Forecasting GDP for European Union (EU) Using an ARIMA Model

التنبؤ بالناتج المحلي الاجمالي للاتحاد الأوربي باستخدام نموذج ARIMA

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Abstract: Gross Domestic Product (GDP) is a significant indicator to describe and evaluate economic activity and levels of development, and also often used by decision-makers to plan economic policy. Therefore, this paper aims to modeling and predict the GDP ratio in European Union; by applying the Box- Jenkins methodology for the period 1991-2022. Based on the results, ARIMA (1.0.1) was found to be the best model for the GDP. In addition, the forecasted values of the GDP ratio for the next three years (2023-2025) were (2.5%; 2.13%; 1.98%) respectively. Compared with 2021, the GDP is forecasted to decrease in 2022, and this implies that the European Union economy is tending toward stagflation

Keywords: GDP; European Union; Forecasting; ARIMAmodel.

Jel Classification Codes: O47, O52, C53.

ملخص: الناتج المحلي الإجمالي هو مؤشر مهم لوصف وتقييم النشاط الاقتصادي ومستويات التنمية ، وغالبًا ما يستخدمه صناع القرار لتخطيط السياسة الاقتصادية. لذلك ، تهدف هذه الورقة إلى نمذجة وتوقع نسبة الناتج المحلي الإجمالي في الاتحاد الأوروبي ؛ من خلال تطبيق منهجية Box- Jenkins للفترة 1991-2022. بناءً على النتائج ، وجد أن ARIMA (1. 0 .1) هو أفضل نموذج للناتج المحلي الإجمالي. بالإضافة إلى ذلك ، كانت القيم المتوقعة لنسبة الناتج المحلي الإجمالي للسنوات الثلاث المقبلة (2023-2025) (2.5٪ ؛ 2.13٪ ؛ 1.98٪) على التوالي. مقارنة بعام 2021 ، من المتوقع أن ينخفض الناتج المحلي الإجمالي في عام 2022 ، وهذا يعني أن اقتصاد الاتحاد الأوروبي يميل نحو الركود التضخمي.

كلمات مفتاحية: الناتج المحلي الإجمالي ، الاتحاد الاوروبي.،التنبؤ.،نموذج ARIMA.

تصنيف JEL: O47, O52, C53

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1. INTRODUCTION

Accurate forecasting of gross domestic product (GDP) is a convenient way to get an idea of the general direction of economic activity in the future needed to frame proper economic development strategies, and economic policies, and to allocate funds according to diverse priorities of the government. GDP is also considered as an important indicator for assessing national economic development and judging the employment status of the economy as a whole (Ghazo, 2021, p. 70).

Therefore, forecasting its values is an interesting topic for researchers and policymakers in the field of business in general and economics, in particular, to set up economic development strategies and policies (Dongdong, 2010). The importance of the GDP grows when the economy is expected to go through extraordinary circumstances such as two crises (the Coronavirus pandemic and Russia's War in Ukraine) these occurred in the world economy after a very long break, and with a two-year interval caused by non-economic factors, where these circumstances affected the entire world, and certainly would affect the GDP. Based on this, the COVID-19-pandemic recession and recovery have been unique compared with previous recessions, mainly due to policies that led to behavioral changes. Lockdowns meant people were traveling less both for work and for leisure, eating out less, and going to fewer entertainment venues, among other things. At the same time, work-from-home and fiscal stimulus packages increased the demand for certain goods such as technological goods, cars, and furniture. These changes resulted in an overall shift away from the consumption of services and toward the consumption of durable goods.

The rapid increase in the demand for durable goods, together with the global nature of the pandemic, has exposed vulnerabilities in the current production structure of these goods. Over the past several decades, the production of durable goods has become more fragmented, relying heavily on the global value chain (GVCs). While supply chains rely heavily on critical inputs from one or a few regions. Take the example of semiconductors. The advancement of technology in nearly every product has made semiconductors a vastly important input for the entire economy; however, their production largely relies on a few countries, such as Taiwan and China. A sharp increase in the demand for products that use this input may create large bottlenecks in semiconductor-dependent industries. Therefore, due to the global nature of supply chains, even a relatively small demand shock to a critical sector can propagate into a larger supply/demand

disruption. This mismatch between supply and demand puts upward pressure on prices(Santacreu & LaBelle, 2022, p. 2). In addition, as a result of the Russian war in Ukraine, the blow to Europe will be one and a half times more tangible than to the United States, due to its heavy dependence on Russian gas (Prohorovs, 2022, p. 8).

