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The Impact of Population Growth on Economic Development: An ARDL Model Analysis Applied on Japan and Ethiopia.

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Abstract

The relationship between population growth and economic development is controversial. The purpose of this paper is to test the link between population growth measured by the fertility rate and the economic development measured by the GDP per capita in Japan as a developed country and in Ethiopia as a non-developed one. The autoregressive distributed lags model ARDL is applied on Ethiopia and Japan for the period 1991-2022. Causality between variables is tested using granger causality test and the coefficient of correlation is calculated. The findings are the existence of a significant inverse causal relation between the population growth and the economic development in Ethiopia in the short run and the long run. However, there is no significant causal relation in Japan. The study conducted tests to assess the reliability of the model such as serial correlation, heteroskedasticity, normality, and stability tests. The results indicated that the model was stable. Furthermore, there were no indications of serial correlation or heteroskedasticity

Keywords: Fertility rate, economic development, population growth, ARDL, Ethiopia, Japan.

1. Introduction

The relationship between population growth and economic development has been a subject of extensive research and debate among economists, demographers, and policymakers. It has been a contentious issue since the days of Malthus. He suggested that population growth tends to surpass food production, leading to constraints manifested in various ways such as famine, disease, and conflict. Many people believe that a growing population hampers economic progress and contributes to increasing poverty levels. Scholars have varying opinions on this matter. Some argue that population growth adversely affects economic development, both in terms of total and per capita income. On the other hand, some suggest that population growth can spur economic growth. Meanwhile, there are those who believe that population growth has minimal impact on economic development. Each perspective is supported by strong theoretical reasoning and statistical evidence.

The aim of this article is to examine the effect of population growth on economic development and to look at the empirical findings of the econometric model applied on the data of Japan as a developed country and on the data of Ethiopia as a developing one. The article also discusses the implications of these findings for population policy.

The article is structured into five sections, beginning with an introduction. The second section explores theoretical perspectives on how population growth influences economic development. The third section presents the methodology used in studying the relation. The fourth section deals with the empirical evidence regarding the relationship between population growth and economic development in Japan. The fifth section deals with the empirical evidence regarding the relationship between population growth and economic development in Ethiopia. Lastly, the concluding section provides a summary of the key findings.

2. Literature review

Population growth can be viewed as an essential input in economic development. A larger population can provide a larger labor force, which may enhance productivity and stimulate economic activities. For instance, Bloom et al. (2001) argue that population growth can lead to a "demographic dividend," where the proportion of the working-age population increases relative to dependents, fostering savings and investment. (Bloom et al. 2001)

However, the relationship is not uniformly positive. High population growth can strain resources, infrastructure, and public services, leading to diminishing returns. For example, a study by Lee and Mason (2011) emphasizes the need for appropriate policies to manage resources effectively in the face of growing populations. (Lee and Mason, 2011)

The debate over whether population growth positively or negatively affects economic development has been a subject of heated discussion for a significant duration. Historically, spanning from the 19th century to the early 20th century, widespread belief was influenced by Malthusian concerns regarding the consequences of population growth on the economic welfare of societies. However, post-World War II, there has been a noticeable shift in scholarly opinions, with varying viewpoints gaining prominence over time. (Ajit Kumar Singh,2021)

Empirical studies provide mixed evidence regarding the impact of population growth on economic development. Some research indicates that moderate population growth can enhance economic performance. For instance, a study by Barro (1991) found that countries with higher population growth rates experienced faster economic growth, attributed to the increased supply of labor and enhanced market size. (Barro , 1991)

Other researchers agree that the connection between population growth and income growth undergoes a transformation as economies progress. Initially, economies operate within a Malthusian framework characterized by limited technological advancement and population growth constraining long-term increases in per capita income. As economies advance, they transition into a Post-Malthusian phase where technological innovations increase and population growth no longer completely hinders overall output growth. Eventually, economies reach a Modern Growth stage marked by decreased population growth rates and consistent income growth over time. (Galor & Weil, 2000, p. 806)

Population growth can be a potential catalyst for economic development. Overall, it is important to recognize that population growth can have different outcomes on economic development depending on the current state of the country. (Furuoka Fumitaka, 2009)

