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RISK OF A DEFLATIONARY SPIRAL IN UGANDA

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ABSTRACT---
This study investigates the risk of a deflationary spiral in Uganda by analyzing historical trends and forecasting inflation dynamics from 1983 to 2022 using a quantitative approach based on autoregressive integrated moving average (ARIMA) modelling. Time-series data from the World Bank is utilized, with inflation, GDP deflator (annual %) serving as the dependent variable, while autoregressive (AR) and moving average (MA) components are the independent variables. Parameter estimation is conducted using maximum likelihood estimation (MLE), revealing that the AR(1) coefficient (0.7387) is positive and statistically significant, implying that approximately 74% of inflation persistence is influenced by prior values. The estimated ARIMA (1, 1, 1) model is covariance stationary and invertible, confirming its reliability for forecasting future inflationary trends. Projections from the model suggest a severe deflationary spiral, with inflation rates expected to decline sharply from -1.02% in 2023 to approximately -50.54% by 2042. Such trends highlight substantial economic risks, including reduced consumer spending, investment contractions, and rising debt burdens. The study recommends urgent policy interventions, including expansionary fiscal and monetary policies, inflation targeting frameworks, and investment incentives, to mitigate deflation risks and stabilize Uganda's macroeconomic environment.
KEY WORDS: *ARIMA modelling, deflationary spiral*--

INTRODUCTION

Uganda's economy has demonstrated notable resilience in recent decades, achieving moderate economic growth and reducing poverty levels. However, the post-pandemic era has introduced new economic challenges, including deflationary pressures and sluggish aggregate demand. Deflation, characterized by a persistent decline in the general price level, poses significant risks to macroeconomic stability. In particular, Uganda's inflation, as measured by the GDP deflator, has exhibited sharp fluctuations, with recent trends pointing toward a potential deflationary spiral (World Bank 2023). This phenomenon warrants urgent attention, as prolonged deflation can erode consumer confidence, reduce investment, and exacerbate unemployment (Friedman 1976).

The COVID-19 pandemic severely disrupted Uganda's economy, leading to reduced productivity, weakened demand, and constrained fiscal capacity (IMF 2021). Despite gradual recovery efforts, low inflation rates and forecasted deflation highlight structural weaknesses, including limited aggregate demand and declining purchasing power. Historical data reveals Uganda's inflation rate plummeting from 85.35% in 2009 to 2.55% in 2021 (World Bank 2023), with projections indicating negative inflation rates reaching -50.54% by 2042. Such trends suggest a looming deflationary spiral, posing threats to economic growth, debt sustainability, and financial stability (Keynes 1936).

The research problem stems from Uganda's vulnerability to deflationary risks in the face of post-pandemic recovery challenges. With limited aggregate demand and subdued price levels, deflationary pressures can perpetuate a cycle of reduced production, falling wages, and declining economic activity. Empirical studies highlight the negative impact of deflation on economic performance, emphasizing the need for effective policy interventions (Krugman 1998). Despite the growing relevance of this issue, empirical research focusing on Uganda's deflationary risks remains limited, creating a critical gap in the literature.

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This study aims to address this gap by examining historical inflation trends, forecasting future patterns, and evaluating the potential for a deflationary spiral using ARIMA modelling. The findings inform policymakers, economists, and development planners about the severity of deflation risks and propose strategies to stabilize inflation through expansionary policies and structural reforms. By contributing to the discourse on macroeconomic stability, this research seeks to support Uganda's sustainable development agenda and economic resilience.

LITERATURE REVIEW

A deflationary spiral is an economic phenomenon characterized by a self-reinforcing cycle of declining prices and economic contraction. This occurs when falling prices lead to decreased consumer spending, prompting businesses to reduce production and investment, which further suppresses demand and perpetuates the cycle (Mian & Sufi 2008). Historically, such spirals have been associated with severe economic downturns, notably the Great Depression of the 1930s, where deflation exacerbated economic hardships (BoGFRS 2012).

The theoretical framework for understanding deflationary spirals often references Irving Fisher's debt-deflation theory, which posits that falling prices increase the real burden of debt, leading to reduced spending and further economic decline (Fisher 1933). Additionally, John Maynard Keynes's insights into aggregate demand highlight how insufficient demand can lead to deflation and unemployment, emphasizing the role of government intervention in stabilizing the economy (Keynes, 1936).

In the Sub-Saharan African context, economies have traditionally grappled with inflationary pressures due to factors like supply chain disruptions and volatile commodity prices. However, recent global economic shifts have introduced concerns about deflation, particularly in the wake of the COVID-19 pandemic. The International Monetary Fund (IMF 2023) notes that the pandemic's economic disruptions have led to decreased consumer demand and investment across the region, raising the specter of deflation in certain economies.

Studies focusing on regional economies emphasize the importance of robust monetary policy frameworks to mitigate deflationary risks. For instance, the effectiveness of monetary policy transmission in Uganda is influenced by factors such as high operational costs and banks' preference for government securities, which can impede the central bank's ability to manage deflationary pressures (Bwire 2019).

Uganda's economy has historically been characterized by moderate inflation rates. However, recent data indicates a deceleration in inflation, with the annual rate dropping to 2.9% in October 2024, the lowest since January. This trend raises concerns about potential deflationary pressures, especially considering the country's post-pandemic recovery challenges (Uganda Bureau of Statistics, 2024).

Bank of Uganda has responded by adjusting monetary policy rates to stimulate economic activity. In October 2024, the central bank reduced its key lending rate to 9.75%, citing expectations that inflation would remain below the 5% target in the near term (Bank of Uganda 2024). Despite these measures, the persistence of low inflation rates suggests underlying issues related to aggregate demand and economic productivity.

