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Predictive analysis of GDP by using ARIMA approach

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Abstract
This study aims to predict India's GDP per capita By ARIMA annual forecasting models. We have used a historic era of Indian GDP from (1960-2020) AD to develop and evaluate various ARIMA models. The ideal model for our data has been chosen using the Box-Jenkins method. We tested several different models among others, ARIMA: (1,1,1), (2,1,2), and (1,2,1). Standard measurements like Mean Absolute Percentage Error (MAPE) and Root Mean Square Error were used to assess each model's performance (RMSE). Our findings indicate that ARIMA models are effective in predicting India's GDP per capita. We discovered that the ARIMA model (0.2.1) fits our data better. Our study has important implications for policymakers and investors who rely on accurate predictions of GDP per capita. By accurately predicting GDP per capita, policymakers can make informed decisions about economic policies that affect the country's development. Investors can use these predictions to make informed decisions about investing in the Indian economy.

Keywords: ARIMA approach, GDP, predictive analysis

Introduction

With a population of more than 1,416,729,000, and according to the most recent official United Nations population statistics 17.7% of the world's population resides in India. also, India is an important member of the G-20's economically and trade, which is currently in its presidency From the beginning of 2023 until 30 November 2023 While India keeps developing, it is essential to accurately predict the country's economic growth, in particular with regard to GDP per person. Accurately forecasting GDP per capita is essential for policymakers, investors, and other stakeholders who make decisions based on economic data. In recent years, time series models such as ARIMA have gained popularity in predicting economic variables. ARIMA models are useful for identifying trends and patterns in time series data, which can be used to make accurate forecasts.

This study aims to predict India's GDP per capita using ARIMA models. We will use annual data from 1960 to 2020 to develop and evaluate various ARIMA models. We'll choose the ideal model for our data using the Box-Jenkins method. We will test several different models, among others, ARIMA (1,2,1),(2,1,2), and (1,1,1)Each model's performance will be assessed using standardized metrics. The study's findings have significant political consequences and investors who rely on accurate forecasts of GDP per capita. By accurately forecasting GDP per capita, policymakers can make informed decisions about economic policies affecting the country's development as well as investors can use these predictions to make decisions about investing in the Indian economy.

This paper focused on achieving the objective of the study without elaborating on many details in which many previous literature have been fought and for achieve to that The methodology section describes the data and the various ARIMA models that we will use in our analysis. The results section presents the findings of our analysis, and the discussion section discusses the implications of our findings.

Methodology

The study is performed on the dataset of net FDI in India from 1950-2020(expressed as US dollars in millions). A customised box-Jenkins ARIMA model was generated in order to forecast the FDI and analysing the trend. Initially, the trend of the investment from 1950-2020 was visualised and it was found to be overall exponential in nature. While forecasting using ARIMA model, Stationarity and differencing has to be taken into consideration. Once the conditions are satisfied and validated using Augmented Dicker Fuller test, the ARIMA model was generated using the 3 parameters: p, q and d. The major steps followed are:

Step 1: Model Identification – Augmented Dickey Fuller test used.

Step 2: Parameter Estimation – Auto correlation Function (ACF) and Partial Auto Correlation Function (PACF) for identification of the order of ARIMA model (parameters p and q).

Step 3: Training and Testing the model- Dividing the dataset into 7:3, the model is fitted using ARIMA (p,d,q). These model parameters were acquired using the minimum AIC score for best accuracy.

Step 4: Diagnostic Check: Determining the Residuals of the ACF and PACF graphs for identical and independent distribution.

Step 5: Forecasting the data: The future FDI expenditure was forecasted for forthcoming years along with its lower bound and upper bound values with 95% confidence.
Linear components of ARIMA models:
A time-series model called ARIMA (Auto Regressive Integrated Moving Average) is used to predict future values of a time series based on its historical trends. Forecasting time series in the financial and economic sectors frequently uses ARIMA models.as well as in other fields where patterns in time-series data need to be analyzed and predicted.
The moving average (MA), integrated (I), and autoregressive (AR) components are the three components that make up the ARIMA model. The relationships between the current value of the series and its past values are modelled by the AR component, those between the current value of the series and its past errors are modelled by the MA component, and the amount of differencing required to make the series stationary is modelled by the I component.
Three variables n, d, and m define the order of the ARIMA model. The parameters n and d and m denote the order of the moving average component, n denotes the order of the autoregressive component, and m denotes the order of differencing required to keep the series stable.
(MA), differential, and (AR) processes are combined to create the ARIMA model. These procedures are widely employed in various applications and are popularly referred to as univariate key time series models in statistical literature.
The expression for an order n autoregressive model, AR (n), is:

$$X_t=c+\beta_1 X_{(t-1)} + \beta_2 X_{(t-2)} + \cdots +\beta_n X_{(t-n)} +\varepsilon_t;\ t=1,2,3,4,5,\cdots T, \quad (1)$$

$\{X_t\}$ is a time series called an autoregressive moving process to order m, MA (m), if:

$$X_t=\varepsilon_t-\alpha_1 \varepsilon_{(t-1)} -\alpha_2 \varepsilon_{(t-2)}-\cdots\alpha_m \varepsilon_{(t-m)}. \quad (2)$$

$\{X_t\}$ is a time series said to following (nand m) order autoregressive moving-average process if:

$$X_t=c+\beta_1 X_{(t-1)} + \beta_2 X_{(t-2)} + \cdots +\beta_n X_{(t-n)} + \varepsilon_t-\alpha_1 \varepsilon_{(t-1)} -\alpha_2 \varepsilon_{(t-2)}-\cdots-\alpha_m \varepsilon_{(t-m)}. \quad (3)$$

Linear equation (3) can combine the aforementioned MA and AR models.

ε_t the element of error in the equation;
A sequence independently also identically distributed [iid] random variables with $E(\varepsilon_t) = 0$ & $var(\varepsilon_t) = \sigma^2$; i.e. $\varepsilon_t \sim iidN(0,\sigma^2)$.
It is possible to extend ARMA models to non-stationary data ARIMA (n, d, m) The generic non-seasonal model, which has three parameters, is called: n is the order of autoregressive, d is the level of differencing, and m is the order of moving-average. If X_t is a non-stationary series, for example to get the first-difference_t to make X_t stationary, then ARIMA (n, 1, m) model is:

$$\Delta X_t=c+\beta_1 \Delta X_{(t-1)} + \beta_2 \Delta X_{(t-2)} +\cdots+\beta_n [\![\Delta X]\!]_{(t-n)} + \varepsilon_t-\alpha_1 \varepsilon_{(t-1)} -\alpha_2 \varepsilon_{(t-2)}-\cdots-\alpha_m \varepsilon_{(t-m)}, \quad (4)$$

Equation (4) changes the model into an ARIMA model, which is a random walk model (0, 1, 0) where; $\Delta X_t = X_t - X_{(t-1)}$, if n = m = 0.
By many researchers of estimation and prediction Future rates of GDP There has been extensive usage of the Box and Jenkins (1976) technique. Another study conducted by Kumar and Singh (2020) employed a hybrid model that combines artificial neural networks (ANNs) and seasonal autoregressive integrated moving average (SARIMA) to predict India's quarterly GDP growth rate. The hybrid model outperformed the SARIMA and ANN models separately, according to the authors, with a reduced MAE and mean squared error (MSE). the ARIMA and ANN models Similarly, Bansal and Kumar (2022) [19] used a hybrid model combining ARIMA and ANNs to forecast India's quarterly GDP growth rate. The authors found that the hybrid model outperformed both individually, with a lower MAE and MSE.
Zhang Haonan (2013) [15] examined the forecast of each region's GDP per capita for Sweden's five Zones from 1993 to 2009. Using three models ARIMA, VAR and AR. The study's findings revealed that all three models is applicable to short-term forecasting. The best model for prediction is the first-order autoregressive one.
In another study, Chauhan and Chakraborty (2019) used a Holt-Winters exponential smoothing model to forecast India's quarterly GDP growth rate. The authors found that the model performed well, with a lower MAE compared to other models.
Applying the ARIMA model (1,2,1) Wei and al. (2010) found that Shaanxi's GDP represents an impressive increase trend after they used data from Shaanxi's GDP to predict the country's GDP for the following six years between 1952 - 2007.
Overall, the literature shows that time series analysis is an effective method for forecasting GDP, and the accuracy of the forecasts can be improved by using a combination of different time series models. With regard to India, the use of hybrid models combining ARIMA, SARIMA, ANN, and Holt-Winters models has shown promising results in forecasting GDP growth rates.
The same methodology was adopted by K Y Ingale, SV Bharati and P V Karale (2023) [23], Utkal Keshari Sahoo, RV Chavan and SV Bharati (2022) [24] and Rede G. D., Bharati S. V. and Munde T. B. (2023) [25] in their studies of FDI inflow forecasting in India, Forecasting of coconut prices in Odisha and pomegranate prices in Solapur district respectively.

