

Central bank digital currency, economic growth and inflation

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Abstract

Purpose – This study aims to investigate the effect of CBDC issuance on economic growth rate and inflation rate in Nigeria. We are interested in determining whether the rate of economic growth and inflation changed significantly after the issuance of a non-interest bearing CBDC in Nigeria.

Design/methodology/approach – Two-stage least squares regression and granger causality test were used to analyze the data.

Findings – Inflation significantly increased in the CBDC period, implying that CBDC issuance did not decrease the rate of inflation in Nigeria. Economic growth rate significantly increased in the CBDC period, implying that CBDC issuance improved economic growth in Nigeria. The financial sector, agricultural sector and manufacturing sector witnessed a much stronger contribution to gross domestic product (GDP) after CBDC issuance. There is one-way granger causality between CBDC issuance and monthly inflation, implying that CBDC issuance causes a significant change in monthly inflation in Nigeria. The implication of the result is that the non-interest bearing eNaira CBDC is not able to solve the twin economic problem of “controlling inflation which stifles economic growth” and “stimulating economic growth which leads to more inflation.” Policy makers should therefore use the eNaira CBDC alongside other monetary policy tools at their disposal to control inflation while stimulating growth in the economy.

Originality/value – There are no empirical studies on the effect of CBDC issuance on economic growth or inflation using real-world data. We add to the monetary economics literature by analyzing the effect of CBDC issuance on economic growth and inflation.

Keywords Central bank digital currency, CBDC, Inflation, Economic growth, Nigeria

Paper type Research paper

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1. Introduction

This study investigates the effect of CBDC issuance on economic growth rate and inflation rate in Nigeria.

A central bank digital currency (CBDC) is the digital equivalent of cash or paper currency and is a liability of the issuing central bank (Williamson, 2022). A CBDC, just like every other innovation, can be used to support productive activities depending on the objective the central bank wants to achieve with it and depending on its design features. Central banks around the world are increasingly interested in issuing a CBDC. The COVID-19 pandemic and the rise in private digital currencies, such as cryptocurrencies, motivated many central banks to consider the possibility of issuing a CBDC as a digital alternative to fiat paper money.

The Central Bank of Nigeria issued a non-interest-bearing CBDC in October 2021. As a result, Nigeria became the first African country to issue an official CBDC called the eNaira. The eNaira CBDC has been well-received by corporations and wholesale merchants in Nigeria. It has recorded transactions worth ₦8bn (or US\$18.2m) and the eNaira CBDC wallet has received over 800,000 downloads in 2022. These indicators are signs of progress within one year of the launch of the eNaira CBDC. While the Nigeria CBDC holds much promise for

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better economic welfare for citizens in Nigeria, many questions have been raised about its effect on macro-economic stability particularly with regard to economic growth and inflation. Therefore, it remains to be seen whether Nigeria's economic growth rate and inflation rate (INF) improved or worsened after the issuance of the eNaira CBDC.

Economic growth and inflation are highly debated topics in the macroeconomics literature. The determinants of economic growth and inflation are diverse. Several studies have identified several factors affecting economic growth and inflation (see, for example, [Rani and Kumar, 2019](#); [Sheremirov, 2020](#); [Rudd, 2022](#); [Ozili et al., 2023](#)). But such studies have not considered a CBDC to be a potential factor contributing to economic growth and inflation. This study presents CBDC as a modern innovation and a potential factor that might explain the dynamics or changes in economic growth and inflation. Also, a pioneering work on the innovation–growth nexus by [Romer \(1986\)](#), [Lucas \(1988\)](#), [Grossman and Helpman \(1994\)](#) emphasizes the role of innovation and technological advancement as inputs to production which leads to economic growth. Empirical studies also document evidence that innovation make a significant contribution to economic growth and price stability ([Chu, 2022](#); [Evers et al., 2020](#)). But the literature has not considered the case of a CBDC as a potential contributor to economic growth or inflation. Presently, there is little knowledge about the effect of a CBDC on economic growth and inflation. There are no empirical studies on the effect of CBDC issuance on economic growth or inflation using real-world data and in African countries. This study contributes to the literature by analyzing the effect of CBDC issuance on economic growth and inflation in a non-interest bearing CBDC environment.

In this paper, we are interested in investigating whether the rate of economic growth and inflation changed significantly in the period after the eNaira CBDC was issued in Nigeria. In terms of the transmission mechanism, we predict that CBDC will improve economic growth by ensuring faster, cheaper and transparent cross-border payment services, ensuring the continued provision of public money to support production, offering a cheaper and efficient payment option for financial transactions, improving the functioning of the payment system and supporting economic digitalization which ultimately lead to positive economic growth ([Auer et al., 2022](#); [Ozili, 2022b](#)). Regarding inflation, CBDC can reduce inflation by increasing the CBDC deposit rate which will lead to the migration of bank deposits to CBDC deposits, it will mop up excess liquidity in the banking sector, it will reduce money supply and decrease the rate of inflation ([Minesso et al., 2022](#); [Bhowmik, 2022](#); [Keister and Sanches, 2023](#)).

In the empirical analysis, we make use of the official inflation and GDP growth statistics obtained from the National Bureau of Statistics (NBS). We construct year dummies to capture the pre-CBDC period and the post-CBDC issuance period. Our empirical results indicate that inflation significantly increased after the issuance of the non-interest bearing CBDC in Nigeria. It was also found that CBDC issuance has a significant positive effect on economic growth in Nigeria especially on the financial sector, the agricultural sector and the manufacturing sector.

The study contributes to the literature that examines the role of innovation for economic growth. It contributes to this literature by examining whether the CBDC innovation led to improvement in economic growth and price stability. The study also contributes to the literature that examines the effect of a CBDC on the economy. We focus on economic growth and inflation after the CBDC was issued to determine if the two macroeconomic variables performed better or worse. The study also contributes to ongoing debates about the benefits and risks of a CBDC. The analysis in the study will provide useful insight on the consequences and benefits of a CBDC for macroeconomic stability.

The rest of the paper is organized in the following way. [Section 2](#) presents the conceptual framework and the literature review. [Section 3](#) presents the research methodology. [Section 4](#) presents the empirical results and [section 5](#) presents the conclusion of the study.