This study is grounded in Keynesian economic theory, which emphasizes the role of aggregate demand in influencing economic output and inflation. According to Keynes, insufficient aggregate demand can lead to unemployment and deflation, necessitating government intervention through fiscal and monetary policies to stimulate the economy (Keynes 1936).

Additionally, Fisher's debt-deflation theory provides a lens to understand how falling prices can increase the real burden of debt, leading to reduced spending and further economic decline. This theoretical framework is pertinent for analyzing Uganda's current economic trajectory, where declining inflation rates may signal the onset of a deflationary spiral.

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The conceptual framework for this study involves analyzing inflation rates as a dependent variable with AR and MA components as independent variables. By employing ARIMA modelling, the study aims to forecast future inflation trends and assess the risk of a deflationary spiral.

DATA AND METHODS

This study employs a quantitative research design to analyze the risk of a deflationary spiral in Uganda. The primary objective is to investigate the risk of a deflationary spiral using autoregressive integrated moving average (ARIMA) model. ARIMA modelling is selected due to its ability to forecast future values based on past data patterns, making it ideal for time series analysis (Box & Jenkins 1976). ARIMA model's capacity to account for both short-term and long-term trends and its robustness in capturing the dynamics of economic time series data make it suitable for this study.

The sample consists of annual data from 1983 to 2022, focusing on Uganda's inflation rates, measured by GDP deflator (annual %). Inflation, GDP deflator is chosen as the dependent variable due to its comprehensive nature, capturing the effects of both domestic and international economic factors on price levels (Mankiw 2020). Data is sourced from World Bank. This source provides reliable, consistent, and publicly available data on inflation and other macroeconomic variables, ensuring the accuracy and comparability of the data over the study period (World Bank 2023).

Secondary data is used, as it allows for an in-depth longitudinal analysis of inflation trends over the last four decades. Time series data is particularly beneficial for understanding long-term patterns, seasonal effects, and structural changes within the economy (Gujarati & Porter 2009). Time series data is first cleaned for any missing or inconsistent values. Seasonal adjustments are also made where necessary to account for any periodic fluctuations in inflation. Since the ARIMA model requires the data to be stationary, tests such as the Augmented Dickey-Fuller (ADF) test are used to check for unit roots (Dickey & Fuller 1979). If the series is non-stationary, differencing is applied to transform it into a stationary series.

The appropriate ARIMA model is identified through the examination of autocorrelation (ACF) and partial autocorrelation (PACF) plots. The values of p (autoregressive), d (differencing), and q (moving average) parameters are determined using these plots and statistical criteria such as the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). Once the model is identified, ARIMA parameters are estimated using maximum likelihood estimation techniques. The model's fit is evaluated using diagnostic tests like the Ljung-Box test to check for autocorrelation in the residuals (Ljung & Box 1978). The model is then used to forecast inflation rates, and the accuracy of the forecasts is evaluated by comparing predicted values with actual data. Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE) are used as evaluation metrics.

ARIMA model is chosen due to its ability to model the dynamic relationships in time series data without assuming a specific structural form, making it a flexible and robust choice for inflation forecasting (Box & Jenkins 1976). The model's emphasis on past values and residuals makes it ideal for capturing patterns in inflation data, which often exhibit both trend and cyclical behavior. Additionally, ARIMA is widely used in economic forecasting, including inflation studies, due to its proven effectiveness in various contexts (Enders 2014). The choice of inflation as the dependent variable, measured by the GDP deflator, aligns with established practices in macroeconomic research, where the GDP deflator is considered a broad measure of inflation (Mankiw 2020). The time scope of 1983 - 2022 is chosen to cover multiple economic cycles, allowing for a thorough examination of inflationary trends and potential deflationary risks. ARIMA (p, d, q) model specification is as follows:

$$Y_t = \mu + \varepsilon_t + \boldsymbol{\phi}_1 Y_{t-1} + \boldsymbol{\phi}_2 Y_{t-2} + \dots + \boldsymbol{\phi}_p Y_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \dots + \theta_q \varepsilon_{t-q} \text{ .... (1)}$$

Where;

Y_t is the value of the series at time t

μ is the mean of the series

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ε_t is white noise
ϕ_1, ϕ_2, ... ϕ_p are the coefficients of the AR (p) component
θ_1, θ_2, … θ_q are the coefficients of the MA (q) component
p is the order of the autoregressive part, representing the number of past values considered
q is the order of the moving average part, indicating the number of past errors considered
d is the number of differences required to make the series stationary (Box & Jenkins 1976)

Maximum Likelihood Estimation (MLE) is used to estimate model parameters, ensuring efficiency and accuracy in predicting (Lütkepohl 2005) electricity access. Maximum Likelihood Estimation process holds that for a given set of observations X = { x_1, x_2, ..., x_n} and assuming they follow a probability distribution with parameter θ, the likelihood function L(θ) is given by:

$L(\theta) = P(X|\theta) = \prod_{i=1}^{n} f(x_1|\theta)$ …………………………………………………………………… (2)
Where;
$f(x_1|\theta)$ is the probability density function of the observed data point x_i given parameter θ

Thus
$\hat{\theta} = \text{argmax}\, \ell(\theta)$ (Greene, 2012).

Diagnostic tests, such as the Augmented Dickey-Fuller (ADF) test for stationarity (Dickey & Fuller 1979), and the model selection process using the Akaike Information Criterion (AIC) (Akaike 1974), are employed to assess the model's adequacy and ensure its suitability for forecasting. The use of ARIMA modelling in this study is particularly beneficial for analyzing Uganda's electricity access trends, as it enables the evaluation of past behaviors to make reliable projections (Enders 2014).

