculture (Khan 2004). Al though over the last two decades, the sector's performance has been poor compared with its enormous potential; agriculture can once again lead growth as it did before 1999. But to rely on the sector to realize inclusive and sustainable growth, several challenges need to be addressed. The review of the agricultural sector's performance shows that between 1990 and 2021, the sector's share in gross domestic product (GDP) was 34.2 percent on average, whereas the sector's contribution to real economic growth was only 2 percent. In addition, the sector is the main source of livelihood for around 65 percent of the population and accounts for a considerable contribution to the labor forces 47 percent of the total labor force was employed in agriculture during the 1990 to 2021 period. Furthermore, the sector has historically been the main source of foreign currency.

Contributing around 80 percent of exports until 1999. That share decreased to around 10 percent during the 1999 – 2011 periods. In the aftermath of the South Sudan secession, the sector has since returned to the top of exports with an average share of 55 percent of total exports (CBoS2021).

The agricultural sector's generally poor performance is reflected in low productivity (relative to other countries in the region). We can attribute the low productivity to several factors, the most important of which are poor access to and use of inputs, technology, credit, and agricultural services. This is compounded by substandard infrastructure.

With the oil sector assuming the central role in development during the oil era (2000–2010), the importance and potential of agriculture as a driver of growth and foreign currency earnings was overlooked. That has led to the reallocation of resources and new investments away from the agricultural sector to benefit the oil sector. This can be observed directly when oil exports declined after the secession of South Sudan, with exports' share in real GDP declining to 1 percent in 2011 from 28 percent in 2010 (World Bank 2023), although that share had been more than 8 percent in 1998 (i.e., before oil exports started). Labor also shifted from agriculture to the oil industry and related services sectors that flourished with the oil, resulting as well in rapid migration from rural to urban centers (due to the concentration of basic services in the main cities); hence, oil has led to uneven development .The low investment in the agricultural sector has led to negative effects on the cost-efficiency and the competitiveness of agricultural exports in the international market.

The promise of agricultural transformation has not materialized given the lack of political commitment by the political elite. This is manifested in the meager allocation of resources and the lack of commitment to follow through on development plans. Furthermore, government expenditure directed to the sector is low and it is unfairly distributed among the subsectors the traditional subsector receives the smallest share compared with the irrigated subsector (World Bank Group 2016). Additionally, climate change represents a serious risk for the sector's current and future performance. Four main climate stressors have been identified as affecting all subsectors, regions, and groups: declining rainfall, rising temperature, drought, and flooding (Siddig et al. 2020).

The research aims to predict the contribution of the agricultural sector on the gross domestic product of the Republic of Sudan using the ARIMA model.

Literature Review

Agricultural Sector

In Sudan, the agricultural sector encompasses various sub-sectors that contribute to the overall agricultural GDP. Some key sectors within agriculture include: Crop Production: This includes the cultivation of crops such as sorghum, millet, wheat, barley, maize, sesame, cotton, and vegetables. Crop production is a significant contributor to agricultural GDP, providing food security and raw materials for industries.(CBoS2021)

Livestock Farming: Livestock farming involves the rearing of animals such as cattle, sheep, goats, and camels for meat, milk, hides, and other products. Livestock farming contributes to agricultural GDP through domestic consumption and export.(CBos2022)

Fisheries: Fisheries play a role in Sudan's agricultural sector, particularly in areas with access to rivers, lakes, and coastal waters. Fish farming and capture fisheries contribute to food security and provide livelihoods for fishing communities.

Forestry: Forestry involves the management and harvesting of timber, fuel wood, and non-timber forest products. It contributes to agricultural GDP through the sustainable use of forest resources and the production of wood products.

Irrigation Agriculture: Irrigation agriculture utilizes water resources from rivers, groundwater, and irrigation schemes to support crop production, particularly in arid and semi-arid regions. Irrigated agriculture contributes to agricultural GDP by increasing agricultural productivity and diversifying crop production.