Conversely, other studies highlight the negative implications of rapid population growth, particularly in developing countries. Hjie (2000) identifies that countries with high fertility rates often struggle to achieve sustainable economic growth due to inadequate healthcare, education, and employment opportunities. Similarly, a comprehensive analysis by Bloom et al. (2004) illustrates how excessive population growth can hinder economic progress by overwhelming resources and leading to higher poverty rates. (Hjie , 2000) ; (Bloom et al. , 2004)

Many researchers believe that decreasing fertility rates and a lower ratio of dependents to working-age individuals present an opportunity for economic development and poverty alleviation. Integrating population policies and family planning initiatives into their broader economic development strategies tend to experience sustained economic growth and notable reductions in poverty levels (Leontief Wassily, 2019)

In addition to growth, the demographic structure plays a critical role in economic development. As many countries experience declining fertility rates and aging populations, the challenges shift. The World Bank (2016) reports that aging populations can lead to labor shortages and increased pressure on pension systems, potentially stunting economic growth if not adequately addressed. (The World Bank , 2016)

While reducing fertility rates alone is not a universal solution for economic growth and is not adequate on its own, it may be a prerequisite for creating an environment where governments can allocate more resources per person to education and healthcare, fostering the development of human capital essential for long-term economic progress. (Steven W Sinding, 2009)

In recent years, a significant body of literature has delved into the empirical analysis of how population growth influences economic growth. While a portion of these studies suggests a detrimental effect of population growth, the majority align with the perspective that population growth has a beneficial impact on economic growth. This ongoing debate is tested in the next sections by applying quantitative analysis using empirical data in 2 different countries.

3. The Empirical Study:Methodology and Data Resources

3.1 Econometric Methodology

In the study analyzing the relationship between population growth, and economic development, the approach of Pesaran et al. (2001) is employed. The benchmark regression model is constructed based on the GDP per capita, PPP (constant 2011 international dollars), serving as an indicator of economic development (y_t) and Fertility rate, total (births per woman) serving as indicator of population growth ($x1_t$) . the study uses two control variables: the inflation rate using the consumer prices (annual %) as x2 and the unemployment rate using the unemployment, youth total (% of total labor force ages 15-24) as x3.

$y_t = f(x1_t, x2_t, x3_t)$

the model is applied once on Japan and once on Ethiopia.

In this model, the factors that help explain the relationship are Fertility rate, total (births per woman) serving as indicator of population growth ($x1_t$), and its previous values represented by ($x1_{t-i}$), the inflation rate using the consumer prices (annual %) as x2 and its previous values represented by ($x2_{t-i}$), and the unemployment rate using the unemployment, youth total (% of total labor force ages 15-24) as x3 and its previous values represented by ($x3_{t-i}$), The endogenous variable is economic development (y_t), and its previous value is denoted as y_t-i.

The ARDL model was calculated by two steps:

Step 1: An ARDL model was utilized to conduct a co-integration test, aimed at determining the presence of a long-term causal relationship between the variables. The specific model that was established is as follows:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta G y_{t-i} + \sum_{i=1}^{q1} \alpha_{2i} \Delta x1_{t-i} + \sum_{i=1}^{q2} \alpha_{3i} \Delta x2_{t-i} + + \sum_{i=1}^{q3} \alpha_{4i} \Delta x3_{t-i} \quad \beta_1 y_{t-1} + \beta_2 x1_{t-1} + \beta_3 x2_{t-1} + \beta_4 x3_{t-1} + \varepsilon_t$$

Where Δ was the first-order differential operator, ε_t was the white noise,

$p,q1,q2,q3$ were the maximum lag orders, determined by AIC. The presence of a long-term equilibrium relationship between the horizontal variables was investigated using the F-statistic. The null hypothesis stated that there was no such relationship. The null hypothesis can be rejected if the value of the F-statistic exceeds the upper bound critical value. If co-integration is found, the analysis will proceed with the conditional autoregressive distributed lag model.