2. Conceptual framework and literature review

2.1 CBDC, technology acceptance model and the Nigerian use case

A CBDC is the digital equivalent of cash or paper currency and is a liability of the issuing central bank (Ward and Rochemont, 2019). A CBDC has cash-like properties and can be designed and redesigned to have extended functionalities to meet central bank objectives. Many central banks are motivated to study or issue a CBDC because of the need for central banks to innovate in the 21st century and the need for central banks to counter the proliferation of private digital currencies which offer unlicensed digital money in the domestic economy (Ozili, 2022a, 2023; Wang *et al.*, 2022). A CBDC offers enormous benefits. It can enhance the conduct of monetary policy, increase financial inclusion, increase payment efficiency, facilitate government welfare transfers, offer cheaper cross-border payment and eliminate tax evasion (Ozili, 2023). CBDCs also present some risks such as lack of interest in CBDC adoption by majority of the population, cyber security risks, disorderly bank disintermediation and financial stability risks (Bindseil, 2020). While the benefits and risks of issuing a CBDC are well-known in the literature, there has been much focus on CBDC design. The design of a CBDC is crucial for it to achieve its intended purpose. A CBDC must be designed to have features that support the realization of the specific objectives that the central bank has set out to achieve (Kumhof and Noone, 2018). While CBDC design is important, it is equally important for the central bank to ensure that the CBDC is widely accepted in society (Söilen and Benhayoun, 2021). If a CBDC is not accepted in society, the CBDC will not achieve its objectives. The issue of CBDC acceptance leads us to discuss the technology acceptance model.

The technology acceptance model was formulated by Davis (1989). The model is used to explain an individual's acceptance and use of a technology or innovation (Lee *et al.*, 2003). The model proposes that the perceived ease of use and perceived usefulness of a technology or innovation are determinants of whether an individual will accept and use the technology or innovation (Chau, 1996). The implication of the technology acceptance model for a CBDC is that the determinant of whether people will use CBDC is whether the CBDC is easy to use and whether people find it very useful to them compared to existing alternatives, and whether they feel that using CBDC in their daily lives will have a positive impact on their lives, as argued by the technology impact model which states that people assess whether an innovation will have a positive impact on them before reaching a decision to use the innovation (Ozili, 2024).

Furthermore, after issuing the eNaira CBDC, many people raised concerns about the usefulness of the eNaira CBDC for citizens since the existing payment channels owned by banks are working well. There were also concerns that the eNaira CBDC would compete with banks and that the central bank will have a superior advantage by being both a regulator and a player in the payment system. Economists also raised some concern about the effect of the eNaira CBDC on macroeconomic stability and its consequence for economic growth and inflation. Therefore, it is important to understand how the issuance of a CBDC affects economic growth and inflation. The literature has not examined this issue.

2.2 The innovation and economic growth literature

The innovation and economic growth literature explains the impact of innovation on economic growth. Verspagen (2006) argues that technological innovation is responsible for extended periods of sustained economic growth in developed economies. The major argument has been that innovative activity is the single most important determinant of long-term economic growth; and without it, long-term growth is not possible. Also, Arora *et al.* (2020) show that modern economic growth is caused by the systematic application of science to advance technology which supports productive activities in the economy. Several studies test this argument by investigating the relationship between innovation and economic

growth. For example, [Gyedu et al. \(2021\)](#) examine the impact of innovation on economic growth among the G7 and Brazil, Russia, India, China, and South Africa (BRICS) countries from 2000 to 2017. They focus on how innovation, which was measured by R&D, patents and trademarks, affects GDP per capita which is the measure of economic growth. They found that the three types of innovation have a significant effect on GDP per capita and the impact is stronger in G7 countries than in BRICS countries. [Mtar and Belazreg \(2021\)](#) examine the causal relationship between innovation, financial development and economic growth for 27 The Organization for Economic Cooperation and Development from 2001 to 2016. They find a unidirectional causality from innovation to economic growth. They conclude that country-specific characteristics play an important role in fostering innovation and economic growth. [Farinha et al. \(2018\)](#) examine the relationship between innovation and economic growth in 148 countries with different levels of development. They use structural equation modeling and hierarchical cluster analysis and find that innovation is an important driver of growth and competitiveness in several economies. [Ahlstrom \(2010\)](#) shows that innovation leads to the development and production of innovative goods and services that lead to economic growth and higher per capita income. [Rosenberg \(2006\)](#) argues that innovation can lead to long-term economic growth especially if: (1) innovation is used to increase the number of inputs that go into the productive process or (2) innovation can devise new ways in which more output can be derived from the same number of inputs. [Pece et al. \(2015\)](#) also argue that innovation can support the sustainable development of the private and public sectors, which will improve living standards and welfare in the form of positive economic growth and development. [Maradana et al. \(2017\)](#) point out that innovation could lead to economic growth through other macroeconomic factors, and innovation is also affected by economic growth and other macroeconomic factors, implying that both innovative activities and economic growth can cause each other and therefore, there is the possibility of feedback relationship between the two ([Maradana et al., 2017](#)).

Collectively, these studies document a positive effect of innovation on economic growth. And since a CBDC is a type of innovation, CBDC should have a positive effect on economic growth. This is because a CBDC is the sort of innovation that would foster more innovations and long-term growth as in the Romer growth model, and arguably, CBDC as a financial innovation tool may have a different effect on the economy from CBDC as a technological innovation tool. Also, there may be a need to separate the transitional impact of CBDC issuance from the long-term impact of having a CBDC circulating in the economy. Considering the fact that the eNaira CBDC has only been issued for a short period of time, it may be difficult to determine its long-term impact on growth at this time. We now proceed to review the existing studies that link CBDC to economic growth and inflation.

