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العلوم الإنسانية

Forecasting the Success Rate of Baccalaureate Exams in Algeria Using ARIMA Model: A Statistical Analysis

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Abstract: Objectives: This study aims to employ the Box-Jenkins methodology to forecast high school graduation rates in Algeria from 2023 to 2030, developing an optimal ARIMA model based on 59 annual baccalaureate exam observations, and providing evidence-based predictions for educational planning. **Methodology:** The study analyzed 59 annual observations of baccalaureate exam results from 1963 to 2022, applying time series analysis techniques and conducting rigorous testing and differentiation. After extensive analysis, the ARIMA (6, 11, 1) model was implemented as the most suitable forecasting tool. **Results:** The analysis revealed that the time series achieved stationarity at the first degree, and the ARIMA (6, 11, 1) model successfully captured graduation rate fluctuations. The model demonstrated high predictive accuracy, with forecasts indicating a steady increase in graduation rates through 2030. **Conclusions:** The selected model effectively predicts Algerian high school graduation rates, with predictions suggesting a positive trend in educational outcomes. The time series analysis proves viable for educational forecasting in this context. **Recommendations:** Future research should implement these findings for educational policy planning, consider additional variables in future models, and explore the model's adaptability across diverse educational settings.

Keywords: ARIMA modeling; Box-Jenkins methodology; educational forecasting; time series analysis; Algerian education system; baccalaureate exam success rates.

التنبؤ بمعدل نجاح امتحانات البكالوريا في الجزائر باستخدام نموذج ARIMA: تحليل إحصائي

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الملخص: **الهدف:** تهدف هذه الدراسة إلى توظيف منهجية بوكس-جينكينز للتنبؤ بمعدلات نسبة النجاح في شهادة البكالوريا في الجزائر من 2023 إلى 2030، وتطوير نموذج ARIMA الأمثل بناءً على 59 ملاحظة سنوية لامتحانات البكالوريا، وتقديم تنبؤات مبنية على الأدلة للتخطيط التربوي. **المنهجية:** حللت الدراسة 59 ملاحظة سنوية لنتائج امتحانات البكالوريا من 1963 إلى 2022، مطبقة تقنيات تحليل السلاسل الزمنية وإجراء اختبارات وتفاضلات دقيقة. بعد التحليل المكثف، تم تطبيق نموذج (1 ,11 ,6) ARIMA كأداة تنبؤ أكثر ملاءمة. **النتائج:** كشف التحليل أن السلسلة الزمنية حققت الاستقرار في الدرجة الأولى، ونجح نموذج (1 ,11 ,6) ARIMA في رصد تقلبات معدلات النجاح. أظهر النموذج دقة تنبؤية عالية، مع توقعات تشير إلى زيادة مطردة في معدلات النجاح حتى عام 2030. **الاستنتاجات:** يتنبأ النموذج المختار بشكل فعال بمعدلات النجاح في المدارس الثانوية الجزائرية، مع تنبؤات تشير إلى اتجاه إيجابي في النتائج التعليمية. يثبت تحليل السلاسل الزمنية جدواه للتنبؤ التربوي في هذا السياق. **التوصيات:** ينبغي أن يطبق البحث المستقبلي هذه النتائج في تخطيط السياسات التعليمية، والنظر في متغيرات إضافية في النماذج المستقبلية، واستكشاف قابلية تكيف النموذج عبر مختلف الأوضاع التعليمية.

الكلمات المفتاحيّة: نمذجةARIMA ؛ منهجية بوكس-جينكينز ؛ التنبؤ التعليمي؛ تحليل السلاسل الزمنية؛ نظام التعليم الجزائري؛ معدلات النجاح في امتحان البكالوريا.

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1 قسم البحث في تكنولوجيا التعليم؛ المعهد الوطني للبحث في التربية العاشور، الجزائر
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Introduction

Education plays a vital role in human progress (Alaazam, M., & Olimat, S. (2015)) (Nimer, M., & al-Jarah, A. al-Mohdi. (2015)), fundamentally impacting individuals' and communities' development (Hanushek & Woessmann, 2020). High school education, in particular, is a crucial stage that prepares students for further academic and professional pursuits (Murnane, 2013). In recent years, high school graduation rates have been of great concern to educational policymakers and researchers worldwide, serving as an essential indicator of education quality and a predictor of future social and economic trends (Rumberger & Losen, 2016; Cutler & Lleras-Muney, 2006).