Step 2: The ARDL model was employed to examine both the long-term and short-term relationships among the variables. Specifically, the ARDL model was utilized to estimate the long-term relationship:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + \sum_{i=1}^{q1} \beta_i \, x1_{t-i} + \sum_{i=1}^{q2} \theta_i x2_{t-i} + \sum_{i=1}^{q2} \eta_i x2_{t-i} + u_t$$

While the short-term relationship can be estimated using the ARDL-ECM model:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta y_{t-i} + \sum_{i=1}^{q1} \alpha_{2i} \Delta x1_{t-i} + \sum_{i=1}^{q2} \alpha_{3i} \Delta x2_{t-i} + \sum_{i=1}^{q3} \alpha_{4i} \Delta x3_{t-i} + \upsilon ECT + \varepsilon_t,$$

3.2 Variable description and Data Sources

The study utilized time series data from 1991 to 2022 in Ethiopia and Japan as the research sample. The data for the variables were obtained from the official database of the World Bank. The relevant variables were defined as follows:

1. GDP per capita (y)

the GDP per capita, PPP (constant 2011 international dollars), serving as an indicator of economic development

2. Fertility rate *(x1)*

Fertility rate, total (births per woman) serving as indicator of population growth*)*.

3. Inflation rate (x2)

Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly.

4. Unemployment rate (x3)

Youth unemployment refers to the share of the labor force ages 15-24 without work but available for and seeking employment.

4. The long-term and Short-term Equilibrium Between the population growth and the economic development in Japan

4.1 Results of unit root test and co-integration test

Initially, a unit root test was conducted to determine the stationarity of the different variable time series. The results indicated that the three variables (Y, X1 and X3) were initially non-stationary series but became stationary after being differenced at the first order. This indicated that these variables had an integration order of 1 [I(1)], as their p-values were less than 5% after taking the first difference. The results indicated as well that X2 is stationary at level.

In addition, this study conducted a co-integration test, specifically the Bound test, to examine the relationship between four variables: Yt, X1t, X2t and X3t. The results of the test, as presented in Table 3, revealed that at various significant levels (10%, 5%, 2.5%, and 1%), there was evidence of a co-integration relationship among Yt, X1t, X2t and X3t.

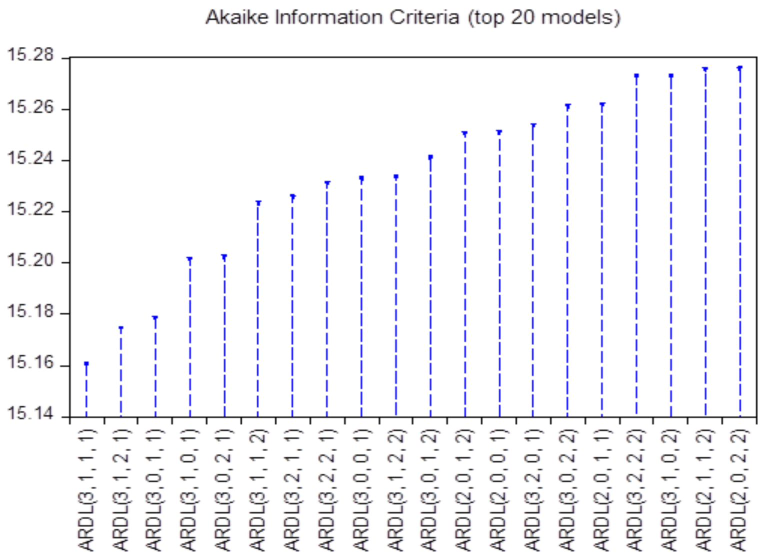
Table (1): Bound test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	10.30239	10%	2.37	3.2
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66
			Finite Sample: n=35	
Actual Sample Size	28			
		10%	2.618	3.532
		5%	3.164	4.194
		1%	4.428	5.816

Source: done by researchers using e-views 10.

4.2 Estimation Results of Short-term and Long-term ARDL Model

To estimate the long-term coefficient, it was crucial to establish the lag order of the model first. The lag order of each variable in the model was determined based on the Akaike Criterion (AIC) using the actual statistics of the sample data as shown in figure 1. The model with an ARDL (3,1,1,1) lag order was identified as the most suitable, as it had the smallest value. The estimation results are provided in Table 2 below.