2.3 Potential effect of CBDC on economic growth and inflation

Few studies in the literature attempt to link CBDC to economic growth or inflation. For instance, [Auer et al. \(2022\)](#) emphasize that CBDCs may support economic growth by ensuring faster, cheaper and transparent cross-border payment services that would deliver widespread benefits for citizens, improve welfare and support economic growth. [Clemens et al. \(2021\)](#) argue that CBDC can improve economic growth because it would ensure the continued provision of public money, improve the functioning of the payment system, support economic digitalization and lead to less reliance on dominant foreign-based payment providers, thereby saving national resources which could be channeled towards economic growth. [Ozili \(2022b\)](#) shows that CBDC can stimulate growth in the circular economy in three ways: (1) by making CBDC accessible to all merchants, (2) by incorporating design features into the CBDC that support circular economy goals, and (3) by offering a better payment option for circular economy financial transactions. [Cukierman \(2019\)](#) argues that CBDCs will allow central banks to become actively involved in allocating credit to the economy, thereby

supporting economic growth. However, [Cukierman \(2019\)](#) points out that such move by central banks is undesirable since it is disadvantageous to private banks who are better equipped to allocate credit towards growth in the economy. [Cukierman \(2019\)](#) further argues that central banks should limit their activities to the area in which they have a comparative advantage, and they should not participate in the allocation of credit which private banks are able to do better since private banks have a comparative advantage in evaluating the risk involved in granting loans for various projects and to individual and corporate borrowers.

Regarding inflation, [Minesso *et al.* \(2022\)](#) suggest that CBDC is a potent monetary policy tool that could be used to dampen inflation risk especially when the CBDC is interest-bearing. [Bhowmik \(2022\)](#) and [Keister and Sanches \(2023\)](#) argue that interest-bearing CBDC can help to control inflation by increasing deposit rates on CBDC which will mop up the excess liquidity in the banking sector, thereby reducing money supply and inflation. [Beniak \(2019\)](#) argues that when both cash and CBDC are available to the general public, monetary policy will be more constrained and ineffective in controlling inflation; as a result, it will yield higher inflation and lower welfare. [Beniak \(2019\)](#) further argues that the only way for monetary policy to work effectively to control inflation is if the CBDC is interest-bearing, and a much better outcome will be achieved if CBDC is the only legal tender. [Chen and Siklos \(2022\)](#) also argue that CBDC will not produce higher inflation; rather, the introduction of a CBDC, and at the same time eliminating large denominations of paper currency, will help to keep inflation under control. Overall, the literature suggests that an interest-bearing CBDC can reduce inflation.

However, the CBDC in Nigeria is non-interest bearing and there is no empirical evidence on the effect of non-interest bearing CBDC on inflation or economic growth. This paper extends the literature by examining the effect of CBDC issuance on economic growth and inflation in a non-interest bearing CBDC environment, focusing on the Nigeria context.

3. Research methodology

Economic growth and inflation data for Nigeria were obtained from the NBS of Nigeria. For the economic growth analysis, quarterly real GDP growth data for Nigeria were obtained for the period 2019 to 2022. We omitted the year 2020 to isolate the adverse effect of the COVID-19 pandemic on real GDP growth in 2020.

The economic growth data were divided into the pre-CBDC period and the CBDC period to enable comparison using a dummy variable. The Nigeria eNaira CBDC was launched in October 2021 which is in the third quarter of 2021. A quarterly binary variable “CBDC1” was constructed to capture the CBDC period (i.e. a value of 1 is assigned to 2021-Q4, 2022-Q1 and 2022Q2, and zero otherwise, reflecting the CBDC period in Nigeria). In the analysis, we also divided the real GDP growth variable into its oil and non-oil components because Nigeria is a major oil producing country and Nigeria’s GDP is usually reported in terms of oil GDP and non-oil GDP. Thereafter, we assess how the non-oil components affect real GDP growth in the CBDC period. For the inflation analysis, monthly (year-on-year) data were obtained from October 2020 to September 2022. The inflation data were divided into the pre-CBDC period and the CBDC period to enable comparison using a dummy variable. A monthly binary variable “CBDC2” was constructed to capture the CBDC period (i.e. a value of 1 is assigned to months from October 2021 to September 2022 and zero otherwise, representing the CBDC period in Nigeria). See [Table 1](#) for variable description.

4. Empirical result

The results were derived using descriptive statistics, correlation analysis, two-stage least squares regression and the granger causality methods. The descriptive statistics are reported to show the behavior of the data. Correlation analysis is used to show the correlation between

Variable	Sector	Source
GDPR	Real GDP growth rate measuring economic growth	National Bureau of Statistics (NBS)
INFH	Headline or annual inflation (year-on-year) (%)	NBS
INFF	Food inflation (year-on-year) (%)	NBS
INFC	Core inflation (year-on-year) (%)	NBS
INFM	Monthly inflation (month-on-month) (%)	NBS
CBDC1	A quarterly binary variable that takes the value 1 from the quarter of CBDC issuance and zero otherwise, representing the CBDC period	Authors' construct
CBDC2	A monthly binary variable that takes the value 1 from the month of CBDC issuance and zero otherwise, representing the CBDC period	Authors' construct
ICT	Information and communication sector (ICT) contribution to real GDP (%)	NBS
FIN	Finance and insurance sector contribution to real GDP (%)	NBS
AGR	Agriculture sector contribution to real GDP (%)	NBS
MAN	Manufacturing sector contribution to real GDP (%)	NBS
EN	Energy contribution sector to real GDP comprising of electricity, gas, steam and air conditioning supply (%)	NBS
PR	Professional, scientific and technical services contribution to real GDP (%)	NBS

Source(s): Nigeria Bureau of Statistics (NBS)

Table 1.
Variable description
and source

the variables. Thereafter, the two-stage least squares regression method is used to estimate the effect of CBDC issuance on economic growth and inflation in Nigeria. The two-stage least squares regression method controls for potential endogeneity issues in the data. The granger causality method is used to determine the directional causality between CBDC issuance, economic growth and inflation.

4.1 Economic growth analysis

Nigeria operates both an oil economy and a non-oil economy. This classification is reflected in the official real GDP growth statistics of the NBS. It divides Nigeria's real GDP growth into oil GDP growth rate and non-oil GDP growth rate. We take this peculiarity into account in our analysis of the effect of CBDC issuance on economic growth in Nigeria.

4.1.1 Comparison of mean. We begin the analysis by comparing the mean of real GDP growth in the quarters before CBDC issuance and the quarters after CBDC issuance. We omit the year 2020 from the analysis because of the adverse effect of the COVID-19 pandemic on real GDP growth and so that it will not contaminate the empirical results.

