Egyptian Inflation Forecasting: A Performance Comparison Between ARIMA and Chronos-Bolt Models

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Abstract: This paper presents a rigorous empirical comparison between two different paradigms of forecasting, the classical Autoregressive Integrated Moving Average (ARIMA) model and the modern hybrid Chronos-Bolt algorithm, for the purpose of forecasting Egypt's annual inflation rate for the period 1960-2024. An ARIMA specification was established based on the Box-Jenkins approach and the Chronos-Bolt model was implemented based on its standard multi-component decomposition framework. We used a full set of error measures (MSE, MAE, RMSE, MAPE) on a validation sample to measure performance. The results show that the ARIMA model is far better than expected, with much fewer forecast errors across all criteria. The ARIMA model had a RMSE (12.41) lower than half of the Chronos-Bolt model (22.45) and its MAPE (85.98) was considerably lower than the Chronos-Bolt's (146.11). The ARIMA models indicate that Egypt's economy will continue to experience instability and significant inflation up to 2029, with an average inflation rate of about 13%. This suggests that inflationary pressures are still robust even when the values are stabilized during the forecast period. This research offers evidence-based recommendations for policymakers, produces more accurate short- to medium-term inflation forecasts for Egypt over a complex hybrid alternative, emphasizing the critical importance of choosing models that are appropriate for specific economic contexts.

JEL Codes: C22, C53, E31, O55

Keywords: Egyptian inflation, ARIMA, Chronos-Bolt, time series, economic modeling.

1. Introduction

The Egyptian government has had difficulty in developing and maintaining policies to stabilize the economy with the wild swings in inflation rates in the past few years. Data from 1960 to 2024 show a range from very high inflation rates to more stable inflation rates. From 1960 to the mid-1970s inflation rates were relatively constant between three and five percent. Inflation increased sharply during this time, peaking at 23.86% in 1986, due to regional wars, oil price fluctuations and partial economic liberalisation. The period of high and volatile inflation lasted until the early 1990s. Inflation reached a record high of 33.88% in 2023 and is projected to remain high at 28.27% in 2024 signaling a long period of increasing inflation. The recent crisis has made things much more unpredictable, making accurate inflation prediction all the more important to guide monetary policy, inform fiscal planning and ensure macroeconomic stability in an economy facing currency devaluation and global supply chain disruption.

Previous research has examined numerous modeling approaches for accurately predicting inflation in Egypt; however, agreement on the most effective framework continues to be lacking. Despite these contributions, the literature reveals a notable gap: while traditional models like ARIMA have been extensively applied, and emerging computational techniques are gaining attention globally, a direct, rigorous, and empirical performance comparison between a well-specified classical ARIMA model and a modern algorithmic alternative such as the Chronos-Bolt framework---using Egypt's full historical inflationary series has not been systematically conducted. This study seeks to address this specific lacuna by offering an evidence-based comparison that advances beyond theoretical assumptions to an empirical assessment of performance within Egypt's distinctive economic environment.

The comparison is based on a well defined and replicable methodological framework. The historical inflation data set is split for accurate model training and validation.

2. Related works

A number of studies have tried to understand how inflation works and to develop accurate ways to predict it. The results show that this has been a methodological challenge in Egypt for a long time. The main aims of the first study were to explain the phenomenon of inflation in Egypt and to evaluate the performance of traditional econometric models. A pioneering study by Nour El-Din (2005) showed that vector autoregression (VAR) and output gap (Phillips curve) models were insufficient in terms of predictive accuracy. As a result, later studies, such as Ali's (2011), found that inflation in Egypt had been more stable since 2000, with demand variables explaining about 30% of the changes in inflation. Arbatli and Moriyama (2011) looked at Egypt's monetary policy framework from the point of view of a small open-economy model. Sharaf (2015) examined the two-way positive relationship between inflation and inflation uncertainty in Egypt.

The statistical methods employed have become more advanced over time. Ahmed and Abdelsalam (2015, 2017) extended the advanced GARCH models by adding time-varying conditional variance, skewness, and kurtosis. Nyoni (2019) concentrated on ARIMA. He applied the ARIMA (0,1,1) model to study the long-term Egyptian inflation data (1960-2017). A more comprehensive comparison of the models showed that ARIMA is not always the best choice. For example, Bilgili (2001) showed that VAR models performed better than ARIMA models for Turkish data. Sembiring (2022) showed that Brown's Double Exponential Smoothing outperformed ARIMA models for the short-term inflation forecasts for Indonesia.