Source: By researchers using e-views

Figure (1): the lag selection of the model

Table (2): The estimation results of the short term and long term of the model

Selected Model: ARDL(3, 1, 4)					
	Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Short run model	Y(-1)	0.273211	0.139593	1.957196	0.0660
	Y(-2)	0.765489	0.200016	3.827131	0.0012
	Y(-3)	-0.307377	0.148150	-2.074766	0.0526
	X1	-3189.733	3016.221	-1.057526	0.3043
	X1(-1)	4533.915	3493.360	1.297867	0.2107
	X2	-179.3750	135.7553	-1.321312	0.2029

	X2(-1)	-183.7780	125.5257	-1.464067	0.1604
	X3	-1213.653	172.9103	-7.018971	0.0000
	X3(-1)	1087.325	168.8494	6.439616	0.0000
	C	9546.424	4716.198	2.024178	0.0581
Long run model	**Variable**	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
	X1	5002.990	8614.039	0.580795	0.5686
	X2	-1351.640	704.2097	-1.919371	0.0709
	X3	-470.1847	255.2042	-1.842386	0.0820
	C	35531.38	12855.72	2.763857	0.0128
Error correction term	CointEq(-1)*	-0.268676	0.033861	-7.934675	0.000 0

Source: done by researchers using e-views 10

According to the findings in Table 2, the analysis reveals that fertility rate and inflation rate do not have a significant effect on GDP per capita in the short term. However, there is a significant relationship between the lag of unemployment rate and GDP per capita in Japan. The first lag of unemployment shows a significant effect at a 99% confidence level. The relationship between unemployment rate from the previous year and the current year's GDP per capita is positive. This means that a decrease in unemployment rate by one unit leads to a decrease in GDP per capita by 1087.325units. The unemployment of the current year shows a significant effect at a 99% confidence level. The relationship between the current unemployment rate and the current year's GDP per capita is negative. This means that a decrease in unemployment rate by one unit leads to an increase in GDP per capita by 1213.653 units.

On the other hand, in the long run, there is no significant relationships. Additionally, the adjustment coefficient of the error correction terms is -0.268676. This suggests that when short-term fluctuations deviate from the long-term equilibrium, the system tends to return to equilibrium with an adjustment intensity of 0.268676. This indicates that economic development tends to self-stabilize in the long run. Causality is checked using Granger causality test as shown in the following table and the result is the absence of causal relation between the fertility rate and the GDP per capita in Japan as the probability value is more than 5% so the null hypothesis is accepted.

The coefficient of correlation between y and x1 is -0.27[1] indicating very week negative association between the two variables.

Table (3): granger causality

Pairwise Granger Causality Tests
Date: 03/04/24 Time: 15:55
Sample: 1991 2022
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
X1 does not Granger Cause Y	29	0.03888	0.9619
Y does not Granger Cause X1		0.02665	0.9737

Source: done by researchers using e-views 10

4.3 Checking the Model

To assess the reliability of the model, the study conducted tests to evaluate serial correlation, heteroskedasticity, normality, and stability. The results indicated that the model was stable, as confirmed by the CUSUM test displayed in figure 2. Additionally, the residuals exhibited a normal distribution, with the Jarque-Bera probability exceeding 5% (as shown in figure 3).

Furthermore, there were no indications of serial correlation or heteroskedasticity, as evidenced by the Chi-squared probability exceeding 5% according to the findings presented in table 4. This suggests that the residuals were not correlated and maintained a constant variance.

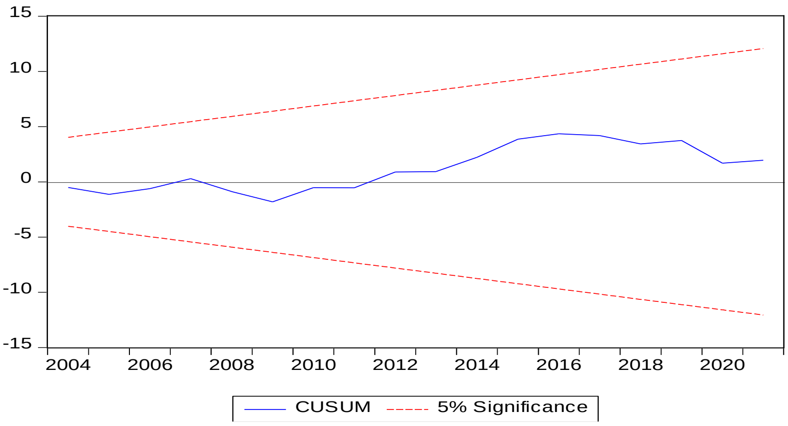


Figure (2): The Cumulative Sum of Recursive Residual (CUSUM) test.