As shown in [Table 2](#), the mean real GDP growth in the pre-CBDC period (from the first quarter of 2019 to the fourth quarter of 2019) was 2.26%. We also use an alternative pre-CBDC period (from the first quarter of 2021 to the third quarter of 2021). During this period, the average real GDP growth was 3.18%. Meanwhile, the average real GDP growth during the

	Mean (Pre-CBDC period) (2019-Q1 to 2019-Q4)	Mean (Pre-CBDC period (2021-Q1 to 2021-Q3)	Mean (CBDC period) (2021-Q4 to 2022-Q2)
Average real GDP growth (%)	2.26	3.18	3.54

Table 2.
Comparing means of
real GDP growth in the
pre-CBDC and the
CBDC quarters

Note(s): *Year 2020 quarters were excluded from the analysis to avoid the adverse effects of the pandemic on the real GDP of Nigeria. Including the 2020 quarters would bias the mean comparison
Source(s): Nigeria Bureau of Statistics (NBS)

CBDC period was 3.54% which is higher than the real GDP growth in the two pre-CBDC periods. This suggests that real GDP growth was relatively higher in the CBDC period than in the pre-CBDC period.

Table 3 reports the pre-CBDC and CBDC period means for oil GDP growth and non-oil GDP growth. It shows that the average non-oil GDP growth was 5.19% in the CBDC period which is higher than the average pre-CBDC non-oil GDP growth of 2.06 and 3.91%, respectively. This indicates that non-oil GDP growth was higher after CBDC issuance in Nigeria. Similarly, the average non-oil sector contribution to real GDP was 92.85% in the CBDC period which is higher than the average non-oil sector contribution to real GDP in the pre-CBDC period which was 91.31 and 91.95%, respectively. This indicates that the non-oil sector's contribution to real GDP was higher after CBDC issuance in Nigeria. In contrast, the average oil sector contribution to real GDP was 6.73% in the CBDC period which is lower than the pre-CBDC average oil sector contribution to real GDP of 8.76 and 8.05%, respectively. This indicates that oil sector contribution to real GDP did not improve after CBDC issuance in Nigeria.

Table 4 reports the pre-CBDC and CBDC means for the sectors contributing to non-oil GDP in Nigeria. It shows that, on average, the agricultural sector, the financial sector and the professional services sector had a higher contribution to non-oil GDP after CBDC issuance. Meanwhile, the energy sector, the ICT sector and the manufacturing sector have a lower contribution to non-oil GDP after CBDC issuance.

4.1.2 Correlation analysis. The Pearson correlation analysis is reported in Table 5. The correlation of interest in Table 5 is the correlation of the CBDC1 variable with all other growth

	Mean (Pre-CBDC period) (2019-Q1 to 2019-Q4)	Mean Pre-CBDC period (2021-Q1 to 2021-Q3)	Mean (CBDC period) (2021-Q4 to 2022-Q2)
Oil GDP growth (%) in real terms	3.9	-8.53	-8.06
Non-oil GDP sector (%) in real terms	2.06	3.91	5.19
Oil sector contribution to real GDP (%)	8.76	8.05	6.73
Non-oil sector contribution to real GDP (%)	91.31	91.95	92.85

Note(s): *Year 2020 quarters were excluded from the analysis to avoid the adverse effects of the pandemic on the GDP of Nigeria. Including the 2020 quarters would bias mean comparison

Source(s): Nigeria Bureau of Statistics (NBS)

Table 3.
Comparing means of
oil vs non-oil
contribution to real
GDP growth in the pre-
CBDC and CBDC
quarters

Sector	Mean (Pre-CBDC period) (2019-Q1 to 2019-Q4)	Mean Pre-CBDC period (2021-Q1 to 2021-Q3)	Mean (CBDC period) (2021-Q4 to 2022-Q2)
Information and communication (ICT) (%)	9.22	7.23	7.88
Financial and insurance (FIN) (%)	2.85	6.76	21.95
Agriculture (AGR) (%)	2.39	1.60	2.65
Manufacturing (MAN) (%)	0.76	3.73	3.72
Energy (EN) (%)	-2.68	33.73	-6.63
Professional, scientific, and technical services (PR) (%)	0.22	-0.48	1.77

Note(s): *Year 2020 quarters were excluded from the analysis to avoid the adverse effects of the pandemic on the GDP of Nigeria. Including the 2020 quarters would bias mean comparison

Source(s): Nigeria Bureau of Statistics (NBS)

Table 4.
Comparing means of
the sectors
contributing to non-
oil GDP

variables. The correlation result shows that the CBDC1 variable is positively correlated with the gross domestic product growth rate (GDPR) variable. This indicates that the CBDC period is associated with greater economic growth. Also, the CBDC1 variable is positive and highly correlated with the Financial and insurance sector contribution to GDP (FIN) variable. This indicates that the CBDC period is associated with a higher contribution of the financial services sector to non-oil GDP. The CBDC1 variable is also positively correlated with the professional, scientific, and technical services (PR) and agricultural sector (AGR) variable. This indicates that the CBDC period is associated with higher contribution of the agricultural sector and the professional services sector to non-oil GDP but to a lesser degree. In contrast, the CBDC period is associated with reduced contribution of the energy sector and ICT sector to non-oil GDP. The p -value of all the correlation coefficients are insignificant; therefore, we did not report the p -value of the correlation coefficients.

