The Relationship between Population Growth Rates and GDP Growth Rates Globally

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Abstract

Research reports that when a country's population growth rate decreases, GDP growth rates decrease as well (Baker, 2005). This research utilizes panel data at the country level from 1973-2022 in order to observe a possible relationship between population growth rates and GDP growth rates. 40.50% of the variation in GDP growth rates is explained using a quadratic model in terms of population growth rates, as well as both country and time-fixed effects. A statistically significant, positive nonlinear relationship is found between population growth rates and GDP growth rates below a 2.90% population growth rate in a country.

I. Introduction

The objective of this research paper is to see if there is a relationship between population growth rates and GDP growth rates in a global context. Research has shown that a population decline causes a decrease in economic growth due to the effect it has on the supply and demand sides of the economy, as well as the environment, the pension system, politics, the agricultural sector, and other variables (Baker et al., 2005). As our world undergoes dynamic changes, understanding the relationship between population growth and economic development becomes increasingly crucial. We expect a positive relationship between the population growth rates and GDP growth rates across different countries due to a larger workforce that can stimulate economic growth, but only until a certain point (Peterson, 2017).

Within this paper, we explore the current proposed relationships between population growth rates, GDP growth rates, and a variety of other macroeconomic factors. We chose to describe and utilize existing panel data from all countries on the World Bank database between the years of 1973 and 2022 to construct an empirical model of a relationship between population growth rates and GDP growth rates. We then compiled our findings and investigated a possible relationship between the two variables. The fixed effects model presented in this paper explains that 40.50% of the variation in GDP growth rates is explained by population growth rates with country and time fixed effects. In testing our relationship between GDP growth rates and population growth rates, we hypothesized that there would be a positive relationship until a turning point of 2.90 which can be depicted in a quadratic model. This positive but diminishing relationship can be expected because a country's GDP growth rate will not benefit from an increasing population growth rate at some point in time because then the country's population and the population's needs will outgrow the progress and the speed at which GDP growth will increase (Headey & Hodge, 2009).

II. Literature Review

The nexus between population growth and economic outcomes has been explored by several scholars. Notably, studies such as (Peterson, 2017) and (Headey & Hodge, 2009) have investigated the impact of population growth on economic performance. Headey & Hodge (2009) also suggest that population growth can exert both positive and negative effects on economic development, depending on various contextual factors. Moreover, the theoretical framework for this research is informed by the demographic transition theory, which posits a shift in population dynamics over stages of economic development (Bloom et al., 2001). This theory helps contextualize the relationship between population growth rates and GDP growth rates, emphasizing the importance of understanding demographic shifts as countries progress economically. This implies that the relationship between population growth and GDP growth may not be linear and could vary depending on the demographic shifts within a country during a given time period.

III. Data Description

This research utilizes panel data at the country level from 1973-2022 in order to observe a possible relationship between population growth rates and GDP growth rates. Information on each variable has been collected from 217 countries between the years 1973 and 2022 leading to a total of 10,833 observations. In order to gather population growth rates at the country level, we accessed the World Bank database and used the Population Growth Rate (annual %) and GDP Growth Rate (annual %) of the 217 countries on this database. The data on Females in the Labor Force, Political Stability, Unemployment, Health Expenditure, and Education Expenditure were also taken from the World Bank database.

The labor force participation of females is integral as it reflects gender dynamics that can influence both population growth and GDP growth. Political stability is essential to isolate the impact of population growth from potential disruptions caused by violence and terrorism, which can significantly affect economic development. Unemployment rates serve as a key control variable, helping distinguish the impact of population growth from the influence of labor market dynamics on economic growth. Health expenditure is important to consider, as it reflects the quality of healthcare services and can influence the relationship between population growth and economic development by accounting for variations in health infrastructure and outcomes. Lastly, education expenditure is an important variable to consider as the level of education in a country can enhance productivity levels and can affect economic output.