Data Collection

Secondary data used by:

Historical Data – GDP of India

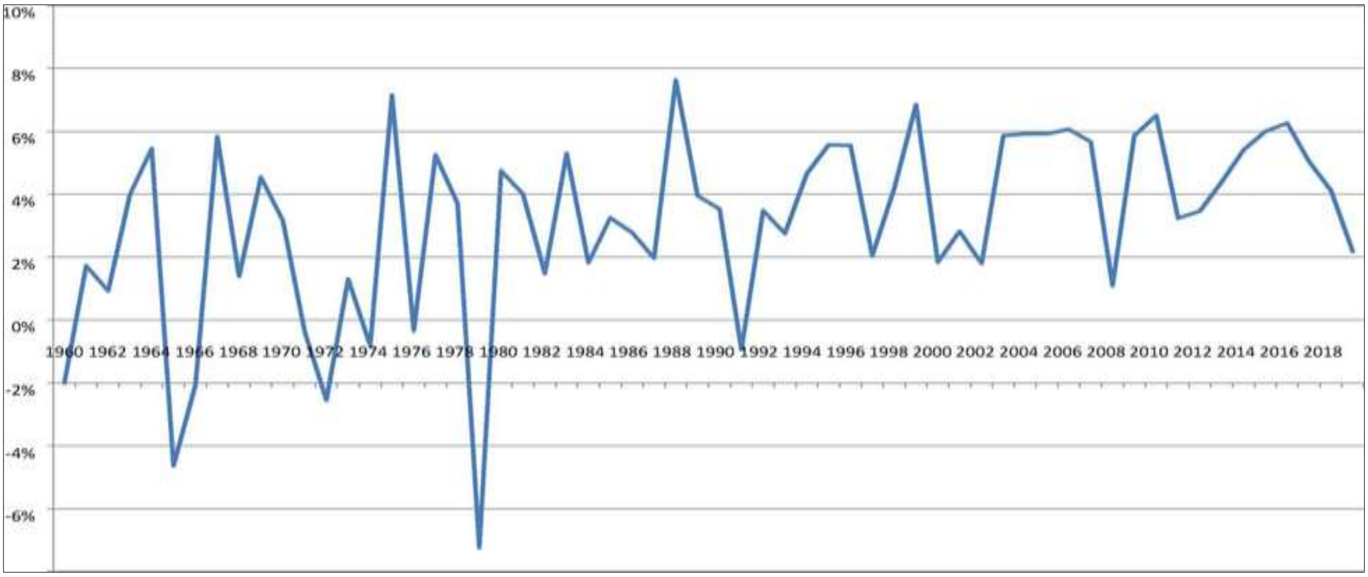
Year	GDP	Per Capita	Growth
1960	$37.03B	$82	0%
1961	$39.23B	$85	3.72%
1962	$42.16B	$90	2.93%
1963	$48.42B	$101	5.99%
1964	$56.48B	$116	7.45%
1965	$59.55B	$119	-2.64%
1966	$45.87B	$90	-0.06%
1967	$50.13B	$96	7.83%
1968	$53.09B	$100	3.39%
1969	$58.45B	$108	6.54%
1970	$62.42B	$112	5.16%
1971	$67.35B	$119	1.64%
1972	$71.46B	$123	-0.55%
1973	$85.52B	$144	3.30%
1974	$99.53B	$163	1.19%
1975	$98.47B	$158	9.15%
1976	$102.72B	$161	1.66%
1977	$121.49B	$186	7.25%
1978	$137.30B	$206	5.71%
1979	$152.99B	$224	-5.24%
1980	$186.33B	$267	6.74%
1981	$193.49B	$270	6.01%
1982	$200.72B	$274	3.48%
1983	$218.26B	$291	7.29%
1984	$212.16B	$277	3.82%
1985	$232.51B	$296	5.25%
1986	$248.99B	$310	4.78%
1987	$279.03B	$340	3.97%
1988	$296.59B	$354	9.63%
1989	$296.04B	$346	5.95%
1990	$320.98B	$368	5.53%
1991	$270.11B	$303	1.06%
1992	$288.21B	$317	5.48%
1993	$279.30B	$301	4.75%
1994	$327.28B	$346	6.66%
1995	$360.28B	$374	7.57%
1996	$392.90B	$400	7.55%
1997	$415.87B	$415	4.05%
1998	$421.35B	$413	6.18%
1999	$458.82B	$442	8.85%
2000	$468.39B	$443	3.84%
2001	$485.44B	$452	4.82%
2002	$514.94B	$471	3.80%
2003	$607.70B	$547	7.86%
2004	$709.15B	$628	7.92%
2005	$820.38B	$715	7.92%
2006	$940.26B	$807	8.06%
2007	$1,216.74B	$1,028	7.66%
2008	$1,198.90B	$999	3.09%
2009	$1,675.62B	$1,358	8.50%
2010	$1,823.05B	$1,458	5.24%
2011	$1,827.64B	$1,444	5.46%
2012	$1,856.72B	$1,450	6.39%
2013	$2,039.13B	$1,574	7.41%
2014	$2,103.59B	$1,606	8.00%
2015	$2,294.80B	$1,733	8.26%
2016	$2,652.75B	$1,982	7.04%
2017	$2,713.17B	$2,006	6.12%
2018	$2,868.93B	$2,100	4.18%

