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Agricultural Production and Economic Reforms in India (1991-2021): A Time Series Analysis

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Abstract

The diversifying impact of Economic Reforms on various sectors reveals that agricultural production on various crops has been intensified and increased manifold. This study tries to apply ARIMA model for the time series data for a period from 1991-92 to 2020-21. Using the software Eviews7 the collected data have been analyzed and the interpretations are given accordingly. It was found that ARIMA (1,1,1) model to be the most appropriate model for the 30 years data. The analysis shows that the present growth rate in the total food grain production in the years will tend to increase based on the other related factors and its impact on the total agricultural production.

Keywords: *Total food grains, ARIMA, time series.*

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Introduction

Economic reforms are much needed and they brought about fundamental changes that were launched in 1991 with the aim of liberalizing the economy and to quicken its rate of economic growth. The reforms mainly intended to bridge the gap and to bring about cooperation of the private sector with that of public sector in the growth method of the Indian Economy. The essential features of economic reforms are – Liberalization, Privatization and Globalization (LPG).

The need of Economic reforms was much felt in order to smoothen the flaws that were prevailing in the form of poor economic performance of public sector, adverse balance of payments, fall in foreign exchange reserves, huge debts of the government, inflationary pressure and also the need for bringing out stabilization measures and to improve the efficiency in the performance of various sectors in the Economy.

A notable feature in the sphere of agriculture in the post Economic Reforms ensured a favourable shift in increasing in the production and productivity of agriculture. But the distribution was not evenly poised all over the country.

- Marketing facilities
- Adaptation to modern technology

Moreover, the decline in the capital formation, lack of adequate expenditure on irrigation and other extension services, cheap institutional credit, livelihood insecurity have led to the slow progress in the overall growth of the economy.

The history of agriculture is complex, spanning back to thousands of years across a wide variety of different geographic regions, climate, cultures and technological approaches.

Agricultural Economics is an applied social science that deals with how producers, consumers and services use scarce and natural resources in the production, processing, marketing and consumption of food and fiber products.

Major Tasks

- Government to initiate policy and programmes
- Investments for resource mobilization and deployment
- To make agriculture more vibrant and viable
- Prevention of fragmentation of land holdings
- Migration of farmers to non-farming activities
- Coverage of credit and insurance

Review of Literature

Volkan S, Edigera, Sertac, Akarb, Cumhurbas Ankaya and Ankara (Volkan S, 2007), in their study on "ARIMA forecasting of primary energy demand by fuel in Turkey" focused on the forecasting of energy demand in emerging markets is one of the most important policy tools used by the decision makers all over the world. In Turkey, most of the early studies used include various forms of econometric modeling. However, since the estimated economic and demographic parameters usually deviate from the realizations, time-series forecasting appears to give better results. In this study, we used the Autoregressive Integrated Moving Average (ARIMA) and seasonal ARIMA (SARIMA) methods to estimate the future primary energy demand of Turkey from 2005 to 2020. The ARIMA forecasting of the total primary energy demand appears to be more reliable than the summation of the individual forecasts. The results have shown that the average annual growth rates of individual energy sources and total primary energy will decrease in all cases except wood and animal–plant remains which will have negative growth rates. The decrease in the rate of energy demand may be interpreted that the energy intensity peak will be achieved in the coming decades. Another interpretation is that any decrease in energy demand will slow down the economic growth during the forecasted period. Rates of changes and reserves in the fossil fuels indicate that inter-fuel substitution should be made leading to a best mix of the country's energy system.