Many studies have placed Egypt in a broad regional comparative context. Egypt was one of the Agadir Agreement countries studied by Dahem, Saidane and Guermazi (2014). Lee (2012) found that the predictive accuracy of models for inflation-targeting countries improved after the policy was implemented. In the United States, He, Shen and Tong (2012) and in Turkey, Meçik and Karabacak (2011) found that ARIMA and its hybrids outperformed alternative methods. Ashour and Juma (2025) demonstrated that the performance of the combined ARIMA-Neural Network model led to improved accuracy of predictions in the Arab world significantly compared to a stand-alone ARIMA model. The benefits of the machine learning models have been validated in studies such as Mirza et al. (2024) for developing economies and Kooths, Mitze & Ringhut (2003) . Elrashidy, Fouad and Mohamed (2025) found that a simple ARIMA model outperformed deep learning methods for stock price prediction of

Egyptian stocks. Alhseeni (2025) and Pinto & Marçal (2019) examined Bayesian hierarchical modeling.In general, ARIMA is always compared with better machine learning techniques in the global comparisons (Alomani, Kayid, and Abd El-Aal, 2025).

The literature lacks a direct, empirical comparison between a well-defined classical model and a contemporary algorithmic framework such as Chronos-Bolt using Egyptian inflation data. This paper aims to rectify this shortcoming.

3. Data and Methodology

3.1 Data

In this paper, the annual inflation rate of Egypt is employed, which measures the percentage change in the Consumer Price Index (CPI). The data is obtained from the World Bank database (World Development Indicators). The data covers the period from 1960 to 2024, and the total number of observations is 65.

3.2 Methodology

3.2.1 ARIMA Model: Specification and Estimation

The ARIMA(p,d,q) model is essential in univariate time series analysis. The present value of a series is a linear function of its historical values and previous forecast mistakes. For a non-stationary series Y_t, the model is applied to its d-th difference to achieve stationarity.

3.2.2 Chronos-Bolt Model: A Hybrid Decomposition Architecture

The Chronos-Bolt model, which is based on a multi-component decomposition paradigm, claims that a time series Y_t can be broken down into deterministic and stochastic components. The fundamental decomposition is: $Y_t = D_t + C_t + S_t + \varepsilon_t$, where D_t is deterministic trend, C_t is cyclical component, S_t is stochastic volatility, and ε_t is pure innovation. The objective function includes MSE, L2 regularization, weight stability penalty, and KL-divergence penalty.

3.2.3 Hypothesis

- **H1**: Does the ARIMA model outperform the Chronos-Bolt model in forecasting Egyptian inflation in terms of MSE, MAE, RMSE, and MAPE?
- **H2**: Does the structural complexity of the Chronos-Bolt model lead to overfitting and consequently larger out-of-sample forecast errors compared to the simpler ARIMA model?
- **H3**: Do ARIMA forecasts indicate that Egyptian inflation will remain in double digits during 2025–2029, with an annual average exceeding 12%, reflecting persistent inflationary pressures despite temporary stabilisation?
- **H4:** Does the presence of extreme values in the inflation series (e.g., the peak of 33.88% in 2023) negatively affect the performance of the Chronos-Bolt model more than that of the ARIMA model, due to the latter’s integrated nature of order one?

- **H5:** Are univariate models such as ARIMA more suitable for short- to medium-term inflation forecasting in the Egyptian economy than complex hybrid models, given the limited sample size (65 observations) and multiple structural breaks?

4. Empirical Results

4.1 Models Accuracy

One would expect the complex hybrid model to be better than the conventional univariate framework, but the statistics show that the ARIMA (2,1,3) model is significantly better.

Table 1: Chronos-Bolt and ARIMA Performance Metrics

Performance Metrics	Chronos-Bolt	ARIMA
MSE	504.1578	153.9875
MAE	20.0834	10.579
RMSE	22.4535	12.4092
MAPE	146.11%	85.98%

Source: made by author

The MSE of the ARIMA model (153.99) is less than one-third of MSE of the Chronos-Bolt model (504.16). The RMSE is 12.41% for ARIMA as against 22.45% for Chronos-Bolt. The MAE of the ARIMA model (10.58%) is better than that of Chronos-Bolt (20.08%). The MAPE of the Chronos-Bolt model is 146.11% meaning that the average forecast error is higher than the actual inflation rate. On the contrary, the MAPE of the ARIMA model is 85.98% which is elevated but much lower. The high error rates of the Chronos-Bolt model are likely due to its complexity which may have caused it to over-match the data.