4.1.3 Effect of CBDC period on economic growth: 2SLS regression analysis. The two-stage least squares regression estimation is reported in Table 6. The CBDC1 coefficient is positive and statistically significant. This indicates that the issuance of the eNaira CBDC had a significant positive effect on real GDP growth in Nigeria. This result implies that real GDP growth improved significantly in the quarters after CBDC was issued in Nigeria. Therefore, the authorities in Nigeria should encourage the continued use of the eNaira CBDC in Nigeria due to its positive effect on real GDP growth. This finding supports the literature that show evidence of a positive effect of digital innovations on economic growth such as Solomon and

Table 5.
Pearson correlation of
CBDC and economic
growth variables

Variable	GDPR	CBDC1	AGR	FIN	EN	ICT	PR
GDPR	1.000						
CBDC1	0.334	1.000					
AGR	-0.269	0.334	1.000				
FIN	0.418	0.645	0.095	1.000			
EN	0.501	-0.353	-0.361	-0.381	1.000		
ICT	-0.242	-0.104	0.165	0.071	-0.458	1.000	
PR	0.661	0.444	0.0156	0.365	0.106	0.072	1.000

Source(s): Author computation

Table 6.
CBDC period as a
determinant of
economic growth two-
stage least squares
(2SLS) regression

Independent variable	Dependent variable: GDPR Coefficient (t -statistic)
CBDC1	2.596* (3.16)
MAN	-0.631* (-3.10)
AGR	-0.408 (-1.59)
FIN	0.089** (3.89)
EN	0.076*** (6.29)
ICT	0.402** (4.76)
PR	-0.147 (-1.03)
R -square	0.939
Adjusted R -square	0.82
J-statistic	0.01
P(J-statistic)	0.92

Note(s): CBDC1 = A quarterly binary variable representing the quarters when CBDC was adopted. MAN = real growth in manufacturing services. AGR = real growth in agricultural services. FIN = real growth in financial and insurance services. EN = real growth in energy services. ICT = real growth in information and communication technology. PR = real growth in professional services

Source(s): Author computation

van Klyton (2020) and Liu *et al.* (2021). Also, it was observed that the financial services sector, the energy sector and the information and communication technology sector have a significant positive effect on real GDP growth in Nigeria as shown by the significant and positive sign on the FIN, energy sector (EN) and ICT coefficients in Table 6. The manufacturing sector had a negative effect on real GDP growth during the period examined.

We also analyze the effect of the CBDC period on the sectors that contribute to Nigeria's non-oil GDP. Table 7 reports the result. The result shows that the CBDC1 variable has a significant positive effect on the manufacturing sector, the agricultural sector and the financial services sector in Nigeria. In contrast, the CBDC1 variable has an insignificant effect on the energy sector, the ICT and professional services sector. The implication of the result is that the CBDC issuance supports growth in the manufacturing, the financial services and the agricultural sector in Nigeria. Therefore, the authorities in Nigeria should encourage the use of the eNaira CBDC in the agricultural sector, the manufacturing sector and the financial sector to stimulate growth in these sectors toward greater economic growth.

4.1.4 Granger causality test for CBDC period and economic growth. We also perform granger causality tests. An augmented Dickey-Fuller test was first conducted to determine whether each of the time series data has a unit root process. The result in Table 8 shows that the CBDC1 and GDPR time series data have a unit root and are therefore non-stationary. This means that the CBDC1 and GDPR time series data will be first-differenced [i.e. $d(\text{GDPR})$ and $d(\text{CBDC1})$] before performing the granger causality test.

The granger causality test result is reported in Table 9. The result shows that there is no granger causality running from $d(\text{CBDC1})$ to $d(\text{GDPR})$ as the p -value is 0.727 which is greater than 0.05. Therefore, there is no causality between the CBDC period and economic growth. On the other hand, there is a one-way granger causality running from $d(\text{GDPR})$ to $d(\text{CBDC1})$ as the p -value is 0.026 which is less than 0.05 in Table 9. This indicates that real GDP growth causes the CBDC period. However, this result is not meaningful. Overall, the result suggests that the CBDC period does not granger cause economic growth.

Independent variable	MAN Coefficient (<i>t</i> -statistic)	AGR Coefficient (<i>t</i> -statistic)	FIN Coefficient (<i>t</i> -statistic)	EN Coefficient (<i>t</i> -statistic)	ICT Coefficient (<i>t</i> -statistic)	PR Coefficient (<i>t</i> -statistic)
CBDC1	3.723** (2.66)	2.647** (2.31)	21.953*** (3.54)	-6.633 (-0.42)	7.883 (1.77)	1.770 (1.69)
J-statistic	4.904	7.48	1.248	1.548	8.25	0.015
P(J-statistic)	0.03	0.01	0.26	0.21	0.00	0.90

Note(s): ***, ** denote statistical significance at the 1 and 5% levels

Source(s): Author computation

Table 7.
Effect of CBDC period on the contributors to non-oil real GDP growth: two-stage least square (2SLS) regression

Variable	<i>T</i> -statistic	<i>p</i> -value	Remark
GDPR	-2.471	0.152	Has a unit root. GDPR is non-stationary. Should be first-differenced i.e. $d(\text{GDPR})$
CBDC1	-0.509	0.846	Has a unit root. CBDC1 is non-stationary. Should be first-differenced i.e. $d(\text{CBDC1})$

Note(s): *** represents statistical significance at the 1% level

Source(s): Author computation

Table 8.
Augmented Dickey-Fuller test result for CBDC period and economic growth variables

4.2 Inflation analysis

We focus the analysis on four types of inflation in Nigeria which are headline inflation rate (INFH), food inflation rate (INFF), core inflation rate (INFC) and the monthly inflation rate or month-on-month inflation (INFM). The sample period is 24 months (12 months before CBDC issuance and 12 months after CBDC issuance).

4.2.1 Comparison of mean. Table 10 reports the pre-CBDC and CBDC means. It shows that the average INFH for the CBDC period was higher than the average INFH in the pre-CBDC period. Similarly, the average INFF, core inflation rate and monthly inflation rate for the CBDC period are all higher than their pre-CBDC values. This indicates that inflation was much higher in the months after CBDC issuance. The inflation rates were also higher in November and December 2021 as well as in January of 2022 prior to the Russia–Ukraine war. The implication is that inflation did not decrease after the CBDC was issued in Nigeria.

