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Empirical Analysis on Annual Population Growth: An Econometric Approach

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Abstract

The current research examines the impact of annual population growth on economic growth. It is critically important to know the impact of population growth for an informed economic planning. We attempt to explain annual population growth rates across various nations, to illustrate the problem of the different variables that either positively or negatively affect population growth rates. We approach this problem by utilizing the analytical model of linear multiple regression. Our important variables include population growth rate, total fertility rate, infant mortality rate, and life expectancy. Our results indicate that annual population growth rate positively affects economic growth rate. We conclude that nations with increased annual population growth will have an increase in workforce productivity, thus more likely to have a higher economic growth rate in the future.

Keywords: Annual population growth; Econometrics; Economic development; Regression models

Introduction

This project intends to apply econometric analysis utilizing predictive modelling for an empirical study [1]. In this empirical project we will attempt to explain annual population growth rate across various nation-states. Then illustrate different variables that can have an affect on population growth rate either positively or negatively. In this model, population growth rate is defined as a dependent variable. Moreover, there are three different independent variables, which may have an affect on population growth rate. These independent variables include total fertility rate, infant mortality rate and life expectancy. In this model our hypothesis is that there is a positive relationship between population growth rate and two of the independent variables, namely total fertility rate and life expectancy and a negative relationship between population growth rate and infant mortality rate.

The positive and negative relationships can be further explored in terms of expected population increase or decrease. Both of these independent variables can have a positive effect on increasing population growth rate. If life expectancy and total fertility rate increase then citizens tend to reproduce more, therefore we expect to see population growth in such societies. If infant mortality rate goes up, then the population will decrease due to infants' death. We therefore expect to find a direct relationship between total fertility rate and life expectancy while expecting to find the inverse between infant mortality rate and annual population growth rate.

Methodology

In this project we plot the data set from the online data bank by Pearson using an excel spreadsheet to explain the relationship between the dependent (Y=annual population growth rate) and the independent (X_2=Total fertility rate, X_3=infant mortality rate, X_4=life expectancy) variables [2]. Annual population growth, as Weil indicates is of critical importance for a nation's economic outlook [3]. This fact has necessitated a closer look at population dynamics among many fields including economics. Economists have been for decades calculating the best method for population growth rate [4]. We believe that there are several variables that are related to annual population growth rate.

One of the variables that we believe impact annual population growth is total fertility rate. Total fertility rate is defined as the number of children who would be born per woman (or per 1,000 women) if they were to pass through the childbearing years, bearing children according to a current schedule of age-specific fertility rates. We expect to have a positive relationship such that as the growth rate for total fertility increases, so does the rate of annual population growth.

The second variable is infant mortality per 1000 live births. It is defined as the ratio of the incidents of deaths in the first year of life per each 1000 occurrences of live births during the same period of time. For this second variable we expect to have a negative relationship.

The third variable is life expectancy. This is defined as the amount of years a person lives. The more years a person lives, the higher the population growth. One of the reasons is because they have more time to have more children, increasing the fecundity of the population. Increased fertility and fecundity naturally leads to an increase in population growth.

Results and Analysis

For the remainder of the empirical project, our dependent variable is Annual Population Growth Rate. Our independent variables are as follows: total fertility rate; infant mortality per 1000 live births and life expectancy.

We ran a regression and found all of our variables to be significant. They were significant because our P-Value and Standard Errors were all positive. Since all of the variables are significant, we do not need to revise the model.

As we can see below in this model the R squared is equal to 35%, which is acceptable, since R square should be between 0 and 1. Also

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the model was based on 173 observations and the standard error is approximately 94% as it is shown in Table 1.

Moreover, as it shown in Table 2 SSR, SSE and SST are equal to 81.001, 150.31, and 231.3 respectively.

In this model the intercept, which represents β_1 in our model, is approximately equal to -0.05.

There is a positive relationship between annual population growth rate, which is our dependent variable in this model, and our two independent variables that are total fertility rate and life expectancy. However, there is a negative relationship with infant mortality per 1000 lives births (Table 3).

β_2, β_3 and β_4 are equal to 0.54, -0.002, and 0.004 respectively.

In addition $SE(b_1)=1.511$, $SE(b_2)=0.1045$, $SE(b_3)=0.006$, and $SE(b_4)=0.0188$ respectively.

General multiple regression model: $Y_i=\beta_1+\beta_2X_{2i}+\beta_3X_{3i}+\ldots\ldots\ldots+\beta_kX_{ki}+\varepsilon_I$

The multiple regression of this model is below:

$$Y=-0.05+0.54\,X_2-0.002\,X_3+0.004\,X_4$$

(1.511) (0.1045) (0.006) (0.0188)

Test for heteroskedasticity

As we know heteroskedasticity means having unequal variances in the data and when there is homoscedasticity it can be shown as below:

$$\text{Var}(\varepsilon_1)=\sigma_i^2 \Rightarrow \text{Homoskedasticity}$$

In this model for testing heteroskedasticity we are using the white test. That is to say we have to find the residual and then the residual square and use the latter as our Y which is the dependent variable for running a regression in excel. Then we have to find Z variables which represent our independent variables. In this model we have three independent variables therefore our Z variables for the white test should be 9 and then here we have to use these 9 variables as our independent variables. In the next step our null hypotheses and the alternative are shown as below:

H_0: Homoskedasticity

H_1: Heteroskedasticity.

Finally, we ran a regression with these independent and dependent variables and the results are shown below:

As we can see in the following Table 4 the R square is almost 4%. Although our R square is not very good, it is acceptable when its value is between 0 and 1.