Agribusiness: Agribusiness encompasses various value-added activities in the agricultural sector, including processing, storage, transportation, and marketing of agricultural products. Agribusiness contributes to agricultural GDP by adding value to raw agricultural commodities and creating employment opportunities along the agricultural value chain. These sectors collectively contribute to Sudan's agricultural GDP, which plays a crucial role in the country's economy, employment, and food security.

Overall, agriculture plays a critical role in Sudan's economy, providing livelihoods for millions of people and contributing to food security, export earnings, and economic development. Addressing challenges and investing in sustainable agricultural practices will be essential for unlocking the full potential of Sudan's agricultural sector.

Methodology

The time series analysis can provide short-run forecast for sufficiently large amount of data on the concerned variables very precisely, see Granger and New-bold (1986). In univariate time series analysis, the ARIMA models are flexible and widely used. The ARIMA model is the combination of three processes: (i) Autoregressive (AR) process, (ii) Differencing process, and (iii) Moving-Average (MA) process. These processes are known in statistical literature as main univariate time series models, and are commonly used in many applications. (Wolters,2013)

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

Model Identification

At the outset, the stationary of the series is examined. In case the data is found to be non-stationary, stationary 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).

Estimation

The parameters are estimated by modified least squares technique appropriate to time series data. (Wabomba,2016)

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

$(z_t-\mu)- \alpha_1 (z_{t-1}-\mu)-\ldots\ldots\ldots-\alpha_p (z_{t-p} -\mu)$

$= e_t-\beta_1 e_{t-1}-\ldots\ldots\ldots - \beta_q e_{t-q}$

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:

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

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

Where:
y_t: is the original Contribution of the agricultural sector yield in different years.
f_t: is the forecasted Contribution of the agricultural sector yield in the corresponding years.
n: is the number of years used as forecasting period.

Result and discussion

Descriptive Statistics

The results of descriptive statistics (Table 1). Data are used directly without transformation

Table 2. Descriptive Statistics:

Agricultural Sector (AGDP)	
Mean	37.05
Standard Error	1.05
Median	36.00
Mode	31.00
Standard Deviation	8.43
Minimum	26.00
Maximum	56.00
Confidence Level (95.0%)	2.11

Source: Data Analysis –SPSS

Note. AGDP = Agricultural Growth Domestic Product.

ARIMA model

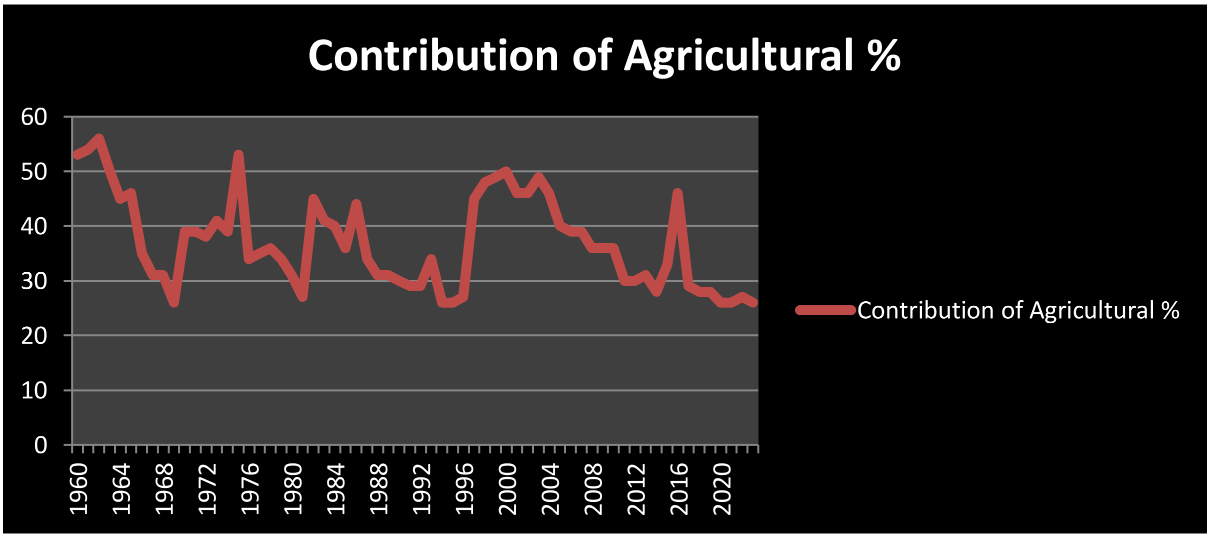
Table (2) shows the percentage of the agricultural sector's contribution to the gross domestic product during the study period (1960 - 2022) data revealed that there is increasing trend in the data. For a precise performance of a forecasting model, it is necessary to make adjustments to the parameters 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 16 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.