Table 1: Variable Descriptions

Time	Time
TimeCode	Time Code
CountryName	Country Name
CountryCode	Country Code
GDPgrowth	GDP Growth Rate (annual %)
Populationgrowth	Population Growth Rate (annual %)
Laborforcefemale	Labor force, female (% of total labor force)
PoliticalStability	Political Stability and Absence of Violence/Terrorism: Percentile Rank
Unemployment	Unemployment, total (% of total labor force)
Healthexpenditure	Domestic general government health expenditure (% of GDP)
Eduexpenditure	Education Expenditure (% of GNI)

Table 2: Summary Statistics

	(1)
GDP growth (annual %)	3.39
	(6.35)
Population growth (annual %)	1.62
	(1.78)
Unemployment (%)	8.13
	(6.08)
Political Stability: Percentile Rank	49.28
	(29.02)
Government health expenditure (%)	3.27
	(2.33)
Labor force, female (%)	40.37
	(9.49)
Education expenditure (% of GNI)	4.15
	(2.73)
Observations	10833

NOTE: Table reports averages with standard deviations in parentheses.

IV. Empirical Model

We estimate a model to construct the GDP growth rates as a function of population growth rates using country level and time fixed effects from the compiled panel data set:

$$GDPgrowth_{it} = \beta_0 + \beta_1 Populationgrowth_{it} + \beta_2 Populationgrowth_{it}^2 + \boldsymbol{X}_{it} + \alpha_i + \lambda_t + u_{it}$$

Within this fixed effects model that holds time *t* and country *i* constant, *GDPgrowth* represents the GDP growth rates in country *i* and time *t*. $\boldsymbol{X}_{it}$ includes our control variables: Labor Force (female), Political Stability and Absence of Violence/Terrorism, Unemployment, Domestic

General Government Health Expenditure, and Education Expenditure. *GDPgrowth* is the dependent continuous variable in this equation. The main independent variable *Populationgrowth* in country *i*, year *t* has a positive coefficient as it is predicted that a higher population growth rate will be associated with a higher GDP growth rate. This regression model is estimated to be quadratic, with a turning point predicted. The relationship between GDP growth rates and population growth rates is positive but diminishing.

Below, Figure 1 is a scatter plot of the relationship between GDP Growth and Population Growth in the 217 selected countries as annual percentages for the year 2018. The fitted values demonstrate a positive but diminishing relationship between the two variables, supporting our initial hypothesis.

Figure 1: Scatterplot of GDP Growth Rates and Population Growth Rates Globally 2018