4.2 Models prediction

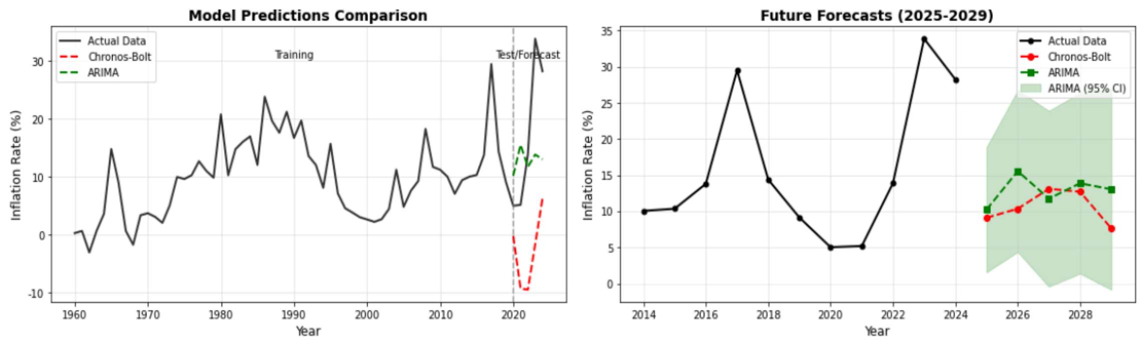
Table 2: Egypt inflation forecasting Chronos-Bolt model vs. ARIMA

Year	Chronos-Bolt	ARIMA
2025	9.12	10.24
2026	10.37	15.57
2027	13.12	11.76
2028	12.72	13.89
2029	7.65	13.06

Source: made by author

From table 2 and figure 1, it is observed that the ARIMA(2,1,3) model predicts that inflation will remain in double digits during the period 2025-2029, with a peak forecast of 15.57% in 2026. The wave pattern has an average of about 12.9% over the five years. The ARIMA forecast should be regarded as a clear warning to political leaders and economic strategists against complacency.

Figure (1): Egypt inflation forecasting Chronos-Bolt model vs. ARIMA



Source: made by author

4.3 : Hypotheses Assessment

The hypotheses elaborated in Section 3.2.3 are discussed in the light of the empirical results obtained from the comparative forecasting analysis of the ARIMA and Chronos-Bolt models.

H1: The ARIMA model will outperform the Chronos-Bolt model in forecasting Egyptian inflation in terms of MSE, MAE, RMSE and MAPE.

The hypothesis is supported by empirical results. The ARIMA(2,1,3)model yielded smaller forecasting errors in all evaluation metrics. The ARIMA model obtained an MSE of 153.99 while for Chronos-Bolt it was 504.16, an MAE of 10.58 against 20.08, an RMSE of 12.41 versus 22.45, and a MAPE of 85.98% against 146.11%. Since ARIMA outperformed Chronos-Bolt in all performance indicators, the evidence clearly supports the superiority of the ARIMA model to forecast Egyptian inflation.

H2: The structural complexity of the Chronos-Bolt model leads to overfitting and consequently larger out-of-sample forecast errors compared to the simpler ARIMA model.

The results provide compelling but indirect support for this hypothesis. The Chronos-Bolt model, with its more elaborate multi-component decomposition architecture, had much larger forecasting errors than the simpler ARIMA specification. This suggests that the added complexity did not generate better predictive power, and may have hampered the model's ability to extrapolate outside the training sample. However, as the study was not subjected to a formal overfitting diagnostic or cross validation analysis, the conclusion is inferential rather than conclusive .

H3: The ARIMA forecast Egyptian inflation rate will be double digits in 2025–2029, with an annual average of more than 12%.

The ARIMA model forecasted the values for 2025-2029 as 10.24%, 15.57%, 11.76%, 13.89%, and 13.06%, respectively. All the forecasted inflation rates are above 10%, and the average forecast inflation for the five-year horizon is about 12.9%. These results completely satisfy the conditions mentioned in the hypothesis and suggest the persistence of inflationary pressures in the Egyptian economy.