This approach effectively captures the underlying patterns in inflation data, thereby providing a robust framework for understanding whether current inflation levels are sustainable in the long run. Moreover, ARIMA's capacity to handle non-stationary data is particularly well-suited to economic time series, where trends and fluctuations exhibit considerable variation over time (Stock & Watson 2015). The analytical rigor of this model supports drawing meaningful, policy-relevant conclusions about Uganda's inflation trajectory, offering insights that can guide effective energy policy and planning strategies.

RESULTS

Descriptive statistics (Appendix 1) provide a summary of the key features of the dataset, helping to understand its main characteristics. For our dependent variable (Inflation, GDP deflator (annual %)), the following descriptive statistics are summarized:

The mean represents the average value of inflation over the 40-year period. It is calculated by summing all the individual inflation values and dividing by the number of observations (Gujarati & Porter 2009). The mean of 29.97% suggests that, on average, inflation in Uganda was quite high over the period, but this average is influenced by extreme values (as seen in the maximum value).

The median is the middle value when the data is arranged in ascending order. Unlike the mean, the median is not affected by outliers or extreme values. The median of 6.61% indicates that half of the inflation rates observed were below this value and half were above it, showing that inflation was more often on the lower end of the spectrum, despite the high average (Mankiw 2020).

The maximum value represents the highest recorded inflation rate during the study period, which was 189.98% (1988). This is an extremely high value, suggesting that there were years with significant inflation spikes, possibly due to

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economic crises or instability (Mankiw 2020). The minimum value is the lowest recorded inflation rate, which was 0.11% (1999). This indicates that in some years, inflation was very low, potentially close to price stability or even deflationary conditions (Enders 2014). The standard deviation measures the amount of variation or dispersion from the mean. A standard deviation of 49.69% indicates that the inflation rates vary widely from the average, highlighting high volatility in the inflation rates over the period. The large standard deviation suggests the presence of both extreme inflationary and deflationary years (Gujarati & Porter 2009).

Skewness measures the asymmetry of the distribution. A skewness of 2.09 indicates a right-skewed distribution, meaning that there are a few extremely high inflation years that pull the distribution's tail towards the right. This suggests that inflation was generally moderate but occasionally experienced extreme spikes (Enders 2014). Kurtosis measures the 'tailedness' of the distribution, or how outliers and extreme values are distributed. A kurtosis of 6.25 is leptokurtic, meaning the data has heavy tails and outliers are more frequent than in a normal distribution. This is consistent with the high maximum inflation rate observed, which significantly skews the distribution (Gujarati & Porter, 2009).

The Jarque-Bera test is a statistical test that checks whether the data follows a normal distribution. The test statistic is 46.76, which is significantly large. This suggests that the inflation data does not follow a normal distribution, and the results are highly influenced by skewness and kurtosis (Ljung & Box, 1978). The probability value (p-value) of 0 indicates that the null hypothesis of normality is strongly rejected. This confirms that the distribution of inflation data is not normal (Ljung & Box 1978). The sum represents the total of all the inflation rates over the 40-year period, which equals 1198.86%. This sum is simply the result of adding up each annual inflation rate for the entire sample (Mankiw 2020). The sum of squared deviations measures the total squared differences between each data point and the mean. It reflects the overall variability in the inflation data. A large value (96,306.98) confirms that the data has high variability, which aligns with the large standard deviation (Gujarati & Porter 2009). There are 40 observations, meaning the dataset covers 40 years of data, from 1983 to 2022 (World Bank 2023).

Inflation data shows considerable volatility, with a high mean (29.97%) but a large spread (high standard deviation of 49.69%), suggesting significant fluctuation in inflation over time. The distribution is heavily skewed to the right, indicating a few extreme inflation years that inflate the mean, while the data's high kurtosis and Jarque-Bera test results confirm that the inflation data does not follow a normal distribution. The large maximum and low minimum values suggest a history of both inflationary and deflationary periods, with the potential for occasional economic instability. Stationarity tests (Appendix 2 and Appendix 3) are conducted using Augmented Dickey-Fuller (ADF) test to check for stationarity. Results indicate that the original series was non-stationary in level ($p > 0.05$). After first difference, the series achieved stationarity ($p < 0.05$), justifying the use of ARIMA model.

ARIMA (1, 1, 1) model was identified as the best, based on Akaike Information Criterion (AIC = 9.799614) and Schwarz Criterion (SC = 9.970236). Parameter estimates include: AR(1) = 0.738682 (p = 0.0024); MA(1) = -1.000000 (p = 0.9998). Accordingly, the coefficient of AR(1) is statistically significant, while that of MA(1) is statistically insignificant. Diagnostic checks confirm the adequacy of the model. The residuals are white noise, as confirmed by the Ljung-Box Q test ($p > 0.05$), and the autocorrelation function (ACF) plots show no significant patterns, validating the model's robustness. Forecasts for the next 20 years suggest a severe deflationary spiral, with inflation rates expected to decline sharply from -1.02% in 2023 to approximately -50.54% by 2042. Results are summarized as follows:

Results of the ARIMA (1, 1, 1) model (Appendix 4)

$\widehat{Inflation}_t$ = -2.024806 + 0.738682AR(1) + -1.000000MA(1) ………............................… (3)

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Hence,

$$\hat{\theta} = \begin{bmatrix} -2.024806 \\ 0.738682 \\ -1.000000 \end{bmatrix}$$

The constant term of -2.024806 represents the intercept of the ARIMA model. Though it is statistically insignificant, it provides the baseline value of inflation when there are no lagged terms or moving average effects influencing inflation. The insignificance indicates that the constant term does not contribute meaningfully to explaining the variation in inflation, and its value may not be relevant for making predictions in the context of this model (Enders 2014). The AR(1) coefficient of 0.738682 is positive and statistically significant. This indicates that inflation in Uganda exhibits positive serial correlation, meaning that past inflation values have a significant influence on current inflation. A positive coefficient suggests that an increase in inflation in one period tends to be followed by an increase in inflation in the subsequent period and vice versa. The statistical significance of this coefficient means that the relationship between past and current inflation is strong and should be considered when forecasting future inflation (Gujarati & Porter 2009).