Purna Chandra Padhan (Padhan, 2012) in his study on "Application of ARIMA Model for Forecasting Agricultural Productivity in India" has made an attempt in forecasting of any issues, events or variables requires an in-depth understanding of the underlying factors affecting it. Such is the case for forecasting annual productivity of agricultural crops. Agricultural productivity, in the context of India, extensively depends upon numerous factors namely: good rainfall, timely use of appropriate fertilizer and pesticides, favorable climate and environments, agricultural subsidies given to farmers etc. Therefore, forecasting productivity of agricultural crops is not only tedious but also indispensable, as large chunk of people depends on agriculture for their livelihood. Various uni-variate and multi-variate time series techniques can be applied for forecasting such variables. In this paper, ARIMA model has been applied to forecast annual productivity of selected agricultural product. For empirical analysis a set of 34 different products has been considered, contingent upon availability of required data. Applying annual data from 1950 to 2010, forecasted values have been obtained for another 5 years since 2011. The validity of the model is verified with various model selection criteria such as Adj R^2, minimum of AIC and lowest MAPE values. Among the selected crops, tea provides the lowest MAPE values, whereas cardamom provides lowest AIC values.

Debnath M K, Kartic Bera, and Mishra P (Debanath M.K, 2013) in their study on "Forecasting Area, Production and Yield of Cotton in India using ARIMA Model" on cotton which is as an important crop in India. India is the second largest exporter of cotton next to US. This study focuses on forecasting the cultivated area and production of cotton in India using Autoregressive Integrated Moving Average (ARIMA) model. Time Series data covering the period of 1950–2010 were used for the Study. The study revealed that ARIMA (0, 1, 0) ARIMA (1, 1, 4) and ARIMA (0, 1, 1) are the best fitted model for forecasting of cotton area, production and yield in India respectively. The analysis shows that if the present growth rates continue then the cotton area, production and yield in the year 2020 will be 10.92 million hectares, 39.19 million bales of 170 kg of each and 527 kg/hectare respectively.

Celik S, Karadas K and Eyduran E (Celik S, 2017) in their study on "Forecasting the Production of Groundnut in Turkey Using ARIMA Model" made an effort to forecast groundnut production amounts between the years 2016 and 2030 by using Autoregressive Integrated Moving Average (ARIMA) models. In the study, ARIMA (0,1,1) was found to be the most appropriate model among the six studied ARIMA models in forecasting the groundnut production amounts for the next 15 years. We forecasted that annual amount of groundnut production obtained in the year 2016 was 138,98 thousand tons and it reached to 167,28 thousand tons in the year 2030 with a significant acceleration for groundnut production. Forecasting results of the ARIMA (0,1,1) illustrated an increasing trend in the amount of groundnut production, and they might help to determine a better policy for increasing groundnut production in Turkey.

Pawan Kumar Sharma, Sudhakar Dwivedi, Lyaqat Ali and Arora R K (Pawan Kumar Sharma, 2018) in their study on "Forecasting Maize Production in India using ARIMA Model" made an attempt to estimate the area, production and productivity of any crop in near future.

There are several methods available for foresting the future figures and autoregressive integrated moving average (ARIMA) is one of them. Maize is an important cereal of India, keeping in view its importance for rainfed areas of the country and diverse uses. The present study was conducted to forecast maize production for the year 2018 to 2022 based on the estimation of suitable ARIMA model. The analysis of ACF & PACF of differenced series revealed that ARIMA (2,1,0) was the most suitable model for forecasting based on the diagnostics, such as ACF, PACF, AIC, SBC etc. The selected ARIMA model predicted an increase of 13.76 percent increase in maize production in next five years w.e.f. 2017 to 2022.

The present study has been conducted by **Ajay Kumar and Urmil Verma** (Verma, 2020) on "Forecasting mustard yield in Haryana with ARIMA model" analyzed to find out mustard yield forecast models for Bhiwani and Hisar districts of Haryana using autoregressive integrated moving average (ARIMA) technique. The main focus of the study is to forecast five years ahead mustard yield in the said districts. The selection criteria like Akaike information criteria and Bayesian information criteria acted as a guiding hint to decide the final models. The forecast figures and real-time yield(s) for both the districts are compared on the basis of mean absolute percentage error to check the validity performance of the developed models.