Furthermore, as we can see Table 5 SSE, SSR and SST are 39.12, 946.94, and 986.07 respectively. According to the standard errors and p-values all the variables in Table 6 are significant.

In the last part of this test we must analyse whether or not we reject or do not reject the hypotheses so we have to do some additional calculations as shown below: Sample of observation (n)=173.

R squares (R^2)=0.039,

We reject the null hypotheses if $n\,R^2>\chi^2_{p,\alpha}$

P=degree of freedom for chi square which is the number of X=9,

α=5%,

$\chi^2_{9,0.05}=16.92$,

Regression Statistics	
Multiple R	0.591762541
R Square	0.350182904
Adjusted R Square	0.33864769
Standard Error	0.943086677
Observations	173

Table 1: Regression statistics.

	df	SS	MS	F	Significance F
Regression	9	81.00162494	27.00054165	30.35772746	9.45019E-16
Residual	163	150.310709	0.889412479		
Total	172	231.312334			

Table 2: SSR, SSE and SST.

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.050393475	1.511856991	-0.03333217	0.973449034
tfr09 (X2)	0.538143146	0.104503405	5.149527384	7.20248E-07
infmor09 (X3)	-0.002039604	0.006662934	-0.30611199	0.759896151
lifeex09 (X4)	0.003905515	0.018807282	0.207659745	0.835744676

Table 3: Annual population growth rate.

Regression Statistics	
Multiple R	0.199184654
R Square	0.039674527
Adjusted R Square	-0.013349579
Standard Error	2.41029138
Observations	173

Table 4: Regression statistics.

	df	SS	MS	F	Significance F
Regression	9	39.12190582	4.346878425	0.748235654	0.664255176
Residual	163	946.9492397	5.809504538		
Total	172	986.0711455			

Table 5: Significance of SSE, SSR and SST.

	Coefficients	Standard Error	t Stat	P-value
Intercept	-9.345150763	40.19405978	-0.232500793	0.816440743
tfr09 (X2)	-5.105201908	6.733872056	-0.758137646	0.449463321
infmor09 (X3)	0.261809723	0.463582043	0.564753806	0.573017621
lifeex09 (X4)	0.414752514	1.039488568	0.398996705	0.69041787
(X2)^2	0.192868124	0.262193277	0.735595229	0.463034219
(X3)^2	-7.82079E-05	0.001266065	-0.061772426	0.950819742
(X4)^2	-0.003602815	0.00687052	-0.524387497	0.600721434
X2*X3	-0.003915849	0.026519094	-0.147661495	0.882792417
X2*X4	0.064535759	0.081520473	0.79165094	0.429714746
X3*X4	-0.004143397	0.006049664	-0.684896981	0.49438169

Table 6: Standard errors and p-values.

Regression Statistics	
Multiple R	0.591762541
R Square	0.350182904
Adjusted R Square	0.33864769
Standard Error	0.943086677
Observations	173

Table 7: Regression Statistics.

	df	SS	MS	F	Significance F
Regression	9	81.00162494	27.00054165	30.35772746	9.45019E-16
Residual	169	150.310709	0.889412479		
Total	172	231.312334			

Table 8: Significance of F.

173*0.039>16.9 ⇒ 6.747<16.92 ⇒ Therefore we do not reject the null hypotheses.

So consequently there is a homoscedasticity in this model.

Our data is a not time series so we do not need to find the first order autocorrelation here.

F-Test: In this section we examine F-Test. In the first step of finding the F value we have to write down the null hypotheses and the alternative as indicated below:

H_0: $\beta_2=\beta_3=\beta_4=0$

H_1: otherwise

In the second step we have to find the F value by using an F formula.

F=SSR /q /SSE /n-k

In this formula q is the number of restriction which is 3 and also it represents a degree of freedom for the nominator. Moreover, n is the number of our observation which is equal to 173 and also k is the number of the β that is 4 in this model and so n-k=173-4=169 which represent the degree of freedom for the denominator. We ran a regression earlier in excel and we found SSE and SSR in the result as is shown in Table 7 [6-10].

F=81.0016/3/150.3107/169 ⇒ F=27.0005/0.8894,

F=30.3581.

Then we have to find the critical value of F by using the F Table 8 in this step. Here we suppose that our α=5% and the degree of freedom for the denominator and the nominator are equal to 169 and 3 respectively.

Therefore, the critical value of F is 2.60.

Finally, we have to make a conclusion.

We reject H_0 if $F>F_{3, 169, 0.05}$ ⇒30.3581>2.60,

So we reject the null hypotheses at α=5%.

Conclusion

By finding out the main variables impacting annual population growth, we can expect to be able to positively impact our economy. According to the results that are shown in this project we can point to three main conclusions. Our first conclusion indicates that there exists a positive relationship between total fertility rate and annual population growth rate. Populations grow larger in countries where we see an increase in total rate of fertility. The second conclusion is that we see a positive relationship between life expectancy rate and annual population growth rate as well. In other words, national populations also grow as a result of an increase in life expectancy. Our third conclusion is that there appears to be a negative relationship between infant mortality rate and population growth rate. This result informs us that as the rate of infant mortality increases, we see national populations take on a declining trend. Our conclusions therefore support our initial expectations.

These conclusions in fact turn out to confirm our initial hypotheses. Therefore, we accept our hypotheses. Many economists believe that the higher the population growth rate, the tendency is to have a less developed nation [5]. Based on our analysis and its final conclusion we do not accept this view. On the other hand, our conclusion supports the view that the more people are in a country, the more resources and manpower they have, which then increases the general health and well being of these nation-states and societies.

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