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Forecasting Sudanese Gross Domestic Product Using ARIMA Models

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Abstract:

In this research, use the time series models to construct a model to predict the series of Gross Domestic Product by Expenditure at Constant Prices (1982 to 2018). The results showed that the model is the appropriate model for the series of Gross Domestic Product is: ARIMA (0,1,0). According to the estimation results of this model, we observe the compatibility between observed and estimated values as these values are consistent with those in the original time series, indicating the strength of the model and predictability.

Keywords: Autocorrelation; Autoregressive; ARIMA Models; Stationary; Identification; Estimation; Forecasting.

1. Introduction

One type of model that does account for autocorrelation is the Autoregressive Integrated Moving Average (ARIMA) model, which is fit using a methodology developed by George Box and Gwilym Jenkins (1970). The application of ARIMA models in health sector is varied, however, it has been used extensively for (i) outbreak detection in the arena of infectious diseases and in (ii) the evaluation of population level health interventions in the format of interrupted time series analysis. Both of these methods require the formal characterization of the inherent pattern in a time series, and using this pattern to forecast future behavior of the time series. For outbreak detection, we forecast the 95% confidence interval for a time series, and deviation of the actual time series values from within 95% CI bounds would constitute a signal. In the interrupted time series, the time series is forecasted into the future, and deviations of actual values from the forecasted values is considered to be a causal effect of public health intervention.

Note:

- ARIMA models do NOT predict rare “black swan” events, as there is no pattern in the time series to suggest a future event of this type.
- The causal framework for ARIMA model differs slightly from Epidemiology frame, and is more consistent with the Granger definition of a cause from economics.

Data Requirements

The data requirements to fit an ARIMA model are:

- A univariate time series (count or continuous) with at least 50-100 observations
- If the time series consists of count data, the interval over which the count is taken must remain the same over time

- If the time series consists of continuous data, the interval between measurements must remain the same over time
- Data must be presented in a vertical vector (column of data)

2. Literature Review

2.1 Components and Fitting of ARIMA Models

Overview:

The ARIMA model divides the pattern of a time series into three components: the autoregressive component, p, which describes how observations are related to each other as the result of being close together in time; the differencing component, d, which is used to make a time series stationary (see below); and the moving average component, q, which describes outside "shocks" to the system.

Stationarity Assumption:

A key requirement of ARIMA models is that the data set of interest is stationary, meaning that it has a constant mean and variance over time. If a data set is not stationary to begin with, stationarity can be achieved by a process called "differencing," which is represented by the "d" component of the model.

Identification:

The identification steps involve fitting the autoregressive component (variable "p"), the moving average component of the ARIMA model (variable "q"), as well any required differing to make the time series stationary or to remove seasonal effects (variable "d").

Together, these user-specified parameters are called the order of ARIMA. The formal specification of the model will be ARIMA (p,d,q) when the model is reported.

The first step in model identification is to ensure the process is stationary. Stationarity can be checked with a Dickey-Fuller Test. Any non-significant value under model assumptions suggests the process is non-stationary. The process must be converted to a stationary process to proceed, and this is accomplished by the differencing the time series using a lag in the variable as well as removing any seasonality effects. The lagged values used to difference the time series will constitute the "d" order.

Ex. An additive difference of 1 and seasonal difference of 12 is reported as d=(1,12). Once the process is stationary, we fit the autoregressive and moving average components. To fit the model we use the Autocorrelation Function (ACF) and the Partial Autocorrelation Function (PACF) in addition to various model fitting tools provided by software. There are various sets of rules to guide p and q fitting in lower order processes, but generally we let the statistical software fit up to 12-14 orders for AR and MA, and suggest combinations that minimize an AIC or BIC criterion. This part is as much as an art form as it is a structured process. The goal during this phase is to minimize the AIC/BIC criterion.

Estimation:

The estimation procedure involves using the model with p, d and q orders to fit the actual time series. We allow the software to fit the historical time series, while the user checks that there is no significant signal from the errors using an ACF for the error residuals, and that estimated parameters for the autoregressive or moving average components are significant.