Table 2. Contribution of Agricultural Sector to Gross Domestic Product (GDP) for the period (1960 - 2022) - Sudan

Year	Agri%	Year	Agri%	Year	Agri%	Year	Agri%
1960	53	1976	34	1991	29	2007	36
1961	54	1977	35	1992	34	2008	36
1962	56	1978	36	1993	26	2009	36
1963	50	1979	34	1994	26	2010	30
1964	45	1980	31	1995	27	2011	30
1965	46	1981	27	1996	45	2012	31
1966	35	1982	45	1997	48	2013	28
1967	31	1983	41	1998	49	2014	33
1968	31	1984	40	1999	50	2015	46
1969	26	1985	36	2000	46	2016	29
1970	39	1986	44	2001	46	2017	28
1971	39	1987	34	2002	49	2018	28
1972	38	1988	31	2003	46	2019	28
1973	41	1989	31	2004	40	2020	26
1974	39	1990	30	2005	39	2021	26
1975	53	1991	29	2006	39	2022	27

Source :Various reports from the Central Bank of Sudan - Central Statistical - Ministry of Finance.

Figure A: Contribution of the Agricultural Sector to GDP (%) Over Years



Source: Data Analysis –Excel

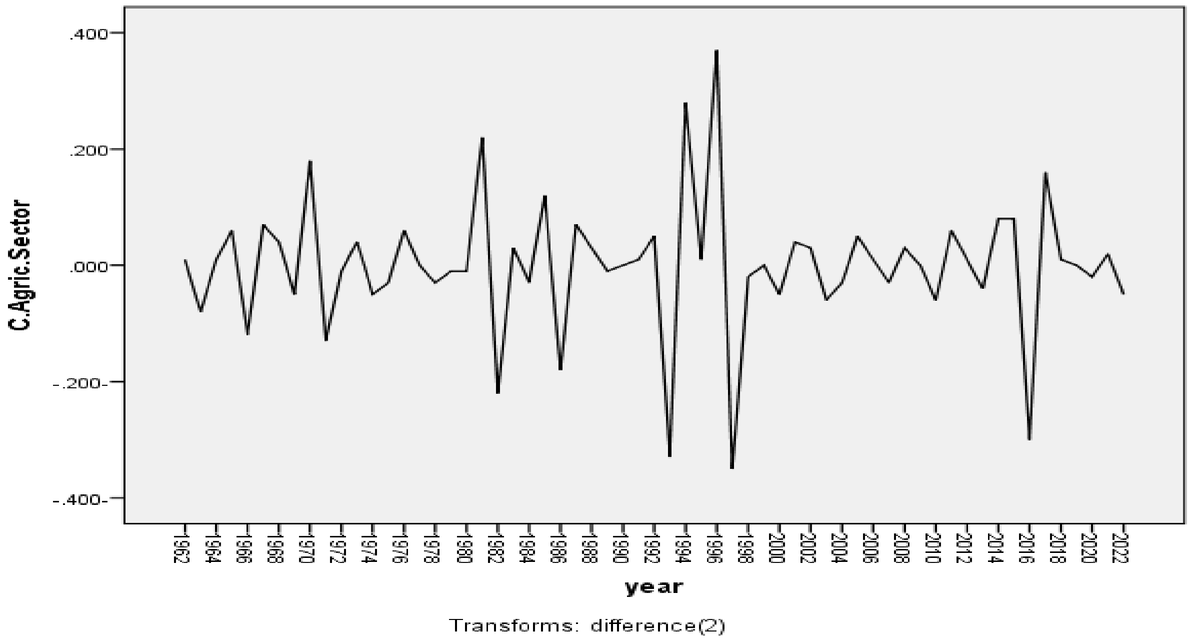
Table 2: ARIMA Parameter (Adjustment Parameters) Forecasts of Agricultural Sector Contribution to GDP - Sudan Using ARIMA Parameter Models (p, d, and q).