The researcher will use ARIMA model to predict by the India GDP and GDP per Capita from 2021 to 2039

Correlation and Regression

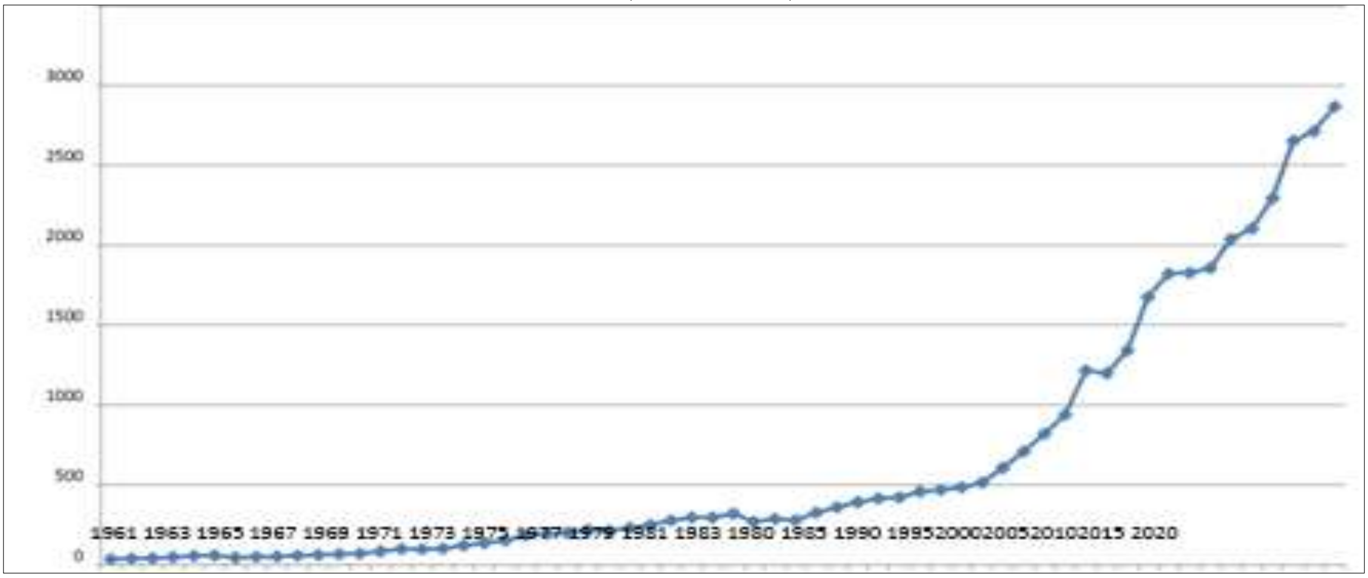
Correlation measures the degree of association ora connection between two variables. When it comes to GDP per capita, The strength of the association between GDP per capita and other variables may be assessed using correlation. and other economic indicators such as unemployment rate, inflation, or trade balance. Also Regression, on the other hand, is a statistical technique for examining the connection between two or more variables. In terms of GDP per capita, Regression analysis is a tool for determining the variables that influence changes in GDP per capita, such as population growth, technological advances, or changes in government policies.