Forecasting:

After a model is assured to be stationary, and fitted such that there is no information in the residuals, we can proceed to forecasting. Forecasting assesses the performance of the model against real data. There is an option to split the time series into two parts, using the first part to fit the model and the second half to check model performance. Usually the utility of a specific model or the utility of several classes of models to fit actual data can be assessed by minimizing a value such as root mean square.

ARIMA (p,d,q) modeling To build a time series model issuing ARIMA, we need to study the time series and identify p,d,q

- Ensuring Stationarity
- Determine the appropriate values of d
- Identification: Determine the appropriate values of p & q using the ACF, PACF, and unit root tests • p is the AR order, d is the integration order, q is the MA order
- Estimation : Estimate an ARIMA model using values of p, d, & q you think are appropriate.
- Diagnostic checking: Check residuals of estimated ARIMA model(s) to see if they are white noise; pick best model with well-behaved residuals.
- Forecasting: Produce out of sample forecasts or set aside last few data points for in-sample forecasting.

2.2 Gross Domestic Product (GDP) :

Gross Domestic Product (GDP) is the total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period. As a broad measure of overall domestic production, it functions as a comprehensive scorecard of the country’s economic health.

(GDP) is one of the most well-known markers used to follow the soundness of a country's economy. It incorporates various factors, for example, consumption and venture. It's additionally a key factor in utilizing the Taylor rule. In this short article, we take a gander at why GDP is such a significant monetary factor, and what it implies for the two business analysts and financial specialists.

The Basics of GDP

GDP includes all private and public consumption, government outlays, investments, additions to private inventories, paid-in construction costs, and the foreign balance of trade (exports are added, imports are subtracted).

It speaks to the absolute dollar estimation all things considered and benefits created over a particular timespan, frequently alluded to as the size of the economy. Gross domestic product is generally communicated as a correlation with the past quarter or year.

Key Takeaways

- Gross residential item tracks the strength of a nation's economy.
- It speaks to the estimation everything being equal and administrations created over a particular timeframe inside a nation's fringes.
- Economists can utilize GDP to decide if an economy is developing or encountering a downturn.
- Investors can utilize GDP to settle on ventures choices—a terrible economy implies lower profit and lower stock costs.

Total national output (GDP) Defined

Gross domestic product is essentially used to check the soundness of a nation's economy. It is the money related estimation of all the completed merchandise and enterprises created inside a nation's outskirts in a particular timeframe and incorporates anything delivered by the nation's residents and outsiders inside its fringes.

As per the International Monetary Fund, the United States is the world's biggest economy, trailed by China and Japan.

Total national output is the absolute benefit of everything created in the nation. It doesn't make a difference if it's delivered by residents or outsiders. On the off chance that they are situated inside the nation's limits, their creation is remembered for GDP.

To evade twofold checking, GDP incorporates the last estimation of the item, yet not the parts that go into it. For instance, a U.S. footwear maker utilizes bands and different materials made in the United States. Just the estimation of the shoe gets checked; the shoelace doesn't.

In the United States, the Bureau of Economic Analysis estimates GDP quarterly. Every month, it reexamines the quarterly gauge as it gets refreshed information.

Calculating GDP

The components of GDP include personal consumption expenditures plus business investment plus government spending plus (exports minus imports). Now that you know what the components are, it's easy to calculate a country's gross domestic product using this standard formula: C + I + G + (X - M).

When economists talk about the “size” of an economy, they are referring to GDP.

Types

There are many different ways to measure a country's GDP. It's important to know all the different types and how they are used.

Genuine GDP: To look at GDP by year, the BEA expels the impacts of expansion. Else, it may appear as though the economy is developing when actually it's experiencing twofold digit swelling. The BEA computes genuine GDP by utilizing a value deflator. It reveals to you how much costs have changed since a base year. The BEA increases the deflator by the ostensible GDP. The BEA makes the accompanying three significant differentiations:

Development Rate: The GDP development rate is the rate increment in GDP from quarter to quarter. It lets you know precisely whether the economy is becoming speedier or more slow than the quarter previously. Most nations utilize genuine GDP to expel the impact of expansion. If the economy produces less than the quarter before, it contracts and the growth rate is negative. This signals a recession. If it stays negative long enough, the recession turns into a depression.