[1] calculated using the software Eviews-10

Source: By researchers using e-views

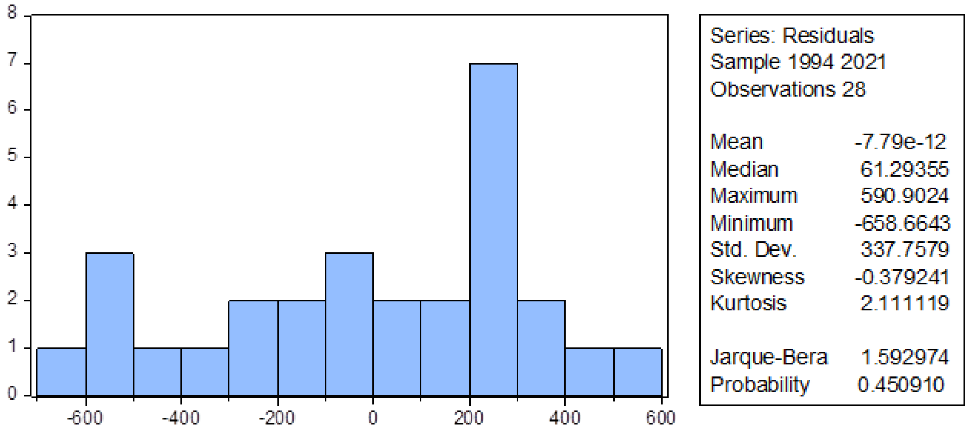


Figure (3): Jarque-Bera normality test

Source: By researchers using e-views 10

Table (4): Tests for serial correlation and Heteroskedasticity

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.357285	Prob. F(2,16)	0.2854
Obs*R-squared	4.061432	Prob. Chi-Square(2)	0.1312

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.024267	Prob. F(9,18)	0.4579
Obs*R-squared	9.483116	Prob. Chi-Square(9)	0.3939
Scaled explained SS	2.177261	Prob. Chi-Square(9)	0.9883

Source: By researchers using e-views 10.

5. The long-term and Short-term Equilibrium Between the population growth and the economic development in Ethiopia

5.1 Results of unit root test and co-integration test

Initially, a unit root test was conducted to determine the stationarity of the different variable time series. The results indicated that the three variables (Y, X2 and X3) were initially non-stationary series but became stationary after being differenced at the first order. This indicated that these variables had an integration order of 1 [I(1)], as their p-values were less than 5% after taking the first difference. The results indicated as well that X1 is stationary at level.

In addition, this study conducted a co-integration test, specifically the Bound test, to examine the relationship between four variables: Yt, X1t, X2t and X3t. The results of the test, as presented in Table 5, revealed that at various significant levels (10%, 5%, 2.5%, and 1%), there was evidence of a co-integration relationship among Yt, X1t, X2t and X3t.

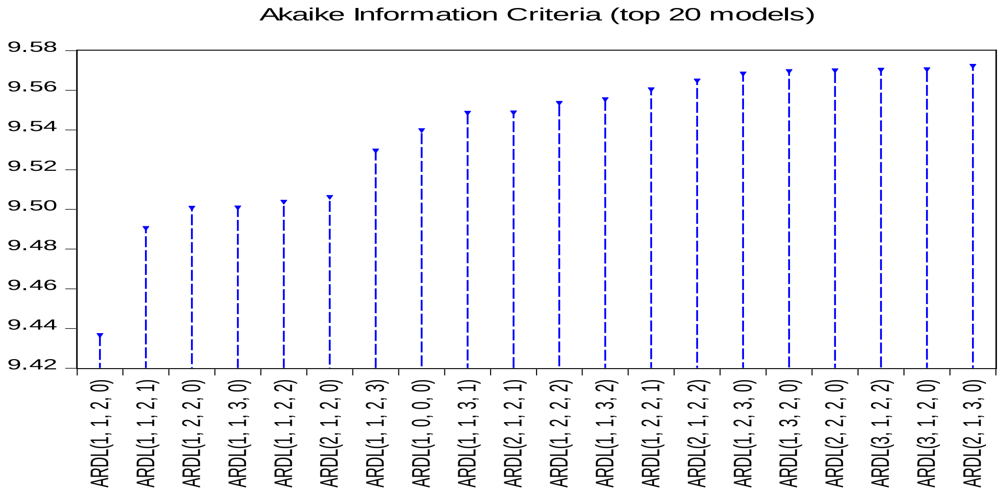
Table (5): Bound test case of Ethiopia

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	19.70039	10%	2.37	3.2
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66
Actual Sample Size	29		Finite Sample: n=35	
		10%	2.618	3.532
		5%	3.164	4.194
		1%	4.428	5.816

Source: done by researchers using e-views 10.

