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Forecasting GDP of Nepal using Autoregressive Integrated Moving Average (ARIMA) Model

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ABSTRACT

Background: Globally many research are working on modeling and forecasting of gross domestic product (GDP). The trend and pattern will help the planner and policy maker to make future monetary policy. The aim of this research is to find the ARIMA model and forecasting.

Methods: Box-Jenkins methodology was use for the modeling and forecasting of annual GDP series of Nepal from 1990/91 to 2019/20. Eviews 10 software was use for data analysis.

Results: Using the Box-Jenkins methodology this research examine the number of ARIMA family model that describe the annual GDP series and the appropriate model is ARIMA(1,1,1).

Conclusions: This research concluded that ARIMA(1,1,1) is the model which capture the GDP series of Nepal for this period.

Keywords: : ARIMA; Box-Jenkins methodology; GDP, Nepal.

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INTRODUCTION

GDP represents the total value of all goods and services produced within a country's borders over a specified period, usually a year.[1] It includes everything from the products manufactured by businesses to the services provided by individuals, such as healthcare, education, and transportation.[2] GDP is considered an important indicator of a country's economic health and growth, as it reflects the total income generated within a country's economy. It is used to measure changes in the standard of living, economic growth, and productivity of a country.[3] However, it should be noted that GDP alone may not necessarily indicate the well-being of the people or the distribution of wealth in a country, as it does not account for factors such as income inequality or non-monetary measures of well-being, such as access to healthcare, education, and social services.[4] Nominal GDP is the total monetary value of the final product in terms of current market prices produced from all productive sectors within a country during a year. If GDP rises from one year to the next, one of two things must be true: (1) the economy is producing a larger output of goods and services, or (2) goods and services are being sold at higher prices.[5] Economists want to separate these two effects while they study the changes in the economy over time. In particular, they want a measure of the total quantity of goods and services the economy is producing that is not affected by changes in the prices of those goods and services. They use real GDP to measure this fact. Real GDP is the total monetary value of final goods and services produced from all productive sectors in terms of constant prices (or base year prices) within a country during a year.[6-7] There are three ways from which the GDP of any country can be measured. In the production approach GDP includes the sum of gross value added of the various institutional sectors or the various industries plus taxes and less subsidies on products. In the expenditure approach GDP includes the sum of final uses of goods and services by resident institutional units (actual final consumption and gross capital formation), plus exports and minus imports of goods and services.[8] While in the income approach GDP is the sum of uses in the total economy generation of income account (compensation of employees, taxes on production and imports less subsidies, gross operating surplus and mixed income of the total economy).[9] Now Nepal is moving toward achieving the sustainable development goals and graduating from the status of least developed country. The support from international community in democratic transition of Nepal, to some extent, is expected to facilitate the country for making progress toward achievement of the Millennium Development Goals. In an attempt toward this direction, growth in GDP remains as the main target variable for Government of Nepal for setting up effective and efficient strategies and policies for economic development. In this backdrop, it is

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necessary to provide a precise forecast of GDP in order to develop meaningful vision of the future trend of Nepalese economy. Framing appropriate strategies and policies for economic development with proper allocation of funds towards priority sectors requires a good estimate of GDP for some period ahead. It is only possible by using appropriate time series model for forecasting (Rana, 2019). Nowadays globally many academician and policy maker are working on the modeling and forecasting the behavior of gross domestic product (GDP). The evolution of academic and policy interest in this area has been basically geared by the fact that GDP is considered as an important index of national economic development. Besides, GDP also helps judging the operating status of macro economy as a whole.[10] From the last few years many theoretical and empirical attempts have witnessed the growing academic interest on GDP growth and its determinants. Lucas (1988) explains that increasing concern toward GDP growth is being accelerated by the need to achieve higher rate of economic growth in both developed and developing nations.[7-11] Many researches are carried out in GDP to find the trend and various factors responsible for such change. Some of the factors are living standard, quality of life, lower investment on productivity.[12] Based upon the forecasted value of GDP Rastra Bank in making the various planning and policy.[13]Gross domestic product (GDP) is one of the most important indicators of national economic activities for countries.[14] For the time series modeling and forecasting of GDP series we used Box and Jenkins (1976) methodology which is also known as ARIMA (Auto-Regressive-Integrated-MovingAverage) methodology.[2]