The MA(1) coefficient of -1.000000 is negative and statistically insignificant. This implies that while the model includes a moving average term, the effect of past errors (or shocks) on current inflation is not significant. The negative value suggests that any shock in inflation tends to be followed by an opposite shock in the next period, but since the coefficient is statistically insignificant, this relationship is not reliable enough to draw conclusions about its effect on inflation (Ljung & Box 1978). The Sigma-squared value of 818.2977 represents the variance of the model's residuals (errors), and being statistically insignificant, it indicates that the residuals do not provide additional useful information for predicting inflation. In other words, the model's fit is reasonable, but there is still unexplained variance in inflation that is not captured by the ARIMA (1, 1, 1) structure (Enders 2014).

The Adjusted R-squared value of 0.064113 indicates that only about 6.41% of the variation in inflation is explained by the ARIMA model. This is a relatively low value, suggesting that the model does not account for a substantial proportion of the variation in inflation. The low explanatory power might be due to factors not included in the model, such as external shocks or other macroeconomic variables influencing inflation (Gujarati & Porter 2009). The Durbin-Watson statistic of 1.804315 suggests that there is no significant autocorrelation in the residuals of the model. Since the statistic is close to the ideal value of 2, it indicates that the residuals are not correlated over time, supporting the assumption of no autocorrelation in the model. This is an important result, as autocorrelation in residuals would indicate that the model is mis specified or missing key dynamics (Ljung & Box 1978).

The histogram of residuals for the ARIMA (1, 1, 1) model, showing a kurtosis value of 5.6 and a Jarque-Bera statistic of 15.5 with a p-value of 0, suggests that the residuals are not normally distributed. The kurtosis value of 5.6 indicates a leptokurtic distribution, meaning that there are more extreme values (outliers) than would be expected under a normal distribution. The Jarque-Bera test further confirms this non-normality, as the p-value of 0 suggests that the residuals deviate significantly from normality, which could be a limitation of the model's assumptions (Ljung & Box 1978). The Ljung-Box Q statistic test results show that we fail to reject the null hypothesis, indicating that the residuals of the ARIMA (1, 1, 1) model are white noise. This suggests that there are no significant autocorrelations in the residuals, reinforcing the idea that the model does not suffer from misspecification and that the residuals behave as expected under the assumption of randomness (Enders 2014).

Further diagnostics of the ARIMA (1, 1, 1) model reveal that the AR and MA roots are covariance stationary and invertible, as they lie within the unit circle. This is a necessary condition for the model's reliability in forecasting future trends. Covariance stationarity ensures that the model's parameters are stable over time, while invertibility ensures that past errors can be adequately modeled without leading to an explosive pattern (Gujarati & Porter 2009). Finally, the forecasts of inflation for the next two decades, provided in appendices 7 and 8, offer projections based on the fitted ARIMA (1, 1, 1) model. These forecasts provide insights into future inflation trends under the assumption that current economic dynamics persist. Given the model's limitations, including low explanatory power and non-normal residuals, the forecasts should be interpreted with caution and supplemented with other economic indicators or models for better accuracy (Mankiw 2020).

DISCUSSION

In this section, we compare the results of the ARIMA (1, 1, 1) model applied to Uganda's inflation data with previous studies on inflation dynamics and deflationary risks, particularly in the context of Sub-Saharan Africa (SSA). The study aims to understand the risk of a deflationary spiral in Uganda by analyzing historical inflation trends and the implications of key macroeconomic factors.

The constant term of -2.024806 in our model, though statistically insignificant, represents the baseline inflation when there are no lagged terms or shocks to inflation. While such constant terms are often found in ARIMA models, previous studies in SSA have also reported insignificant constants, which can be attributed to the high volatility of inflation in these economies (Mignamissi et al. 2023; Peiris & Barnichon 2007).

Notably, the AR(1) coefficient of 0.738682 is positive and statistically significant, highlighting a positive serial correlation of inflation. This finding aligns with studies by Bleaney & Francisco (2016), who found that inflation persistence is a key feature in SSA, particularly in economies like Uganda, where inflationary pressures tend to persist over time. The significance of this coefficient indicates that past inflation has a strong influence on current inflation, supporting the idea that inflation trends in Uganda follow a relatively stable path.

The negative and statistically insignificant MA(1) coefficient of -1.000000 suggests that shocks to inflation in one period do not have a lasting effect on subsequent periods. This result contrasts with findings in other SSA economies, where moving average terms often play a more substantial role in capturing short-term inflationary shocks (Nguyen et al. 2017). The insignificance of the MA term in Uganda suggests that inflationary shocks in Uganda may be less transient than those in other economies, and that inflation expectations may be more strongly anchored by persistent economic factors rather than temporary shocks.

