Impact of population growth on GDP per capita

Submitted by: Ali Ammar (18U00160)

Submitted to: Miss Shafaq Junaid

Lahore School of Economics

Acknowledgment

The compilation of this final project would not have been possible without the guidance and expertise of Miss Shafaq Junaid.

Abstract

This paper investigates the impact of population growth on GDP per capita, using the regression of fixed effect, time fixed effects and robust fixed effects models. A data set (panel) from 50 countries (both developing and developed) covering a 21-year period from 2000 to 2020 is used. The results indicate that there is a positive relationship between population growth and GDP per capita. The population growth rate has a significant and positive impact on per capita income, and it change GDP per capita with greater proportion for developed countries as compare to developing countries. Therefore, the optimistic view can be adopted for developed countries where population growth rate is low. In contrast, the neutralist view is applicable in countries where population growth is relatively high. The model's results also indicate that changes in population affect per capita income, changes which describe a linear relationship. The 'primary school enrolment' has a consistently significant and negative effect on per capita income while the fertility rate has a significant and positive effect on per capita income. However, the 'fertility rate' has a fragile and contradictory effect on per capita income. Therefore, the view of proponents of age structure is generally acceptable.

Contents

Abbreviations

Variables	**Abbreviation**
GDP per capita	GDP/C(+/-)
Fertility rate	Frt(-)
Infant mortality	Ifmt(-)
Population growth	PG(-/+)
Exports	Expts(+)
FDI	Fdi(+)
Imports	IMP(-)
Primary School Enrolment	PSE(+)

1. Introduction

How does population growth affect economic growth? More concretely, in the context of a high fertility developing country, how much higher would income per capita be if the fertility rate were to fall by a specified amount? This is an old question in economics, going back at least to Malthus (1798). Over the last half century, the consensus view has shifted from fertility declines having strong effects, to their not being very important, and recently back toward assigning them some significance (Sindig 2009; Das Gupta, Bongaarts, & Cleland 2011).

For an issue that has been studied for so long, and with such potential import, the base of evidence regarding the economic effects of fertility (or population growth more generally) is rather weak. In some ways, this should not be a surprise. Population growth changes endogenously as a country develops. Further, factors that impact population, such as changes in institutions or culture, are also likely to affect economic growth directly, and they are poorly observed as well. Finally, the lags at which fertility changes affect economic outcomes may be fairly long. Thus, at the macroeconomic level, it is very hard to sort out the direct effects of population growth from those of other factors. Much of the current thinking about the aggregate effects of fertility decline relies on results from cross country regressions in which the dependent variable is growth of GDP per capita and the independent variables include measures of fertility and mortality, or else measures of the age structure of the population. Our goal in this paper is to quantitatively analyze the economic effects of reductions in fertility in a developing country where initial fertility is high.

Population explosion is a major issue for developing nations because four fifth (7.7billion world’s population, 6.1 living in developing) of the world’s population are living in developing countries and it has adverse effects on economy. One of the major reason for this explosion is increase in birth rate because these countries have lack of resources and awareness programs to control birth rate. On an average 6 to 8 birth per female in these countries as compare to developed countries has average 2 birth per female because use of contraceptive is high in developed countries. For example, in 1960 Thailand has 40% population less than age 15 and an average 6 to

8 child per female were accounted. But after that they create an awareness to use of contraceptives and birth fell to 2 child per female in 1990s.

Pakistan is a developing country having 212million population with 2.2% population growth rate due to high fertility or birth rate and less use of contraceptives to control pregnancy or fertility (NIPS, 2021). It has 2.86 total fertility rate, 29.8 birth/ 1000 population crude birth rate and 7.5 death/ 1000 population crude death rate. Also it has 48% unintended pregnancies, 54% unintended pregnancies aborted, 30% post abortion complication rate and 6000+ abortions per day due to less use of contraceptives according to 2020 report. This fast pace population growth has threat to Pakistan socially and economically. With this growth rate Pakistan would unable to attain economic goals because half of the population are live on $2 a day and it needs to slow down the population growth rate (WHO, 2021).

To address the research question, we would construct a demographic-economic simulation model in which fertility can be exogenously varied. We would trace out the paths of economic development under two scenarios: a baseline, in which fertility follows a specified time path, and an alternative in which fertility is lower. Because we want to realistically model high-fertility developing countries in which fertility will likely be falling over the next several decades, both our baseline and alternative scenarios involve falling paths of fertility; the difference is that fertility falls faster in the alternative scenario. We would use the United Nations (UN, 2020) medium-fertility population projection as our baseline, and the UN low-fertility population projection as our alternative scenario.

GDP per capita has affected by certain exogenous and endogenous variables. In the neoclassical growth model, technological progress and labor growth are exogenous, inward foreign direct investment (FDI) merely increases the investment rate, leading to a transitional increase in per capita income growth but has no long-run growth effect. The new growth theory in the 1980s endogenizes technological progress and FDI has been considered to have permanent growth effect in the host country through technology transfer and spillover (Hsiao & Hsiao, 2019; UNCTAD, 2006). In empirical analysis, the policy of outward orientation is generally measured by exports (Greenaway & Morgan, 1998). As such, the topic of exports-growth nexus has been a subject of extensive debate since the 1960s, as can be seen from a recent comprehensive survey of more than 150 papers by Giles and Williams (2020). They found surprisingly that there is no obvious agreement to whether the causality dictates export-led-growth or growth-led-exports, although the early cross-section studies favor the former. A number of studies have investigated the correlates of maternal and infant mortality outcomes. These correlates range from distal factors, such as the level of national income suggest that per capita income is an important determinant of child and maternal mortalities globally (Grepin & Klugman, 2013) and regionally.