Against this background, the present paper aims to predict the values for the GDP ratio in Eurozone for the next three years to forecasting the negative impact on economic growth that could have in the Eurozone; by using Autoregressive Integrated Moving Average (ARIMA) model developed by Box and Jenkins (1976) to forecast economic time series.

2. Literature Review

2.1.The Indicators of the Economic Growth

The process of selecting the indicators to measure the economic growth of a country has been for many years at the center of much reappraisal and discussion. Historically, variables have been used to measure the wealth produced in a country and its trends are as follows(Sciarelli & Rinaldi, 2017, pp. 41-45):

1- **The Gross Domestic Product (GDP)** is the monetary value of finished goods and services produced in a country within a specific time period, usually one year. The GDP represents the wealth produced in a year, expressed in currency (euros, US dollars, and so on), or rather in market value. The goods and services considered are produced and sold at a market price according to the law of supply and demand: the seller is willing to receive a certain sum in exchange for the sale of goods or services, and the buyer is willing to pay a certain sum. On this basis, all market exchanges that do not result in a monetary transaction with a collection and payment are excluded from the calculation of GDP.Also, considering only finished goods and services means including in GDP measurement only the goods and services that are not raw materials or intermediate goods that are then used to produce other goods and services. This procedure is intended to eliminate duplication accounting arising from the fact that the same asset can be incorporated in other further processed goods. For example, when selling tables, the price of one already includes the price of wood used, the price of the screws, and so on; so if the price of raw wood is included in the calculation of GDP, dual accounting will have taken place. Regarding the nature of the goods concerned, GDP includes both consumer goods and capital goods which have a multi-year useful life.

2- **The growth rate of GDP:** we should remember that one of the requirements of the capitalist production system, which almost all the countries of the world are inspired by, is accumulation, or growth. This is why every year we measure the growth rate of the product that has been realized within the country concerning the previous year.The growth rate of GDP is calculated as the ratio between the value of GDP during the year to which it refers and the value of GDP in the year chosen as a reference (usually the previous year). For example, the growth rate of the GDP of Italy in 2015 is calculated by dividing the value of the Italian GDP in 2015 by the value of the Italian GDP in 2014. The growth rate of GDP, therefore, provides an estimate of the dynamism of the national economy, based, as we said, on the assumption that GDP in the current year should always be greater than the GDP of previous years. If this does not occur, and the GDP shows a lower rate of growth or even negative growth, the country will be in a period of low production or even in or close to a state of recession.

3- **The Gross National Income (GNI):** Alongside GDP, another indicator used to measure the development of a country, based on the income produced, is Gross National Income (GNI). GNI considers the final goods and services belonging to a country: it is obtained from GDP plus taxes and duties that weigh on the products, net of government subsidies. Also, a further specification relative to the external sector of the economy has been introduced by adding the net income obtained from abroad by citizens of the country, while the incomes paid to foreign citizens who are inside the country are subtracted.

4- **The GNI per capita** is the last measure of growth closely connected to GDP is the GNI per capita. GNI per capita is achieved thanks to the ratio between the GNI of a country and the volume of its population. The concept that inspires the measurement of GNI per capita is a perfect ideal of distributive equity. The measure of GNI per capita would be at its maximum if was it possible to actually redistribute the entire national income equally among all citizens. However, it is clear that this does not happen, and that in each country there are strong inequalities caused by pockets of high concentration of income.GNI per capita, therefore, provides only a hypothetical measure of the general wealth of the country that could be realized in a condition of perfect distributive equality, in other words when the entire income of the country could be divided equally among all citizens. This indicator allows also maximum comparability between countries with different population volumes.