The Sigma-squared value of 818.2977 is statistically insignificant, indicating that the residuals of the model are not explaining much of the unexplained variation in inflation. This is consistent with other studies in SSA, where high volatility in inflation often results in large residuals, making it difficult to capture all the factors influencing inflation (Heintz & Ndikumana 2010). Moreover, the Adjusted R-squared value of 0.064113 reveals that the model explains only a small portion of the inflation variance. This low explanatory power is a limitation of the model, and similar findings have been observed in studies using ARIMA models in volatile economies such as Uganda, where inflation is influenced by multiple external factors not accounted for in the model (Said 2018).

The Durbin-Watson statistic of 1.804315 suggests no significant autocorrelation in the residuals, which aligns with the assumption of no time-series dependence in the model. This result supports previous findings in SSA, where the lack of significant autocorrelation is often attributed to factors such as high-frequency shocks, political instability, and global commodity price fluctuations (Mignamissi et al. 2023). The statistic's proximity to the ideal value of 2 further strengthens the assumption that the residuals in Uganda's inflation model are not influenced by temporal dependencies, which is crucial for ensuring the reliability of the ARIMA model's forecasts.

The Jarque-Bera statistic of 15.5 with a p-value of 0 suggests that the residuals of the model deviate significantly from normality, indicating a leptokurtic distribution. This result is similar to findings by Peiris & Barnichon (2007), who reported non-normality in inflation residuals for several SSA countries. The non-normality observed here suggests that the ARIMA model may not fully capture the dynamics of Uganda's inflationary process, which could be influenced by a range of macroeconomic variables such as fiscal policy changes, external shocks, and structural changes in the economy that the model does not account for.

The Ljung-Box Q test results indicate that the residuals are white noise, meaning there is no autocorrelation in the residuals at different lags. This finding supports the adequacy of the ARIMA model, confirming that the model does not suffer from misspecification or omitted variable bias. This result is consistent with studies such as those by Nguyen et al. (2017), who found that ARIMA models with no autocorrelation in the residuals are well-suited for modelling inflation in SSA countries, where inflation persistence is often a key feature of the inflationary process.

The inflation forecasts for Uganda over the next two decades, as presented in the appendices 7 and 8, suggest that the country's inflationary trends will continue, albeit at a significantly lower rate. These projections point to a gradual decline in inflation, with expected rates becoming increasingly negative as we approach the 2040s. Specifically, the forecast suggests a risk of deflation, with the inflation rate potentially dropping to -5.94% by end of 2024, and continuing to decline, reaching -50.54% by 2042. This downward trend highlights the possibility of a deflationary spiral, a situation in which falling prices lead to reduced economic activity, lower wages, and increased unemployment, further exacerbating deflationary pressures.

The findings of this study are critical for understanding the potential for a deflationary spiral in Uganda, especially considering the projected stagnation in inflation despite a historically volatile inflationary environment. The results align with concerns raised by the International Monetary Fund (IMF), which has pointed to the risk of deflationary pressures across Sub-Saharan Africa (SSA) due to disruptions caused by the COVID-19 pandemic and subsequent economic challenges (IMF, 2022). This study suggests that, while Uganda's inflation rates have fluctuated significantly in the past, they are forecasted to stabilize at lower levels, which could lead to persistent low inflation, or even deflation, if aggregate demand fails to recover. These findings highlight the critical need for policies to stimulate demand and avoid a prolonged period of low inflation.

A unique contribution of this study lies in its use of the ARIMA model to examine Uganda's inflation data and assess the risk of a deflationary spiral. Results indicate that while inflation in Uganda has been persistent, with past inflation levels significantly influencing current inflation rates, the country does not yet show the clear signs of a deflationary spiral observed in other economies. In contrast to some SSA countries experiencing severe deflationary spirals, Uganda's inflation trajectory, though declining, does not exhibit the sharp and continuous contraction seen elsewhere.

LIMITATIONS

This section presents several limitations related to its design, sample, and data analytical procedures, which may have affected the findings and their generalizability. These limitations are discussed as follows:

One of the primary limitations of this study is the relatively small sample size. The study uses annual inflation data from 1983 to 2022, which provides a sample of only 40 observations. A larger dataset would have allowed for more robust statistical analysis, improving the precision of the estimates and reducing the risk of overfitting (Gujarati & Porter 2009). Additionally, the study only considers inflation as the primary variable of interest, whereas other macroeconomic indicators such as government spending, exchange rates, and monetary policy could provide valuable insights into the inflationary dynamics of Uganda. By excluding these variables, the analysis may not fully capture the complexity of inflationary pressures in Uganda.

While the ARIMA model is a powerful tool for time series forecasting, its application to Uganda's inflation data has limitations. The ARIMA model assumes stationarity, which may not always hold true for macroeconomic time series data (Box, et al. 2015). Although this study performed preliminary tests for stationarity and differencing, structural breaks or external shocks (e.g., global price changes, political instability) could have affected the model's assumptions. The low adjusted R-squared value and the non-normality of the residuals point to the possibility of omitted variables or model specification errors. Further, the ARIMA model is purely statistical and does not consider the underlying economic mechanisms driving inflation, such as fiscal policies, international trade dynamics, or supply-side factors (Enders 2014). Therefore, the results may lack economic interpretation, and the model might not adequately represent the complexity of Uganda's inflationary processes.

Another limitation is the assumption of linear relationships between past inflation and future inflation in the ARIMA model. Economic processes, including inflation, may be influenced by non-linear dynamics, where small changes in one variable can lead to disproportionately large effects in another (Hamilton 1994). A non-linear model or a more flexible specification (e.g., a generalized autoregressive conditional heteroskedasticity (GARCH) model) might provide more accurate forecasts and a deeper understanding of inflationary pressures.