The major stake holder are policy makers, normal people, and large families. This research opens the avenues for policy makers to make effective policies for economic growth by looking at the results of our findings. This would help normal people and large families to make decisions for family planning, so they can save their income for their future and economic welfare.

The rest of this paper is structured as follows. Section 2 discusses how our work relates to the previous literature. Section 3 discusses the baseline and alternative fertility scenarios we consider and shows how the dynamic paths of population size and age structure differ between them. Section 4 presents the economic model and discusses our choice of base case parameters. Section 5 presents simulation results for the base case model, discusses the sensitivity of results to altering our parameter assumptions, and presents a decomposition of the effects of fertility on output via different channels. Section 6 looks more deeply at different choices regarding the fertility rate and how they interact with demographic change. Section 7 would be conclusion.

2. Literature Review

2.1 Historical Background

From decades, researchers, scientists, economists, and researchers trying to find the relationship between fertility, population growth and GDP per capita. At present plethora of research is available on this topic which is helpful for future and present findings. Some studies show the negative relationships between population growth and GDP per capita but most of the studies shows the positive relationships between them.

The decision to have a child can be a costly decision. So, is there any reason to suppose that financial factors play a part in determining whether or not to have children?

In nations with a GDP per capita of less than $1,000 per year, women in particular are more likely to have three children. Women in nations with a GDP per capita of more than $10,000 per year are more likely to have two children.

Economists and demographers alike are aware of the decreasing relationship between fertility and income. Furthermore, it stays true throughout time: prosperous nations, such as the United States, have seen a significant drop in their fertility rate as they become wealthier. Furthermore, the association stays true at the individual level, with wealthier families having fewer children than poor families.

Why is fertility so much higher in poor countries? There are several possible reasons:

- In under develop countries, time is generally cheap, thus taking time off work to care for a child is not as expensive as it would be in a wealthy country. If this impact is large enough,it can (and presumably does) compensate for the fact that raising a child on a low income is tough.
- In a developed nation, a youngster may need more schooling to succeed. As a result, a kid may be more expensive there, prompting families to choose for fewer, better educated children.
- Infant mortality may be a factor. When infant mortality is high, as it is in developing nations, more births may be required to reach the necessary number of surviving children.

- When parents get older, children can take care of them. However, in developed nations with well-developed social security systems and functioning financial markets, this is unnecessary.

Population explosion is a major issue for developing nations because four fifth (7.7billion world's population, 6.1 living in developing) of the world's population are living in developing countries and it has adverse effects on economy. One of the major reasons for this explosion is increase in birth rate because these countries have lack of resources and awareness programs to control birth rate. On an average 6 to 8 birth per female in these countries as compare to developed countries has average 2 birth per female because use of contraceptive is high in developed countries. For example, in 1960 Thailand has 40% population less than age 15 and an average 6 to 8 child per female were accounted. But after that they create an awareness to use of contraceptives and birth fell to 2 child per female in 1990s.

Pakistan is a developing country having 212million population with 2.2% population growth rate due to high fertility or birth rate and less use of contraceptives to control pregnancy. It has 2.86 total fertility rate, 29.8 birth/ 1000 population crude birth rate and 7.5 death/ 1000 population crude death rate. Also, it has 48% unintended pregnancies, 54% unintended pregnancies aborted, 30% post abortion complication rate and 6000+ abortions per day due to less use of contraceptives according to 2014 report. This fast pace population growth has threat to Pakistan socially and economically. With this growth rate Pakistan would unable to attain economic goals because half of the population are live on $2 a day and it needs to slow down the population growth rate. Population growth is threat to developing countries as diarrhea is deadly for children.

2.2 Theoretical Literature

According to (Malthus, 1798), population increase at the rate of geometric progression and it is doubled after every twenty-five years, if it is unchecked but food or natural resources increase only at linear rate. As a result, population overrun the food supply which leads to the shortage of food and leads to overpopulation.

Malthus theory was criticized during late 19th and early 20th because it was not proved empirically. He ignored the technological sector which contribute to the new food processing techniques and modern population control measures i.e., contraceptives or government policies to control fertility rate. It is later evident that population growth was stable and food increased at geometric progression.

2.2.1 Classical Growth Theory

According to classical growth theory, the economic growth will decrease as population growth increases with scares resources. This is a consequence of classical growth theory economists' assumption that a transitory boost in real GDP per person will ultimately lead to a population explosion, limiting a country's resources and, as a result, reducing real GDP. As a result, the economy of the country will begin to slow.

A stagnant situation is one in which wages and total production are equal and no surplus may be produced. Classical economics, on the other hand, believe that as technology advances, the production function will shift higher. Economic stagnation can also be postponed, but not prevented, according to the Classical Growth Theory.

The classical growth model overlooks the importance of efficient technological improvement in the smooth operation of an economy. Technology advancements can help to mitigate declining returns.

The classical growth model posits that total earnings do not rise beyond or fall below the level of subsistence. This is not fully accurate, though. Total salaries might exceed or fall below the subsistence threshold as a result of changes in the industrial structure and significant economic development. Furthermore, the traditional theory of growth ignores the importance of trade unions in the wage-setting process.

2.2.2 Neoclassical Theory

The Neoclassical Growth Theory is an economic growth model that explains how three economic factors, labor, capital, and technology, interact to produce a stable pace of economic growth. The Solow-Swan Growth Model is the most basic and widely used variant of the Neoclassical Growth Model.

Short-term economic equilibrium, according to the theory, is the outcome of variable levels of labor and capital, both of which are critical in the production process. According to the thesis, technological development has a substantial impact on an economy's general functioning. The three variables required for a rising economy are outlined in neoclassical growth theory. The theory, on the other hand, emphasizes that transitory, or short-term equilibrium, differs from long-term equilibrium and does not necessitate any of the three components.