2.2. Previous Studies

There are numerous studies that forecast economic activity and growth using the ARIMA model and following Box and Jenkins method, overall we will be classified previous studies into two groups. The first includes a concentration on GDP per capita prediction, while the second concentrate on the GDP growth rate.

Within the first group, Eissa, N. (2020) forecasted GDP per capita while applying the ARIMA model for Egypt and Saudi Arabia, following the Box Jenkin methodology. Conclusions convey that the most accurate statistical model that forecasts GDP per capita for Egypt and for Saudi Arabia is ARIMA (1,1,2) and ARIMA (1,1,1) respectively. And the result presents a continuous rise in GDP per capita in both countries for the upcoming 10 years(Eissa, 2020).n the same context, Voumik and Smrity (2020) forecast in their study Bangladesh's real per capita GDP for the next decade using ARIMA model of a yearly series from 1972 to 2019, and the ADF, PP, and KPSS tests showed that the appropriate model to forecast Bangladeshi GDP per capita is ARIMA (0, 2, 1). Finally, the future GDP per capita shows that living standards in Bangladesh will continue to rise(Voumik & Smrity, 2020). Wherein the study of Nyoni and Bonga (2019) concludes that the ARIMA (3, 1, 1) model is the best model to model and forecast GDP per capita in Rwanda over the period 1960 – 2017. The study indicates that the GDP per capita of Rwanda is expected to slowly rise in the next decade; unfortunately Rwanda's Vision 2020 is likely not to be achieved, as revealed by the optimal model(Nyoni & Bonga, 2019).

In contrast, the second group used annual GDP data from the study of Jamile Y, et al (2021) for forecasting the economic activity of the vastest Gulf Cooperation Council (GCC) countries: Qatar, Saudi Arabia, and the United Arab Emirates. By using the annual GDP variable and (ARIMA) model for the three countries, Gross Domestic Product is obtained using the Box-Jenkins methodology during the 1980 - 2020 period. The appropriate models for the three economies are of ARIMA (0, 2, 1), the forecasts are at a 95% confidence level and predict growth in the three countries for the upcoming five years(Youssef & et al, 2021). Also, Abonazel, M. R., & Abd-Elftah, A. I. (2019) find that the appropriate statistical model for Egyptian GDP is ARIMA (1, 2, 1). And they used the fitted ARIMA model to forecast the GDP of Egypt for the next ten years(Abonazel & Abd-Elftah, 2019).Dritsaki. C, (2015) aimed to forecast the real GDP rate in Greece. For this purpose using the Box- Jenkins methodology during the period 1980-2013 with one ARIMA (1, 1, 1) model. Using this model, he

forecasted the values of the real GDP rate for 2015, 2016, and 2017. Statistical results show that Greece's real GDP rate is steadily improving(Dritsaki, 2015). Finally, the paper of Zakai.M, (2014) studied the features of annual data on Pakistan's GDP from the International Monetary Fund (IMF) starting from 1953 to 2012. To model the GDP, a set of Autoregressive Integrated Moving Average (ARIMA) models are constructed following the Box-Jenkins technique. ARIMA (1, 1, 0) has been obtained through expert modeler method by considering best fit model. Finally, forecast values for a few coming year have been generated applying the best fitted ARIMA model. The finding shows that the forecast values of Pakistan's GDP will be 23477Billion rupees in 2013 and 103918 billion rupees in 2025(ZAKAI, 2014).

3.Methodology

1.3. Autoregressive Integrated Moving Average (ARIMA) Models

Autoregressive Integrated Moving Average (ARIMA) model have become a popular model after George Box and Gwilym Jenkins approach in the early 1970s. It is acknowledged as univariate time series and presents a forecasting approach. The ARIMA model comprises of: Autoregressive (AR), differencing, and Moving-Average (MA) processes.