Algeria has shown significant interest in improving its high school education system, implementing various policies and initiatives to enhance education quality (Kada et al, 2024). As a result, high school graduation rates in Algeria have steadily increased over the past few years (UNESCO Institute for Statistics, 2023). However, forecasting these rates remains a complex task requiring sophisticated statistical methods.

The Box-Jenkins methodology, widely used for time series forecasting, has been successfully applied in various fields (Box et al, 2015). This study aims to apply this methodology to predict Algeria's high school graduation rates from 2023-2030, focusing on constructing a standard ARIMA model based on time series analysis.

The research questions guiding this study are:

- Does the time series of annual high school baccalaureate examination rates contain a unit root?
- What level of integration can be relied upon in the time series of annual high school baccalaureate examination rates?
- What is the optimal arrangement of autoregressive and moving average models that minimize the Akaike information criterion (AIC) value and maximize forecast accuracy?

This study contributes to the current knowledge of time series forecasting in educational contexts and provides valuable insights for educational policymakers and stakeholders in Algeria.

Literature Review and Theoretical Framework

Previous research has demonstrated the applicability of time series analysis and forecasting methodologies in various fields, including education. Tariq et al. (2018) successfully used the Box-Jenkins methodology to forecast enrollment rates in higher education institutions in Pakistan. Similarly, Chen et al. (2017) applied this methodology to forecast electricity demand in Taiwan. In the education sector, Alghamdi (2019) and Akomolafe and Adewumi (2018) used time series analysis to forecast student enrollment and graduation rates in Saudi Arabian and Nigerian universities, respectively.

The theoretical framework for this study is based on time series analysis and the Box-Jenkins methodology. Time series analysis examines and forecasts trends in data collected at consistent intervals over time (Brockwell & Davis, 2016). The Box-Jenkins methodology relies on three fundamental elements: autoregression (AR), moving average (MA), and integration (I) (Hyndman & Athanasopoulos, 2021).

The application of the Box-Jenkins methodology in this study is based on several key assumptions:

- The presence of a unit root in the time series may necessitate differencing to achieve stationarity (Dickey & Fuller, 1979).
- Determining the appropriate level of integration is critical for identifying the degree of differencing needed to stabilize the time series (Kwiatkowski et al., 1992).
- The optimal arrangement of ARIMA parameters is selected based on minimizing the Akaike Information Criterion (AIC) and ensuring forecast accuracy (Akaike, 1974).

Methodology

This study analyzes the annual mean results of the high school baccalaureate in Algeria, denoted by (X), spanning from 1963 to 2022 with 59 observations. We employed the following steps:

- Data Collection and Preliminary Analysis: We collected data on annual baccalaureate exam results from 1963 to 2022.
- Stationarity Testing: We used the Augmented Dickey-Fuller (ADF) test to check for stationarity in the time series.
- Model Identification: We analyzed the autocorrelation and partial autocorrelation functions to identify potential ARIMA models.
- Model Estimation and Selection: We estimated multiple models and selected the best one based on criteria such as AIC, Schwarz Criterion (SC), and R^2.
- Model Validation: We conducted various diagnostic tests to ensure the selected model's appropriateness.
- Forecasting: We used the validated model to forecast graduation rates for 2023-2030.

Results and Discussion

This study's analysis is based on the annual mean results of the high school baccalaureate in Algeria, denoted by (X), spanning from 1963 to 2022 with 59 observations. The mean value of X during the study period was 36.89%, with the highest value of 62.45% recorded in 2011 and the lowest value of 10.54% in 1993.

The analysis indicates that the annual average results exhibit random fluctuations, as shown in Figure 1, and present an overall irregular trend. Thus, examining the stability of the time series is crucial.