According to the Neoclassical Growth Model, capital accumulation in an economy, as well as how individuals utilize it, are essential factors in determining economic growth.

It also says that an economy's total production is determined by the interaction between capital and labor. Finally, the idea claims that technology boosts worker productivity, resulting in higher overall production due to increased labor efficiency. As a result, the neoclassical growth model's production function is used to assess an economy's economic growth and equilibrium. In the neoclassical growth model, the general production function looks like this:

“Y = AF (K, L)”

“Y – Income, or the economy’s Gross Domestic Product (GDP)”

“K – Capital”

“L – Amount of unskilled labor in the economy”

“A – Determinant level of technology”

The first two theories ignored the technological factors as they developed before industrial revolution but last neoclassical theory incorporated this factor and empirically proved.

2.3 Empirical Evidences

A number of studies followed Kuznets (1967)'s lead in looking at the relationship between population increase and other elements thought to be causes of income growth. Kelley (1988), for example, discovered no link between population increase and per capita income growth, as well as no link between population growth and saving rates. He found, after reviewing a number of other research, that the evidence for a detrimental impact of population expansion on economic development was poor or nonexistent.

Many studies of the impact of population on economic results have followed the growth regression paradigm popularized by Barro (1991) and Mankiw, Romer, and Weil since the early 1990s (1992). Right-hand side variables in these regressions contain terms representing population growth, labor force growth, and dependence ratios. Kelley and Schmidt (2005), for example, regress the growth rate of income per capita on the growth rates of the total population and the working-age population, taking into account both Solow effects (capital stock dilution due to rapid expansion in the number of employees) and dependency effects. The demographic terms are shown to be quantitatively significant. More particular, their regression accounts for almost 20% of the average gain in per capita income from 1960 to 1995. Bloom and Canning (2008) found a positive and significant coefficient when they regressed the growth rate of income per capita on the growth rate of the working-age percentage of the population (along with conventional controls). They regard this as evidence of the economic benefits of reduced fertility since rapid growth of the working-age fraction follows mechanically from fertility decreases.

Coale and Hoover (1958), who set out to explore the effect of changing fertility in India, are the philosophical forerunners of present economic-demographic models. They begin by estimating India's population under three different exogenous fertility scenarios: high (stable at 1951 levels), medium (declining 50% between 1966 and 1981), and low (declining 50% between 1956 and 1981). In their model, total population in 1986 is 22% higher in the high fertility scenario than in the medium fertility scenario, and 7% lower in the low fertility scenario than in the medium fertility scenario. The authors assume that there is an exogenous incremental capital-output ratio that is invariant to investment and population in terms of production (there is no human capital or land in the production function). Their findings show that, over a 30-year time horizon, income per capita in the low fertility scenario is 15% higher and income per capita in the high fertility scenario is 23% lower than in the medium fertility scenario. The main driver of their findings is capital accumulation: with fast population growth, a high dependency ratio has a negativeinfluence on saving rates, which in turn has a negative impact on investment and growth. It's worthnoting that the model sees child educational and health spending as consumption rather than investment.

Denton and Spencer have adopted a clearly more modern production model (1973). They employ a neoclassical production function that permits capital and labor marginal products to change according to the capital-labor ratio. Fertility and death rates are considered exogenous variables (Denton Frank T, 1973). Capital accumulation (with saving as a fixed percentage of disposable income) and age-specific labour supply are included in the model. The model is based on Canadian data and is used to assess the overall effects of changes in the fertility path.

According to (Simon, 1976), social overhead capital increases as the population grows, allowing for production economies of scale (specifically, better road networks that facilitate more efficient production). Similarly, technical change in the industrial sector is influenced by the population's overall size. The model, unlike (Enke, 1971), has a clear labor-leisure choice as well as discrete agricultural and industrial sectors. Simon (1976) finds that, over the first 60 years of the simulation, maintaining a steady population size leads to higher income per capita than increasing population, though the difference is smaller.

The National Research Council (1986) is frequently cited as the standard-bearer of the revisionist viewpoint that fertility change has a minor impact on economic development. However, over the previous decade, the pendulum has swung back in the opposite direction. Kohler (2021) begins by noting that, while the majority of the world's population now lives in countries where fertility has fallen below the replacement rate, there are still large areas of the globe where fertility remains high – specifically, with an NRR of 1.5 and a population growth rate of 2.5 percent per year. He examines the degree to which ongoing high fertility or delayed fertility drops pose a threat to economic development in these places (as part of a broader cost-benefit analysis of actions aimed at lowering population growth). He devotes special attention to the perspectives of a new generation of population pessimists, such as Campbell and colleagues (2007). Resource scarcity, the demographic dividend from changes in population age structure, and the effects of population size on innovation are all discussed in Kohler's (2012) examination of the various pathways via which population affects economic results. His obviously sloppy conclusion is that in today's high-fertility countries, a one percent drop in population growth per year would result in a one percent gain in income per capita growth per year. At bottom, there is little fundamental dispute on the subject, finds another recent synthesis of current studies (Das , Bongaarts , & Cleland , 2011). There is widespread agreement that growth-friendly policy settings are the primary drivers of economic growth, with population size and structure playing a secondary role in enabling or inhibiting growth." Sindig (2009) examines the present literature and finds a growing consensus that, while not a sufficient condition for economic growth, it may well be a necessary one.