Importance of the Study

Future of Indian agriculture is a very important question for the planners and all other stakeholders. Government should address the key challenges in the area of small holdings, primary and secondary processing units, supply chain, infrastructural facilities, efficient use of resources, marketing facilities, reducing the intermediaries, etc. This study focuses on the growth rate of agricultural production since the economic reforms from 1991 to 2021.

Statement of the Problem

Inspite of the advantageous weather and soil conditions, high demand for food, untapped opportunities, various fiscal incentives given by the government for inputs, production infrastructure, availability of cheap credit facilities, better marketing accessibility, individual startups of entrepreneurial ventures to do lot of investments, research and development and other aspects have got greater impact on total agricultural production. This study would highlight the growth pattern of some of the selected crops in terms of production over a period of time.

Objectives of the study

- To evaluate the agricultural production in India over a period of time.
- To predict the growth pattern using ARIMA model with respect to total food production.

Methodology

This study is based on the secondary data collected from the reports of Reserve Bank of India. The study period covers from 1990-91 to 2020 – 21. The selected crops are rice, wheat, cereals, pulses and total food production measures in terms of lakh tonnes. The data are analyzed using MS Excel and EViews 7. Graph and tables are being presented and interpreted accordingly.

Statistical Analysis and Interpretation

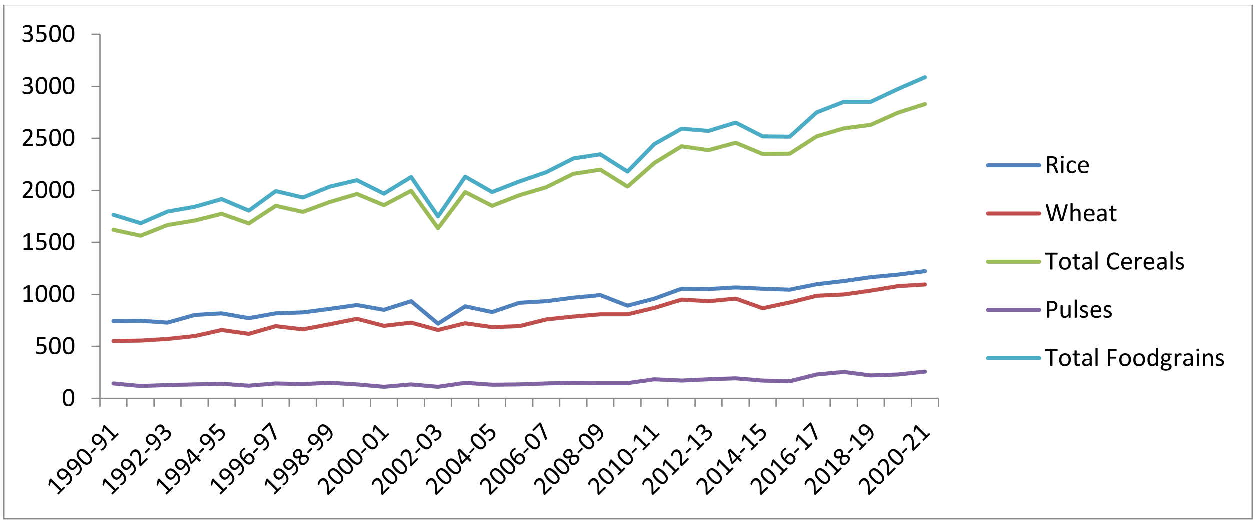
Table 1: Statistical data on Total Cereals, Pulses and Food grains in tonnes