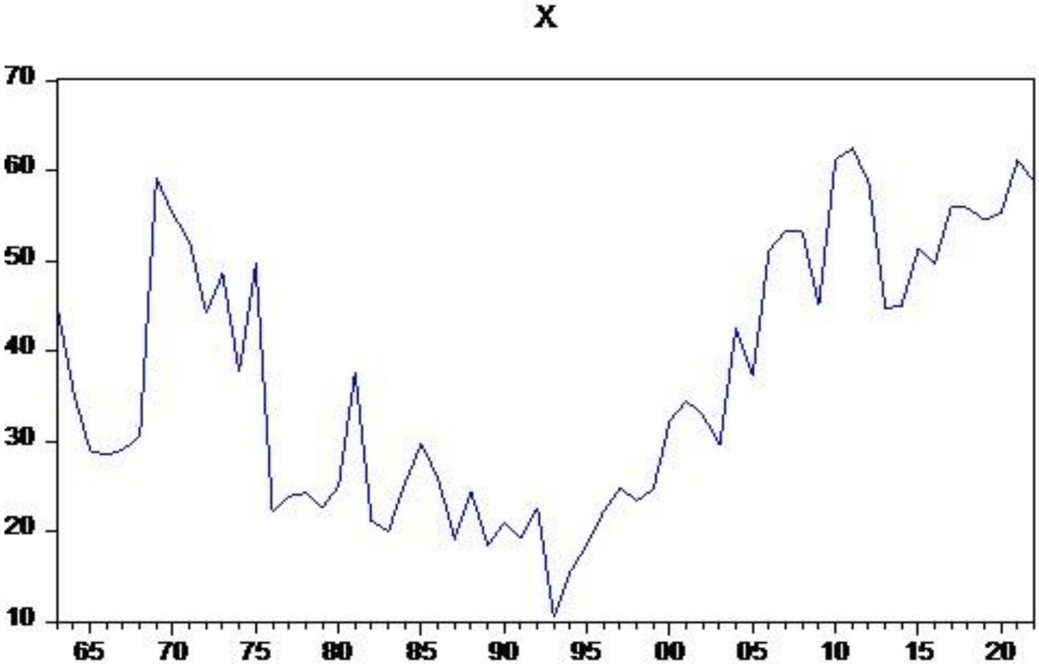
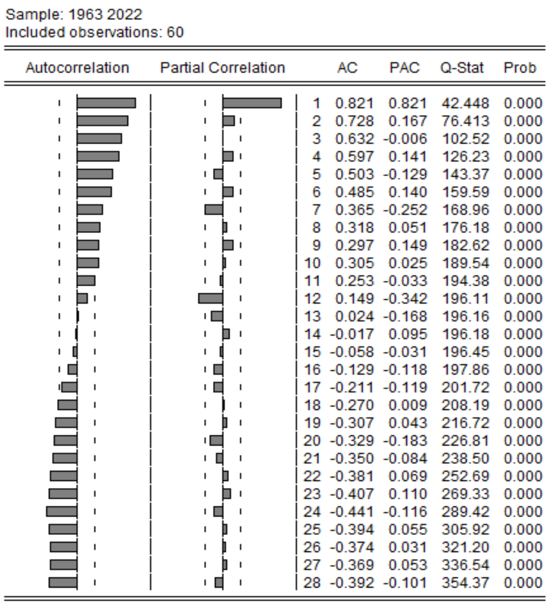


Figure (1): The Annual Mean Results Ratio of the High School Baccalaureate Stage in Algeria.

The self-correlation and partial correlation functions of the time series, displayed in Figure 2, show outliers beyond the 95% confidence interval. This deviation from zero at the 5% significance level suggests that the time series is unstable and prone to trend fluctuations.



	AC	PAC	Q-Stat	Prob
1	0.821	0.821	42.448	0.000
2	0.728	0.167	76.413	0.000
3	0.632	-0.006	102.52	0.000
4	0.597	0.141	126.23	0.000
5	0.503	-0.129	143.37	0.000
6	0.485	0.140	159.59	0.000
7	0.365	-0.252	168.96	0.000
8	0.318	0.051	176.18	0.000
9	0.297	0.149	182.62	0.000
10	0.305	0.025	189.54	0.000
11	0.253	-0.033	194.38	0.000
12	0.149	-0.342	196.11	0.000
13	0.024	-0.168	196.16	0.000
14	-0.017	0.095	196.18	0.000
15	-0.058	-0.031	196.45	0.000
16	-0.129	-0.118	197.86	0.000
17	-0.211	-0.119	201.72	0.000
18	-0.270	0.009	208.19	0.000
19	-0.307	0.043	216.72	0.000
20	-0.329	-0.183	226.81	0.000
21	-0.350	-0.084	238.50	0.000
22	-0.381	0.069	252.69	0.000
23	-0.407	0.110	269.33	0.000
24	-0.441	-0.116	289.42	0.000
25	-0.394	0.055	305.92	0.000
26	-0.374	0.031	321.20	0.000
27	-0.369	0.053	336.54	0.000
28	-0.392	-0.101	354.37	0.000

Figure (2): The Self-Correlation and Partial Correlation Functions for the Time Series of the Annual Mean Results Ratio of the High School Baccalaureate Stage in Algeria.