How GDP Affects You

Gross domestic product impacts individual fund, speculations, and employment development. Speculators take a gander at a countries' development rate to choose in the event that they ought to alter their advantage distribution. They likewise contrast nation development rates with locate their best worldwide chances. They buy portions of organizations that are in quickly developing nations.

The U.S. national bank, the Federal Reserve, utilizes the development rate to decide fiscal arrangement. It executes expansionary money related strategy to avert downturn and contractionary financial approach to avoid swelling. Its essential instrument is the government finances rate.

For instance, on the off chance that the development rate is expanding, at that point the Fed raises financing costs to stem expansion. For this situation, you should secure a fixed-rate contract. Your installments on a movable rate home loan will ascend alongside the fed finances rate.

In the event that development eases back or gets negative, at that point you should refresh your resume. Slow monetary development prompts cutbacks and joblessness. That can take a while. It requires some investment for administrators to gather the cutback list and get ready leave bundles.

Utilize the GDP report from the BEA to figure out which divisions of the economy are developing and which are declining.

You can go after positions in developing segments. In any event, during the 2008 money related emergency, human services ventures kept on including employments. This report additionally encourages you decide if you ought to put resources into, state, a tech-explicit shared reserve versus a store that spotlights on agribusiness.

Investment

A speculation is an advantage or thing procured with the objective of creating pay or appreciation. In a financial sense, a speculation is the acquisition of merchandise that are not devoured today however are utilized later on to make riches. In account, a venture is a money related resource obtained with the possibility that the benefit will give salary later on or will later be sold at a more significant expense for a benefit.

A speculation consistently concerns the cost of some advantage today (time, cash, exertion, and so forth.) with expectations of a more noteworthy result later on than what was initially placed in.

Contributing is giving cash something to do to begin or extend an undertaking - or to buy an advantage or premium - where those assets are then given something to do, with the objective to pay and expanded an incentive after some time. The expression "speculation" can allude to any component utilized for producing future pay. In the budgetary sense, this incorporates the acquisition of securities, stocks or land property among a few others.

Furthermore, a built structure or other office used to deliver products can be viewed as a venture. The generation of products required to deliver different merchandise may likewise be viewed as contributing.

Making a move with expectations of raising future income can likewise be viewed as a speculation. For instance, when deciding to seek after extra training, the objective is regularly to expand information and improve aptitudes with expectations of eventually creating more salary. Since contributing is arranged toward future development or pay, there is hazard related with the interest for the situation that it doesn't work out or misses the mark. For example, putting resources into an organization that winds up failing or a task that comes up short. This is the thing that isolates contributing from sparing - setting aside is aggregating cash for sometime later that isn't in danger, while speculation is giving cash something to do for future increase and involves some hazard.

Financial development can be empowered using sound speculations at the business level. At the point when an organization builds or secures another bit of creation hardware so as to raise the all out yield of merchandise inside the office, the expanded generation can cause the country's (GDP) to rise. This enables the economy to develop through expanded generation dependent on the past hardware venture.

The IS-LM model, which means "speculation reserve funds" (IS) and "liquidity inclination cash supply" (LM) is a Keynesian macroeconomic model that shows how increments in venture at a national level mean increments in financial interest, and the other way around.

A speculation bank gives an assortment of administrations intended to help an individual or business in expanding related riches. This does exclude conventional purchaser banking. Rather, the organization centers around venture vehicles, for example, exchanging and resource the executives. Financing alternatives may likewise be accommodated the reason for helping with the these administrations.