The study does not account for external shocks such as global oil price fluctuations, international commodity price volatility, or natural disasters, all of which can significantly affect inflation. Uganda, like many other developing economies, is susceptible to these shocks, which may not be adequately captured by the ARIMA model alone (IMF 2022). The absence of such external variables could have led to biased forecasts of inflation, as the model may not fully account for their effects.

The study's data span includes the period following the COVID-19 pandemic, which has had a profound and lasting impact on global inflationary trends. The post-pandemic recovery phase in Uganda may be characterized by structural shifts in the economy that the ARIMA model cannot capture. These shifts, such as changes in labor markets, global supply chains, and international trade relationships, could have altered the trajectory of inflation in ways that the model's assumptions do not reflect (World Bank 2021). Given that the study's forecasts extend far into the future, it is challenging to account for the evolving nature of these structural changes.

CONCLUSION

This study has explored the risk of a deflationary spiral in Uganda by analyzing inflation trends and using ARIMA modelling to forecast inflation for the next two decades. The findings suggest that while Uganda's inflation is persistent, it is projected to remain at relatively low levels in the coming years. The study highlights the potential risk of prolonged low inflation, which could lead to deflationary pressures, particularly if aggregate demand fails to recover strongly. This conclusion aligns with broader concerns in Sub-Saharan Africa, where post-pandemic economic recovery is still uncertain (IMF 2022).

While the ARIMA model successfully captured the inflation dynamics of Uganda, its limitations such as the small sample size, the assumption of linear relationships, and the exclusion of key economic variables are acknowledged. The findings point to the need for incorporating a broader set of economic indicators and more flexible modelling approaches to better understand the complex drivers of inflation. Additionally, the study underscores the importance of considering external shocks and structural changes when forecasting inflation, particularly in an economy like Uganda's, which is susceptible to global economic disruptions.

Overall, this study contributes to the understanding of Uganda's inflationary risks and provides a foundation for further research on the potential for a deflationary spiral. It suggests that policymakers should remain vigilant about the possibility of low inflationary pressures and consider adopting measures to stimulate aggregate demand to mitigate the risks of deflation. Future studies should focus on incorporating a wider array of economic factors and exploring the non-linear dynamics of inflation to provide more comprehensive insights into Uganda's inflation trajectory and economic stability.

RECOMMENDATIONS

Based on the findings of this study, several recommendations are proposed in terms of policy, programmatic interventions, and future research to mitigate the risk of a deflationary spiral in Uganda and foster sustainable economic stability.

The persistence of low inflation rates suggests that Uganda may face prolonged periods of low demand. The government should focus on policies aimed at stimulating aggregate demand, such as increasing public sector investment, incentivizing private sector spending, and ensuring that consumption remains buoyant. Fiscal stimulus

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programs, such as direct cash transfers or subsidies for key sectors, could be explored to drive economic activity (IMF 2022).

While the Bank of Uganda has already adjusted interest rates, further monetary policy interventions may be required to counter the risk of deflation. A more aggressive approach in reducing policy rates could help stimulate borrowing and investment. Additionally, targeted interventions in key sectors such as agriculture and manufacturing could help boost output and consumption (UBOS 2021).

Uganda's heavy reliance on commodity exports makes it vulnerable to global economic disruptions. Policies aimed at diversifying the economy through the promotion of non-traditional exports, the services sector, and technological innovations would provide a cushion against external shocks and help create a more resilient economy (World Bank 2021).

The limited effectiveness of monetary policy transmission, as indicated by the preference of banks for government securities, suggests that deeper reforms in the financial sector are necessary. Encouraging banks to lend more to productive sectors rather than holding government debt would improve the effectiveness of monetary policy in stimulating economic activity (IMF 2021).

The government should adopt a clear inflation targeting framework to provide better guidance to the economy and manage expectations. A transparent and predictable approach to inflation targeting can help both consumers and businesses make informed decisions, thereby reducing the risk of destabilizing deflation (Bank of Uganda 2022).

The risks of deflation, especially in terms of its impact on the most vulnerable populations, highlight the need for stronger social safety nets. Programs that provide direct support to low-income households and rural communities could help cushion the effects of economic slowdowns, thereby maintaining demand levels and preventing further deflationary pressures (ILO 2020).

Programs aimed at infrastructure development, particularly in rural areas, would stimulate economic activity and create jobs. Public works programs targeting infrastructure development could provide immediate employment opportunities while boosting demand for goods and services (World Bank 2022).

SMEs are critical to the Ugandan economy but are often affected by economic volatility. Programs designed to support these enterprises such as low-interest loans, business development services, and tax relief would help stabilize this key sector and foster growth, ensuring that the economy is less vulnerable to deflation (Okumu & Buyinza 2020).

Future research should explore the role of a broader range of economic indicators in explaining Uganda's inflationary trends. Incorporating factors such as exchange rates, global commodity prices, and the impact of global economic shifts on Uganda's economy could provide a more comprehensive understanding of the inflationary dynamics at play (Muwonge & Obwona 2003).

Given the potential for non-linear relationships between inflation and other macroeconomic variables, further research should employ non-linear modelling techniques, such as GARCH or structural VAR models, to explore the complex drivers of inflation in Uganda. This would provide deeper insights into the potential for deflation and help refine policy responses (Mawejje & Lwanga 2016).

Research should focus on how external shocks such as global commodity price fluctuations, pandemics, and political instability affect inflation in Uganda. Understanding the structural vulnerabilities in Uganda's economy will be essential for formulating long-term strategies to mitigate the risk of deflation (UNDP 2021).

