Forecasting of GDP (Gross Domestic Product) Per Capita Using (ARIMA) Data-Driven Intelligent Time Series Predicting Approach

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Abstract

Gross Domestic Product is the aggregate value of all final services and products generated by the country during the measurement period, including private inventories, paid-in capital expenditures, government purchases, personal consumption, and the balance of international commerce. During the Pandemic period of the last two years, the COVID-19 outbreak has caused chaos in the worldwide economy. Sickness outbreaks, supply-chain disruptions, and, more recently, inflation have made policymaking exceedingly difficult. This research aims to forecast GDP (Gross Domestic Product) per capita for the coming years while also examining historical and present trends in India. This study's objective is to forecast India's future GDP per capita over ten years, from 2021 to 2030, using ARIMA. According to a study, India's GDP per capita has been growing during the last 10 years, and this movement is likely to last over the following ten years.

Keywords- *ARIMA, PACF, ACF, GDP, Forecasting*

I. Introduction

After declining in 2020-21, the Indian economy is anticipated to increase by 9.2% in 2021-22. This indicates that overall economic activity has rebounded to levels before the epidemic [1]. Almost all data reveal that the "second wave" in Q1 had a far lesser economic impact than the complete lockdown period in 2020-21, even though the health damage was much worse. Over the last decade, India has become an increasingly vital element of the global economic scene. Following economic changes, its economy has become more accessible to foreign commerce, its workforce has grown rapidly, and investment has increased. The GDP is a key indicator that reflects the state of the economy and people's income [2]. It is a crucial metric for determining the country's affluence and economic power. The gross domestic product (GDP) contains everything that has been generated domestically, whether via the use of locals' or foreigners' production aspects [3]. GDP is inextricably linked to a country's employment rate and standard of living. As a result, GDP forecasting may be beneficial to a country's future macroeconomic regulation and control, as well as the computation of the international balance of payments. The spending technique and the income approach are the two most used ways of calculating GDP [4].

To continuously monitor the health of any economy, policymakers and economists use the GDP per capita as a determinant of economic progress, a driver of living standards, and a resource distributor for increased efficiency in an economy. Forecasting economic development in emerging nations is a difficult endeavor, owing to the unique challenges they confront. Policymakers and experts are constantly reviewing the economy's status. Economists and predictors now have access to a wide range of observed time series, including hard and soft variables, aggregated and disaggregated data, and real and nominal variables[5]. Linear time-series approaches (Box Jenkins method) were introduced by Box and Jenkins (1976) The ARIMA (Auto-Regressive-Integrated-Moving

Average) approach is widely used among the primary methodologies in GDP forecasting [3]. Many scholars have utilized the Box and Jenkins model to forecast future rates of gross domestic output (GDP) [6].

II. Review of Literature

The suitability of ARIMA for forecasting GDP per capita has been demonstrated in earlier literature, as evidenced by empirical findings from many studies. The Auto-Regressive Integrated Moving average (ARIMA 1,2,1) model was chosen as the suitable model for the data since the model diagnostic tests revealed substantial parameter estimates and unpredictability in the residual plot [7]. In a study by Ma et al, the forecast technique with the ARIMA model is demonstrated using EViews software [8]. To estimate the GDP, Using the Box-Jenkins method, various ARIMA models were developed. Using recognition benchmarks and stationary test of time series (AIC criterion) ARIMA (2, 2, 2) was found the most effective in simulating Kenyan GDP [9]. Yahaya studied yearly GDP statistics from Nigeria from 1981 to 2019, the study tested for stationarity using an Augmented Dick Fuller test, and it was found to be stationary at the second differencing. After analyzing the AIC values, Eviews 11 program chose ARIMA (1, 2, 1) as the best model. The Residual's Ljung-Box test confirmed that the model was sufficient, and it was used to anticipate out-of-sample data [7]. In ARIMA and the ANFIS models, compare the linear and non-linear models of Algerian GDP projections in 1990 and 2019 [3]. Annual GDP data related to Egypt and Saudi Arabia were used to forecast GDP per capita using the Box-Jenkins ARIMA model [10].

