GDP and Population Growth in India: An Examination of Cointegration and Causality Behaviour

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Abstract

The present paper is an attempt to examine the existence of relationship, if any, between GDP and population in Indian Economy during post liberalisation period (i.e., from 1980-81 to 2019-20). For this purpose a variety of econometric techniques, such as Augmented Dickey Fuller (ADF) test Phillips-Perron (PP) tests of Stationarity; Johansen Juselius Cointegration Technique (trace test and max-eigen test) and bi-variate Granger Causality test were made use of. On the basis of the behaviour of growth pattern of GDP and population growth during the study period, it was observed that the growth rate of GDP has been surpassing than the growth rate of population during the entire study period, which may be viewed as a healthy sign for the development of an economy. Further, the econometric analysis revealed that there exists long run relationship between GDP growth and population as these variables were found to be cointegrated, while these variables do not Granger cause one another in the short run at the lower-ordered lags length, but at the higher ordered lag ,it has been observed that population growth granger causes GDP growth, which signifies that if more effective policy measures are undertaken to put increased population into skill building activities, then it can produce skilled labour force, thereby contributing to the further growth of an economy.

Keywords: Stationarity; GDP ; Population Growth; Cointegration; Causality.

JEL Classification: C12; C14; J11; J21; O11.

Introduction

As the global population approaches 8 billion, Indian economy, the powerful driver of this resource, has been experiencing a slowdown in the pace of growth of population. No doubt. India's population has increased more than threefold since independence, from 361 million in the 1951 census to more than 1.2 billion in 2011. but, India's annual population growth has averaged 1.2% since 2011. As of 2020, India gains roughly 1 million (10 lakh) inhabitants each month, and it is

projected that it will overtake China as the world's most populous country by 2030, according to the United Nations Population Division. Now the question arises whether the population growth is a boon or bane for the growth and development of our economy?

The relationship between population growth and economic growth has been a subject matter of debate and discussion over the decades. This is the area of interest not only for demographers but also for development economists (Rodriguez et al., 2016). There are different schools of thought so far as the relationship between population and economic growth is concerned. One group of economists believes that the population growth significantly affects GDP growth of an economy while other believes that GDP growth affects population growth. In either of the two situations, the question further arises whether these two variables are associated positively or inversely to each other. In some of the conventional theories, related to population and economic growth (Malthusian View), it has been believed that increase in population growth often causes poverty, famines, unemployment war etc thereby leading to economic crises. Those theories rigidly followed Malthus (1786) viewpoint that focused on gloomy sides of population growth and forecasted various future problems due to population explosion (Singha and Jaman, 2013) The second school of thought, known as 'Revisionism' believes that, increase in population brings more manpower, skilled labour and thus productive human capital which leads to economic development of a country, thereby considering the population as an important asset rather than a mere liability ; and the third one (The Transition Theory) takes the opposite of the above two; believing that population growth is not the cause, but the consequence of economic growth (Hodgson, 1988; Blanchet, 1991).

Thus, in this regard, the present study is an attempt to examine whether population growth granger causes economic growth or economic growth granger causes population growth in case for Indian economy, covering 30 years time series data (from 1980-81 to 2019-20). The study is organized section-wise as follows. The second section presents the literature reviewed related to the topic under study; third section explains database and methodology used for examining the causal relationship between the two variables; the fourth section is devoted to empirical results and discussions and section fifth concludes the current study.

Literature Reviewed

A lot of research has been conducted to investigate the relationship between population and economic growth worldwide. But, no consensus among the research workers about the existence and direction of relationship among these two variables i.e, whether the population growth is a boon or bane for economic growth or does economic growth influence population growth or not.