s.n	Year	Lcl	Ucl	ARIMA(1.0.0)
1	2022 – 2023	.21	.61	.29
2	2023 – 2024	.21	.61	.29
3	2024 – 2025	.21	.60	.29

4	2025 – 2026	.20	.60	.29
5	2026 – 2027	.20	.60	.28
6	2027 – 2028	.20	.60	.28
7	2028 – 2029	.20	.60	.28
8	2029 – 2030	.20	.59	.28
9	2030 – 2031	.19	.59	.28
10	2031 – 2032	.19	.59	.27
11	2032 – 2033	.19	.59	.27
12	2033 – 2034	.19	.59	.27
13	2034 – 2035	.19	.59	.27
14	2035 – 2036	.19	.58	.27
15	2036 – 2037	.18	.58	.27
16	2037 – 2038	.18	.58	.28
MAPE		18.8		
RMSE		0.101		

Source: Data Analysis –SPSS

Figure B: **Difference Series over the Year**

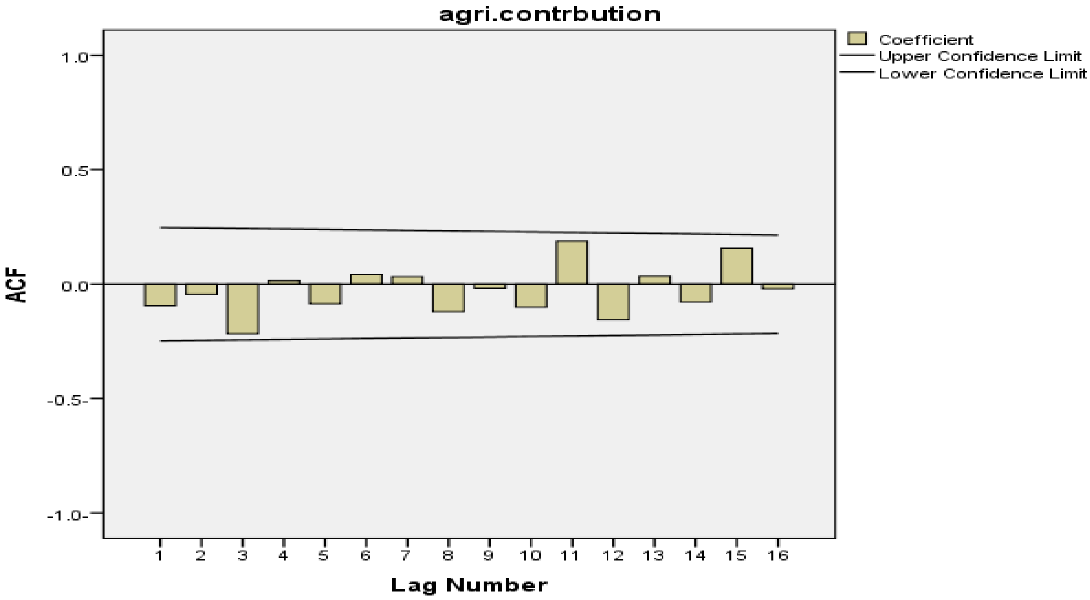


Source: data analysis - SPSS

Figure (A) shows a general trend toward decline, so the first differences will be taken to fix the arithmetic mean. Also, the contrast is not constant. Figure (B) shows the change that occurred to the data after taking the second differences of the data, which made the arithmetic mean constant.