Year	Rice	Wheat	Total Cereals	Pulses	Total Food grains
1990-91	743	551	1621	143	1764
1991-92	747	557	1564	120	1684
1992-93	729	572	1667	128	1795
1993-94	803	598	1710	133	1843
1994-95	818	658	1775	140	1915
1995-96	770	621	1681	123	1804
1996-97	817	694	1852	142	1994
1997-98	825	664	1793	138	1931
1998-99	861	713	1887	149	2036
1999-00	897	764	1964	134	2098
2000-01	850	697	1857	111	1968
2001-02	933	728	1995	134	2129
2002-03	718	658	1637	111	1748
2003-04	885	722	1983	149	2132
2004-05	831	686	1852	131	1984
2005-06	918	694	1952	134	2086
2006-07	934	758	2031	142	2173
2007-08	967	786	2160	148	2308
2008-09	992	807	2199	146	2345
2009-10	891	808	2035	147	2181
2010-11	960	869	2263	182	2445
2011-12	1053	949	2422	171	2593
2012-13	1052	935	2388	183	2571
2013-14	1067	959	2458	193	2650
2014-15	1055	865	2349	172	2520
2015-16	1044	923	2352	164	2516
2016-17	1097	985	2520	231	2751
2017-18	1128	999	2596	254	2850
2018-19	1165	1036	2631	221	2852
2019-20	1189	1079	2745	230	2975
2020-21	1223	1095	2829	257	3087

Source: www.rbi.org.in/DBIE

The above table represents the time series data on Total Cereals, Pulses and food grains produced from 1990 – 91 to 2020 - 21. It is clear from the above data that there is marginal increase in the overall production of cereals, pulses and food grains. Due to the technological development and mechanization in Indian agriculture and using of modern equipments tend to increase the overall productivity and production at a gradual rate. Use of hybrid seeds, advanced irrigation techniques, usage of chemical fertilizers has increased the production.

Figure 1: Graphical presentation of the total cereals, pulses and food grains from 1990-91 to 2020-21.



The above graph shows the graphical presentation of the time series data of Rice, Wheat, total cereals, total pulses and total food grains over a period of thirty years since 1990-91 onwards. The graph depicts that there is an increasing trend in all the food grains production over the study period. In the year 2004-05 there is a slump in the overall food production which caused because of the monsoon failure and other impediments. Later on, slowly by the adoption of modern techniques such as improved seeds, better irrigation facilities, etc. there was a gradual increase in the overall food grain production till 2020-21.

Econometric Model

Auto Regressive Integrated Moving Average (ARIMA) model.

Equations

Autoregressive model (AR)

$Y_t = \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \ldots.. + \alpha_p Y_{t-p} + \varepsilon_t$

Where

Y_t = dependent variable at time t,

α_i = coefficients to be estimated

ε_i = series of random errors with zero mean and constant variance $\varepsilon t \approx N(0, \delta^2)$

Moving Average (MA)

$Y_t = \varepsilon_t - \varphi_1 \varepsilon_{t-1} - \varphi_2 \varepsilon_{t-2} - \ldots. - \varphi_q \varepsilon_{t-q}$

Y_t = dependent variable at time t,

ε_t = series of random errors with zero mean and constant variance $\varepsilon t \approx N(0, \delta^2)$

φ_i = parameters of the moving average model

q = degree model

$\varepsilon_{t-1}, \varepsilon_{t-2} \ldots\ldots \varepsilon_{t-p}$ = errors in previous time periods that are incorporated in the response of Y_t