Barlow (1994) in his study examined the relationship between population growth and per capita income growth for 86 countries, the results of which showed that the growth in per capita income was found to be to be negatively associated with population growth and positively with lagged fertility. Tsen and Furoka (2005) studied the relationship between population and economic growth in Asian economies. The analysis pointed out the absence of any long term relationship between population and economic growth, while Savas (2008) observed the existence of long run relationship between population growth and real income in Central Asian economies. Covering the period from 1980-2010, Mamingi and Perch (2013) analysed the relationship between population growth and economic growth, spanning 1980-2010 for a developing country, Barbados. On the basis of the statistical analysis, the authors concluded that population growth positively affected economic growth whereas economic growth negatively affected population growth. Moreover, net international migration affected population growth negatively while population density had a positive impact on economic growth. Singha and Jaman (2013) in their paper studied the relationship between population and economic development i.e., whether the population has been promoting or obstructing the economic development in India. Results of Granger Causality test found that population growth neither caused GDP growth and vice versa. Agarwal (2014) theoretically expressed her views on the impact of growth of population in India on its economic development. The authors was of the view that high rate of

growth of population generally slows down the rate of economic development in developing countries, while Rodriguez et al., (2016) found the negative effect of economic growth on population growth and positive effect of population growth on Per capita GDP. Sibe et al (2016) conducted a study to examine the relationship between population growth and per capita income for 30 most populated countries. The results of the error correction mechanism confirmed the existence of long run relationship between population growth and economic growth. Moreover on the basis of the granger causality test, the authors concluded that there existed two-way causal linkage between economic growth and population growth. Wesly and Peterson (2017) studied the relationship between population growth and economic growth for some Europeon countries. On the basis of the analysis,it was concluded that low population growth, in the countries, having high income creates multiple social and economic problems, while high population growth in low-income countries may slow down the development process.

There exists various other studies like Birdsall (1988), Darrat and Al-Yousif (1999), Thornton (2001), Sedano (2008), Furoka and Munir (2011), Dao (2013) etc, which have also studied the causal relationship between demographic growth and economic growth. Some of these studies have observed the existence of positive relationship between population growth and economic development, while some studies have observed the existence of negative or absence of relationship between these two variables. Moreover, the reverse causation (i.e. from economic growth to population) was also found in some of the studies.

To sum up the literature reviewed, we can say that the nature and direction of relationship between demographic growth and economic growth is still controversial. Different studies have come out with varied conclusions about the nature of relationships between these two vital variables. Despite the vast literature that exists on the describing the relationship between population and economic growth, the empirical evidence about the Indian economy seems to be scanty. Thus the present study fills that void by examining the cointegration (long-run relationship) and Granger Causality (short-run relationship) between population and real gross domestic product for the post liberalization period (i.e. from 1980-81 to 2019-20) using various econometric techniques.

Database and Methodology

The present study covers the post reforms time period i.e., from 1980-81 to 2019-20. Data on Gross Domestic Product for the Indian economy were sourced from various issues of National Accounts Statistics at 2011-12 constant prices and data on year wise population of Indian economy were sourced from World Development Indicator (World Bank).

In order to examine the relationships between the real GDP and population growth, various econometric techniques for testing stationarity, cointegration and causal linkage were applied. The stationarity properties of the time series on real GDP and population growth were assessed through Augmented Dickey-Fuller (1979) and Phillips-Perron (1988) unit root tests.

It can be mentioned here that Phillips-Perron test is generally considered, to be better than Augmented Dickey Fuller test, as PP test has a feature of an automatic correction to the Dickey-Fuller procedure to control for serial correlation, while testing for a unit root in time series (Bento 2011). In order to test for long run relationship between the real GDP and Population, Johansen and Juselius (1990) cointegration test was performed.

The form adopted for the ADF test was:

$$\Delta Y_t = \beta + \beta_1 t + \partial Y_{t-1} + \alpha \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t$$

Where, Y indicates variable say real GDP, Δ is t the difference operator, t = time subscript, L = number of lags and ε is a white noise error term. $\beta, \beta_1, \partial, t\text{-}1, \alpha$ are a set of parameters to be estimated and ΔY =Y t+1 – Yt . This test was performed under null hypothesis of non-stationarity of the time series.