2.3. Box Jenkins Method

George Box and Gwilym Jenkins (1970) propose four steps to conduct ARIMA modeling, these steps are: identification, estimation, diagnostic checking, and forecasting. They are recognized as the Box-Jenkins method.

a. Model Identification

The appropriate model identification starts by evaluating whether the time series is stationary or not, through plotting the initial data and implementing unit root tests (such as Phellips-Perron). Afterwards, the differencing degree is selected accordingly. Next, the Autocorrelation (ACF) and the partial autocorrelation (PACF) functions are used to identify the parameters of the ARMA model.

b. Model Estimation

The parameters estimation of the selected ARIMA (p, d, q) model is through computation of algorithms practice. Non-linear minimum-square estimate or Maximum Likelihood Estimate (MLE) remain the most common methods used. ARIMA models with different orders areestimated. The best fit is selected in the

basis of minimum Akaike's Information Criterion(AIC) and Bayesian Information Criteria (BIC) of the assessed tentative models.

c. Diagnostic Checking

The purpose of this step is to check the adequacy of the selected model, and if it is good fit toforecast. The model residuals should follow a normal distribution, be constant in variance andmean over time, and has no serial correlation with each other. If any of the assumptions areviolated, adjustments in step one should be considered to build the best fitted model.

d.Model Forecasting

The selected ARIMA model is considered adequate after the residual diagnosis and itforecasts on the basis of its own past values and that of the stochastic term to predict futuretime series.

EMPIRICAL RESULTS

In this study, the annual data was used and collected over the period 1991-2022 from World Bank Data Bank. For predicting the GDP ratio of the European Union (EU) over the period of 2023 to 2025, ARIMA model is used for forecasting. For identifying the factors which affect GDP, the regression analysis method is used. GDP was considered as a dependent variable which was expressed as a function of several macroeconomic measures of growth.

In the begging, we collect historical annual GDP data at current prices for the period between 1990 and 2022. Additionally, this specific period gives us data about how previous crises (the Financial Crisis, the European Sovereign Debt Crisis, and covid-19) affected economic growth. Then, we saw whether our times series was stationary by running a Philips-Perron (PP) test.

$\mathbf{H_0}$: A unit root is present in the time series;

$\mathbf{H_1}$: The time series is stationary;

The test results are shown in Table 1,the results stationary test for the annual time series is enough for us to reject the null hypothesis at a 5% significance level and accept our time series as stationary.

Table 1. Stability test results

UNIT ROOT TEST RESULTS TABLE (PP)
Null Hypothesis: the variable has a unit root

At Level

		GDP_CH	GDP_US	GDP_EU
With Constant	t-Statistic	-2.9067	-4.8253	-5.9370
	Prob.	*0.0557*	*0.0005*	*0.0000*
		*	***	***
With Constant & Trend	t-Statistic	-4.2991	-4.9004	-6.1714
	Prob.	*0.0094*	*0.0021*	*0.0001*
		***	***	***
Without Constant & Trend	t-Statistic	-0.6267	-2.1276	-4.0252
	Prob.	*0.4379*	*0.0340*	*0.0002*
		n0	**	***

At First Difference

		d(GDP_CH)	d(GDP_US)	d(GDP_EU)
With Constant	t-Statistic	-6.5259	-12.2962	-22.7926
	Prob.	*0.0000*	*0.0000*	*0.0001*
		***	***	***
With Constant & Trend	t-Statistic	-6.4736	-12.0086	-26.2257
	Prob.	*0.0000*	*0.0000*	*0.0000*
		***	***	***
Without Constant & Trend	t-Statistic	-6.5715	-12.7794	-23.0593
	Prob.	*0.0000*	*0.0000*	*0.0000*
		***	***	***

Notes:
a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant
b: Lag Length based on SIC
c: Probability based on MacKinnon (1996) one-sided p-values.