3. Theoretical framework

3.1 Data

Panel data will be used to access impacts of fertility on growth per capita from last 40 years. The sample population consists of household individuals who are married, both males and females, and other members are excluded from this study. we will also see the impacts of fertility in developed and under developed countries to draw the comparison and will see that how policies are effective in developed nation. This could help us to make efficient policies which could decrease the fertility rate. Our main focus on rural areas of Punjab because previous literature proved that high fertility rate in rural areas as compare to urban because of lack of awareness and contraceptives use.

Data source is secondary that would be collected World Bank or WDI which will enrich of demographic variables that would be sufficient for our research. It is quantitative in nature that would be measured impacts of fertility on GDP/C and use of contraceptives to control the fertility rate. It is non-contrived study that would be conducted in natural environment without any disruption or interference. Hence, this study would be conducted in minimal interference environment.

3.2 Empirical estimation

This research is aim to analyze empirically impacts of fertility on growth and how use of contraceptive to control fertility. The dependent variable is GDP per capita “GDP per capita is gross domestic product divided by midyear population” (world Bank). Plethora of research has been conducted on population growth and economic growth. Some empirically proved that these two variables have inverse relationship while some finds that there are direct relationships. But these relationships depend on country to country.

The regression model equation for this research is:

$$GDP/capita_{i,t}=\beta_0 + \beta_1(fertility)_{i,t} + \beta_2(infant\ mortality)_{i,t} + \beta_3(PG)_{i,t} + \beta_4(exports)_{i,t} + \beta_5(FDI)_{i,t} + \beta_6(Imports)_{i,t} + \beta_7(PSE) + e_{i,t}$$

Variables	**Abbreviation**
GDP per capita	GDP/C(+/-)
Fertility rate	Frt(-)
Infant mortality	Ifmt(-)
Population growth	PG(-/+)
Exports	Expts(+)
FDI	Fdi(+)
Imports	IMP(-)
Primary School Enrolment	PSE(+)

The popg represent the population growth that is “annual average rate of change of population size, for a given country, territory, or geographic area, during a specified period” (World Bank) and expected sign would be negative because as population increases, the gdp/c will go down, subscript frt represent the fertility “the average number of children a hypothetical cohort of women would have at the end of their reproductive period if they were subject during their whole lives to the fertility rates of a given period and if they were not subject to mortality”, imft means infant mortality “probability of a child born in a specific year or period dying before reaching the age of one”, umpt represent the unemployment “the share of the labor force that is without work but available for and seeking employment”, FDI represent the foreign direct investments “net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor”, and ltrcy represent the literacy rate “ the percentage of the population of a given age group that can read and write”.

The above all definitions of independent variables are taken from world Bank, WHO, and UNESCO for accuracy measurements.

David, Quamrul, and Juashu (2013) concluded that reduced fertility is seen by a significant portion of the academic community as an essential contributor to economic progress but they could not find any significant relationship between fertility and gdp or income per capita.”

“Kuznets's examination of the relationship between population growth and development is the most well-known early aggregate analysis (1967). In contrast to popular belief at the time, his research discovered a positive correlation between population increase and per capita income within large country groups, which he took as proof of the lack of a negative causal influence of population expansion on income growth. Bloom and Canning (2008) found a positive and significant coefficient when they regressed the growth rate of income per capita on the growth rate of the working-age percentage of the population (along with conventional controls). They regard this as evidence of the economic benefits of reduced fertility since rapid growth of the working-age fraction follows mechanically from fertility decreases.

Adolescent fertility is positively correlated with higher maternal (Blanc, Winfrey, & Ross, 2013) and infant mortality rates (Chen et al.,2007; Hajizadeh, Nando, & Heymann, 2014), although estimates of the size of the increased risk vary greatly (Nove, Matthews, Neal, & Camacho, 2014). The WHO identified the presence of a skilled birth attendant as a significant factor in reducing maternal mortality (Betran, Wojdyla, Posner, & Gülmezoglu, 2005). A 2018 study of 47 Muslim-majority countries found that skilled birth attendants had a significant positive impact on rates of infant mortality (Akseer et al., 2018).

3.3 Hypothesis

The below hypothesis will be tested in this research paper to find whether there is exists significant relationship between GDP/C and fertility rate; If inverse or direct.

Null hypothesis

Ho: fertility rate does not affect on GDP/C

$$H_0: \beta_2 = 0$$

Alternate hypothesis

H1: Fertility rate does effects on GDP/C

$$H_1: \beta_2 \neq 0$$

4. Data Descriptive

4.1 Data Summary

We will see the regression that we will going to run to see the impact of population growth on GDP. The data I took from Worldbank.org for all variables which include population growth, primary school enrollment, exports, imports, infant mortality, GDP growth rate and FDI.

Table 1

Variables and their respective source

Variables	*Sources*
GDP per capita	World Bank Database
Primary School Enrolment	IMF Database
Infant Mortality Rate	World Bank Database
Population Growth	World Bank Database
FDI	World Bank Database
Imports	World Bank Database
Exports	World Bank Database

4.2 Correlations

Table 2
Matrix of correlation Overall

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) GDP-growth	1.000							
(2) PSE	0.024	1.000						
(3) Exports	0.026	-0.070	1.000					
(4) Imports	0.043	-0.032	0.914	1.000				
(5) Fertility rate	0.204	0.120	-0.303	-0.294	1.000			
(6) FDI	0.024	-0.001	0.319	0.382	-0.082	1.000		
(7) PG	0.126	0.084	0.055	-0.092	0.618	-0.053	1.000	
(8) IMR	0.267	-0.022	-0.367	-0.316	0.861	-0.069	0.412	1.000

Table 1 shows the overall matrix between all the variables concerned with the regression and shows that for overall data GDP is positively correlated with all variables except exports and imports however the relation is weakly negative moreover population growth rate and fertility rate are positively related implying they move in the same direction and exports is negatively correlated with GDP growth, FDI is also negatively correlated with GDP growth rate.