The form adopted for the PP test was (viz., constant with trend in Z-tau):

$$\Delta Y_t = \tau + \beta_2 t + \delta Y_{t-1} + u_t$$

Further, the cointegrating rank (r) was tested through two different methods, viz., trace test and the maximum eigen value test.

Johansen- Juselius Test of Cointegration

When variables are stationary at first difference, we can examine whether long run relationship among variables is present or not. In this case, we considered two tests, i.e. the Trace test and Maximum Eigenvalue test. As per Johansen-Juselius Test, null hypothesis assumes no cointegration, while the alternative implies cointegration (Johansen &Juselius, 1990).

Bi-Variate Granger Causality Analysis

The standard Granger causality test investigates to analyse whether past values of any variable help to forecast the changes in the values of another variable. A variable say, X is said to cause another variable say, Y if past and present values of X forecast the values for Y i.e.,

$$X_t = \sum_{j=1}^{p} \alpha_j X_{t-j} \sum_{j=1}^{p} \beta_j Y_{t-j} + \mu_t$$

$$Y_t = \sum_{j=1}^{p} \eta_j X_{t-j} \sum_{j=1}^{p} \gamma_j Y_{t-j} + \vartheta_t$$

In this case, the Null hypothesis specifies no causal relationship among variables.

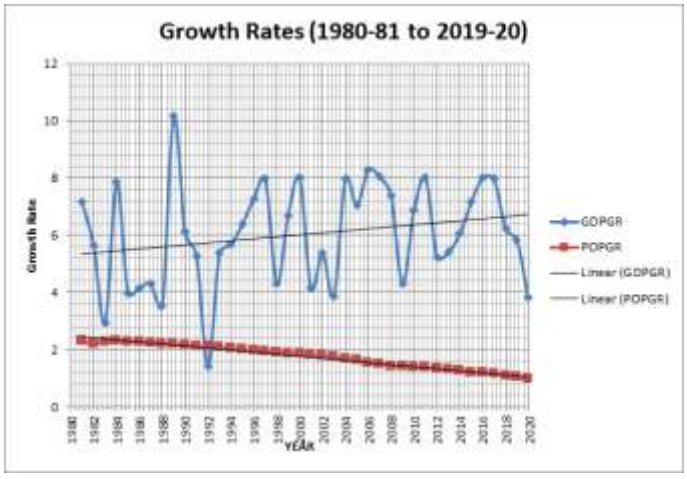
Empirical Findings

The empirical findings of the current study in this section have been presented in four different sub-sections. The first section exhibits the graphic presentation of growth pattern of Real GDP (GDP at 2011-12 constant prices) and population. The second sub-section is concerned with the testing of stationarity properties of the two time series (i.e. Real GDP and Population growth) so that the Granger's causality does not produce spurious results. The third sub section deals with the results from the application of Johansen-Juselius cointegration methodology, which was applied to ascertain whether real GDP and population growth were cointegrated or not and the fourth sub-section presents the results from bi-variate Granger's causality so as to explore the causal linkage (if any) between real GDP and population growth.

GDP and Population Growth Rates:

The annual growth rates of real gross domestic product (GDP) and population in Indian economy for the period under study have been depicted in figure 1.

A perusal at the figure 1 exhibits that the growth rate of population has been declining consistently from 1980-81 to 2019-20; though marginally. On the other hand, the growth in GDP at constant 2011-12 prices has been following a fluctuating trend, but lying above the growth rate of population during the entire study period (except in the year 1991-92). Such kind of pattern may be an indication that the demographic profile of our Indian economy is a not posing any threat in the growth of our economy and secondly, it may be viewed in a way that the population growth and GDP growth are moving independently, without affecting each other. Now the question arises whether these two variables are correlated or not i.e., does there exist short run or long run relationship between these variables or not. For this purpose, econometric analysis was carried out, the results of which have been presented in the subsequent sections.