Miah estimated GDP statistics from Bangladesh from 1960 to 2017. The correlogram and unit root test was used to assess the series graphical method's stationarity [11]. The GDP time series plot displays a non-stationary pattern that resembles an exponential curvature curve. ARIMA (autoregressive integrated moving average) was used as the model (1, 2, 1). The model was fitted to data to estimate the parameters of the ARIMA (1, 2, 1) model's autoregressive and moving average components. Correlogram, Q-statistic, histogram, and normality test were utilized for residual diagnostics [12]. Singh forecasted Gujarat's GDP based on 34 years of GDP data and explanatory factors. The ARIMA model uses the Box-Jenkins approach. The regression coefficients are assessed using univariate and multivariate econometric models to estimate in-sample and out-of-sample projections [13]. Yang uses the yearly data of Chinese GDP from 1978 to 2014 as the study object, and uses the Eviews6.0 program to create the ARIMA (2, 4, 2) model that anticipates GDP for the next five years and compares the forecasted and actual GDP figures [4]. In the study Durka & Silvia, compares and contrasts the ARIMA and ARIMAX techniques for analyzing and forecasting macroeconomic time series, to determine if the more complicated ARIMAX model produces significantly better outcomes than the simpler ARIMA model. [14]. Results from a study that used ARIMA to estimate Egypt's GDP show that, when model selection criteria are taken into account, ARIMA (3,1,3) is the best model. To further demonstrate the model's accuracy, goodness-of-fit tests were carried out. As long as there are no significant changes in the economy over the projected period, it appears that Egypt's GDP will keep growing [15].

III. Research Methodology

This research aims to examine past and present GDP (Gross Domestic Product) per capita trends in India and project GDP per capita for the coming years. The research's goals are divided into two categories to fulfill its intended purpose: (1) Finding the appropriate and most suitable ARIMA model to estimate the GDP per capita and (2) projecting India's GDP per person for the next ten years. This study's objective is to forecast India's future GDP per capita using ARIMA for ten years, from 2021 to 2030.

This study tests utilize of secondary sources of data to examine India's GDP per capita levels for the recent past and the foreseeable future and to

make GDP per capita projections. The World Bank database is a secondary data source for GDP per capita. Information about India's current GDP per capita is gathered from records in the World Bank database. To forecast India's GDP per capita, the ARIMA (Autoregressive Integrated Moving Average) a very accurate time series modeling technique is used. To determine whether the data series under investigation is stationary, ADF (Augmented Dickey-Fuller) test is utilized. ACF (Autocorrelation function) and PACF (partial autocorrelation function) plots are employed to complete the selection of a suitable best fit model. Parameters (p, d, and q) related to the ARIMA model are established using partial autocorrelation correlograms and correlograms. Auto. Arima function of the R Software is used to examine the model's validity is examined using the statistical analysis package. For data analysis and forecasting, the statistical program R is employed.

IV. Forecasting of GDP per capita in India

4.1 Analysis and Discussion

The plot of GDP per capita in Figure 1.1 revealed recent moving patterns with few variances. The visual analysis of GDP per capita reveals that descriptive statistics such as mean, variance, and covariance do not follow a constant trend and fluctuate over time, proving that the GDP per capita series of India is not stationary. Figure 1.1 of the total GDP per capita time series may be visually examined and is shown to have an upward trend, showing that it is not stagnant.

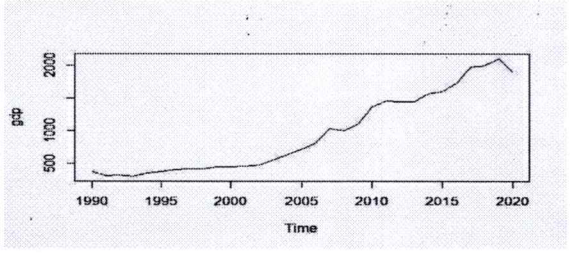

Figure 1.1 GDP Per Capita in India

Testing the level of stationarity in data series is the very first requirement of forecasting using time series models. Visual inspection or application of various unit root tests (ADF or Philip Perron test) can be used to check the level of a unit root in time series. Visual inspection of figure 1.1 showed an upward trend in data series with minor fluctuations which confirmed the existence of unit root in the data series of GDP per capita. Augmented Dickey-Fuller (ADF) test is also used to confirm the results obtained from the visual inspection of the time series data.

Table 1-ADF test Statistics		
Level of differencing	At Level	At First Order
T-statistics	0.575	-4.2
Probability	0.98	0.002
At a 1% level of significance	-3.67	-3.67
At 5% level of significance	-2.96	-2.96
At 10% level of significance	-2.62	-2.62

Table 1's ADF test results show the value of the test at the original data series. The test's result confirms the existence of unit root in time series. To transform the non-stationary GDP per capita original data series into a stationary, it is differenced at the first-order level.