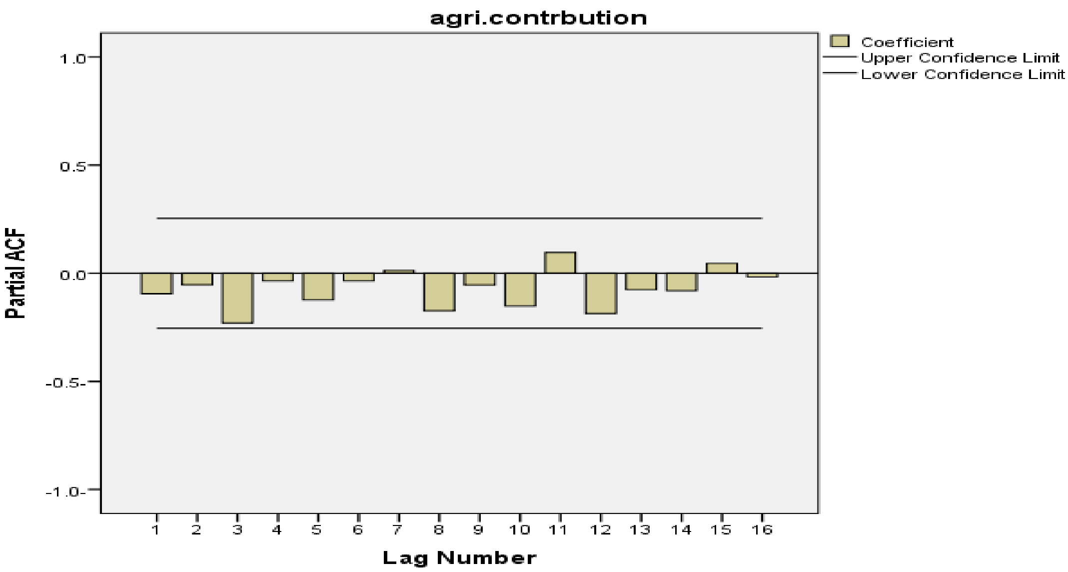
Most of the autocorrelation agreements between the error terms fall within the 95% confidence interval, which means that the autocorrelation between the error terms is not significant, and therefore the model does not suffer from the problem of autocorrelation of the buffer. . The graphs of sample ACFs 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).

Figure C: Auto-correlation function in ARIMA model



Source: data analysis –SPSS

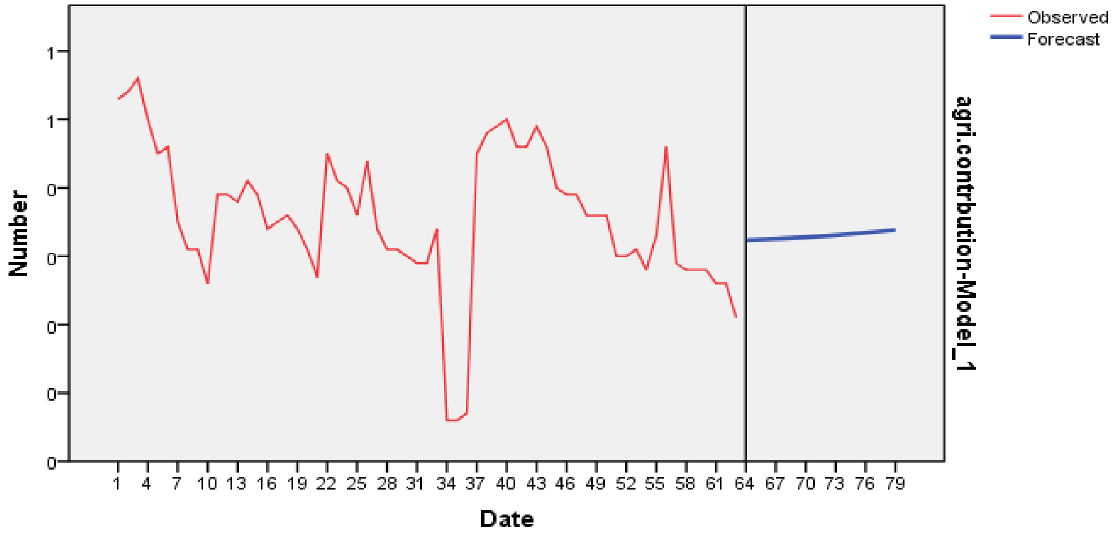
Figure D: Partial Autocorrelation Analyses in the ARIMA Model



Source: data analysis –SPSS

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).