To further validate the stationarity of the series, the Dickey-Fuller (ADF) test (Dickey, DA. and WA. Fuller 1979) was performed, with results summarized in Table 1.

Table (1): Results of the Dickey-Fuller Test on Sequence (X).

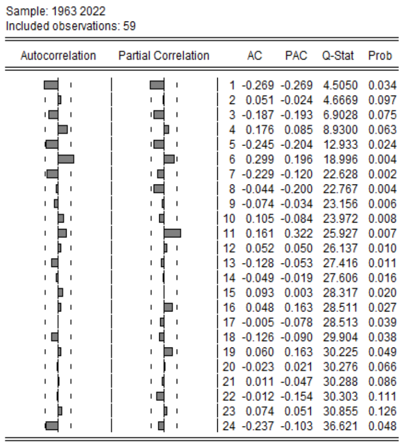
The outcome	Results of the Dickey-Fuller Test,		The outcome
	Prop	statistic	
Instability	0.6128	1.323802	Instability
Instability	0.6576	1.869199	Instability
Instability	0.6632	0.046484	Instability

The test confirmed that the time series is non-stationary, indicated by probability values exceeding 0.05. To address this, first-degree differencing was applied, yielding a stationary series as shown by the second application of the ADF test (Table 2), where the probabilities dropped to 0.0000.

Table (2): Results of the Developer Dickey-Fuller Test on Series (X).

The outcome	At the onset of the initial disparities		Variables
	statistic	Prop	
Establishments	9.992164	0.0000	The relentless progression of time unfolds without any discernible direction
Establishments	9.997664	0.0000	In spite of impediments and temporal direction
Establishments	10.05335	0.0000	The relentless progression of time unfolds without any discernible direction

Subsequent model selection was based on the autocorrelation and partial autocorrelation coefficients, displayed in Figure 3, which identified models AR (1) and AR (11) as suitable candidates. After evaluating multiple models using criteria such as Akaike Information Criterion (AIC), Schwarz Criterion (SC), and R^2, the ARIMA (6, 11, 1) model was selected (Table 3) as the most appropriate.


Sample: 1963 2022
Included observations: 59

Lag	AC	PAC	Q-Stat	Prob
1	-0.269	-0.269	4.5050	0.034
2	0.051	-0.024	4.6669	0.097
3	-0.187	-0.193	6.9028	0.075
4	0.176	0.085	8.9300	0.063
5	-0.245	-0.204	12.933	0.024
6	0.299	0.196	18.996	0.004
7	-0.229	-0.120	22.628	0.002
8	-0.044	-0.200	22.767	0.004
9	-0.074	-0.034	23.156	0.006
10	0.105	-0.084	23.972	0.008
11	0.161	0.322	25.927	0.007
12	0.052	0.050	26.137	0.010
13	-0.128	-0.053	27.416	0.011
14	-0.049	-0.019	27.606	0.016
15	0.093	0.003	28.317	0.020
16	0.048	0.163	28.511	0.027
17	-0.005	-0.078	28.513	0.039
18	-0.126	-0.090	29.904	0.038
19	0.060	0.163	30.225	0.049
20	-0.023	0.021	30.276	0.066
21	0.011	-0.047	30.288	0.086
22	-0.012	-0.154	30.303	0.111
23	0.074	0.051	30.855	0.126
24	-0.237	-0.103	36.621	0.048

Figure (3): The Series D(X) Simple and Partial Autocorrelation Function.

Table (3): Estimation Results for the Optimal Model.

Dependent Variable :D(X) Method:ARMA Conditional Least Squares (Gauss-Newton/Marquardt steps)				
Variable	**Coefficient**	**Std Error**	**t-Statistic**	**Prob**
AR (11)	0.315609	0.137504	2.295266	0.0264
MA (1)	-0.190551	0.086603	-2.200292	0.0330
MA(6)	0.759339	0.071482	10.62287	0.0000
R-squared	0.402437	Mean dependent var		0.438958
Adjusted R-squared	0.375878	S.D. dependent var		7.813122
S.E. of regression	6.172475	Akaike info criterion		6.538538
Sum squared resid	1714.475	Schwarz criterion		6.655188
Log likelihood	-153.9249	Hannan-Quinn criter		6.582734
Durbin-Wats stat	2.183574			
Inverted AR Roots	.90	.76-.49i	.76+.49i	.37-.82i
	.37+.82i	-.13-.89i	-.13+.89i	-.59-.68i
	-.59+.68i	-.86-.25i	-.86+.25i	
Inverted MA Roots	.86+.48i	.86-48i	.03-.95i	.03+.95i
	-.80+.48i	-.80-.48i		

Validation of the estimated model: To ensure that the selected model is appropriate for representing the analysed data and to use it for future predictions, The following tests were conducted to validate the stationarity and accuracy of the ARIMA model.