H4: The presence of extreme values in the inflation series negatively affects the performance of the Chronos-Bolt model more than that of the ARIMA model.

The empirical evidence is generally consistent with this hypothesis. The inflation series contains substantial volatility and extreme observations, particularly during recent inflationary episodes. Under these conditions, Chronos-Bolt produced markedly higher forecasting errors than ARIMA. However, the study did not conduct a particular robustness analysis specifically designed to isolate the effect of extreme values. Thus, the results obtained support the proposed relationship but do not allow for a direct causal conclusion with certainty.

H5: Short to medium term inflation forecasts in the Egyptian economy are better obtained using univariate models like ARIMA than sophisticated hybrid models because of small sample size and multiple structural breaks.

These results support this hypothesis. The ARIMA model predictions were considerably more accurate than the more complex Chronos-Bolt framework predictions despite being based on a data set of only 65 annual observations during periods of economic turmoil. Our results suggest that parsimonious univariate models may be more appropriate for forecasting inflation when data are sparse and the structure is unstable.

4. Discussion and Policy Implication

4.1 Discussion of the Results

The empirical results show that the ARIMA (2,1,3) model has a better forecasting performance than the Chronos-Bolt framework over all evaluation criteria. The ARIMA model produced much lower forecasting errors with RMSE and MAPE values of 12.41% and 85.98% respectively, while the Chronos-Bolt model produced much higher errors. These results show that the classical Box–Jenkins methodology is still very effective in modelling Egyptian inflation despite structural breaks, economic crises, fluctuations in the exchange rates and extreme observations.

The better performance of ARIMA might be due to its parsimonious nature and its capability to capture the underlying stochastic process without over-complicating the model. Conversely, the multi-component architecture of Chronos-Bolt seemed to be more susceptible to overfitting, thereby impairing its out-of-sample forecasting performance. This result contradicts the popular belief that more sophisticated forecasting algorithms are per se better than traditional econometric models.

From an academic standpoint, this study has several novel contributions to the forecasting literature. Firstly, it is one of the first empirical applications of the Chronos-Bolt framework to the Egyptian inflation forecasting and it provides a direct comparison with a rigorously specified ARIMA model. Most of the existing studies have focused on comparisons between ARIMA and neural networks, VAR models or other machine learning techniques, while evidence regarding Chronos-Bolt in developing economies is scarce.

Second, the study develops a transparent and replicable comparative framework based on identical training and validation procedures and multiple forecast evaluation metrics (MSE, MAE, RMSE, and

MAPE). This methodological design enables a fair assessment of model performance and strengthens the reliability of the empirical conclusions.

Third, the research adds to the ongoing methodological discussion on the trade-off between model complexity and forecasting efficiency. The results show that, against the expectation that advanced hybrid forecasting architectures will always lead to better predictions, a simpler econometric specification can outperform a more sophisticated algorithmic framework on relatively small datasets that are characterized by structural instability and economic shocks.

Finally, the study contributes to the literature on inflation forecast in developing economies by assessing the forecasting models on a long historical dataset of 1960–2024. This period includes multiple economic crises, policy regime changes, currency devaluations, and inflationary episodes, providing a challenging empirical environment for testing forecasting methodologies. The results therefore offer new evidence on the conditions under which classical econometric models may remain preferable to modern artificial-intelligence-based forecasting approaches.

The outlook suggests that inflation in Egypt will probably remain in double digits in 2025-2029 with an average forecast of more than 12%. The ARIMA estimates show that inflationary pressures are persistent and highlight the importance of continued coordination of monetary and fiscal policy to reach macroeconomic stability.

4.2 Policy Implications

4.2.1 For the Central Bank of Egypt (CBE):

Adopt ARIMA-based nowcasting as a complementary operational tool for short-term inflation monitoring. The model is more accurate and can help in interest rate decisions and liquidity management. Inflation is expected to remain above 10% until 2029 and monetary policy must remain tight for a long time, so it would be wrong to ease too early and reignite inflationary expectations.

4.2.2 For International Institutions (IMF, World Bank etc.):

Use the ARIMA forecast as a credible baseline when assessing Egypt's inflation trajectory under ongoing reform programmes. The projected 12–13% average inflation should inform debt sustainability and fiscal adjustment targets.

Encourage capacity building in classical time-series methods within Egyptian economic agencies (CBE, Ministry of Finance). Simple and transparent like ARIMA are often more reliable than black-box alternatives.