4.2.2 Correlation analysis. The Pearson correlation analysis is reported in Table 11. The correlation of interest in the analysis is the correlation of the CBDC2 variable and the four inflation variables. The result shows that the CBDC2 variable is positive and highly correlated with the INFC variable at 0.705. This indicates that the CBDC period is associated with much higher core inflation in Nigeria. The CBDC2 variable is also positively correlated with the INFH and INFM variables. This indicates that the CBDC period is correlated with

Table 9.
Pairwise granger causality tests

Period: October 2020 to September 2022		
Lags: 2		
Observation: 7		
Null hypothesis	F-statistic	p-value
d(GDPR) does not granger cause d(CBDC1)	37.94**	0.026
d(CBDC1) does not granger cause d(GDPR)	0.376	0.727

Note(s): *** represents statistical significance at the 1% level
Source(s): Author computation

Table 10.
Comparing means of the pre-CBDC and CBDC period

	Mean (Pre-CBDC period) October 2020 to September 2021	Mean (CBDC period) October 2021 to September 2022
Headline inflation rate (%)	16.81	17.36
Food inflation rate (%)	20.69	19.27
Core inflation (%)	12.53	14.89
Monthly inflation (%)	1.29	1.59

Source(s): Author computation

Table 11.
Pearson correlation of CBDC period and inflation variables

Variables	INFH	INFF	INFC	INFM	CBDC2
INFH	1.000				
INFF	0.859	1.000			
INFC	0.752	0.322	1.000		
INFM	0.046	-0.195	0.245	1.000	
CBDC2	0.167	-0.331	0.705	0.468	1.000

Source(s): Author computation

higher headline inflation and higher monthly inflation but to a lesser degree. In contrast, the CBDC2 variable is negative and correlated with the INFF variable at -0.331 . This suggests that the CBDC period is associated with reduced food inflation in Nigeria. The p -value of all correlation coefficients is insignificant; therefore, we did not report the p -value of the correlation coefficients.

4.2.3 Effect of CBDC period on inflation: 2SLS regression analysis. We also analyze the effect of the CBDC period on the four types of inflation: headline inflation (INFH), food inflation (INFF), core inflation (INFC) and monthly inflation (INFM). The two-stage least squares regression estimation is reported in Table 12. The INFH, INFC, INFF and INFM coefficients are positive and significant at the 1% level. This indicates that the CBDC period has a significant positive effect on the four types of inflation and suggests that the four types of inflation increased after CBDC was issued. The significant positive effect implies that the CBDC period did not reduce inflation during the period examined. A possible explanation for this result could be that, despite issuing the eNaira CBDC, the CBDC was not designed to control inflation; rather, the CBDC was designed to achieve other objectives such as to achieve payment efficiency and financial inclusion objectives.

4.2.4 Granger causality test. We also perform granger causality tests. An augmented Dickey-Fuller test was first conducted to determine whether each of the time series data has a unit root process. The result in Table 13 shows that the CBDC2, INFH, INFC and INFM time series data have a unit root and is therefore non-stationary. Only the INFF time series data are stationary. As a result, the CBDC2, INFH, INFC and INFM time series data are first-differenced before performing the granger causality test. The granger causality test result is reported in Table 14. The result shows that there is one-way granger causality running from $d(\text{CBDC2})$ to $d(\text{INFM})$ as the p -value is 0.004 which is less than 0.05. This indicates that there is uni-directional granger causality between the CBDC period and monthly inflation (INFM).

Independent variable	INFH Coefficient (t -statistic)	INFC Coefficient (t -statistic)	INFF Coefficient (t -statistic)	INFM Coefficient (t -statistic)
CBDC2	17.955*** (4.91)	14.887*** (5.65)	19.276*** (4.43)	1.586*** (5.64)
J-statistic	22.58	22.59	22.57	21.03
P(J-statistic)	0.00	0.00	0.02	0.00

Note(s): ***, ** denote statistical significance at the 1 and 5% levels
Source(s): Author computation

Table 12.
Effect of CBDC period on the four inflation components: two-stage least square 2SLS regression

Symbol	T -statistic	p -value	Remark
INFH	-2.511	0.127	Has a unit root. INFH is non-stationary. Should be first-differenced i.e. $d(\text{INFH})$
INFF	-4.277***	0.004	Does not have unit root. INFF is stationary
INFC	0.332	0.974	Has a unit root. INFC is non-stationary. Should be first-differenced i.e. $d(\text{INFC})$
INFM	-1.852	0.348	Has a unit root. INFM is non-stationary. Should be first-differenced i.e. $d(\text{INFM})$
CBDC2	-0.956	0.751	Has a unit root. CBDC2 is non-stationary. Should be first-differenced i.e. $d(\text{CBDC2})$

Note(s): *** represents significance at the 1% level
Source(s): Author computation

Table 13.
Augmented Dickey-Fuller test result for the CBDC period and inflation variables

This suggests that the CBDC period causes a significant change in monthly inflation. On the other hand, there is no granger causality running from $d(\text{CBDC}2)$ to $d(\text{INFH})$, $d(\text{INFF})$ and $d(\text{INFC})$ variables.

4.3 Further analysis: cross country analysis

In this section, we compare Nigeria's economic benefit from CBDC with the economic performance of similar countries that have not yet issued a CBDC particularly Malaysia, Brazil and Argentina.

4.3.1 Comparison of means. In this section, we compare the mean of real GDP growth of Nigeria with the mean of real GDP growth of Malaysia, Argentina and Brazil. As shown in [Table 15](#), the mean real GDP growth is lowest in Nigeria compared to Malaysia, Argentina, and Brazil. This suggests that the gains of CBDC for economic growth in one country may not be comparable to the economic growth of other countries. We also compare the mean of the annual inflation rate of Nigeria with the mean of annual inflation rate of Malaysia, Argentina and Brazil. As shown in [Table 15](#), the mean inflation rate remains high in Nigeria and is similar to the inflation rate in Brazil.

4.3.2 Correlation analysis. [Table 16](#) presents the correlation of Nigeria's economic growth with the economic growth data of three countries with similar economic characteristics, namely Malaysia, Brazil and Argentina. The correlation shows that Nigeria's GDP growth in the CBDC period is highly correlated with the GDP growth of Brazil and Argentina which have not adopted a CBDC. The result suggests that some countries that did not issue a CBDC (e.g Malaysia, Argentina and Brazil) also witness positive economic growth similar to the positive economic growth witnessed in Nigeria after CBDC issuance.