Matching test: Comparing the original and forecasted sequences (Figure 4) shows a similarity, but residual fluctuations around.

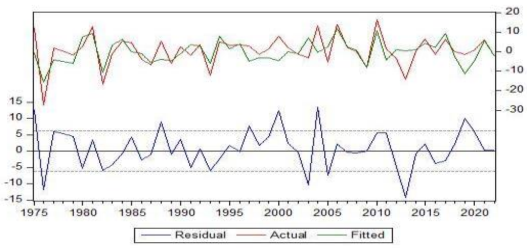
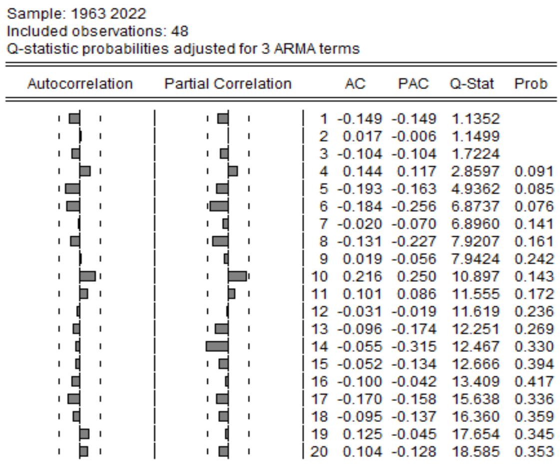


Figure (4): A comparison between the original and estimated sequences.

zero were observed: The Ljung-Box statistic (18.585) and its associated p-value indicated no serial correlation, as shown in Figure 5, confirming that the residual series is stationary.


Sample: 1963 2022
Included observations: 48
Q-statistic probabilities adjusted for 3 ARMA terms

Lag	AC	PAC	Q-Stat	Prob
1	-0.149	-0.149	1.1352	
2	0.017	-0.006	1.1499	
3	-0.104	-0.104	1.7224	
4	0.144	0.117	2.8597	0.091
5	-0.193	-0.163	4.9362	0.085
6	-0.184	-0.256	6.8737	0.076
7	-0.020	-0.070	6.8960	0.141
8	-0.131	-0.227	7.9207	0.161
9	0.019	-0.056	7.9424	0.242
10	0.216	0.250	10.897	0.143
11	0.101	0.086	11.555	0.172
12	-0.031	-0.019	11.619	0.236
13	-0.096	-0.174	12.251	0.269
14	-0.055	-0.315	12.467	0.330
15	-0.052	-0.134	12.666	0.394
16	-0.100	-0.042	13.409	0.417
17	-0.170	-0.158	15.638	0.336
18	-0.095	-0.137	16.360	0.359
19	0.125	-0.045	17.654	0.345
20	0.104	-0.128	18.585	0.353

Figure (5): Autocorrelation and Partial Autocorrelation Function of the Residual Sequence.

The Breusch-Godfrey test confirmed no autocorrelation issues within the model (Table 4).

Table (4): Results of the Breusch-Godfrey Test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.553042	Prob.F(2,43)	0.5792
ObsR-squared	1.203735	Prob.Chi-Square(2)	0.5478

The normality of residuals was examined using the Jarque-Bera test (Figure 6), and results confirmed that the residuals follow a normal distribution. Furthermore, both simple and partial autocorrelation functions (Figure 7) fell within the confidence interval, indicating stable variance.

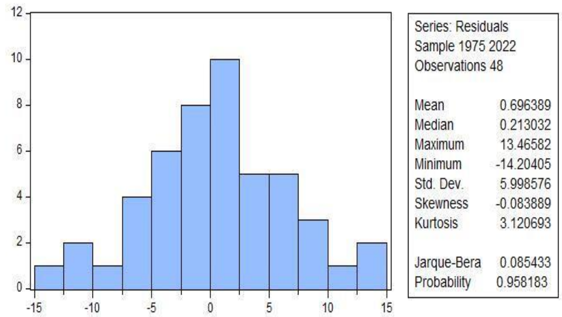


Figure (6): The normal distribution test for the remainder of the estimate.