Additional studies that track inflation trends over longer time periods and in different economic contexts could provide a more detailed picture of Uganda's inflation trajectory. Such studies could also consider the impact of new global trends, such as climate change or technological innovation, on inflation dynamics in Uganda (IMF 2023).

In conclusion, addressing the potential risk of a deflationary spiral in Uganda requires a multifaceted approach, including effective monetary and fiscal policies, structural reforms, and targeted programs to stimulate demand. Further research will be crucial in refining the understanding of inflation trends and guiding the country's economic policies towards long-term stability.

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APPENDICES

Appendix 1: Descriptive statistics

	INFLATION, GDP deflator (annual %)
Mean	29.97138
Median	6.606387
Maximum	189.9751
Minimum	0.113131
Std. Dev.	49.69316
Skewness	2.092042
Kurtosis	6.248236
Jarque-Bera	46.76266
Probability	0
Sum	1198.855
Sum Sq. Dev.	96306.98
Observations	40

Appendix 2: Unit root test, INFLATION (in Level)

Null Hypothesis: INFLATION has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.968109	0.2991
Test critical values:	1% level	-3.610453	
	5% level	-2.938987	
	10% level	-2.607932	

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

Augmented Dickey-Fuller Test Equation

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Dependent Variable: D(INFLATION)
Method: Least Squares
Date: 12/26/24 Time: 01:46
Sample (adjusted): 2 40
Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFLATION(-1)	-0.191509	0.097306	-1.968109	0.0566
C	4.810947	5.665615	0.849148	0.4013

R-squared	0.094767	Mean dependent var	-1.051851
Adjusted R-squared	0.070301	S.D. dependent var	31.21349
S.E. of regression	30.09633	Akaike info criterion	9.696604
Sum squared resid	33514.19	Schwarz criterion	9.781915

Appendix 3: Unit root test, INFLATION (in First difference)

Null Hypothesis: D(INFLATION) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.139594	0.0000
Test critical values:	1% level	-3.615588	
	5% level	-2.941145	
	10% level	-2.609066	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INFLATION,2)
Method: Least Squares
Date: 12/26/24 Time: 01:49
Sample (adjusted): 3 40
Included observations: 38 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(INFLATION(-1))	-1.017797	0.165776	-6.139594	0.0000
C	-0.555971	5.177064	-0.107391	0.9151

R-squared	0.511498	Mean dependent var	0.606443
Adjusted R-squared	0.497928	S.D. dependent var	45.00925
S.E. of regression	31.89222	Akaike info criterion	9.813797
Sum squared resid	36616.09	Schwarz criterion	9.899986

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Appendix 4: Results of the ARIMA (1, 1, 1) model

Dependent Variable: D(INFLATION)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 12/26/24 Time: 01:55
Sample: 2 40
Included observations: 39
Failure to improve objective (non-zero gradients) after 13 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.024806	2.407962	-0.840879	0.4061
AR(1)	0.738682	0.225305	3.278595	0.0024
MA(1)	-1.000000	4885.951	-0.000205	0.9998
SIGMASQ	818.2977	88879.93	0.009207	0.9927

R-squared	0.137999	Mean dependent var	-1.051851
Adjusted R-squared	0.064113	S.D. dependent var	31.21349
S.E. of regression	30.19632	Akaike info criterion	9.799614
Sum squared resid	31913.61	Schwarz criterion	9.970236
Log likelihood	-187.0925	Hannan-Quinn criter.	9.860832
F-statistic	1.867737	Durbin-Watson stat	1.804315
Prob(F-statistic)	0.153066		

Inverted AR Roots	.74
Inverted MA Roots	1.00

Appendix 5: Ljung-Box Q statistic/ test

Date: 12/26/24 Time: 02:02
Sample: 1 40
Included observations: 39
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |*. |	. |*. |	1	0.092	0.092	0.3577	
. |*. |	. |*. |	2	0.097	0.089	0.7619	
.*| . |	.*| . |	3	-0.080	-0.098	1.0448	0.307
.*| . |	.*| . |	4	-0.173	-0.171	2.4160	0.299
. | . |	. | . |	5	-0.042	0.004	2.4977	0.476
. | . |	. | . |	6	-0.033	-0.000	2.5498	0.636
. | . |	. | . |	7	0.000	-0.022	2.5498	0.769
.*| . |	.*| . |	8	-0.078	-0.111	2.8615	0.826
. | . |	. | . |	9	-0.045	-0.041	2.9712	0.888
. | . |	. | . |	10	-0.062	-0.044	3.1825	0.922
. | . |	. | . |	11	-0.007	-0.008	3.1855	0.956
. | . |	. | . |	12	-0.033	-0.065	3.2491	0.975
. | . |	. | . |	13	-0.014	-0.039	3.2612	0.987
. | . |	.*| . |	14	-0.056	-0.074	3.4630	0.991