METHODS

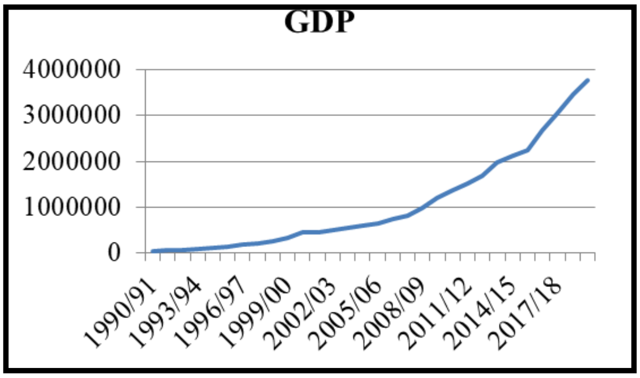
A cross sectional study was conducted by taking 30 years' time series GDP data of Nepal from 1990/91 to 2019/20 for the modeling and forecasting using Box-Jenkins methodology. For the data analysis Eviews 10 software was used.[2] Autoregressive integrated moving average (ARIMA) model was used in this research. An ARIMA model has three component functions: AR (p), the number of lag observations or autoregressive terms in the model; I (d), the difference in the nonseasonal observations; and MA (q), the size of the moving average window. An ARIMA model order is depicted as (p,d,q) with values for the order or number of times the function occurs in running the model. Values of zero are acceptable. In order to model a time series data with this approach, at first the series must be stationary. Statistically, the series is confirmed to be stationary if the n values seem to fluctuate with constant variation around a constant mean. If time series data set is non-stationary, differencing process is used to make it stationary. If the first order differences of the original time series values are also non-stationary, then second order differences are used to produce stationary time series values. Since the essence of engaging an ARIMA model is to forecast a series, the B-J methodology uses four steps: identification, estimation, diagnostics and forecasting.[2]

RESULT

Identification for stationary

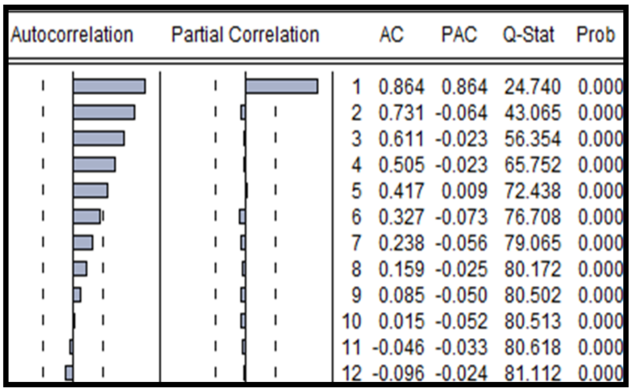
Figure 1 showed the plot of annual GDP of Nepal from 1990/91-2019/20, which showed the upward pattern.

Figure 1. Annual GDP of Nepal, 1990/91-2019/20*



Above figure 1 showed the annual GDP of Nepal from 1990/91-2019/20. Which shows that the trend is indicating series is non stationary.

Figure 2: Correlogram of Annual GDP of Nepal, 1990/91-2019/20



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.864	0.864	24.740	0.000
		2	0.731	-0.064	43.065	0.000
		3	0.611	-0.023	56.354	0.000
		4	0.505	-0.023	65.752	0.000
		5	0.417	0.009	72.438	0.000
		6	0.327	-0.073	76.708	0.000
		7	0.238	-0.056	79.065	0.000
		8	0.159	-0.025	80.172	0.000
		9	0.085	-0.050	80.502	0.000
		10	0.015	-0.052	80.513	0.000
		11	-0.046	-0.033	80.618	0.000
		12	-0.096	-0.024	81.112	0.000