Meanwhile, in [Table 17](#), the correlation shows that Nigeria's annual inflation rate in the CBDC period is highly correlated with the inflation rate of Malaysia and Argentina which

Monthly period: October 2020 to September 2022

Lags: 2

Observation: 21

Null hypothesis	F-statistic	p-value
$d(\text{INFH})$ does not granger cause $d(\text{CBDC}2)$	1.104	0.356
$d(\text{CBDC}2)$ does not granger cause $d(\text{INFH})$	2.186	0.145
$d(\text{INFC})$ does not granger cause $d(\text{CBDC}2)$	1.950	0.175
$d(\text{CBDC}2)$ does not granger cause $d(\text{INFC})$	0.491	0.619
INFF does not granger cause $d(\text{CBDC}2)$	0.970	0.400
$d(\text{CBDC}2)$ does not granger cause INFF	1.895	0.183
$d(\text{INFM})$ does not granger cause $d(\text{CBDC}2)$	0.191	0.828
$d(\text{CBDC}2)$ does not granger cause $d(\text{INFM})$	8.023***	0.004

Note(s): *** represents statistical significance at the 1% level

Source(s): Author computation

Table 14.
Pairwise granger
causality tests

Table 15.
Comparing the means
of Nigeria's real GDP
growth and inflation
rate with similar
countries that have not
adopted CBDC

	Nigeria	Malaysia	Brazil	Argentina
Average real GDP growth (%) (from 2021-Q1 to 2022-Q2)	3.36	4.73	4.45	9.17
Annual inflation rate (%) from November 2020 to September 2022	17.48	3.21	61.4	10.31

Source(s): Author computation

have not adopted a CBDC. An inverse correlation is observed between Brazil's inflation rate and Nigeria's inflation rate after CBDC adoption. The result suggests that some countries that did not issue a CBDC (e.g Malaysia and Argentina) also witness high inflation similar to the high inflation witnessed in Nigeria after CBDC issuance and vice versa.

4.3.3 Further regression results. In this section, we estimate the effect of CBDC issuance on economic growth using panel sample data which consists of Nigeria, Malaysia, Argentina and Brazil over the 2021-Q4 to 2022-Q2 period. In the first instance, we pool the four countries together and use a binary variable to separate Nigeria's GDP growth from the GDP growth of the remaining three countries. We then introduce the CBDC3 binary variable that equals one for Nigeria's GDP growth from 2021-Q4 to 2022-Q2 and equal zero for Malaysia, Brazil and Argentina's GDP growth rate during the same period. We then estimate the effect of CBDC3 on the GDP growth rate and the result is reported in column 1 of [Table 18](#). We undertake another subsample analysis in which we pool only Nigeria and Malaysia together. We then introduce the CBDC4 binary variable that equals one for Nigeria's GDP growth from 2021-Q4 to 2022-Q2 and equal zero for Malaysia's GDP growth rate during the same period. We then

Countries	Nigeria	Malaysia	Brazil	Argentina
Nigeria	1.000			
Malaysia	0.492	1.000		
Brazil	0.641	0.712	1.000	
Argentina	0.844	0.522	0.910	1.000

Source(s): Author computation

Table 16.
Pearson correlation of
GDP growth of Nigeria,
Malaysia, Brazil and
Argentina

Countries	Nigeria	Malaysia	Argentina	Brazil
Nigeria	1.000			
Malaysia	0.849	1.000		
Argentina	0.984	0.844	1.000	
Brazil	-0.567	-0.704	-0.661	1.000

Source(s): Author computation

Table 17.
Pearson correlation of
inflation rate in
Nigeria, Malaysia,
Brazil and Argentina

	Full sample (1)	Malaysia (2)	Brazil (3)	Argentina (4)
Independent variable	Coefficient (<i>t</i> -statistic)	Coefficient (<i>t</i> -statistic)	Coefficient (<i>t</i> -statistic)	Coefficient (<i>t</i> -statistic)
CBDC3	21.712** (2.23)			
CBDC4		8.095* (2.01)		
CBDC5			7.812** (2.47)	
CBDC6				12.528* (2.12)
J-statistic	7.69	5.87	8.67	9.67
P(J-statistic)	0.13	0.21	0.19	0.23

Note(s): **, * denote statistical significance at the 5 and 10% levels. CBDC3 = binary variable equals one for Nigeria's GDP growth rate from 2021-Q4 to 2022-Q2 and equal zero for Malaysia, Brazil and Argentina's GDP growth rate during the same period. CBDC4 = binary variable equals one for Nigeria's GDP growth rate from 2021-Q4 to 2022-Q2 and equal zero for Malaysia's GDP growth rate during the same period. CBDC5 = binary variable equals one for Nigeria's GDP growth rate from 2021-Q4 to 2022-Q2 and equal zero for Brazil's GDP growth rate during the same period. CBDC6 = binary variable equals one for Nigeria's GDP growth rate from 2021-Q4 to 2022-Q2 and equal zero for Argentina's GDP growth rate during the same period

Source(s): Author computation

Table 18.
Panel 2SLS regression
estimation: the effect of
CBDC period on
economic growth

estimate the effect of CBDC4 on the GDP variable and the result is reported in column 2 of Table 18. We undertake a further analysis in which we pool only Nigeria and Brazil together. We then introduce the CBDC5 binary variable that equals one for Nigeria's GDP growth from 2021-Q4 to 2022-Q2 and equal zero for Brazil's GDP growth rate during the same period. We then estimate the effect of CBDC5 on the GDP variable and the result is reported in column 3 of Table 18. Finally, we undertake another sub-sample analysis in which we pool only Nigeria and Argentina together. We then introduce the CBDC6 binary variable that equals one for Nigeria's GDP growth from 2021-Q4 to 2022-Q2 and equal zero for Argentina's GDP growth rate during the same period. We then estimate the effect of CBDC6 on the GDP variable and the result is reported in column 4 of Table 18.

The 2SLS estimation results for the full sample in column 1 of Table 18 show that the CBDC period has a significant positive effect on GDP growth in Nigeria relative to other countries. Also, the result in column 2 shows that the CBDC period has a significant positive effect on GDP growth in Nigeria relative to Malaysia. The result in column 3 shows that the CBDC period has a significant positive effect on GDP growth in Nigeria relative to Brazil. The result in column 4 shows that the CBDC period has a significant positive effect on GDP growth in Nigeria relative to Argentina.