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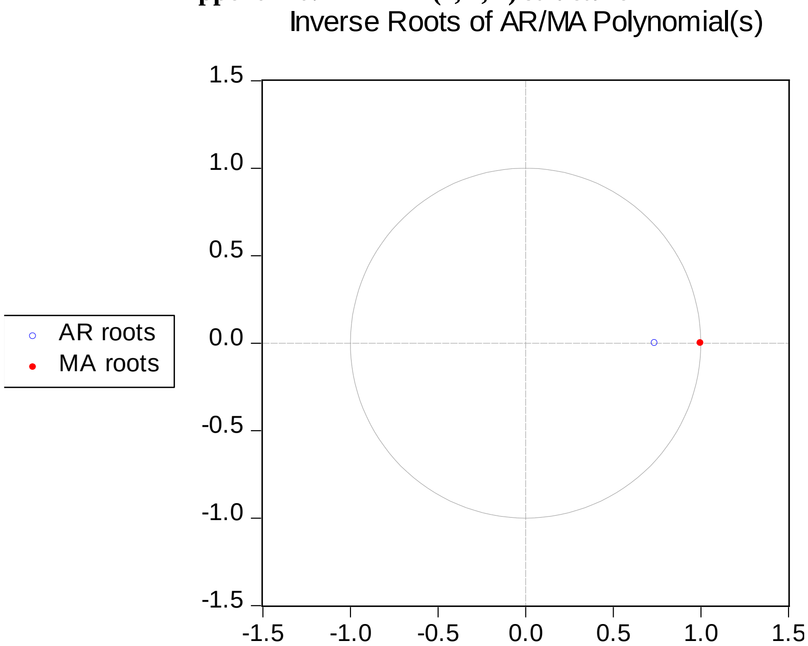
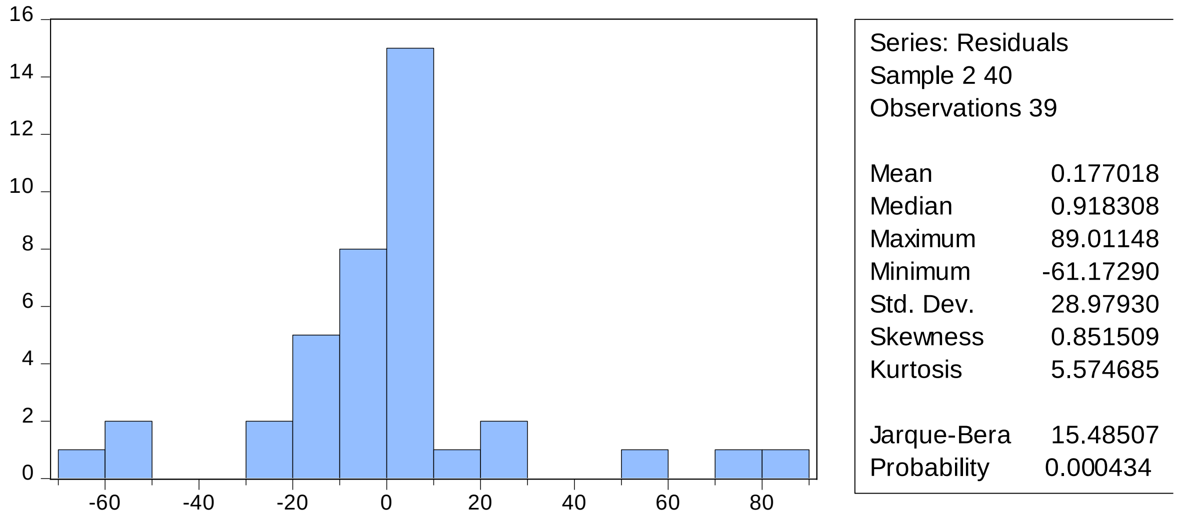
. | . |	. | . |	15	-0.039	-0.044	3.5623	0.995
. | . |	. | . |	16	-0.001	-0.018	3.5624	0.998

Appendix 6: ARIMA (1, 1, 1) structure



Appendix 7: Histogram of residuals



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Appendix 8: Uganda's INFLATION and INFLATION forecast results

Year	INFLATION, GDP deflator (annual %)	INFLATION FORECAST, GDP deflator (annual %)
1983	45.94449	45.94449
1984	25.27681	25.27681
1985	120.3359	120.3359
1986	137.2809	137.2809
1987	180.988	180.988
1988	189.9751	189.9751
1989	115.4467	115.4467
1990	44.38009	44.38009
1991	26.01934	26.01934
1992	45.06803	45.06803
1993	30.13687	30.13687
1994	6.848498	6.848498
1995	9.376438	9.376438
1996	4.572481	4.572481
1997	3.095269	3.095269
1998	8.785707	8.785707
1999	0.113131	0.113131
2000	11.11731	11.11731
2001	4.534476	4.534476
2002	3.169556	3.169556
2003	7.806741	7.806741
2004	15.58755	15.58755
2005	1.741185	1.741185
2006	2.40562	2.40562
2007	7.321247	7.321247
2008	6.364277	6.364277
2009	85.35328	85.35328
2010	5.637612	5.637612
2011	9.391655	9.391655
2012	3.837456	3.837456
2013	3.586906	3.586906
2014	5.106307	5.106307
2015	5.18786	5.18786
2016	4.781	4.781

2017	4.649051	4.649051
2018	4.443385	4.443385
2019	3.000012	3.000012
2020	2.721484	2.721484
2021	2.545119	2.545119
2022	4.922287	4.922287
2023	NA	-1.021392
2024	NA	-5.941001
2025	NA	-10.10415
2026	NA	-13.7085
2027	NA	-16.9001
2028	NA	-19.78679
2029	NA	-22.44826
2030	NA	-24.94335
2031	NA	-27.31555
2032	NA	-29.59697
2033	NA	-31.81133
2034	NA	-33.97616
2035	NA	-36.1044
2036	NA	-38.20561
2037	NA	-40.28685
2038	NA	-42.35335
2039	NA	-44.40895
2040	NA	-46.4565
2041	NA	-48.49811
2042	NA	-50.53533

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Appendix 9: Graph showing Uganda's INFLATION and INFLATION FORECAST result