Venture banking is a particular division of banking identified with the production of capital for different organizations, governments and different substances. Speculation banks guarantee new obligation and value protections for a wide range of enterprises, help in the closeout of protections, and help to encourage mergers and acquisitions, redesigns and merchant exchanges for the two foundations and private speculators. Venture banks likewise give direction to guarantors in regards to the issue and arrangement of stock, for example, with an IPO or rights advertising.

Saving

Reserve funds, as indicated by Keynesian financial aspects, are what an individual has left over when the expense of their customer consumption is subtracted from the measure of discretionary cash flow earned in a given timeframe. For the individuals who are monetarily reasonable, the measure of cash left over after close to home costs have been met can be certain; for the individuals who will in general depend using a loan and credits to make a decent living, there is no cash left for investment funds. Reserve funds can be utilized to build pay through putting resources into various venture vehicles.

Saving account pays enthusiasm on money not required for day by day costs however accessible for a crisis. Stores and withdrawals are made by telephone, mail or at a bank office or ATM. Loan costs are higher than on financial records.

A currency advertise account requires a higher least equalization, pays more enthusiasm than other financial balances and permits barely any month to month withdrawals through registration benefits or charge card use.

A testament of store (CD) limits access to money for a specific period in return of a higher loan fee. Store terms go from a quarter of a year to five years; the more drawn out the term, the higher the loan cost.

Compact discs have early-withdrawal punishments that can delete premium earned, so it is ideal to keep the. Cash in the CD for the whole term. (For related perusing, see "The amount Cash Should I Keep in the Bank?")

Consumption

Consumption, in financial matters, the consumption of products and ventures by family units. Consumption is unmistakable from consumption use, which is the acquisition of merchandise and enterprises for use by families. Consumption contrasts from consumption use basically in light of the fact that strong merchandise, for example, cars, produce a use chiefly in the period when they are obtained, however they create "consumption administrations"

The investigation of consumption conduct assumes a focal job in both macroeconomics and microeconomics. Macroeconomists are keen on total consumption for two particular reasons. In the first place, total consumption decides total sparing, on the grounds that sparing is characterized as the bit of salary that isn't expended. Since total sparing feeds through the monetary framework to make the national inventory of capital, it pursues that total consumption and sparing conduct impacts an economy's long haul gainful limit. Second, since consumption use represents the majority of national yield, understanding the elements of total consumption use is fundamental to understanding macroeconomic vacillations and the business cycle.

Microeconomists have read utilization conduct for some, various reasons, utilizing consumption information to gauge destitution, to look at families' readiness for retirement, or to test hypotheses of rivalry in retail businesses. A rich assortment of family unit level information sources, (for example, the Consumer Expenditure Survey directed by the U.S. government) enables market analysts to analyze family spending conduct in minute detail,

and microeconomists have additionally used these information to look at collaborations among consumption and other microeconomic conduct, for example, work chasing or instructive achievement.

In their investigations of consumption, business analysts for the most part draw upon a typical hypothetical system by accepting that purchasers base their uses on a balanced and educated appraisal regarding their present and future monetary conditions. This "levelheaded advancement" supposition that is untestable, nonetheless, without extra presumptions concerning why and how buyers care about their degree of consumption; along these lines purchasers' inclinations are thought to be caught by an utility capacity. For instance, business analysts generally expect (1) that the desperation of consumption needs will decay as the degree of consumption builds (this is known as a declining minimal utility of consumption), (2) that individuals like to confront less instead of more hazard in their consumption (individuals are chance opposed), and (3) that unavoidable vulnerability in future salary creates some level of prudent sparing. In light of a legitimate concern for straightforwardness, the standard renditions of these models likewise make some less-harmless presumptions, including affirmations that the delight yielded by the present consumption doesn't rely on one's past consumption (there are no propensities from an earlier time that impact the present consumption) and that present joy doesn't rely on correlation of one's consumption to the consumption of others (there is no "envy").