ARMA

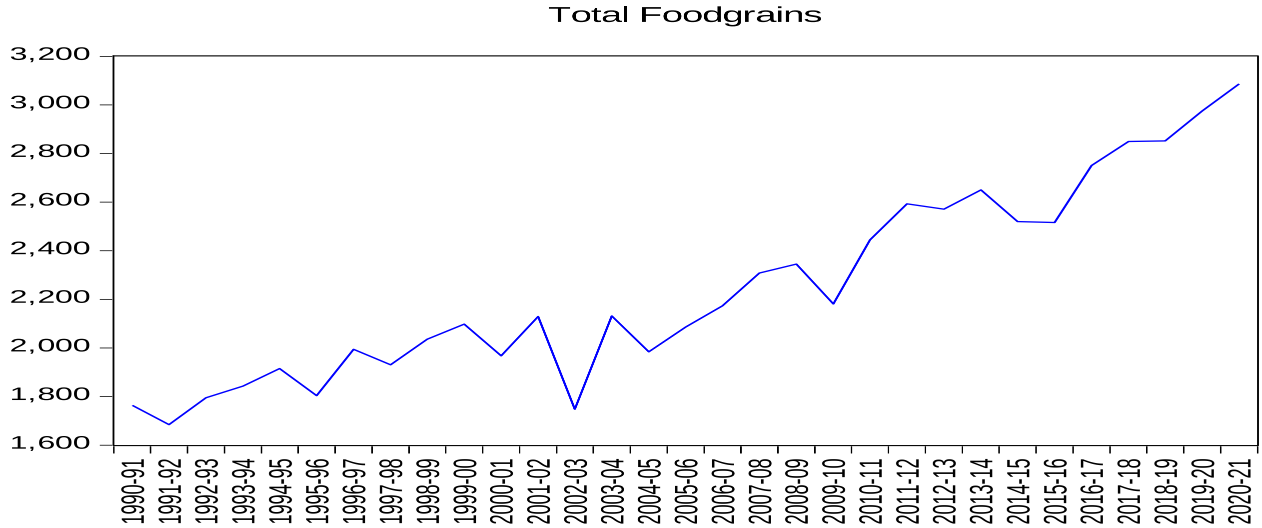
$Y_t = \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \ldots.. + \alpha_p Y_{t-p} + \varepsilon_t - \varphi_1 \varepsilon_{t-1} - \varphi_2 \varepsilon_{t-2} - \ldots. - \varphi_q \varepsilon_{t-q}$

ARIMA

$Y_t = \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \ldots.. + \alpha_p Y_{t-p} + \ldots.. + dY_{p-d} + \varepsilon_t - \varphi_1 \varepsilon_{t-1} - \varphi_2 \varepsilon_{t-2} - \ldots. - \varphi_q \varepsilon_{t-q}$

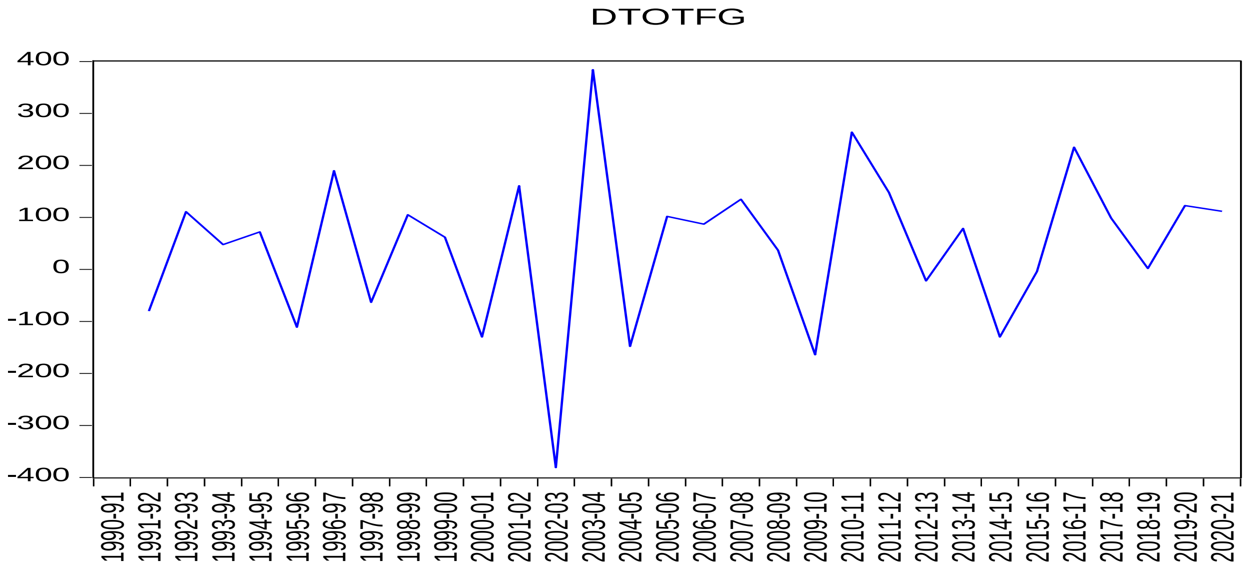
Based on the above equation the collected data were compiled and with the help of EViews the data were analyzed and presented in the following graphs and tables. In order to run an ARIMA model the first condition is to make the data stationary over the period of time. First the actual data are depicted in the form of a line graph and with the help of the pattern it can be decided about the stationarity of the data. In the graph below it is clear that the data are not stationary and its shows an increasing trend over the study period.