Table 3
Matrix of correlations Developed

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) GDP growth	1.000							
(2) PSE	-0.002	1.000						
(3) Exports	0.215	-0.138	1.000					
(4) Imports	0.179	-0.123	0.950	1.000				
(5) Fertility rate	0.214	-0.002	-0.017	-0.160	1.000			
(6) FDI	0.053	-0.025	0.340	0.408	-0.125	1.000		
(7) PG	0.188	-0.102	0.296	0.127	0.589	-0.028	1.000	
(8) IMR	0.282	0.061	0.018	0.010	0.447	-0.020	0.197	1.000

Table 2 Shows the correlation between GDP growth has a positive correlation with all of independent variables except for developed countries includes in the regression equation except PSE (primary school enrollment) and it shows a weak negative relationship between GDP growth and PSE which elaborates that both variables move in opposite direction.

Fertility rate and PG (population growth) have a strong positive correlation. Now if we examine the relationship between the major independent variable PG, it shows a positive correlation, according to which they both move in same direction note that the population growth here indicates is reduction in value of PG implying that as countries become less populated as PG value-decreases.

Table 4
Matrix of correlations Developing

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) GDP growth	1.000							
(2) PSE	0.016	1.000						
(3) Exports	-0.039	-0.009	1.000					
(4) Imports	-0.043	0.050	0.834	1.000				
(5) Fertility rate	0.051	0.125	-0.376	-0.448	1.000			
(6) FDI	0.120	0.136	0.386	0.523	-0.199	1.000		
(7) PG	-0.012	0.167	-0.182	-0.388	0.757	-0.279	1.000	
(8) IMR	0.136	-0.085	-0.524	-0.575	0.818	-0.269	0.513	1.000

Table 3 shows the correlation between GDP growth and its independent variables for developing countries, it shows a weak positive relation between GDP and PSE (primary school enrollment) implying as countries become less educated, the GDP decreases, however relation between GDP and population growth is negative which asserts that an increase the population for developing countries is negatively related with GDP. However, an interesting fact is that as fertility rate is negatively correlated with FDI this could be due to the risk associated with higher interest rates as countries risk increases the interest rate increases hence foreign direct investments in such risky countries fall.

4.2 Summary Statistics

Table 5
Overall data summary statistics

Variable	Mean	Std.Dev.	Min	Max	Observations		
PSE							
overall	103.011	8.893	70.791	149.308	N	=	1050
between		7.033	82.541	135.227	n	=	50
within		5.529	69.269	125.484	T	=	21
Exports							
overall	39.494	24.098	8.257	163.12	N	=	1050
between		23.254	11.493	136.512	n	=	50
within		7.092	6.109	69.523	T	=	21
Imports							
overall	39.298	21.334	10.273	159.557	N	=	1050
between		20.678	14.866	133.627	n	=	50
within		5.977	9.029	65.228	T	=	21
Fertility							
overall	2.349	1.164	1.078	6.866	N	=	1050
between		1.151	1.312	5.978	n	=	50
within		0.237	1.195	3.321	T	=	21
GDP-growth							
overall	3.33	4.031	-17.945	19.681	N	=	1050
between		1.826	-0.104	8.697	n	=	50
within		3.602	-19.38	18.848	T	=	21
FDI							
overall	5.138	22.444	-40.291	449.083	N	=	1050
between		12.469	0.446	90.099	n	=	50
within		18.741	-96.096	364.122	T	=	21
PG							
overall	1.194	1.303	-2.171	7.776	N	=	1050
between		1.189	-0.805	4.682	n	=	50
within		0.558	-2.334	4.651	T	=	21
IMR							
overall	18.444	19.912	1.9	110	N	=	1050
between		19.233	2.579	87.802	n	=	50
within		5.798	-1.994	52.006	T	=	21

Table 1a shows the summary statistics for the entire data consisting of both developed and developing countries. There are a total of 1050 observations (N=1050), 50 countries (n=50) and 21 time periods (T=21). The mean annual percentage growth rate of GDP growth is 3.30 percent whilst the minimum is -17.94 percent, maximum is 19.68 percent and standard deviation is 4.031 percent. Between countries, the minimum *GDP Growth* is -0.104 percent, maximum is 8.69 percent and standard deviation is 1.82 percent. Within time periods, the minimum *GDP growth* is -19.38 percent, maximum is 18.84 percent and standard deviation is 3.602 percent. The mean primary school enrollment as percentage of PSE is 103.011 percent whilst the minimum is 70.79 percent, maximum is 149.30 percent and standard deviation is 8.89 percent which implies that values of PSE deviate 8.89 times from mean. Between countries, the minimum *PSE* is 82.54 percent, maximum is 135.22 percent and standard deviation is 7.033 percent. Within time periods, the minimum *PSE* is 69.269 percent, maximum is 125.48 percent and standard deviation is 5.529 percent. The mean exports as percentage of GDP is 39.49 percent whilst the minimum is 8.257 percent, maximum is 163.12 percent and standard deviation is 24.098. Between countries, the minimum *Exports* is 11.49, maximum is 136.512 and standard deviation is 23.25. Within time periods, the minimum *Exports* is 6.109, maximum is 69.52 and standard deviation is 5.092. The mean imports as percentage of GDP is 39.29 whilst the minimum is 10.27, maximum is 159.55 and standard deviation is 21.33. Between countries, the minimum *Imports* is 14.866, maximum is 133.62 and standard deviation is 20.67. Within time periods, the minimum *Imports* is 9.029, maximum is 65.22 and standard deviation is 5.977. The mean value for fertility rate is 2.349 whilst the minimum is 1.078, maximum is 6.866 and standard deviation is 1.164. Between countries, the minimum *Fertlilty rate* is 1.312, maximum is 5.978 and standard deviation is 1.151. Within time periods, the minimum *FR* is 1.19, maximum is 3.321 and standard deviation is 0.237. The mean for net foreign direct investment (*FDI*) is USD 5.137 whilst the minimum is USD -40.291, maximum is USD 449.083 and standard deviation is 5.138. Between countries, the minimum *FDI* is USD 0.446, maximum is USD 90.099 and standard deviation is 12.469