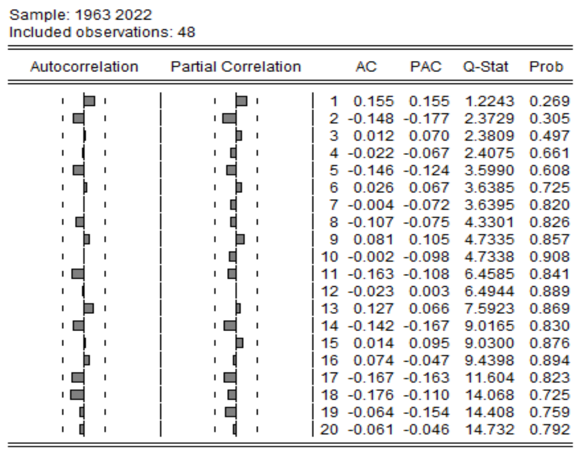


Figure (7): The Autocorrelation Function of the Squares of the Residuals.

Finally, the inverse roots of the ARIMA model (Figure 8) indicated that all roots lie within the unit circle, confirming the stability of the model. The BDS independence test (Table 5) further demonstrated that the time series is independent, allowing for short-term predictability.

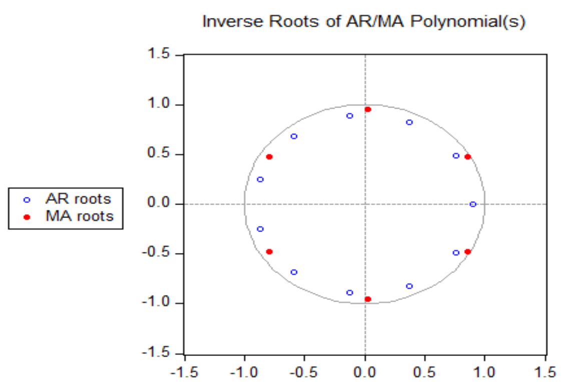


Figure (8): The results of the inverse roots of the estimated model (1, 11, 6) ARIMA

Table (5): Results of the BDS Independent Observations Test.

BDS Test for X Included observations :60				
Dimension	**BDS Statistic**	**Std.Error**	**z-Statistic**	**Prob**
2	0.101629	0.005674	17.90981	0.0000
3	0.165766	0.009069	18.27885	0.0000
4	0.202838	0.010854	18.68714	0.0000
5	0.218670	0.011370	19.23249	0.0000
6	0.215276	0.011019	19.53648	0.0000

The statement that the Box-Jenkins model is effective for short-term forecasting refers to its ability to produce reliable forecasts within a relatively limited time frame, typically 1–3 years ahead. In this context, 'short term' is defined by the stability of the model and the decreasing accuracy of predictions as the forecast horizon extends. The validation tests confirmed that the residuals exhibit characteristics of white noise, ensuring reliable short-term predictions but warranting caution in interpreting longer-term forecasts.

Prediction stage: The prediction stage, the most crucial phase of the Box-Jenkins methodology, is conducted after the model has been validated. To facilitate this phase, we used Eviews 10 software to forecast and obtain the values instantly. The table below shows Algeria's predicted percentages of official baccalaureate exams from 2023 to 2030.

After validating the model, the most critical phase of the Box-Jenkins methodology is the prediction stage. We used Eviews 10 software to make forecasts and obtain immediate results. The table below displays the predicted percentages of official baccalaureate exams in Algeria from 2023 to 2030.

Table (6): Forecasted Baccalaureate Success Rates (2023-2030).

2023	55.17454
2024	52.40434
2025	60.00626
2026	66.45730
2027	66.20410
2028	68.18612
2029	68.12616
2030	67.70955

The prediction stage is crucial in the Box-Jenkins methodology, and it follows the validation of the model. We used Eviews 10 software to forecast the values and obtain instant results. The table below showcases the projected percentages of official baccalaureate exams in Algeria from 2023 to 2030.