Figure 2: Graphical presentation of the total food grains over the period of time



The above graph shows the graphical pattern of the time series data which have random walk pattern in which there is an increasing trend of the data which shows the non-stationary pattern over the years.

Figure3: Graphical presentation of the total food grains with first order differentiation



After the data depicting the random walk pattern for the entire time series data first order differentiation was applied and by which the data became stationary and ready for further statistical test and inference.

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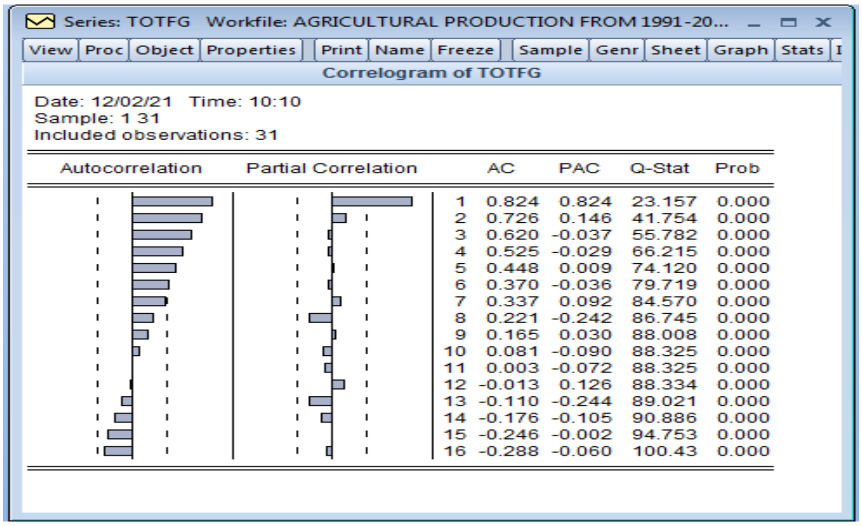
Table 2: Autocorrelation and partial autocorrelation of the Collected data


Series: TOTFG Workfile: AGRICULTURAL PRODUCTION FROM 1991-20...

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Correlogram of TOTFG

Date: 12/02/21 Time: 10:10
Sample: 1 31
Included observations: 31

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.824	0.824	23.157	0.000
		2	0.726	0.146	41.754	0.000
		3	0.620	-0.037	55.782	0.000
		4	0.525	-0.029	66.215	0.000
		5	0.448	0.009	74.120	0.000
		6	0.370	-0.036	79.719	0.000
		7	0.337	0.092	84.570	0.000
		8	0.221	-0.242	86.745	0.000
		9	0.165	0.030	88.008	0.000
		10	0.081	-0.090	88.325	0.000
		11	0.003	-0.072	88.325	0.000
		12	-0.013	0.126	88.334	0.000
		13	-0.110	-0.244	89.021	0.000
		14	-0.176	-0.105	90.886	0.000
		15	-0.246	-0.002	94.753	0.000
		16	-0.288	-0.060	100.43	0.000