Table 6
Developing Summary

Variable	Mean	Std.Dev.	Min	Max	Observations		
PSE							
overall	103.494	11.233	70.791	149.308	N	=	525
between		9.066	82.541	135.22	n	=	25
within		6.864	69.752	125.967	T	=	21
Exports							
overall	32.803	16.738	8.257	86.604	N	=	525
between		15.722	12.266	70.565	n	=	25
within		6.513	13.221	51.844	T	=	21
Imports							
overall	36.211	15.429	10.666	88.609	N	=	525
between		14.454	15.626	71.274	n	=	25
within		6.092	5.941	60.081	T	=	21
Fertility rate							
overall	2.975	1.343	1.078	6.866	N	=	525
between		1.334	1.336	5.978	n	=	25
within		0.307	1.821	3.946	T	=	21
GDP-growth							
overall	4.418	4.074	-17.945	15.329	N	=	525
between		1.587	1.581	8.697	n	=	25
within		3.765	-18.292	14.439	T	=	21
FDI							
overall	3.562	3.51	-3.175	31.247	N	=	525
between		2.431	0.895	8.352	n	=	25
within		2.577	-7.593	26.718	T	=	21
PG							
overall	1.427	1.301	-2.171	7.35	N	=	525
between		1.236	-0.805	3.893	n	=	25
within		0.473	-1.887	4.884	T	=	21
IMR							
overall	30.475	22.033	1.9	110	N	=	525
between		20.942	4.219	87.802	n	=	25
within		7.977	10.037	64.037	T	=	21

Table 5 shows the summary statistics for the entire data consisting of developing countries. There are a total of 525 observations (N=1050), 25 countries (n=25) and 21 time periods (T=21). The mean annual percentage growth rate of GDP growth is 4.418 whilst the minimum is -17.94, maximum is 15.329 and standard deviation is 4.074. Between countries, the minimum *GDP Growth* is 1.581, maximum is 8.697 and standard deviation is 1.587. Within time periods, the minimum *GDP growth* is -18.29, maximum is 14.43 and standard deviation is 3.76. The mean primary school enrollment as percentage of PSE is 103.49 whilst the minimum is 70.79, maximum is 149.038 and standard deviation is 9.066 which implies that values of PSE deviate 9.066 times from mean. Between countries, the minimum *PSE* is 82.54 percent, maximum is 135.22 percent and standard deviation is 7.033 percent. Within time periods, the minimum *PSE* is 69.269 percent, maximum is 125.48 percent and standard deviation is 5.529 percent. The mean exports as percentage of GDP is 39.49 percent whilst the minimum is 8.257 percent, maximum is 163.12 percent and standard deviation is 24.098. Between countries, the minimum *Exports* is 11.49, maximum is 136.512 and standard deviation is 23.25. Within time periods, the minimum *Exports* is 6.109, maximum is 69.52 and standard deviation is 5.092. The mean imports as percentage of GDP is 39.29 whilst the minimum is 10.27, maximum is 159.55 and standard deviation is 21.33. Between countries, the minimum *Imports* is 14.866, maximum is 133.62 and standard deviation is 20.67. Within time periods, the minimum *Imports* is 9.029, maximum is 65.22 and standard deviation is 5.977. The mean value for fertility rate is 2.349 whilst the minimum is 1.078, maximum is 6.866 and standard deviation is 1.164. Between countries, the minimum *Fertlilty rate* is 1.312, maximum is 5.978 and standard deviation is 1.151. Within time periods, the minimum *FR* is 1.19, maximum is 3.321 and standard deviation is 0.237. The mean for net foreign direct investment (*FDI*) is USD 5.137 whilst the minimum is USD -40.291, maximum is USD 449.083 and standard deviation is 5.138. Between countries, the minimum *FDI* is USD 0.446, maximum is USD 90.099 and standard deviation is 12.469

Table 7
Developed Summary

Variable	*Mean*	*Std.Dev.*	*Min*	*Max*	*Observations*		
PSE							
overall	102.528	5.629	87.283	128.643	N	=	525
between		4.278	96.9	114.112	n	=	25
within		3.753	87.666	120.876	T	=	21
Exports							
overall	46.185	28.155	9.034	163.12	N	=	525
between		27.633	11.493	136.512	n	=	25
within		7.634	12.8	76.214	T	=	21
Imports							
overall	42.386	25.573	10.273	159.557	N	=	525
between		25.38	14.866	133.627	n	=	25
within		5.866	18.279	68.315	T	=	21
Fertility rate							
overall	1.723	0.353	1.1	2.845	N	=	525
between		0.333	1.312	2.362	n	=	25
within		0.135	1.246	2.291	T	=	21
GDP growth							
overall	2.242	3.682	-14.895	19.681	N	=	525
between		1.352	-0.104	4.79	n	=	25
within		3.435	-15.826	17.761	T	=	21
FDI							
overall	6.713	31.482	-40.291	449.083	N	=	525
between		17.502	0.446	90.099	n	=	25
within		26.391	-94.521	365.697	T	=	21
PG							
overall	0.961	1.265	-1.854	7.776	N	=	525
between		1.117	-0.232	4.682	n	=	25
within		0.632	-2.567	4.055	T	=	21
IMR							
overall	6.414	4.273	1.9	31.4	N	=	525
between		3.894	2.579	17.219	n	=	25
within		1.918	-2.205	20.595	T	=	21