This Result is The Out-Put of Program Has Developed By:
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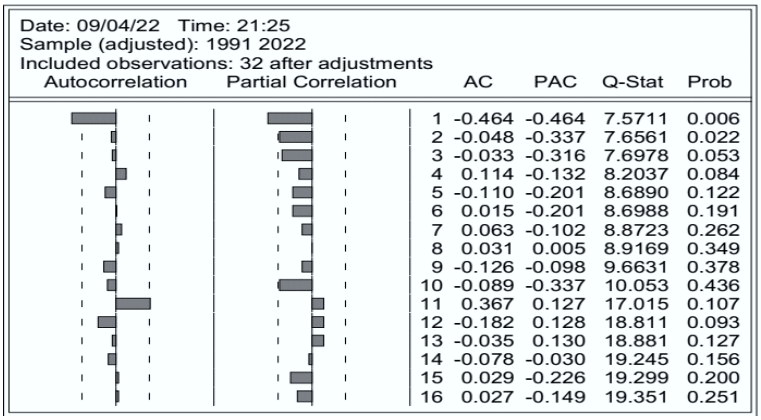
Source: Author's Computation Using Eviews 12

Now that we can guarantee with some degree of confidence that our time series possesses stationarity, we can use an ARIMA model to make our forecasts. ARIMA models are composed of three parameters: p, d, and q; p is the number of time lags of the model, d is the degree of differencing, and q the order of the moving average.

Fig.1.The self-correlation and partial correlation test results of the sequence

Correlogram of D(GDP_EU)



	AC	PAC	Q-Stat	Prob
1	-0.464	-0.464	7.5711	0.006
2	-0.048	-0.337	7.6561	0.022
3	-0.033	-0.316	7.6978	0.053
4	0.114	-0.132	8.2037	0.084
5	-0.110	-0.201	8.6890	0.122
6	0.015	-0.201	8.6988	0.191
7	0.063	-0.102	8.8723	0.262
8	0.031	0.005	8.9169	0.349
9	-0.126	-0.098	9.6631	0.378
10	-0.089	-0.337	10.053	0.436
11	0.367	0.127	17.015	0.107
12	-0.182	0.128	18.811	0.093
13	-0.035	0.130	18.881	0.127
14	-0.078	-0.030	19.245	0.156
15	0.029	-0.226	19.299	0.200
16	0.027	-0.149	19.351	0.251

Source: Author's Computation Using Eviews 12

Through the Figure 1, a set of possible models was obtained, ARIMA(1,0,1), ARIMA(1,0,2), then we estimate them and take the lowest value for each of the "Akaike" and "Schwarz" criteria and the largest value for "Darbin-Watson" and we found that the ARIMA(1,0,1) model is the best as shown in Table 2.

Table2. Coefficient estimation of ARIMA(1,0,1) model

Dependent Variable: GDP_EU
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 09/04/22 Time: 22:15
Sample: 1990 2022
Included observations: 33
Failure to improve objective (singular hessian) after 20 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	1.000000	0.972288	1.028502	0.3119
MA(1)	-0.999997	0.001652	-605.2179	0.0000
SIGMASQ	4.574455	0.912147	5.015042	0.0000

R-squared	-0.031251	Mean dependent var	1.677879
Adjusted R-squared	-0.100001	S.D. dependent var	2.138796
S.E. of regression	2.243190	Akaike info criterion	4.631426
Sum squared resid	150.9570	Schwarz criterion	4.767472
Log likelihood	-73.41853	Hannan-Quinn criter.	4.677202
Durbin-Watson stat	2.044904		

Inverted AR Roots	1.00
Inverted MA Roots	1.00

Source: Author's Computation Using Eviews 12

From the above table, the mathematical specification of the model ARIMA(1,0,1) is expressed as:

GDP_EU = 0 + [AR(1)=0.999999,MA(1)=0.999996,UNCOND,ESTSMPL="1990 2022"]

Before adopting ARIMA (1.0.1) in forecasting, we should check the robustness of that model by using the Residual Diagnostics: Normality test, Serial correlation LM test, and Heteroskedasticity test (ARCH), as shown in the following Table 3.

Table3. Residual Diagnostics tests

Statistics	Values	Probability
Normality test		
Jarque-Bera	**2.23**	0.523
Serial correlation LM test		
Obs*R-squared	**0.19**	0.65
Heteroskedasticity test (ARCH)		
Obs*R-squared	**0.17**	0.67

Source: Author's Computation Using Eviews 12

Through Table 3, the result of the Normality test was insignificant (α> 0.05) and the value of **Jarque-Bera** = 2.23 was less than x^2= 5.99. This means accepting the Null hypothesis and residuals are subject to normally distributed residuals; alsothe result of **the Serial correlation LM test** is shown that the Prob chi-square is greater than 0.05, therefore we accept the null hypothesis (there is no Autocorrelation); finally, the result of **the Heteroskedasticity test** is shown that the f-statistics is insignificant, prob F is greater than 0.05, therefore accepting the null hypothesis (the variance of error terms is not constant).