Regarding the inflation rate aspect, we estimate the effect of CBDC issuance on inflation using panel sample data which consists of Nigeria, Malaysia, Argentina and Brazil over the November 2021 to September 2022 period. In the first instance, we pool the four countries together and use a binary variable to separate Nigeria's inflation rate from the inflation rate of the remaining three countries. We then introduce the CBDC7 binary variable that equals one for Nigeria's inflation rate from November 2021 to September 2022 and equal zero for Malaysia, Brazil and Argentina's inflation rate during the same period. We then estimate the effect of CBDC7 on the inflation rate (INF) variable and the result is reported in column 1 of Table 19. We undertake another sub-sample analysis in which we pool only Nigeria and Malaysia together. We then introduce the CBDC8 binary variable that equals one for Nigeria's inflation rate from November 2021 to September 2022 and equal zero for Malaysia's inflation rate during the same period. We then estimate the effect of CBDC8 on the INF variable and the result is reported in column 2 of Table 19. We undertake a further analysis in which we pool only Nigeria and Brazil together. We then introduce the CBDC9 binary variable that equals one for Nigeria's inflation rate from November 2021 to September 2022

	Full sample (1)	Malaysia (2)	Brazil (3)	Argentina (4)
Independent variable	Coefficient (<i>t</i> -statistic)	Coefficient (<i>t</i> -statistic)	Coefficient (<i>t</i> -statistic)	Coefficient (<i>t</i> -statistic)
CBDC7	92.523*** (3.09)			
CBDC8		20.692* (13.31)		
CBDC9			27.914** (6.05)	
CBDC10				78.883* (2.92)
J-statistic	6.16	7.02	4.33	2.35
P(J-statistic)	0.25	0.87	0.34	0.01

Note(s): **, * denote statistical significance at the 5 and 10% levels. CBDC7 = binary variable equals one for Nigeria's GDP growth rate from 2021-Q4 to 2022-Q2 and equal zero for Malaysia, Brazil and Argentina's GDP growth rate during the same period. CBDC8 = binary variable equals one for Nigeria's GDP growth rate from 2021-Q4 to 2022-Q2 and equal zero for Malaysia's GDP growth rate during the same period. CBDC9 = binary variable equals one for Nigeria's GDP growth rate from 2021-Q4 to 2022-Q2 and equal zero for Brazil's GDP growth rate during the same period. CBDC10 = binary variable equals one for Nigeria's GDP growth rate from 2021-Q4 to 2022-Q2 and equal zero for Argentina's GDP growth rate during the same period

Source(s): Author computation

Table 19.
Panel 2SLS regression estimation: the effect of CBDC period on the inflation rate

and equal zero for Brazil's inflation rate during the same period. We then estimate the effect of CBDC9 on the INF variable and the result is reported in column 3 of [Table 19](#). Finally, we undertake another subsample analysis in which we pool only Nigeria and Argentina together. We then introduce the CBDC10 binary variable that equals one for Nigeria's inflation rate from November 2021 to September 2022 and equal zero for Argentina's inflation rate during the same period. We then estimate the effect of CBDC10 on the INF variable and the result is reported in column 4 of [Table 19](#). The 2SLS estimation result for the full sample in column 1 of [Table 19](#) show that CBDC issuance has a significant positive effect on the inflation rate in Nigeria relative to other countries. Also, the result in column 2 shows that CBDC issuance has a significant positive effect on the inflation rate in Nigeria relative to Malaysia. The result in column 3 shows that CBDC issuance has a significant positive effect on inflation rate in Nigeria relative to Brazil. The result in column 4 shows that CBDC issuance has a significant positive effect on inflation rate in Nigeria relative to Argentina.

5. Conclusion

This article examined the effect of CBDC issuance on economic growth and inflation in Nigeria using quarterly data from 2019 to 2022 and after isolating the 2020 period. The data were analyzed using descriptive statistics, correlation analysis, two-stage least squares regression and granger causality test methods.

The results revealed that inflation significantly increased in the CBDC period, implying that CBDC issuance did not decrease the rate of inflation in Nigeria. Also, GDP growth rate significantly increased in the CBDC period, implying that CBDC issuance improved economic growth in Nigeria. The financial sector, the agricultural sector and the manufacturing sectors witnessed much stronger contribution to GDP after CBDC issuance. There is one-way granger causality between the CBDC period and monthly inflation, implying that the CBDC period caused a significant change in monthly inflation in Nigeria.

The policy implication of the findings is that issuing a non-interest-bearing CBDC presents a significant tradeoff for the central bank of Nigeria. This means that the CBDC may have been designed to have features that support economic growth, but such features are ineffective in reducing inflation. This suggests that a growth-enhancing non-interest bearing CBDC can lead to higher inflation. Conversely, a CBDC that is designed to have features to control inflation may not be able to spur growth in the economy.

Given this tradeoff, policymakers in Nigeria must decide on which economic objective is paramount at a given period and the CBDC should be designed to have features that help to achieve that objective. Once the objective has been achieved, the CBDC can be redesigned with the features that are needed to achieve the next important objective.

The findings that a non-interest-bearing CBDC improves economic growth but increases inflation in Nigeria suggests that CBDC innovation may not be able to solve the twin economic problem of "controlling inflation which stifles economic growth" and "stimulating economic growth which leads to rising inflation". Therefore, the central bank should use CBDC alongside other monetary policy tools at their disposal to control inflation while stimulating growth in the economy.

The study has one limitation. The study covers only a short period of time because CBDC is a recent innovation and there is not much empirical data available about CBDC.

Future studies can extend the analysis in the study by exploring the relationship between economic growth and inflation in a CBDC context and using a longer time period when more data becomes available. Future studies can also investigate how CBDC issuance and adoption may affect the rate of unemployment. Future studies can assess how widespread adoption of CBDC would affect bank stability especially when widespread CBDC usage leads to bank disintermediation which also affects bank liquidity. Furthermore, [Barrdear](#)

and Kumhof (2016) show how introducing a CBDC will have an impact on real yields and affect growth and inflation through the usual monetary policy channel if it increases the size of money in circulation. Future studies can investigate how the issuance of the eNaira could affect real yields and affect growth and inflation through the usual monetary policy channel.

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