Table 6 shows the summary statistics for the entire data consisting of developed countries. There are a total of 525 observations (N=1050), 25 countries (n=25) and 21 time periods (T=21). The mean annual percentage growth rate of GDP growth is 4.418 whilst the minimum is -17.94, maximum is 15.329 and standard deviation is 4.074. Between countries, the minimum *GDP Growth* is 1.581, maximum is 8.697 and standard deviation is 1.587. Within time periods, the minimum *GDP growth* is -18.29, maximum is 14.43 and standard deviation is 3.76. The mean primary school enrollment as percentage of PSE is 103.49 whilst the minimum is 70.79, maximum is 149.038 and standard deviation is 9.066 which implies that values of PSE deviate 9.066 times from mean. Between countries, the minimum *PSE* is 82.54 percent, maximum is 135.22 percent and standard deviation is 7.033 percent. Within time periods, the minimum *PSE* is 69.269 percent, maximum is 125.48 percent and standard deviation is 5.529 percent. The mean exports as percentage of GDP are 39.49 percent whilst the minimum is 8.257 percent, maximum is 163.12 percent and standard deviation is 24.098. Between countries, the minimum *Exports* is 11.49, maximum is 136.512 and standard deviation is 23.25. Within time periods, the minimum *Exports* is 6.109, maximum is 69.52 and standard deviation is 5.092. The mean imports as percentage of GDP are 39.29 whilst the minimum is 10.27, maximum is 159.55 and standard deviation is 21.33. Between countries, the minimum *Imports* is 14.866, maximum is 133.62 and standard deviation is 20.67. Within time periods, the minimum *Imports* is 9.029, maximum is 65.22 and standard deviation is 5.977. The mean value for fertility rate is 2.349 whilst the minimum is 1.078, maximum is 6.866 and standard deviation is 1.164. Between countries, the minimum *Fertlilty rate* is 1.312, maximum is 5.978 and standard deviation is 1.151. Within time periods, the minimum *FR* is 1.19, maximum is 3.321 and standard deviation is 0.237. The mean for net foreign direct investment (*FDI*) is USD 5.137 whilst the minimum is USD -40.291, maximum is USD 449.083 and standard deviation is 5.138. Between countries, the minimum *FDI* is USD 0.446, maximum is USD 90.099 and standard deviation is 12.469.

4.4 Comparison

Comparing developed and developing countries, it can be seen that the average value of GDP growth rate is lower for the developed countries which usually the case is. It is 2.42 for developed countries and 4.97 for developing countries. The range of values for developed countries is smaller (-17.806 to 15.12) compared to developed countries (-14.287 to 19.40). Standard deviation for between the countries is lower for developed countries as compared to developing countries implying less variation for developed countries and the range has narrowed. Similar is the case for within the time frame. Population growth has higher mean for under developed economies (1.96) compared to developed countries (0.96). The standard deviation for between the countries for under developed economies is higher compared to developed countries and the range has widened for developed countries compared to developed countries. Similar is the case for within the time frame. Primary school enrollment (PSE) has a higher mean for developed countries (102.52) compared to developing countries (103.43), however the difference is small. The standard deviation for developing countries is higher compared to develop countries for between the countries and within the time frame. The range is lower for developing countries compared to developing countries. Exports also has higher mean value for developed countries (46.75) compared to developing countries (32.24). The standard deviation for developed countries is lower compared to developing countries for between the countries and within the time frame. The range is narrower for developed countries compared to developing countries. FDI has greater average value for developed countries (6.71) compared to developing countries (3.157), the difference is 50%. The standard deviation for developed countries is lower compared to developing countries for between the countries and within the time frame and the range has narrowed for developed compared to developing countries.

4.5 Two sample t-test with equal variance

Table 7
Mean comparison T-Test

	obs1	***obs2***	***Mean1***	***Mean2***	***dif***	***St Err***	***t value***	***p value***
PSE	**525**	**525**	**103.494**	**102.528**	**.966**	**.548**	**1.75**	**.079**
Exports	**525**	**525**	**32.803**	**46.185**	**-13.382**	**1.43**	**-9.35**	**0**
Imports	**525**	**525**	**36.211**	**42.386**	**-6.175**	**1.304**	**-4.75**	**0**
Fertility rate	**525**	**525**	**2.974**	**1.723**	**1.252**	**.06**	**20.65**	**0**
GDP growth	**525**	**525**	**4.418**	**2.242**	**2.176**	**.24**	**9.1**	**0**
FDI	**525**	**525**	**3.563**	**6.713**	**-3.151**	**1.383**	**-2.3**	**.023**
PG	**525**	**525**	**1.427**	**.961**	**.466**	**.079**	**5.9**	**0**
IMR	**525**	**525**	**30.475**	**6.414**	**24.061**	**.98**	**24.55**	**0**

Table 7 shows the mean difference test between developed and developing countries for 525 observations each; it shows that the T-values except primary school enrollment are all significantly different from zero between the two countries. Such as for PG it is significant with T-value of 5.9,gdp growth, FDI, infant mortality rate, imports and exports: the results are highly significant at 5% level of significant hence we reject the null hypothesis and accept that these variable differ across the developed and developing countries especially IMR that are highly significant with t-value of 24.55 except PSE which does not show a significant with t value of 1.75 and difference implying both developed and developing countries experienced similar population growth.