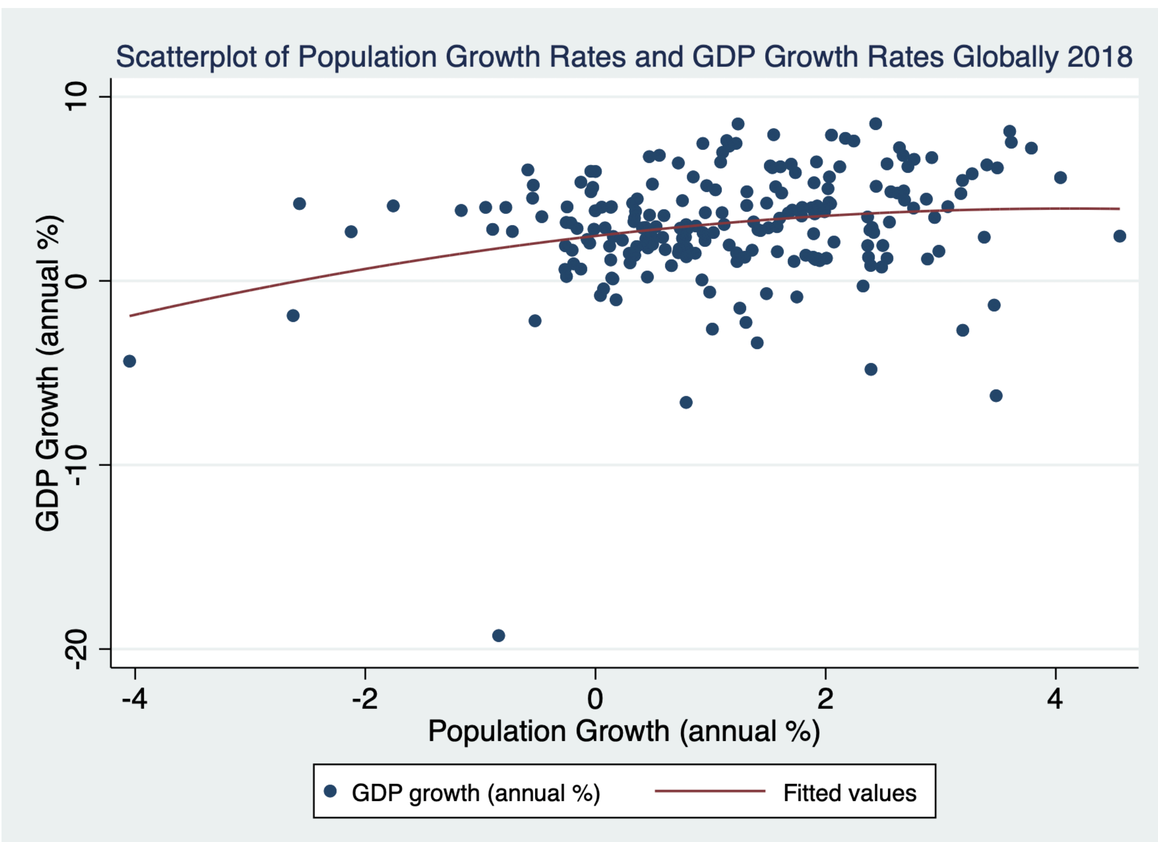
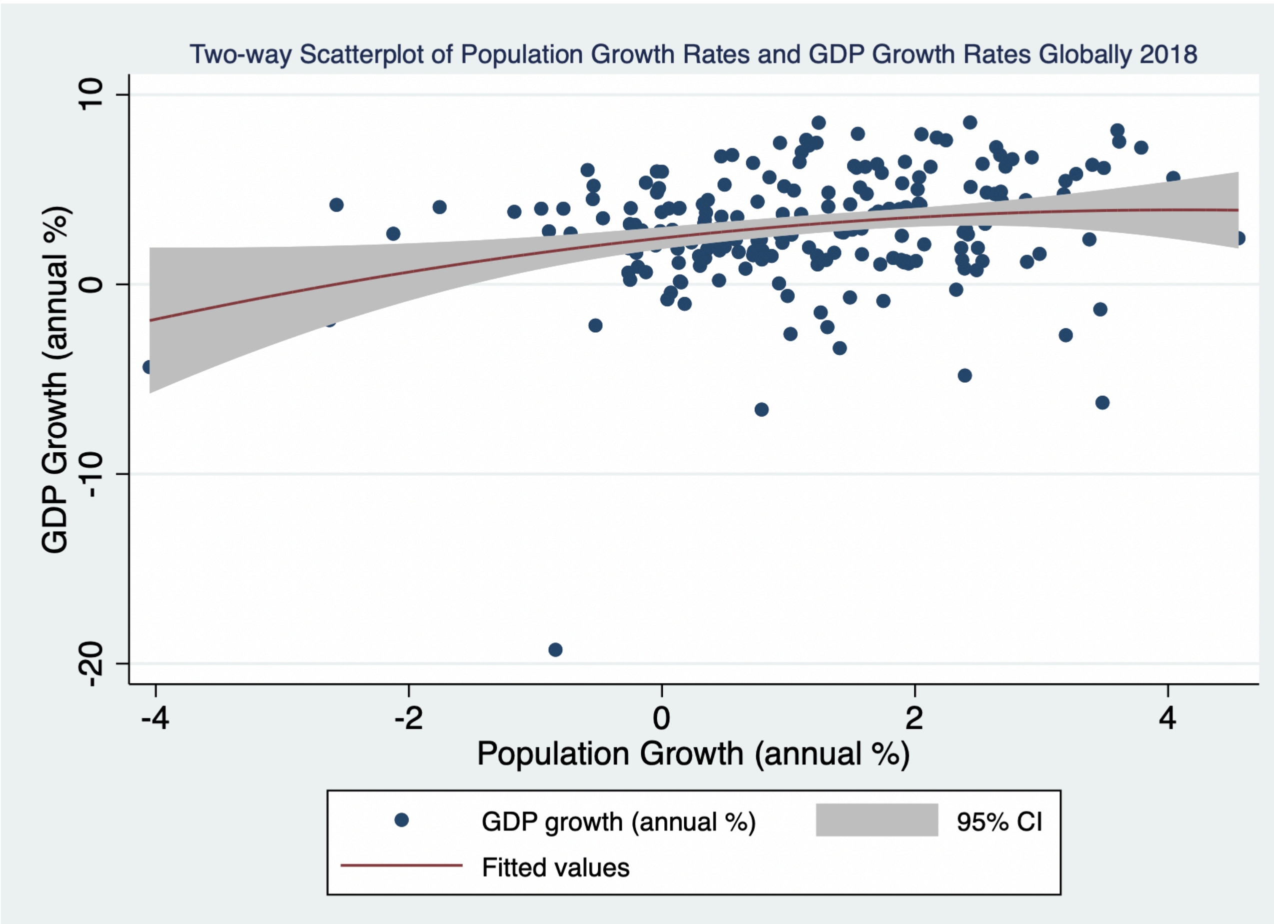