Results and Discussion



Growth Rate of GDP

GDP (Billions of US $)



Trend of GDP

ARIMA MODEL Steps in Prediction

Predicting GDP in India by using ARIMA model Steps for ARIMA modelling include:a-Investigative analysis

- Fitting the model
- Diagnostic measures
- Predicted the future values.

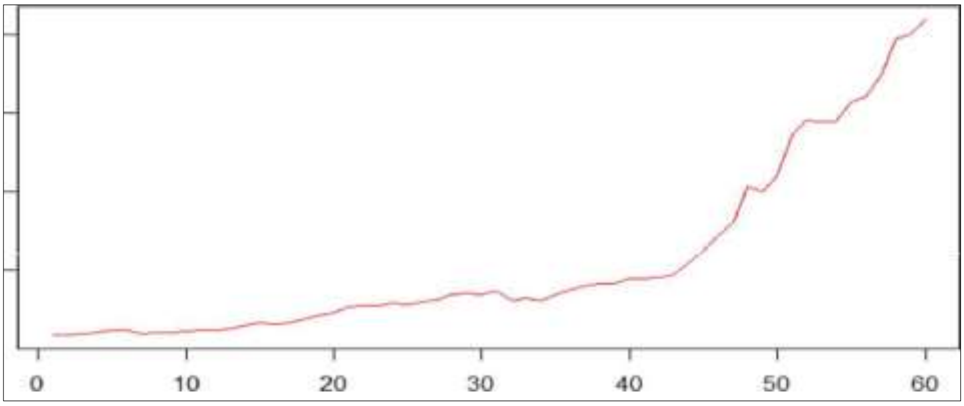


Fig 1: Sequence Graph of the GDP per-capita

(ACF) and (PACF) graphically

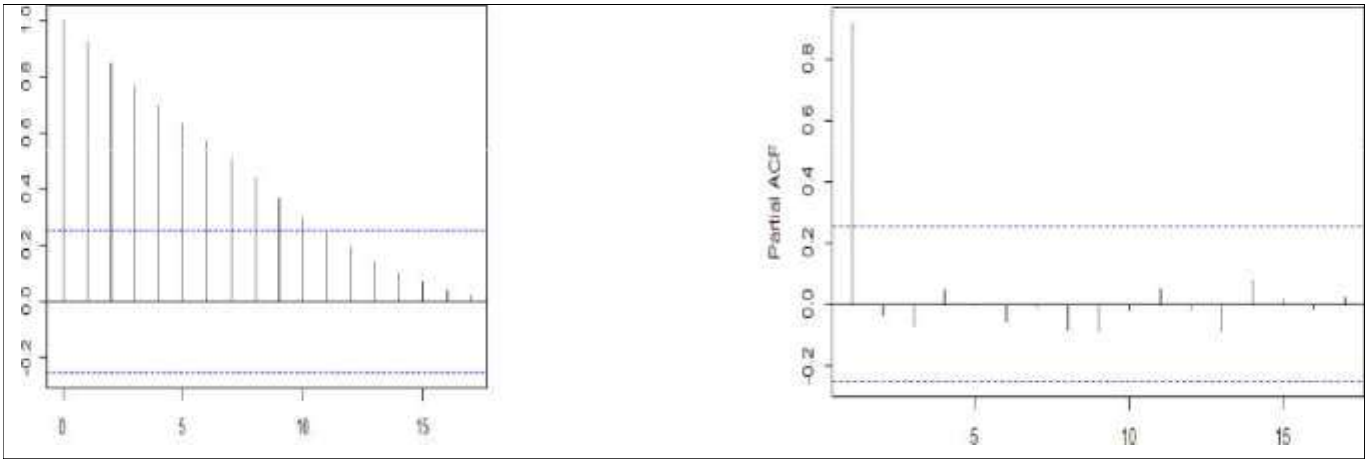


Fig 2: Shows the sample charts of the function of automatic association (ACF) and partial automatic association (PACF) respectively