4.2 First-Order Difference

The original data series of India's GDP per capita is differenced at a first-order level to create a series of data that has a stationary pattern.

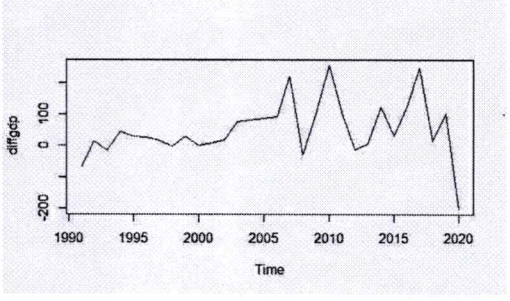

Figure 1.2 GDP Per Capita at the first order of differencing

Figure 1.2 illustrates how a first-order differenced time series plot seems persistent on descriptive

statistics measures like (mean, variance, and covariance) signifying data series of India's GDP per capita tracks a stable pattern. ADF test results in table 1 confirm the results of stationarity in differenced data series at level 1 which are consistent with the alternate hypothesis of no unit root in differenced time series while rejecting the null hypothesis of a unit root in data series. As a result, the d parameter of the ARIMA model is set to 1. (p,d,q).

4.3 Partial Auto Correlogram and Correlogram

Rest of the ARIMA model's parameter (p, q) that fits data the best may be determined using PACF and ACF graphs. To get the AR and MA (p & q) parameters PACF and ACF plots are used to find the most appropriate ARIMA Model.

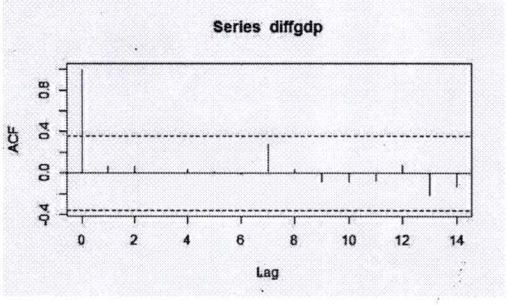

Figure 1.3 ACF Plot at the first order of differencing

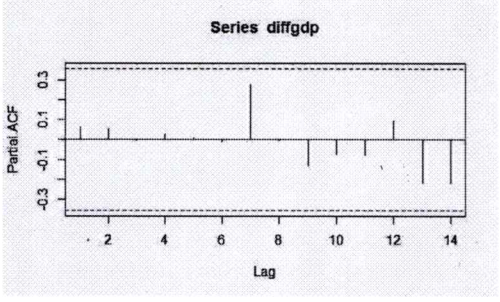

Figure 1.4 PACF Plot at the first order of differencing

The auto-regression (AR =p = 0) may be seen visually in a PA Correlogram or PACF plot as it abruptly ends before lag 1 and all of its bars are inside the border. The Moving Average (MA = q) equals 0 since it degrades swiftly with the lag length, according to a visual study of the ACF plot. As a result, the AR and MA (p & q) values in the ARIMA (p, d, q) equation are 0 and 0 respectively. The expected parameters of the ARIMA model are therefore AR = 0, integrated = 1, and moving average = 0. Outcome of the above procedure confirmed the ARIMA (0, 1, 0) as the model that fits the data series' characteristics the best for predicting India's GDP per capita.

4.4 AUTO.ARIMA Function

Auto. Arima function in the R programming language recommends the best fit ARIMA model based on the properties of the data series and the selection measures for the best fit ARIMA model (p.d.q). Using the built-in "auto. Arima" function of the R software, which suggests the best appropriate and acceptable model based on the data pattern, the acceptability of the selected ARIMA (0,1,0,) model is evaluated. The "Auto. Arima()" tool helped us identify the best-fit model, which is ARIMA (0,1,0) with drift. This model matches the one we previously identified using partial PACF and ACF plots.

Table 2- Best-fit ARIMA Model

Table 2- ARIMA model coefficients		
Series	GDP per capita	
Model	ARIMA (0,1,0) with drift	
Coefficients:		
drift:	51.1	
S.e.	16.3596	
sigma^2 estimated as	8306	
log likelihood=	-177.43	
AIC=358.86	AICc=359.31	BIC=361.66

The output of "auto.Arima()" is displayed in table 2 since we used it to forecast India's GDP per capita because the ARIMA (0,1,1) with drift meets all investigative tests.