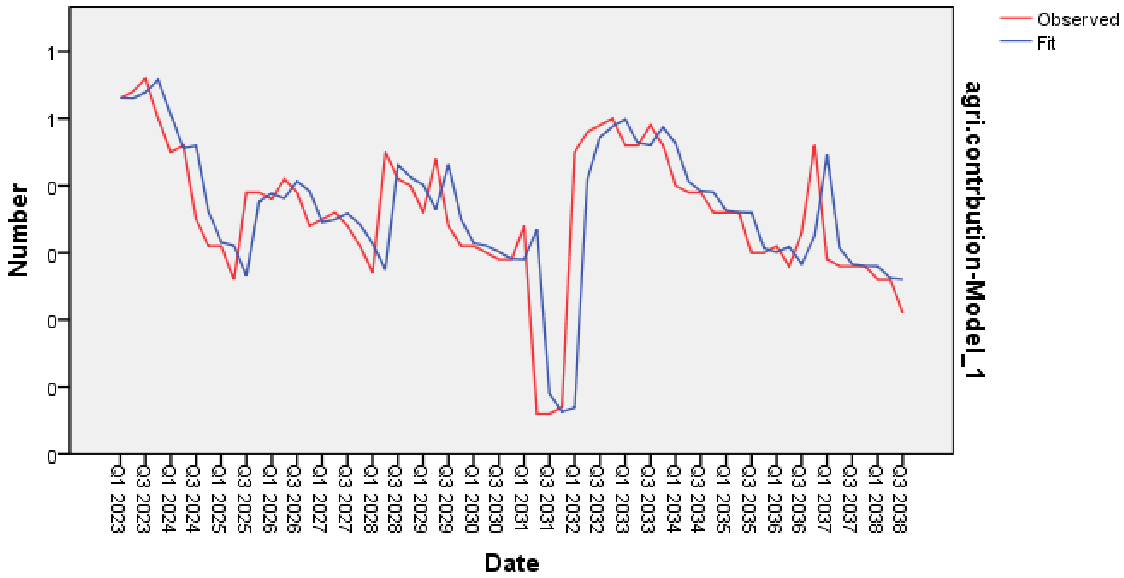
Figure E: Actual Agricultural Sector Contribution and forecast Application of ARIMA Model



Source: Data Analysis –SPSS

For this model the RMSE came out to be 0.101. MAPE (18.8) and RMSE were computed for the forecasted Agricultural contribution for the year 2022 -2038 (table 2).the results revealed that; ARIMA (1, 0, and 0) model came out to be performing better when the forecasts were validated. The timeline of these predictions was also determined, which showed the same node tracking the encryption, figure (F)/.

Figure F: Drawing Showing the Original Series of Data and the Predicted Series



Source: Data Analysis –SPSS

Summary and Conclusion

The aim of the study was to model and forecast agricultural sector contribution to gross domestic product based on ARIMA model approach based on the annual data (from 1960 to 2022). Approach is conducted Econometrics to obtain an appropriate ARIMA model, and we used this model to forecast the agricultural sector contribution for the next 16 years (from 2023 to 2038). Time series plots and the correlogram plots were used for testing the stationary of the data. Also, the MLE was used for estimating the model. Using the different goodness-of-fit measures (MSE, AIC, and BIC), the various ARIMA models with different order of autoregressive and moving-average terms were compared. We find that the best model is ARIMA (1,0, 0), because have the minimum values of MSE, AIC, and BIC. Moreover, we expect that the agricultural sector contribution will continue to raise according to the forecasted values form our model.

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