Tests for Stationarity

Two tests viz., Augmented Dickey Fuller (ADF) and Phillips-Perron(PP) tests were applied to detect the presence or absence of unit root in the real GDP and population growth series. Both of these tests were computed at both normal scale as well as log scale, the results from which have been presented in Table No.1. Moreover, the tests were computed at levels, first difference and at second difference.

A glance at the table 1 reveals that real GDP happened to be insignificant at levels as well as at the first difference. But at the second difference, it was found to be highly significant (i.e., significant at 1% level). Thus, the order of integration in this case happened to be I(2). So far as, population is concerned, the value of test statistic was found to be insignificant at levels, first difference as well as at second difference. When the data on both the variables were log transformed (in order to overcome the possible problems of heteroscedasticity), the results of the ADF test, applied on logarithmic values of the real GDP and population growth showed

Table1. Results for Unit Root Test- Real GDP and Population

Variable	ADF test (Test Statistic at Normal Scale)			
	Δ^0	Δ^1	Δ^2	Degree of Integration
Real GDP	0.8178^{NS}	-3.3818^{NS}	-9.6356**	I(2)
Population	0.0407^{NS}	-0.8492^{NS}	-3.0932^{NS}	-
	ADF test (Test Statistic at Log Scale)			
Variable	Δ^0	Δ^1	Δ^2	Degree of Integration
Real GDP	-2.2517^{NS}	-5.9052**	-	I(1)
Population	1.6547^{NS}	-1.6743^{NS}	-3.8806^{*}	I(2)
	PP test (Test Statistic at Normal Scale)			
Variable	Δ^0	Δ^1	Δ^2	Degree of Integration
Real GDP	4.4080^{NS}	-3.365^{NS}	-7.4480**	I(2)
Population	0.9310^{NS}	0.0942^{NS}	-3.2230^{NS}	-
	PP test (Test Statistic at Log Scale)			
Variable	Δ^0	Δ^1	Δ^2	Degree of Integration
Real GDP	-1.6118^{NS}	-6.9360^{**}	-	I(1)
Population	11.1373^{NS}	-4.5583^{**}	-	I(1)

Source: Own Estimates
Note: Δ0: At levels; Δ1: At First differenced; Δ2: At Second differenced
* : Value is significant at 5% level; ** : Value is significant at 1% level

somewhat different picture. The order of integration of the real GDP happened to be I(1) and the order of integration for Population growth was found to be I(2). Thus, the results on logarithmic scale were found to be better than those at normal scale. On the other hand, the results from the Phillips Perron test were similar to the results of ADF test at normal scale, while the results at log scale were found to be different. At log scale, both the variables i.e., real GDP and Population were observed to be stationary at first difference I(1) . Thus it can be concluded that PP test has helped us in detecting stationarity in the time series through a relatively lower order of difference (especially in case of population growth). Thus, we may rely on the results obtained through PP test and that too at log scale for real GDP as well as population growth. Therefore, we considered the logarithmic values of real GDP and Population growth for the further computations.

Tests of Cointegration

Conitegration between the two time series (having the same degree of integration I(1)) was ascertained following Johansen Juselius Cointegration test (involving two variants viz., trace test and maximum Eigen Value test), the results of which have been presented in Table 2. A perusal

Table 2: Cointegration Test (Trace Statistic and Max-Eigen Statistic) for real GDP and Population at logarithmic scale

Variables	Trace Statistic			
	Null Hypothesis	Alternative Hypothesis	λ_{trace}	95% Critical Value s
LRGDP AND LPOP	r = 0 r = 1	r > 0 r > 1	22.02 1.15	18.40 3.84
Max Eigen Statistic				
Variables	Null Hypothesis	Alternative Hypothesis	λ_{maxegn}	95% Critical Value s
LRGDP AND LPOP	r = 0 r = 1	r = 1 r = 2	20.87 1.15	17.15 3.84