Figure 2 showed the correlogram of annual GDP series of Nepal. The ACF and PACF were taken only up to 12 lags. From the above figure result we can conclude that the coefficients of autocorrelation

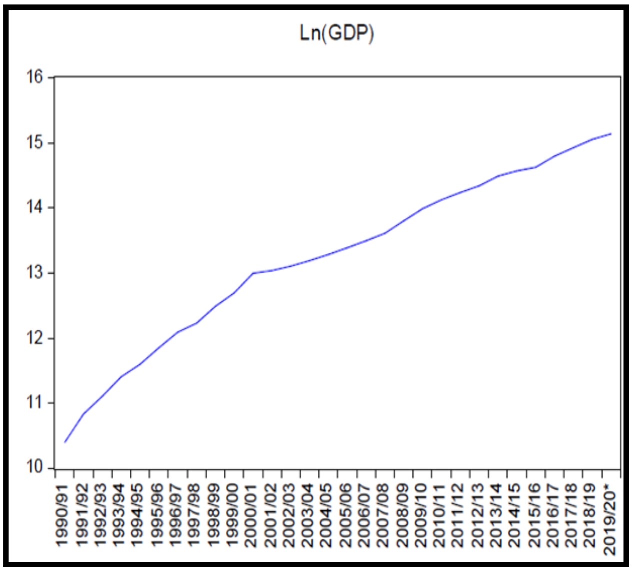
(ACF) starts with a high value and declines slowly, indicating that the series is non-stationary. Also the Q-statistic of Ljung-Box which was smaller than 0.05, so we cannot reject the null hypothesis that the GDP series is non-stationary. For the further conformation ADF unit root was carried out.

Table 1: ADF Unit root test result of annual GDP of Nepal

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		10.21184	1.0000
Test critical values:	1% level	-3.679322	
	5% level	-2.967767	
	10% level	-2.622989	

*MacKinnon (1996) one-sided p-values.

Above table 1 shoed the result of ADF unit root test. Which showed that GDP series is non stationary (p-value>0.05). This indicates that we have no enough evidence to reject the null hypothesis of



unit root. Thus, the series must be configured in first or second differences.

Figure 3: Trend line of Ln(GDP) series

Above figure 3 shoed the trend line of Ln(GDP) series of Nepal. After taking logarithm the trend is still increasing indicating that, Ln(GDP) series is also non stationary. Above figure 4 showed the trend line of first difference of Ln(GDP) series which is fluctuating indicating the data is stationary. For the confirmation correlogram and ADF unit root test was carried out.

Figure 4. Trend line of first difference of Ln (GDP)

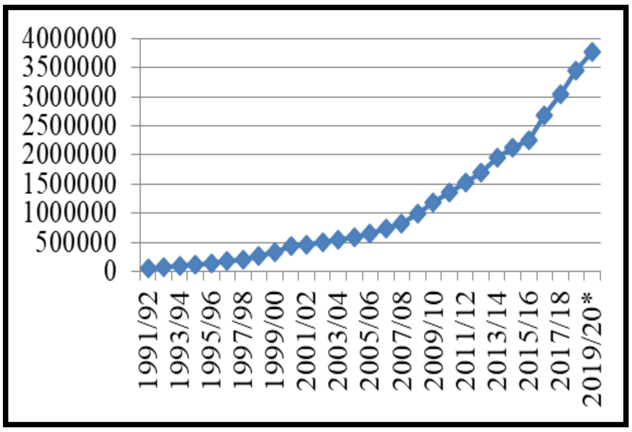
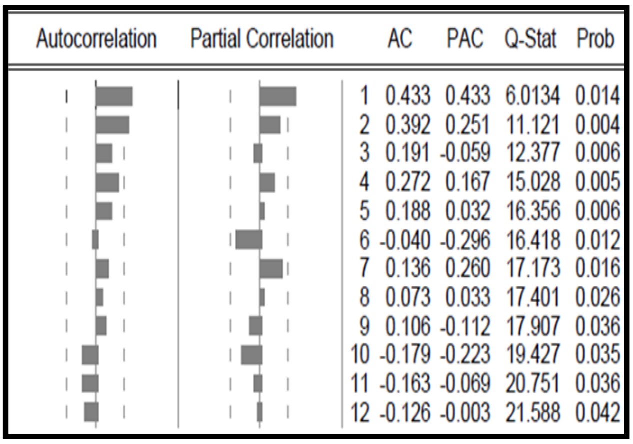