Figure 2: Two-way Scatterplot of GDP Growth Rates and Population Growth Rates Globally 2018



V. Regression Results

Table 3A: Regression Results, First Four Models

Dep. Var. GDP Growth Rates

VARIABLES	(1) OLS	(2) FE	(3) FE	(4) FE
Population Growth	0.554***	0.717***	0.689***	0.397
	(0.205)	(0.118)	(0.126)	(0.248)
Unemployment				-0.173***
				(0.0395)
Political Stability				0.00940
				(0.0112)
Health Expenditure				-0.643***
				(0.192)
Labor Force, Female				0.0986
				(0.0724)
Education Expenditure				-0.119
				(0.179)
Constant	2.372***	2.269***	3.593***	4.042
	(0.346)	(0.186)	(0.671)	(2.912)
Observations	209	8,828	8,828	2,202
Adjusted R-squared	0.049	0.014	0.095	0.419
Country FE	NO	YES	YES	YES
Year FE	NO	NO	YES	YES
Number of countrynum		213	213	168

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3B: Regression Results, Last Three Models

Dep. Var. GDP Growth Rates

	(5)	(6)	(7)
VARIABLES	FE	FE	FE
Population Growth	-0.0616	0.542**	-0.288
	(0.263)	(0.233)	(0.255)
Unemployment	-0.183***	-0.156***	-0.177***
	(0.0395)	(0.0413)	(0.0355)
Political Stability	0.0107	0.00941	
	(0.0114)	(0.0111)	
Health Expenditure	-0.635***	-0.634***	-0.626***
	(0.192)	(0.190)	(0.170)
Labor Force, Female	0.0867	0.0908	
	(0.0741)	(0.0722)	
Education Expenditure	-0.136	-0.121	
	(0.180)	(0.180)	
Population2	0.0372***		0.0496***
	(0.0127)		(0.0122)
Pop Growth * Unemployment		-0.0318	
		(0.0223)	
Constant	4.960*	4.266	8.644***
	(2.871)	(2.861)	(0.739)
Observations	2,202	2,202	2,398
Number of countrynum	168	168	184
Adjusted R-squared	0.423	0.421	0.405
Country FE	YES	YES	YES
Year FE	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Within Table 3A, we have our first four models. It is seen in the first simple linear regression model that the main independent variable *Population Growth* has a coefficient of 0.554, indicating a positive relationship that we hypothesized. Before introducing our control variables in the model, we decided to test how our main independent and dependent variables change when adding them into a fixed effects model. As shown in Table 3A, model 2, we created a fixed effects model, only holding country effects constant. In this model, we saw the adjusted R-squared value decrease. Next, we decided to test the independent and dependent variables in a fixed effects model with both country and time in our third model. From this, we saw the R-squared value increase from 0.014 to 0.095, showing that holding country and time will help explain more variation in our model. In model 4, we included control variables for unemployment, political stability of a country, government health expenditure, percentage of the labor force that is female, and education expenditure, as these are all factors that can contribute to explaining GDP growth rates. When including all of these variables in the model, we see our R-squared term increase significantly to 0.419. We initially predicted that the final regression would be quadratic, so we created a term called *Population2*. When adding this squared term into our fifth model (along with our controls), we saw that the *Population2* p-value was significant at the 1% level, indicating that we need to keep the squared term in our final model.