Forecasting Analysis of GDP

We use the ARIMA(1,0,1) model to forecast the GDP in 2023, 2024, and 2025. Firstly, we use the GDP from 1991to 2017 to forecast the GDP of 2018. The main calculation method is the deferred method. Then, we take the forecast GDP data of 2018 data back, combined the data from 1991 to 2019 to forecast the GDP of 2020. The deferred method can get more accurate results. The predicated GDP from 2018 to 2025 are shown in Table4.

Table 4 Prediction results of GDP ratio from 2019 to 2025

Date	Predictive value	Actual value	Relative error	Average error
2018	1.75	2.06	-15%	-11%
2019	1.24	1.82	-32%	
2020	-4	-5.9	-32%	
2021	5.9	5.38	10%	
2022	3.1	2.7	15%	
2023	**2.5**			
2024	**2.13**			
2025	**1.98**			

Source: Author's Computation Using Eviews 12

The predicated errors are shown in Fig. 3. As can be seen from Fig. 3, the Thiel inequalitycoefficient is 0.497 and its decomposition table shows that the error ratio is close to zero, and thevariance is small. So, this shows that the model has better prediction effect.

Fig.3.The Predicated Errors

Source: Author's Computation Using Eviews 12

Comparing the forecast value and the actual value, we can see that, the average error is 11%, which is close to 10%. Therefore, the ARIMA (1,0,1) model is an effective forecasting model.

Seen from prediction results of Table 4, the European Union's GDP ratio will reach to 2.5% in 2023 and reach to 1.98% in 2025. Therefore, the European Union's GDP will decrease in the next three years.

4. CONCLUSION

The GDP forecast model is a significant contribution to government and policy makers. It is critical for future planning and to understand the economy well-being. Forecasting techniques help in decision making and choosing to implement new ideas and technologies. Many researchers used the ARIMA model to forecast a country's GDP ((Youssef & et al, 2021)(Eissa, 2020)(Dritsaki, 2015)).

This paper aims to develop an empirical forecast of the GDP ratio of the European Union (EU) using the ARIMA model. The growth in EU economies has been of interest to researchers. An annual GDP series from 1991 to 2022 is used in this study. The model ARIMA (1,0,1) is recognized as the best-suited model to predict GDP in European Union. Empirical results show that the forecasted data is reliable, and the series is consistent and statistically significant. The analysis suggests the European Union's GDP ratio will decrease in the next three years. In fact, these results were expected Especially since Britain's exit from European Zone had many negative effects on the European balance, which lives on the

cause of Germany's power in particular, because the rest of the countries are below the required level economically compared to Germany, France, and Britain, and also the study of (Prohorovs, 2022) discussed that where historical experience shows that once the inflationary is out of the bottle, regardless of the policy response, a recession would already be hard to avoid. The slowdown in business activity is due to the fact that its surge after two years of lockdowns led to a shortage of energy, food, and transport at the end of 2021This caused disruptions in world trade and accelerated inflation, and also the consumption is falling because life is becoming more expensive and people are saving, while investment is decreasing as lending rates rise with prices, uncertainty increases, and company profits fall (International Monetary Fund 2022). In another hand, Due to the Russian war in Ukraine, the economic and financial impact of the war and the associated stagflation shock will be greatest in Russia and Ukraine, followed by the European Union, due to its heavy dependence on Russian gas, anddue to its dependence on Ukrainian products as the leading supplier of food.

A possible limitation of this study is the number of observations of the GDP series. This study is restricted to the use of annual GDP from 1991to 2022 because of data availability. Although such number of observations is suitable for a forecast by means of the ARIMA model. For future work, researchers are encouraged to compare several forecasting techniques like exponential smoothing, vector autoregressive, and neural networks.

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