Note: 'L' stands for Logarithmic Scale ; RGDP stands for real GDP (GDP at 2011-12 Prices); 'POP' stands for Population.

at the table evidences that both the tests viz., Trace test and Max-Eigen Value test pointed out the existence of cointegration (long run relationship) between real GDP and population growth , as both the test statistic values happened to be significantly different from zero. The value of trace statistic turned out to be 22.02, which turned out to be higher than critical value of 18.40. Similarly, in case of max-eigen test statistic, the calculated value has been observed to be greater than its tabulated value, which points out that population and GDP growth are cointegrated.

Bi-Variate Granger's Causality Test

The results of Bi-variate Granger's Causality test between real GDP and Population growth have been depicted in Table 3. The table reveals that at lag length 1,2 and 3, GDP growth neither granger causes nor granger caused by population growth in the short run, though these variables are cointegrated in long run. At higher ordered lag length 4, population growth was found to be significantly effecting GDP growth. As mentioned earlier that population in Indian economy has been growing at a declining rate and at the same, GDP is comparatively growing at a faster rate, which shows that declining growth in population has favourable effect on the economic growth. So current demographic pattern of Indian economy is not an issue for the development and growth of an economy. It delineates the fact that increase in population is not an obstacle in the path of economic growth. Rather, it provide the main resource (labour) to the economy, which

Table 3: Results of Bi-Variate Granger Causality Test among GDP and Population Growth at different Lag lengths.

Null Hypothesis	F-Statistic	Probability	Direction of Causality
Lag 1			
LGDP does not cause LPOP	0.28399^{NS}	0.59737	LGDP LPOP
LPOP does not cause LGDP	2.27568^{NS}	0.14014	LPOP LGDP
Lag 2			
LGDP does not cause LPOP	0.21853^{NS}	0.80485	LGDP LPOP
LPOP does not cause LGDP	1.70160^{NS}	0.19801	LPOP LGDP
Lag 3			
LGDP does not cause LPOP	0.36268^{NS}	0.78038	LGDP LPOP
LPOP does not cause LGDP	2.15737^{NS}	0.11381	LPOP LGDP
Lag 4			
LGDP does not cause LPOP	0.2719^{NS}	0.8934	LGDP LPOP
LPOP does not Granger Cause LGDP	3.2227*	0.0173	LPOP LGDP

acts as a prime mover to the growth of it; as also observed in my earlier paper (Sethi and Kaur, 2013). Thus, it can be concluded that if more serious efforts are made to improve the skills and productivity of the work force, so that it can further enhance the growth of our Indian economy rather than acting as a stumbling block.

Conclusion

The present analytical study attempted to examine the cointegration (long-run relationship) and bi-variate causal linkage (short-run relationship) between real GDP growth and population in India during post reforms period (i.e., from 1980-81 to 2019-20). The study used a variety of econometric computations such as Augmented Dickey Fuller (ADF) test, Phillips-Perron (PP) tests of Stationarity; Johansen Juselius Cointegration Technique (Trace test and MaxEigen Test) and bi-variate Granger Causality test. Data on Gross Domestic Product for the Indian economy were sourced from various issues of National Accounts Statistics at 2011-12 constant prices and data on year wise population of Indian economy were sourced from World Development Indicator (World Bank). From the behaviour of growth pattern of GDP and population, it was concluded that the growth rate of GDP has been consistently higher than the growth rate of population during the study period. Furthermore, the findings from Johansen Juselius Cointegration Technique revealed the existence of long run relationship between GDP growth and population (as these variables were found to be cointegrated), but these variables didn't Granger cause one another in the short run at the lower-ordered lags length. At the higher ordered lag ,it has been observed that population growth granger causes GDP growth, which signifies that if effective policy measures are undertaken to put population into productive use, then it can contribute to the further development of the economy. In this way, growth in population may not be viewed as a detrimental factor to the growth of an economy.

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