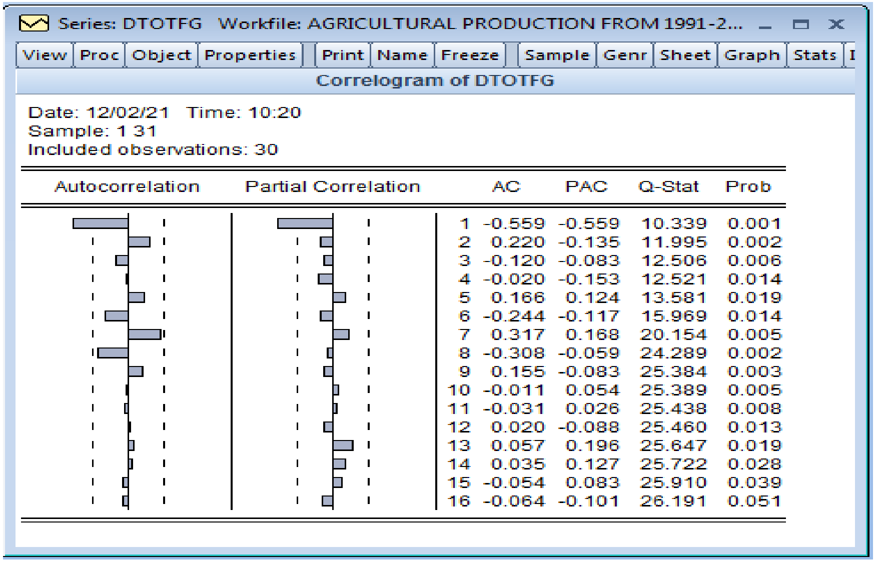
In the above correlogram the ACFs suffered from linear decline and there is only one significant spike in PACFs. The graph of the correlogram suggests that ARIMA (1,1,1) may be an appropriate model. Then the first order difference is taken for further statistical analysis to see whether the time series data become stationary to apply for AR(p) and MA(q)

Table 3: Presentation of unit root test

Null Hypothesis: DTOTFG has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, max lag=7)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-9.942943	0.0000
Test critical values:	1% level		-3.679322	
	5% level		-2.967767	
	10% level		-2.622989	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(DTOTFG)				
Method: Least Squares				
Date: 12/02/21 Time: 10:17				
Sample (adjusted): 3 31				
Included observations: 29 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DTOTFG (-1)	-1.562458	0.157142	-9.942943	0.0000
C	71.86678	24.59967	2.921453	0.0070
R-squared	0.785480	Mean dependent var		6.620690
Adjusted R-squared	0.777534	S.D. dependent var		270.6873
S.E. of regression	127.6731	Akaike info criterion		12.60330
Sum squared resid	440111.3	Schwarz criterion		12.69759
Log likelihood	-180.7478	Hannan-Quinn criter.		12.63283
F-statistic	98.86211	Durbin-Watson stat		2.143495
Prob(F-statistic)	0.000000			

Now after the first order difference the time series DTOTFG becomes stationary as showing in the line graph and is free from white noise and the data become stationary. The unit root test also confirms that the first order difference becomes stationary and the level of significance is statistically accepted.

Table 4: Correlogram first order differentiation



Series: DTOTFG Workfile: AGRICULTURAL PRODUCTION FROM 1991-2...

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Correlogram of DTOTFG

Date: 12/02/21 Time: 10:20
Sample: 1 31
Included observations: 30

	AC	PAC	Q-Stat	Prob
1	-0.559	-0.559	10.339	0.001
2	0.220	-0.135	11.995	0.002
3	-0.120	-0.083	12.506	0.006
4	-0.020	-0.153	12.521	0.014
5	0.166	0.124	13.581	0.019
6	-0.244	-0.117	15.969	0.014
7	0.317	0.168	20.154	0.005
8	-0.308	-0.059	24.289	0.002
9	0.155	-0.083	25.384	0.003
10	-0.011	0.054	25.389	0.005
11	-0.031	0.026	25.438	0.008
12	0.020	-0.088	25.460	0.013
13	0.057	0.196	25.647	0.019
14	0.035	0.127	25.722	0.028
15	-0.054	0.083	25.910	0.039
16	-0.064	-0.101	26.191	0.051

From the above correlogram it is clear that only one spike is extended outside the confidence interval level it means that the residuals of this selected ARIMA model are of not with white noise, so there are no other significant patterns left in the time series, so the model is fit for further evaluation. So, the ARIMA (1,1,1) is the best model.