Figure 5 Correlogram of first difference of Ln (GDP) series.



From the above figure 5 showed correlogram of first difference of Ln(GDP). The coefficient of autocorrelation (ACF) starts with a high value and declines slowly, indicating that the series is non-stationary. Also the Q-statistic of Ljung-Box (1978) at the 24th lag (only 12 lags values were reported) has a probability value of 0.000 which is smaller than 0.05, so we cannot reject the null hypothesis that the GDP series is non-stationary in first difference.

Table 2. ADF Unit root test result of first difference of Ln(GDP) series

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.021744	0.0045
Test critical values:	1% level	-3.689194	
	5% level	-2.971853	
	10% level	-2.625121	

*MacKinnon (1996) one-sided p-values.

Above table 2 showed the result of ADF unit root test of fist difference of Ln(GDP) series. Which showed that GDP series is non stationary (p-value<0.05). This indicates that there is no enough evidence to reject the null hypothesis of unit root. The p-value of Augmented Dickey Fuller test is less than 0.05 so we have sufficient evidence to say that the first difference of Ln(GDP) is stationary. This indicates that Ln(GDP) data is stationary in first differences. Therefore for our model ARIMA (p,d,q), So, the order of differencing is 1 i.e d=1. Above correlogram was used to determine the model ARMA (p,q), i.e. the values of parameters p and q. Which is already mentioned in the above figure, an AR(p) model has a PACF that truncates at lag p and an MA(q)) has an ACF that truncates at lag q. The orders of autoregressive and moving average process has been determine by observing the value of ACF and PACF of the second difference of GDP. The ACF of first difference of Ln(GDP) series is significantly decrease after at lag order 1, 2. This implies that the autocorrelation of the successive pair of observations in time period 1, 2 So, the tentative order of moving average process can be 1, 2 (that is q=1, 2). The PACF of first difference of Ln(GDP) series is significantly decrease after lag order 1,2,6. So, the tentative order of autoregressive process can be 1 (that is p=1,2,6). So, the tentative models are ARIMA(1,1,1), ARIMA (1,1,2), ARIMA(2,1,1), ARIMA(2,1,2), ARIMA (6,1,1), ARIMA(6,1,2)

Estimatmation Process

After identifying the tentative ARIMA model, in the next steep need to find the best ARIMA model. In to select the best ARIMA model Adj. R^2, SER, AIC and SIC of all tentative model was carried out. Appropriate model should have most significant coefficients, lowest volatility, highest R^2, and lowest AIC and SBIC.

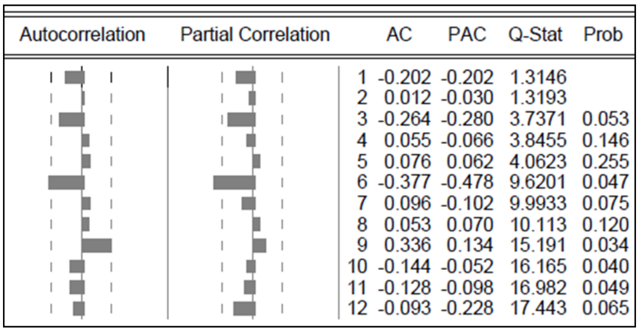
Table 3. Result of ARIMA (p,d,q) Model fitting