5.2 Estimation Results of Short-term and Long-term ARDL Model in ethiopia

To estimate the long-term coefficient, it was crucial to establish the lag order of the model first. The lag order of each variable in the model was determined based on the Akaike Criterion (AIC) using the actual statistics of the sample data as shown in figure (4). The model with an ARDL (1,1,2,0) lag order was identified as the most suitable, as it had the smallest value. The estimation results are provided in Table (6) below.



Source: By researchers using e-views

Figure (4): the lag selection of the model

Table (6): The estimation results of the short term and long term of the model

Selected Model: ARDL(3, 1, 4)					
	Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Short run model	Y(-1)	0.880829	0.099480	8.854319	0.0000
	X1	484.3092	225.9063	2.143850	0.0439
	X1(-1)	-572.9761	262.7302	-2.180853	0.0407
	X2	0.127860	0.553103	0.231169	0.8194
	X2(-1)	0.559152	0.570886	0.979445	0.3385
	X2(-2)	1.338388	0.467486	2.862950	0.0093
	X3	-6.573944	15.88832	-0.413760	0.6832
	C	763.5320	338.2799	2.257101	0.0348
Long run model	**Variable**	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
	X1	-744.0283	228.9013	-3.250432	0.0038

	X2	16.99570	10.82208	1.570465	0.1313
	X3	-55.16382	175.7228	-0.313925	0.7567
	C	6407.013	2589.842	2.473901	0.0220
Error correction term	CointEq(-1)*	-0.119171	0.011005	-10.82886	0.0000

Source: done by researchers using e-views 10

According to the findings in Table 6, the analysis reveals that fertility rate and GDP per capita have a significant relation in the short term. There is a significant relationship indeed between the lag of inflation rate and GDP per capita in Ethiopia. The first lag of fertility rate shows a significant effect at a 5% confidence level. The relationship between fertility rate from the previous year and the current year's GDP per capita is negative. This means that an increase in fertility rate by one unit leads to a decrease in GDP per capita by 572.9761 units.

On the other hand, in the long run, there is a significant relationship. The relationship between fertility rate and GDP per capita is negative. This means that an increase in fertility rate by one unit leads to a decrease in GDP per capita by 744.0283 units in the long term. Additionally, the adjustment coefficient of the error correction terms is -0.119171. This suggests that when short-term fluctuations deviate from the long-term equilibrium, the system tends to return to equilibrium with an adjustment intensity of 0.119171. This indicates that economic development tends to self-stabilize in the long run. Causality is checked using Granger causality test as shown in table (7) and the result is the existence of causal relation between the fertility rate and the GDP per capita in Ethiopia as the probability value is less than 5% so the null hypothesis is rejected. The coefficient of correlation between y and x1 is -0.94[2] indicating the existence of a high negative association between the two variables.

Table (7): granger causality

Pairwise Granger Causality Tests
Date: 04/21/24 Time: 15:06
Sample: 1991 2022
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
X1 does not Granger Cause Y	29	6.23055	0.0066
Y does not Granger Cause X1		0.28674	0.7532

Source: done by researchers using e-views 10

[2] Calculated using the software EViews-10

5.3 Checking the Model

To assess the reliability of the model, the study conducted tests to evaluate serial correlation, heteroskedasticity, normality, and stability. The results indicated that the model was stable, as confirmed by the CUSUM test displayed in figure 5. Additionally, the residuals exhibited a normal distribution, with the Jarque-Bera probability exceeding 5% (as shown in figure 6).

Furthermore, there were no indications of serial correlation or heteroskedasticity, as evidenced by the Chi-squared probability exceeding 5% according to the findings presented in table (8). This suggests that the residuals were not correlated and maintained a constant variance.