Inside the normal advancement system, there are two fundamental methodologies. The "life-cycle" model, first enunciated in "Utility Analysis and the Consumption Function" (1954) by financial experts Franco Modigliani and Richard Brumberg, recommends that families' spending choices are driven by family unit individuals' appraisals of use needs and salary over the rest of their lives, considering unsurprising occasions, for example, a sharp drop in pay at retirement. The standard adaptation of the life-cycle model likewise accept that customers would like to spend everything before they bite the dust (i.e., it expect there is no

inheritance thought process). Life-cycle models are most normally utilized by microeconomists modeling household-level data on consumption, income, or wealth Macroeconomists will in general utilize a disentangled variant of the advancement structure called the "perpetual salary speculation," whose sources follow back to market analyst Milton Friedman's treatise A Theory of the Consumption Function (1957). The changeless pay speculation overlooks the point by point treatment of socioeconomics and retirement enveloped in the life-cycle model, concentrating rather on the angles that issue most for macroeconomic examination, for example, expectations about the idea of the utilization work, which relates customer spending to components, as income, wealth, interest rates, and the like.

Friedman stated that by and large just around 33% of any bonus (a one-time unexpected increase) would be gone through inside a year. He further contended that a one-for-one relationship between's expanded salary and expanded spending would happen just when the pay increment was seen to mirror a perpetual change in conditions (e.g., another, more lucrative occupation).

The cutting edge numerical variants of the life-cycle and changeless salary theory models utilized by most financial experts carry some conceivable refinements to the first thoughts. For instance, the cutting edge models suggest that the negligible affinity to expend out of fortunes is a lot higher for poor than for rich families. This propensity makes it difficult to decide the effect of a tax break or government program on utilization spending without knowing whether it is pointed principally at low-riches or high-riches families. The hypothesis further shows that tax reductions or spending programs, (for example, expanded joblessness benefits) pointed principally at lower-pay families ought to be significantly increasingly compelling at invigorating or keeping up total spending than programs went for more extravagant family units.

3. Case Study

3.1 Data and Methodology

The data of the study obtained from According to official data from the Sudan Monetary Agency, consists of annual data (GDP) in Sudan from 1982-2018. We use ARIMA model for forecast one period a head of the series by applying Box-Jenkins approach. An ARIMA is a generalization of an ARIMA model. The model is generally referred to as ARIMA (p, d, q) model, where p, d and q are integers greater than or equal zero and refer to the order of autoregressive integrated and moving average aspects.

The Box-ARIMA model is a combination of the AR (Autoregressive) and MA (moving average) model as follows:

$$Yt = \beta 0 + \beta 1 Yt\text{-}1 + \ldots + \beta p Yt\text{-}p - \alpha 1 Ut\text{-}1 - \alpha 2 Ut\text{-}2 - \ldots - \alpha q Ut\text{-}q + Ut$$

The Box-Jenkins methodology is a five step process for identifying, selective and Assessing conditional means models.

3.2 Data Analysis

Time Series Modeler

Model Description

		Model Type
Model ID	Gross Domestic Product by Expenditure at Constant Prices الناتج المحلي الاجمال حسب الاسعار	Model_1 ARIMA(0,1,0)

The model description table contains an entry for each estimated model and includes both a model identifier and the model type.

The model identifier consists of the name (or label) of the associated dependent variable and a system-assigned name. In the current example, the dependent variable is Sales of Men's Clothing and the system-assigned name is Model_1.

The Time Series Modeler supports both exponential smoothing and ARIMA models. Exponential smoothing model types are listed by their commonly used names such as Holt and Winters' Additive. ARIMA model types are listed using the standard notation of ARIMA(p,d,q)(P,D,Q), where p is the order of autoregression, d is the order of differencing (or integration), and q is the order of moving-average, and (P,D,Q) are their seasonal counterparts.

The Expert Modeler has determined that sales of men's clothing is best described by a seasonal ARIMA model with one order of differencing. The seasonal nature of the model accounts for the seasonal peaks that we saw in the series plot, and the single order of differencing reflects the upward trend that was evident in the data.