	SIGMASQ	Adj R^2	SSR	AIC	SIC
ARIMA(1,1,1)	0.005039	0.2853	0.0760	-2.144	-1.955
ARIMA(1,1,2)	0.005327	0.2445	0.0786	2.101	-1.912
ARIMA(2,1,1)	0.005040	0.2850	0.0764	-2.149	-1.961
ARIMA(2,1,2)	0.007697	-0.0915	0.0944	-1.735	-1.547
ARIMA(6,1,1)	0.006482	0.0867	0.0867	-1.910	-1.721
ARIMA(6,1,2)	0.006509	0.0770	0.0868	-1.898	-1.709

Above table 3 showed the best model fitting among all the models. The best fitted model is ARIMA (1,1,1) which have more significant coefficient, lowest volatility, high adj R^2, and lowers AIC as well as SIC.

Diagnostics

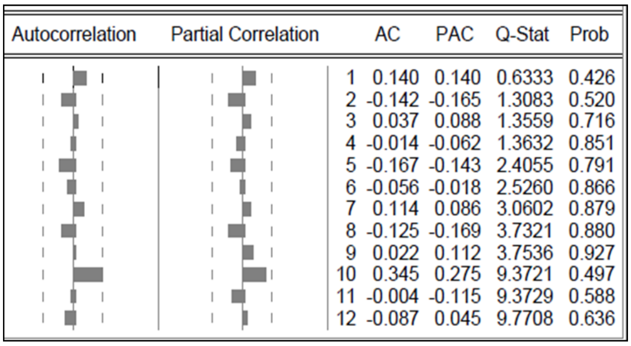
Figure 6. Correlogram of residuals for ARIMA (1,2,1)



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.202	-0.202	1.3146	
		2	0.012	-0.030	1.3193	
		3	-0.264	-0.280	3.7371	0.053
		4	0.055	-0.066	3.8455	0.146
		5	0.076	0.062	4.0623	0.255
		6	-0.377	-0.478	9.6201	0.047
		7	0.096	-0.102	9.9933	0.075
		8	0.053	0.070	10.113	0.120
		9	0.336	0.134	15.191	0.034
		10	-0.144	-0.052	16.165	0.040
		11	-0.128	-0.098	16.982	0.049
		12	-0.093	-0.228	17.443	0.065

From the above table the appropriate model is (1,1 ,1). A flat correlogram is ideal. If a lag is significant re-estimated the model. The correlogram of the residuals is flat (all the values are lies in between standard error bound -95% CI) which indicate that all information has been capture. So the forecast will be based on this model.

Figure 7. Ljung- Box test for squared residuals (autocorrelation test)



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.140	0.140	0.6333	0.426
		2	-0.142	-0.165	1.3083	0.520
		3	0.037	0.088	1.3559	0.716
		4	-0.014	-0.062	1.3632	0.851
		5	-0.167	-0.143	2.4055	0.791
		6	-0.056	-0.018	2.5260	0.866
		7	0.114	0.086	3.0602	0.879
		8	-0.125	-0.169	3.7321	0.880
		9	0.022	0.112	3.7536	0.927
		10	0.345	0.275	9.3721	0.497
		11	-0.004	-0.115	9.3729	0.588
		12	-0.087	0.045	9.7708	0.636

Ljung- Box test for squared residuals (autocorrelation test). Above figure 7 showed the result of Ljung- Box test for squared residuals. This is a result of autocorrelation test of residuals. Here from lag 1 to lag 12 all the probability values are more than 0.05 which indicate that there is no autocorrelation in this model. This concludes that the fundamental idea of the B-J methodology is that of parsimony (meagerness or stinginess). Parsimonious model produce better results than over-parameterized model. On the figure 5 the inverse roots of AR and MA characteristic polynomials for the stability of ARIMA model are presented. From the diagram we can see that the ARIMA model is stable since the corresponding inverse roots of the characteristic polynomials are in the unit circle. An observation of Figure 6 demonstrates that the selected ARIMA model is stable as inverse roots of the characteristic polynomials are inside the unit circle meaning that they are less than unit.