Before going forward with the significant relationship we found in adding the squared term to our model, we decided to test an interaction term to control for unemployment. In adding this interaction term called *Popgrowth_unemploy*, we find that the p-value of the main variable *Populationgrowth* is significant at the 5% level, with a positive coefficient of 0.542. This interaction term was chosen due to research showing that a higher unemployment rate is linked to the size of families in the country, which decreases the decision to have children. This affects the population growth rate's relationship with the GDP growth rate in a country (Peterson, 2017). While the interaction term was significant at the 5% level when we initially tested it with just *GDPgrowth* and *Populationgrowth* in a fixed effects model, the interaction term becomes highly insignificant when all of the controls are added into the model. So, therefore, we excluded it from our models going forward. From here, we ran a joint F test on our variables that were insignificant in model 5, including *Politicalstability*, *Laborforcefemale*, and *Eduexpenditure*. In this joint F test, we found that the three variables are jointly insignificant with a p-value of 0.5758. After omitting all three jointly insignificant variables, we arrive at our seventh and final model. In this model, all of the variables are significant at the 1% level, excluding *Populationgrowth*, with a p-value of 0.261. In this model, 40.50% of the variation of *Populationgrowth* is explained by *GDPgrowth*, which is a significant increase from our first model, where the variation was explained by only 4.90%.

VI. Summary and Conclusion

Our final model (Model 7), demonstrating a moderate level of explanatory power, explains approximately 40.50% of the variance in GDP growth rates. Notably, unemployment and health expenditure emerge as the most significant variables in highlighting the variations in GDP growth rates within the model. The quadratic relationship observed between population growth and GDP growth rates is in line with our initial hypothesis of a non-linear positive but diminishing relationship between the variables.

While political stability, the proportion of the female labor force, and education expenditure do not significantly contribute to explaining GDP growth rates in this model, the inclusion of fixed effects for both country and time helps account for unobserved heterogeneity at these levels. The insignificant p-value for population growth, despite the significance of its squared term, aligns with our initial hypothesis of a quadratic, non-linear relationship. Additionally, due to differences in beta1 and beta2, we have a turning point that reinforces the robustness of the model and is aligned with broader theoretical frameworks. The identified variables, particularly unemployment and health expenditure, offer tangible entry points for policymakers seeking to bolster economic growth. This might include implementing labor market reforms and increasing public spending on healthcare. Conversely, the lack of significance in political stability, the female labor force, and education expenditure prompts a reevaluation of conventional policy approaches. However, that does not mean they should be completely disregarded as testable macroeconomic variables.

VII. Limitations and Future Research

For future research, it would be interesting to select data from only a few years (3 to 5 years) and compare the relationships between the growth rates to note whether some years had higher or lower increases in growth. We could have also focussed our research on a specific sample of countries, for example, developed countries, emerging economies, OECD countries, etc. to see if the population growth variable would have been significant under different selection conditions. Similarly, we could have also selected just one country and observed how the relationship may have changed over several years.

An extension to our research would be to test population growth with GDP per capita to provide more insight into the standard of living within a country. This is also because analyzing GDP growth rates per capita would provide a clearer understanding of how population changes affect individual prosperity. This would create a more comprehensive picture of the relationship between demographic trends and economic growth rather than solely examining overall GDP growth rates. Additionally, we could also add control variables like birth rate, access to natural resources, or technological advancements of a country to account for possible omitted variable bias.

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