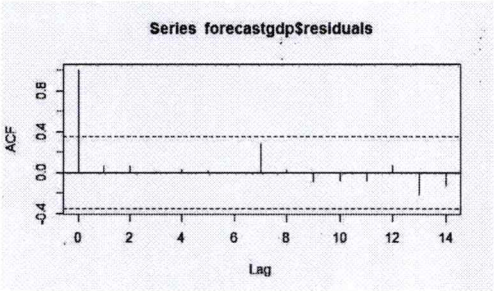

Figure 1.5 ACF Plot residuals at the first order of differencing

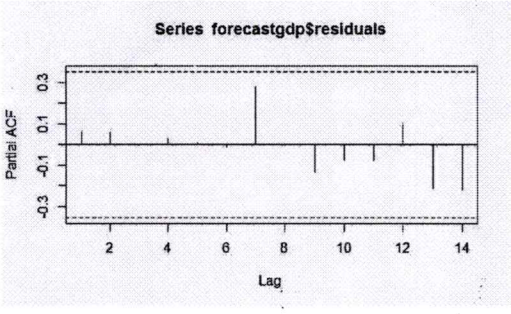

Figure 1.6 PACF Plot residuals at second order of differencing

Exhibits 1.5 and 1.6 show how ARIMA generated residuals (0,1,0,). Figure 1.5 displays an appropriate ACF plot of residuals within the settings that advise against autocorrelation. The variance of the residual series does not significantly vary over time, as seen by the PACF chart in Figure 1.6 The results of the PACF plot imply that any change in the residual may be thought of as lasting forever and that the recommended ARIMA (0,1,0,) appropriately and correctly fits the data. The ARIMA (0,1,0) with drift passes all diagnostic tests relating to residual and is approved for all ARIMA (0,1,0) with drift property tests.

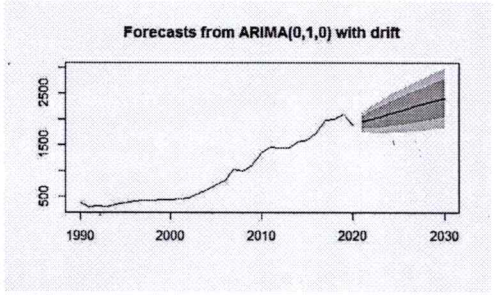

Figure 1.7 The forecasted value of GDP per capita

Using the PACF and ACF plot, the ARIMA (0,1,0) model was chosen and verified by AUTO. After performing all diagnostic and property tests, the ARIMA function is used to project GDP per capita for the following 10 years.

Table 3- The forecasted value of GDP per capita

Year	Forecast	Lo-80	HI-80	LO-95	HI-95
2021	1952.1	1835.3	2068.89	1773.45	2130.72
2022	2003.2	1838.02	2168.37	1750.58	2255.81
2023	2054.3	1852	2256.59	1744.91	2363.68
2024	2105.4	1871.8	2338.99	1748.14	2462.65
2025	2156.5	1895.33	2417.66	1757.08	2555.91
2026	2207.6	1921.5	2493.69	1770.05	2645.14
2027	2258.7	1949.68	2567.71	1786.1	2731.29
2028	2309.8	1979.44	2640.15	1804.57	2815.02
2029	2360.9	2010.51	2711.29	1825.02	2896.77
2030	2412	2042.65	2781.34	1847.13	2976.86

Over the next 10 years, India's GDP per capita is expected to increase, according to the ARIMA (0,1,0) model. Table 3 and Figure 1.7 provide the anticipated GDP per capita estimates. From 2021 through 2030, Figure 1.7 depicts a rising trend in GDP per capita. The shaded region of Figure 1.7 shows the estimated amount of GDP per capita at the levels of 85% and 95% certainty. According to the GDP per capita's historical pattern, the likely figure is accurate. The anticipated Indian GDP per capita value is expected to increase in line with historical trends. According to the aforementioned statistics, it is expected that India's GDP per capita would increase over the ensuing 10 years.

V. SIGNIFICANCE OF STUDY

The previous studies related to the prediction of GDP using ARIMA were carried out at the time when the same trend of growth was found in time series data of the Indian economy but during the last decades, a significant change in the pattern of time series of GDP was notice due to structural economic changes like demonetization in India, implementation of GST and recent pandemic all over the world. A declining trend in time series

GDP was observed during this situation. This study predicts the flow of GDP after recent changes using time series of GDP. This finding helps the government and policymakers to frame the strategies for economic control.