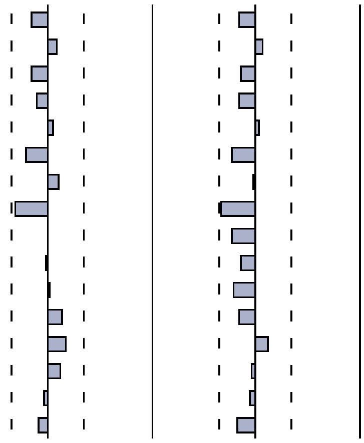
Table 5: Regression test on total food grains over the period of time

Dependent Variable: TOTFG				
Method: Least Squares				
Date: 12/02/21 Time: 10:22				
Sample (adjusted): 2 31				
Included observations: 30 after adjustments				
Convergence achieved after 136 iterations				
MA Backcast: OFF (Roots of MA process too large)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1533.482	142.8500	10.73491	0.0000
AR(1)	1.060859	0.016841	62.99206	0.0000
MA(1)	-1.417418	0.233655	-6.066287	0.0000
R-squared	0.955320	Mean dependent var		2265.467
Adjusted R-squared	0.952010	S.D. dependent var		392.8668
S.E. of regression	86.06348	Akaike info criterion		11.84269
Sum squared resid	199986.9	Schwarz criterion		11.98281
Log likelihood	-174.6403	Hannan-Quinn criter.		11.88751
F-statistic	288.6488	Durbin-Watson stat		2.271067
Prob(F-statistic)	0.000000			
Inverted AR Roots	1.06			
	Estimated AR process is nonstationary			
Inverted MA Roots	1.42			
	Estimated MA process is noninvertible			

The residual diagnostics tests show that the over fitting process is used and the goodness of fit of the ARIMA (1,1,1) values show that the value standards are fit and it is relied that this is the appropriate model when compared to other models.

Table 6: Correlogram first order differentiation

Date: 12/02/21 Time: 10:24
Sample: 2 31
Included observations: 30
Q-statistic probabilities adjusted for 2 ARMA term(s)



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.159	-0.159	0.8385	
		2	0.091	0.067	1.1196	
		3	-0.162	-0.142	2.0510	0.152
		4	-0.101	-0.158	2.4291	0.297
		5	0.042	0.026	2.4963	0.476
		6	-0.221	-0.234	4.4452	0.349
		7	0.106	-0.009	4.9134	0.427
		8	-0.333	-0.342	9.7508	0.136
		9	-0.007	-0.240	9.7532	0.203
		10	-0.022	-0.146	9.7764	0.281
		11	0.011	-0.215	9.7826	0.368
		12	0.141	-0.162	10.838	0.370
		13	0.184	0.127	12.742	0.311
		14	0.121	-0.031	13.614	0.326
		15	-0.033	-0.054	13.685	0.396
		16	-0.083	-0.188	14.154	0.438

In the above correlogram since there are no significant spikes of ACFs and PACFs, it is concluded that there is stationarity in the data series and most of the values within the confidence interval and that the significant value of autocorrelation coefficients by using the Q statistic test.

Conclusion

The impact of economic reforms on agriculture is a mixed challenge. Changing demand due to increase in incomes, health consciousness will affect the agricultural production in the future. Use of biotechnology and breeding will be very important in developing eco-friendly and disease resistant, climate resistant, more nutritious and tastier crop varieties. India has improved remarkably in its digital connectivity and market access has become very easy.

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