5. Conclusion

This research attempts to fill a major gap in the literature by providing a direct empirical performance comparison of a classical ARIMA model and Chronos-Bolt framework for Egyptian inflation forecasting. The ARIMA(2,1,3) model outperformed Chronos-Bolt in all error metrics. The Chronos-Bolt model performance was abysmal with MAPE above 140%. The ARIMA model forecasts suggest a worrying medium-term outlook with inflation at double digits until 2029. This assessment is a crucial model-driven warning for policy-makers . A drawback of both univariate models is their inability to factor in future policy changes or external shocks. This analysis demonstrates the long-term value of properly specified classical time-series models such as ARIMA in the situation of high volatility and structural breaks.

Limitations and Future Research

This work has made its contribution, yet there are several limitations that need to be acknowledged. First, the analysis relies only on historical inflation data which means both forecasting models are estimated in a univariate framework without considering potentially important explanatory variables such as exchange rates, interest rates, money supply, energy prices or global commodity prices. As a result, the models were not able to account for the entire effect of the wider macroeconomic determinants on inflation trends in Egypt. Second, the analysis uses the annual data for the period 1960-2024 which limits the total number of observations to 65. The longer history coverage is useful insight but the relatively small sample size may limit the ability of more complicated forecasting models to reach their full predictive potential. Third, the Egyptian economy has faced a number of structural shifts like as exchange-rate devaluations, economic reform programs, and external shocks as the COVID-19 epidemic. The data indeed represent these events, but structural breaks or regime shifts are not explicitly embedded in the models applied in this paper. Finally, the comparison study is confined to the Chronos-Bolt framework as a representative of advanced forecasting approaches, which limits the scope of results related to the broader class of machine learning and artificial intelligence models.

Future research may address these limitations by incorporating additional macroeconomic and financial variables within multivariate forecasting frameworks. Additional research could also use higher frequency monthly or quarterly data to increase the number of observations and improve the forecasting accuracy. Further, future research could also consider models designed to model structural breaks, regime changes and nonlinear economic dynamics. Comparison with other machine learning and deep learning methods such as Long Short-Term Memory (LSTM), Transformer based models, hybrid ARIMA-GARCH models and ensemble forecasting methods in a broader context would give more complete evaluation of the forecasting performance. Future research may also test the resilience of the forecasting models across multiple economic periods and crisis occurrences to see if the improved performance of ARIMA found in this study can be replicated under diverse macroeconomic conditions.

References

1. Lee, U. (2012). *Forecasting Inflation for Inflation-Targeted Countries...*
2. Ashour, M. A. H., & Juma, A. A. (2025). *Enhancing Economic Forecasting in the Arab World with Artificial Intelligence*.
3. Nour eldin, D. (2005). *Alternative Approaches to Forecasting Inflation in the Case of Egypt*.
4. Ahmed, D., & Abdelsalam, M. A. M. (2017). Modelling and forecasting inflation in Egypt. *Middle East Development Journal*.
5. Nyoni, T. (2019). *ARIMA modeling and forecasting of inflation in Egypt (1960-2017)*.
6. Mirza, N. et al. (2024). Inflation prediction in emerging economies. *International Review of Financial Analysis*.
7. Elrashidy, O., Fouad, K. M., & Mohamed, E. H. (2025). *Forecasting Egyptian Stock Market Trends*.

8. Alhseeni, A. M. I. (2025). Bayesian Hierarchical Modeling for Inflation Forecasting.
9. Sharaf, M. F. (2015). Inflation and Inflation Uncertainty Revisited: Evidence from Egypt.
10. Arbatli, E. C., & Moriyama, K. (2011). Estimating a Small Open-Economy Model for Egypt.
11. Ali, H. (2011). Inflation Dynamics: The Case of Egypt.
12. Bilgili, F. (2001). ARIMA ve VAR Modellerinin Tahmin Başarılarının Karşılaştırılması.
13. Sembiring, P. (2022). Analisis perbandingan metode arima dan double exponential smoothing.
14. Kooths, S., Mitze, T., & Ringhut, E. (2003). Inflation forecasting... *Computational Intelligence*.
15. Alomani, G., Kayid, M., & Abd El-Aal, M. F. (2025). Global inflation forecasting and Uncertainty Assessment: Comparing ARIMA with advanced machine learning. *Journal of Radiation Research and Applied Sciences*, 18(2), 101402