Thule's criterion for inequality: Thale's criterion for inequity states that a prediction is considered reliable when the calculated statistic is equal to zero, denoted by U = 0. On the other hand, if U = 1, it indicates a failed prediction.

Table 7 indicates a failed operation as the calculated value of Thale's criterion for inequality, U, equals 1, indicating that the forecasted values deviate significantly from the actual values. This suggests better models than the ARIMA (6,11,1) model for predicting the proportion of secondary education graduates in Algeria from 2023 to 2030.

Upon examining Table 7, we can deduce that the value of Thale's criterion for inequality, U, equals 0, which is closer to 0 than 1. This implies that the ARIMA (6, 11, 1) model can predict the reality of the baccalaureate examination success rate in Algeria. Therefore, using this model to accurately forecast the baccalaureate exam success rate in Algeria is valid.

Table (7): Forecast Accuracy and Model Validation Metrics for ARIMA (6, 11, 1) in Predicting Baccalaureate Success Rates

Forecast: XF Actual: X Forecast sample: 1963 2026 Adjusted sample: 1975 2026 Included observations: 52	
Root Mean Squared Error	15.68694
Mean Absolute Error	14.24804
Mean Abs. Percent Error	48.60064
Theil Inequality Coefficient	0.209778
Blas Proportion	0.000002
Variance Proportion	0.855256
Covariance Proportion	0.144742
Theil U2 Coefficient	2.500221
Symmetric MAPE	40.79358

The ARIMA (6, 11, 1) model accurately captured the fluctuations in Algeria's high school graduation rates and produced reliable forecasts for the 2023–2030 period. These findings align with previous studies that applied the Box-Jenkins methodology in educational contexts (Tariq et al., 2018; Chen et al., 2017). However, the variation in graduation rates across years reflects Algeria's changing educational landscape, potentially influenced by factors such as reforms in education policies, student access to resources, and socioeconomic conditions

The forecasts provided by the model show a steady increase in graduation rates, though some fluctuations are expected. The predicted values offer critical insights for policymakers, aiding resource allocation and future planning.

Conclusion, Limitations, and Recommendations

The Box-Jenkins methodology, through the ARIMA (6,11,1) model, successfully forecasts Algeria's high school graduation rates. The model's predictions are highly reliable, supported by multiple statistical tests. The increasing trend in predicted graduation rates suggests a positive outlook for the Algerian education system.

However, several limitations of this study should be acknowledged:

1. Sample Size: The data set spans only 59 years, which may limit the generalizability of the findings. While this provides sufficient data for the ARIMA model, a longer time series could potentially enhance the model's predictive accuracy.
2. Exclusion of External Variables: The ARIMA model does not account for external variables such as economic conditions, educational policy changes, or socioeconomic factors that may influence graduation rates. The model's univariate nature, while effective for time series analysis, may not capture the full complexity of factors affecting graduation rates.
3. Model Assumptions: The ARIMA model assumes stationarity, which may not fully capture the complexity of the data. While differencing improved stationarity in our analysis, other models like structural breaks or regime-switching could provide a more nuanced analysis of the graduation rate patterns.

Based on these findings and limitations, we recommend the following:

1. For Educational Policymakers:
   - Use these forecasts as a baseline for resource planning and allocation
   - Consider implementing systematic data collection for additional variables that may affect graduation rates
   - Develop contingency plans for scenarios where actual rates deviate from predictions
2. For Future Research:
   - Incorporate additional variables to improve the model's predictive power, such as:
     - Economic indicators
     - Educational policy changes
     - Demographic factors
     - Resource allocation metrics
   - Explore alternative modeling approaches that can account for structural breaks and regime changes
   - Conduct comparative analyses with other educational systems in similar contexts
   - Investigate the impact of specific policy interventions on graduation rates
3. For Educational Institutions:
   - Develop systematic approaches to data collection and analysis
   - Consider implementing early warning systems based on the predictive models
   - Use the forecasts for capacity planning and resource allocation

The insights gained from this study can significantly inform educational policy and resource planning in Algeria. While acknowledging the limitations, the model provides valuable predictions that can help stakeholders make informed decisions about the future of education in Algeria. The recommended extensions for future research will further enhance our understanding of the factors influencing graduation rates and improve the accuracy of forecasting models.

Disclosure Statement

- **Ethical approval and consent to participate:** This article does not contain any studies with human participants or animals performed by any authors.
- **Availability of data and materials:** The data analyzed in this study are available from the corresponding author upon reasonable request.

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