Model Summary

Model Fit

Fit Statistic	Mean	SE	Minimum	Maximum	Percentile						
					5	10	25	50	75	90	95
Stationary R-squared	9.992E-16	.	9.992E-16	9.992E-16	9.992E-16	9.992E-16	9.992E-16	9.992E-16	9.992E-16	9.992E-16	9.992E-16
R-squared	.998	.	.998	.998	.998	.998	.998	.998	.998	.998	.998
RMSE	440.796	.	440.796	440.796	440.796	440.796	440.796	440.796	440.796	440.796	440.796
MAPE	2.866	.	2.866	2.866	2.866	2.866	2.866	2.866	2.866	2.866	2.866
MaxAPE	11.908	.	11.908	11.908	11.908	11.908	11.908	11.908	11.908	11.908	11.908
MAE	358.748	.	358.748	358.748	358.748	358.748	358.748	358.748	358.748	358.748	358.748
MaxAE	868.613	.	868.613	868.613	868.613	868.613	868.613	868.613	868.613	868.613	868.613
Normalized BIC	12.277	.	12.277	12.277	12.277	12.277	12.277	12.277	12.277	12.277	12.277

The Model Fit table provides fit statistics calculated across all of the models. It provides a concise summary of how well the models, with re-estimated parameters, fit the data. For each statistic, the table provides the mean, standard error (SE), minimum, and maximum value across all models. It also contains percentile values that provide information on the distribution of the statistic across models. For each percentile, that percentage of models have a value of the fit statistic below the stated value. For instance, 95% of the models have a value of MaxAPE (maximum absolute percentage error) that is less than 3.676.

While a number of statistics are reported, we will focus on two: MAPE (mean absolute percentage error) and MaxAPE (maximum absolute percentage error). Absolute percentage error is a measure of how much a dependent series varies from its model-predicted level and provides an indication of the uncertainty in your predictions. The mean absolute percentage error varies from a minimum of 0.669% to a maximum of 1.026% across all models. The maximum absolute percentage error varies from 1.742% to 4.373% across all models. So the mean uncertainty in each model's predictions is about 1% and the maximum uncertainty is around 2.5% (the mean value of MaxAPE), with a worst case scenario of about 4%. Whether these values represent an acceptable amount of uncertainty depends on the degree of risk you are willing to accept.

Note : For the descriptive statistics of the model, R-squared represents the coefficient of good fit if the value is greater = 0.998 more than 0.05 this mean the model represent data exactly (good model) .

Model Statistics						
Model	Number of Predictors	Model Fit statistics	Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	Statistics	DF	Sig.	
Gross Domestic Product by Expenditure at Constant Prices الناتج المحلي الاجمال حسب الاسعار-Model_1	0	9.992E-16	16.221	18	.577	0

The model statistics table provides summary information and goodness-of-fit statistics for each estimated model. Results for each model are labeled with the model identifier provided in the model description table. First, notice that the model contains two predictors out of the five candidate predictors that you originally specified. So it appears that the Expert Modeler has identified two independent variables that may prove useful for forecasting.

Although the Time Series Modeler offers a number of different goodness-of-fit statistics, we opted only for the stationary *R*-squared value. This statistic provides an estimate of the proportion of the total variation in the series that is explained by the model and is preferable to ordinary *R*-squared when there is a trend or seasonal pattern, as is the case here. Larger values of stationary *R*-squared (up to a maximum value of 1) indicate better fit. A value of 0.948 means that the model does an excellent job of explaining the observed variation in the series.

The Ljung-Box statistic, also known as the modified Box-Pierce statistic, provides an indication of whether the model is correctly specified. A significance value less than 0.05 implies that there is structure in the observed series which is not accounted for by the model. The value of 0.984 shown here is not significant, so we can be confident that the model is correctly specified.