It is clear in the PACF form that a single prominence falls outside the limits of confidence indicating the hypothetical primary value of n = 1. And the same thing gets, at ACF 10 heights outside confidence limits indicating m = 10

Fitting ARIMA model

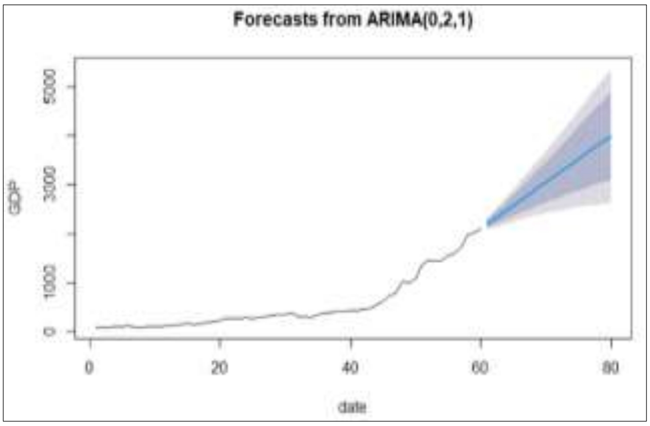
after using all the possible permutations of*n =(n-1,.i)* and *m=(m-1,.i)* the software gave the best values of *n* and *m* as 0 and 0 respectively, Second order non-seasonal differencing (d=2) is used to stabilize the data.

i.e. The best model was (0,2,1)

Predicted values of future GDP per capita using ARIMA model

Years	Forecast GDP per capita	Lo 95	Hi 95
2022	2384.337	2166.131	2602.543
2023	2479.116	2206.684	2751.548
2024	2573.895	2246.174	2901.616
2025	2668.674	2284.116	3053.231
2026	2763.453	2320.287	3206.618
2027	2858.232	2354.585	3361.878
2028	2953.011	2386.969	3519.052
2029	3047.789	2417.433	3678.146
2030	3142.568	2445.987	3839.15
2031	3237.347	2472.652	4002.042
2032	3332.126	2497.458	4166.795
2033	3426.905	2520.434	4333.377
2034	3521.684	2541.612	4501.757
2035	3616.463	2561.024	4671.902
2036	3711.242	2578.704	4843.78
2037	3806.021	2594.681	5017.361
2038	3900.8	2608.988	5192.612
2039	3995.579	2621.652	5369.506

From the above table; it is observed that the GDP per capita in 2039 will be approximately between (2621.652, 5369.506)



Model Summary

Coefficients[a]						
Model		Unstandardized\Coefficients		Standardized Coefficients	t	Sig
		B	Std-Error	Beta		
1	(Constant)	-1401.6	171.495		-8.173	0
	Population	2.30E-06	0	0.853	12.429	0
a. Dependent Variable: GDP (Billions of US J						

From the above table:
1. R value =0. 853
2. P value (<0.001**)

The Linear regression equation is (Y =2.302E-06 X - 1401.578)
Here the coefficient of X is)2.302E-06)This number indicates the population's impact, with all other factors being held constant. The predicted positive sign suggests that the effect would be favourable increasing GDP by 2.302E-06. And the level of statistical significance at 1%.

Conclusion
Our paper found that ARIMA models are effective in predicting India's GDP per capita. We used annual data from 1960 to 2020 to develop and evaluate various ARIMA models. and discovered that the best model for our data was the ARIMA (0,2,1) model. also, findings of our study are consistent with previous research, which has also found that ARIMA models are useful for predicting economic variables such as GDP. Our research contributes operationally through offering detailed explanations of how ARIMA models may be used to forecast India's per-capita GDP. and the study had concluded it is observed that the GDP per capita in 2039 will be approximately between (2621.652, 5369.506) and suggests that the effect would be favourable increasing GDP by 2.302E-06.
Overall, used time series analysis in forecasting GDP growth rates is essential for policymakers, investors, and economists To make wise decisions,and help guide decision-making and offer insights on how India's economy will develop in the future.

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