Table 4: Estimation Model ARIMA (1,1,1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.190511	0.077902	2.445515	0.0218
AR(1)	0.914376	0.129197	7.077397	0.0000
MA(1)	-0.468557	0.271717	-1.724429	0.0970
SIGMASQ	0.005039	0.001123	4.487739	0.0001

The results in the above table 4 indicate that one coefficient is statistically significant at 5% and 10% level of significance. The roots are 0.91 and 0.46, both inside the unit circle indicating. The results in the above table 4 indicate that one coefficient is statistically significant at 5% and 10% level of significance. The roots are 0.91 and 0.46, both inside the unit circle indicating stationary and inevitability respectively. The chosen model as summarized in Table 3 is ARIMA (1,1,1) and is given by

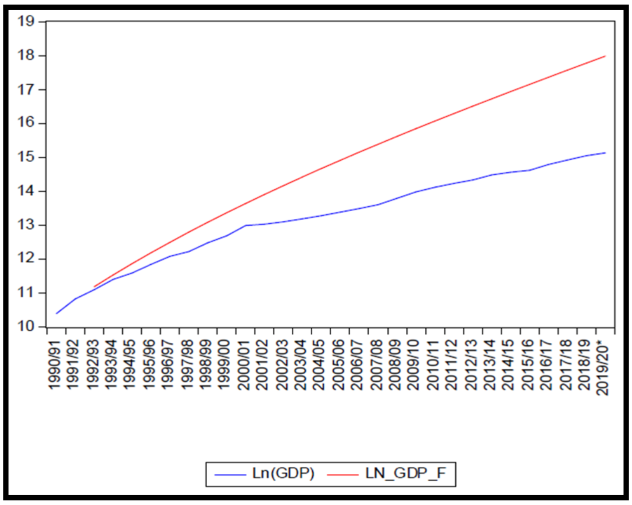
$$D(LnGDPt)= 0.190511+0.914376D(LnGDPt-1) -0.468557\varepsilon t-1 + \varepsilon t$$

The figure shows actual values by solid line, fitted values by upper dotted line and residual of the model by lower dotted line. The actual, fitted and residual graph shows the actual and fitted values of the dependent variable and the residuals from the regression. The actual values are the sum of fitted values and residuals. The residuals are shown with a bound of plus minus one estimated standard error.

Forecasting

Essence of fitting an ARIMA model is to forecast future values of the series by using the past value of the series itself. The forecast is based on the final selected model. In order to verify whether the forecast is correct or not need to plot the forecast graph. The forecast is based on the ARIMA model for second differenced GDP.

Figure 9. In-Sample Forecast of GDP series



DISCUSSION

By sing Box and Jenkins (1976) methodology the best ARIMA model is (1, 1, 1) while the research of Rana forecast annual time series of GDP in Nepal from mid July, 1960 to mid-July, 2018 he found the best ARIMA model as (0,1,2).[14] Wei and al. (2010) use data from Shaanxi GDP for 1952-2007 to forecast country's GDP for the following 6 years. Applying the ARIMA (1,2,1) model they find that GDP of Shaanxi present an impressive increasing trend.[10] Maity and Chatterjee (2012) examine the forecasting of GDP growth rate for India using ARIMA (1,2,2) model and a time period of 60 years. The results of their study showed that predicted values follow an increasing trend for the following years.[8] Hisham use Sudan GDP during the period 1960-2018 by using the Box- Jenkins methodology the appropriate model is ARIMA (1,1,1).[5] Wei, Bian and Yuan (2010) forecast the GDP of the Shanxi province in China based on the ARIMA model. Using GDP data from 1952 to 2007, they set up an ARIMA (1, 2, 1) time series model, and compare the actual and predicted values from 2002 to 2007.[19] Dritsaki forecast the GDP data of Greece, during the period 1980-2013, they set up ARIMA (1,1,1).[4]

CONCLUSIONS

ARIMA(1,1,1) is the best ARIMA model which captures the GDP series of Nepal. The forecasted data showed that the growth and trend of GDP of Nepal is in increasing order.

Conflict of Interest: None .

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