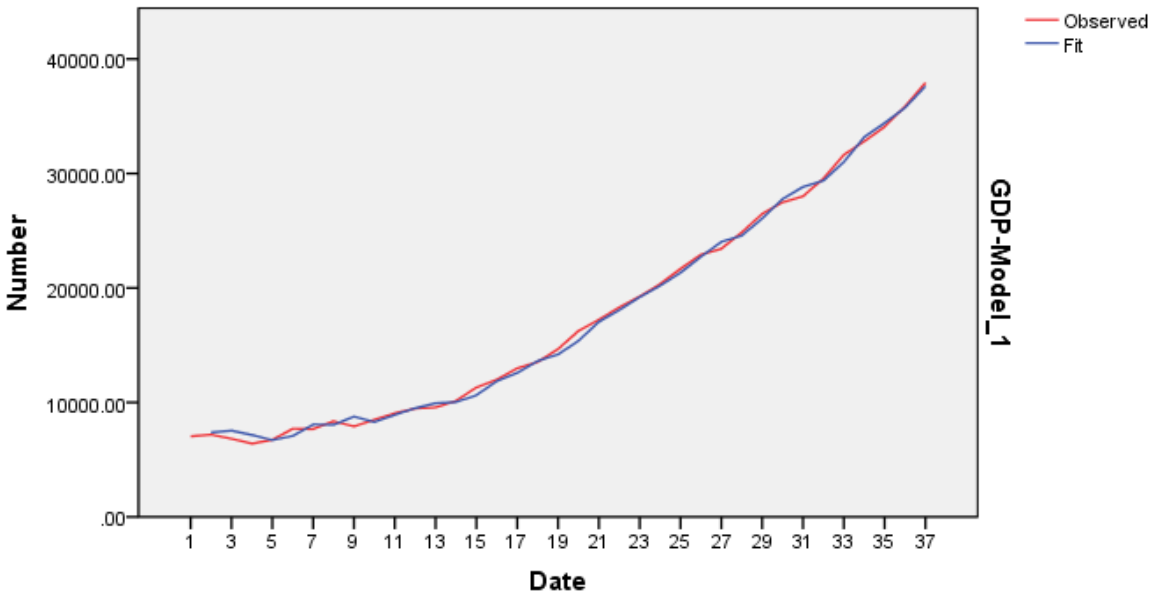
ARIMA Model Parameters							
				Estimate	SE	t	Sig.
Gross Domestic Product by Expenditure at Constant Prices الناتج المحلي الاجمال حسب الاسعار-Model_1	Gross Domestic Product by Expenditure at Constant Prices الناتج المحلي الاجمال حسب الاسعار	Natural Logarithm	Constant	.047	.007	6.768	.000
			Difference	1			

The Expert Modeler detected nine points that were considered to be outliers. Each of these points has been modeled appropriately, so there is no need for you to remove them from the series.

Note: (value of Sig. = 0.577) ,by Using residual error test, and when Sig value greater than 0.05 that means the data are random and valid for prediction .

The ARIMA model parameters table displays values for all of the parameters in the model, with an entry for each estimated model labeled by the model identifier. For our purposes, it will list all of the variables in the model, including the dependent variable and any independent variables that the Expert Modeler determined were significant. We already know from the model statistics table that there are two significant predictors. The model parameters table shows us that they are the *Number of Catalogs Mailed* and the *Number of Phone Lines Open for Ordering*.

Note : This table provides an estimate of the coefficients of the model, from the model we note that the level of significance Sig= 0.00. Less than 0.05, which indicates that the coefficients are statistically significant, also effective and predictable .



The predicted values show good agreement with the observed values, indicating that the model has satisfactory predictive ability. Notice how well the model predicts the seasonal peaks. And it does a good job of capturing the upward trend of the data.

Note : As in the diagram we observe the compatibility between the observed and real values. Thus we have predicted a model that represents the data well by using all statistically significant measures .

4. Conclusion

For the descriptive statistics of the model, R-squared represents the coefficient of good fit if the value is greater = 0.998 more than 0.05 this mean the model represent data exactly (good model) .

This table provides an estimate of the coefficients of the model, from the model we note that the level of significance Sig= 0.00. Less than 0.05, which indicates that the coefficients are statistically significant, also effective and predictable .

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