VI. CONCLUSION

Economic development is a big challenge to the countries like India. GDP per capita as a measure of economic development is of prime concern for policymakers and the government. India's GDP per capita is still very low in comparison to developing countries. The government is targeting to achieve the target of a $ 5 trillion economy by 2025 and $ 9 trillion by the year 2030 and $ 5625 GDP per capita by the year 2030. The government is making policies to achieve the target of $5625 GDP per capita through various economic programs like make in India, skill India, etc. Forecast for GDP per person The yearly GDP per capita value will be projected using the projective method, which will help the government and policymakers make the appropriate plans. The government's development of plans and tactics to raise GDP per capita and reach the goal of a $ 9 trillion economy and a GDP per capita of 5625 by the year 2030 is projected to be aided by the projection of GDP per capita in India.

References

[1] S. S. Gandhi, "Government of India," *Rehabilitation*, vol. 24101801, no. March, p. 2010, 2010, [Online]. Available: http://www.credall.org.in/images/npvol07.pdf.

[2] T. Roy, "Economic Change In India," *Econ. Hist. India, 1857-1947*, pp. 287–316, 2013, doi: 10.1093/acprof:oso/9780198074175.003.0012.

[3] A. Sahed, H. Kahoui, and M. Mekidiche, "Forecasting Algerian Gdp Using Adaptive Neuro Fuzzy Inference System During the Period 1990-," vol. 5, no. 2, pp. 11–21, 2020.

[4] B. Yang, C. Li, M. Li, K. Pan, and D. Wang, "Application of ARIMA Model in the Prediction of the Gross Domestic Product," *Proc. 2016 6th Int. Conf. Mechatronics, Comput. Educ. Informationization (MCEI 2016)*, vol. 130, no. January 2016, 2017, doi: 10.2991/mcei-16.2016.257.

[5] K. Barhoumi, O. Darné, and L. Ferrara, "Are disaggregate data useful for factor analysis in forecasting French GDP?," *J. Forecast.*, vol. 29, no. 1–2, pp. 132–144, 2010, doi: 10.1002/for.1162.

[6] G. E. P. Box, G. M. Jenkins, G. C. Reinsel, and G. M. Ljung, *Time series analysis: forecasting and control*. John Wiley & Sons, 2015.

[7] A. E. Yahaya, E. H. Etuk, N. Kingdom, and N. W. Chimee, "ARIMA Model for Gross Domestic Product (GDP): Evidence from Nigeria," *Arch. Curr. Res. Int.*, no. December, pp. 49–61, 2020, doi: 10.9734/acri/2020/v20i730213.

[8] L. Ma, C. Hu, R. Lin, and Y. Han, "ARIMA model forecast based on EViews software," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 208, no. 1, 2018, doi: 10.1088/1755-1315/208/1/012017.

[9] M. Sammy Wabomba, "Modeling and Forecasting Kenyan GDP Using Autoregressive Integrated Moving Average (ARIMA) Models," *Sci. J. Appl. Math. Stat.*, vol. 4, no. 2, p. 64, 2016, doi: 10.11648/j.sjams.20160402.18.

[10] N. Eissa, "Forecasting the GDP per Capita for Egypt and Saudi Arabia Using ARIMA models," *Res. World Econ.*, vol. 11, no. 1, pp. 247–258, 2020, doi: 10.5430/RWE.V11N1P247.

[11] M. M. MIAH, "Modelling and Forecasting of GDP in Bangladesh: An ARIMA Approach," *J. Mech. Contin. Math. Sci.*, vol. 14, no. 3, 2019, doi: 10.26782/jmcms.2019.06.00012.

[12] M. R. Abonazel and A. I. Abd-Elftah, "Forecasting Egyptian GDP using ARIMA models," *Reports Econ. Financ.*, vol. 5, no. 1, pp. 35–47, 2019, doi: 10.12988/ref.2019.81023.

[13] A. K. Singh, "An empirical analysis to assess the GDP projection of Gujarat state of India," *JNNCE J. Eng. Manag.*, 2017, [Online]. Available: https://www.academia.edu/download/58809421/16_Singh_A.K.2018__JJEM_.pdf.

[14] P. Drka and P. Silvia, "'ARIMA vs. ARIMAX – which approach is better to analyze and forecast macroeconomic time series?' Proceedings of 30th International Conference Mathematical Methods in Economics Section," *Int. Conf. Math. Methods Econ.*, pp. 136–140, 2022.

[15] V. Shaker, "Modeling and Forecasting Egyptian GDP: Autoregressive-Integrated Moving-Average Model," *J. Agric. Econ. Soc. Sci.*, vol. 13, no. 7, pp. 279–283, 2022, doi: 10.21608/jaess.2022.147684.1060.