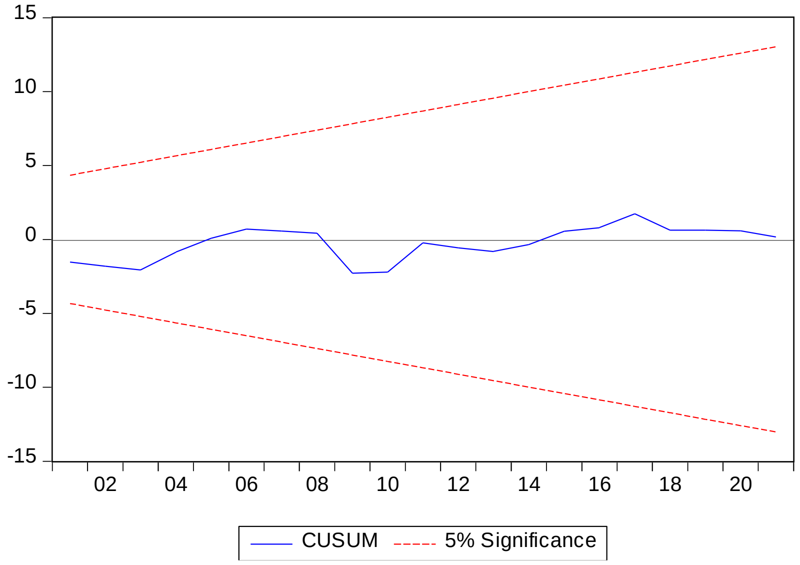


Figure (5): The Cumulative Sum of Recursive Residual (CUSUM) test.

Source: By researchers using e-views

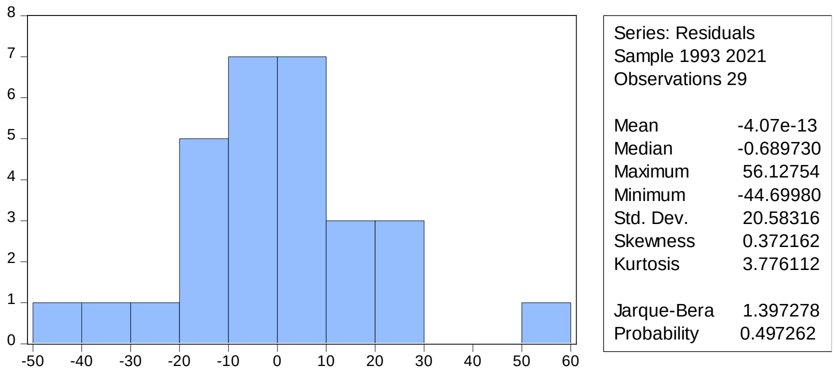


Figure (6): Jarque-Bera normality test

Source: By researchers using e-views 10

Table (8): Tests for serial correlation and Heteroskedasticity

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.129341	Prob. F(2,19)	0.1464
Obs*R-squared	5.309922	Prob. Chi-Square(2)	0.0703

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.920453	Prob. F(7,21)	0.1168
Obs*R-squared	11.31870	Prob. Chi-Square(7)	0.1253
Scaled explained SS	8.238460	Prob. Chi-Square(7)	0.3120

Source: By researchers using e-views 10.

6. **Results and Conclusion:**

There is a notable connection between population growth, as indicated by the fertility rate, and economic development, measured by GDP per capita, in Ethiopia. Additionally, the relationship is negative, suggesting that population growth is adversely impacting economic development. Rapid population growth is associated with economic distress and poverty in Ethiopia. However, this relationship is absent in Japan. The paper points to a weak correlation between the two variables in Japan.

The relationship between population growth and economic development is multifaceted, with no one-size-fits-all conclusion. While population growth can provide a vital source of labor and market expansion, unmanaged growth can lead to resource strain and increased poverty. Therefore, appropriate policies aimed at education, health, and economic adaptation are essential to leverage the positive effects of population growth while addressing its challenges.

The population is only one of the many factors that affect economic development. If appropriate economic policies are followed, rising economic growth and development will be able to overcome any adverse effect of population growth.

Rapid population growth can exacerbate inequality if economic opportunities are not evenly distributed. Governments must create policies to balance growth with sustainable development, addressing both opportunities and challenges posed by population changes.

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