5. Figures

Fig. 1

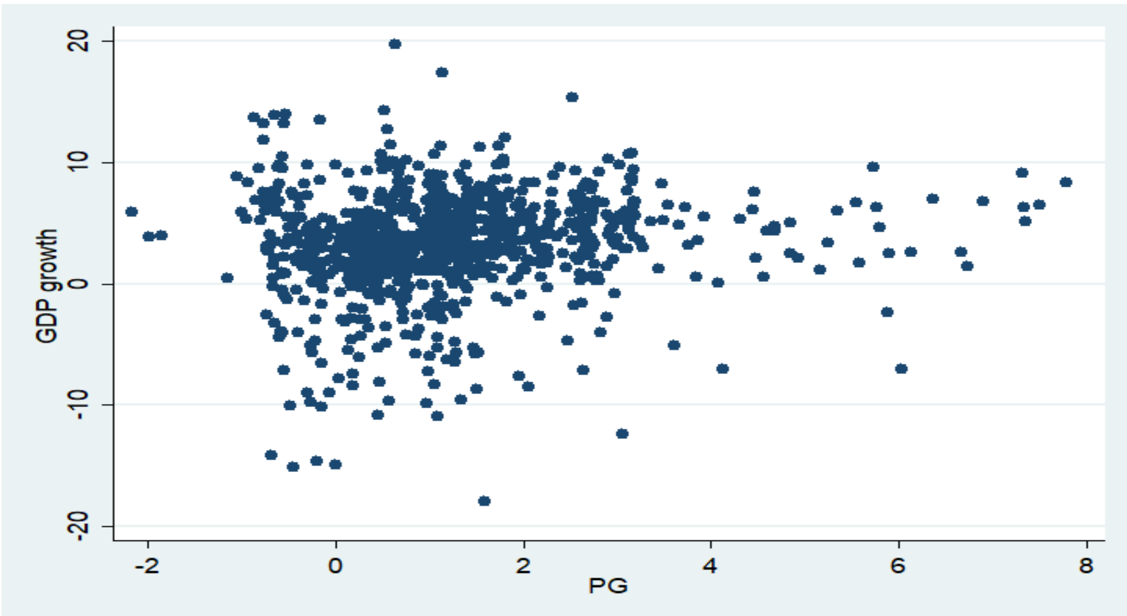

Fig. 1 shows the positive correlation between growth rate and population growth. As countries population increases the growth rate also increases at certain level but economic growth further not increases as population increases further.

Fig. 2

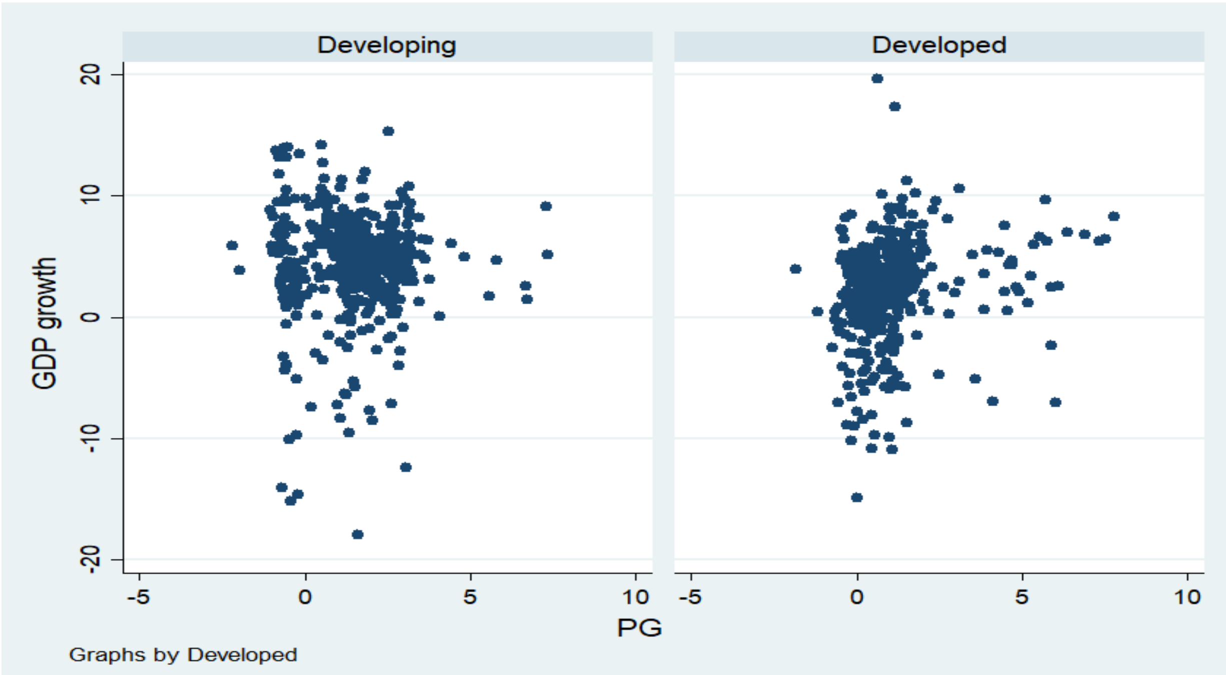

Fig 2 compares the relationship between GDP growth and population growth for developed and developing countries, developed countries follow the same trend the overall data but here we see a trend the countries that are highly developed which have very high growth rate and low population growth rate due to the presence of laws related to one child policy etc. Developing countries shows the higher population growth and less growth rate. In case of India and Pakistan, the population growth rate is way higher than USA and United Kingdom.

Fig. 3

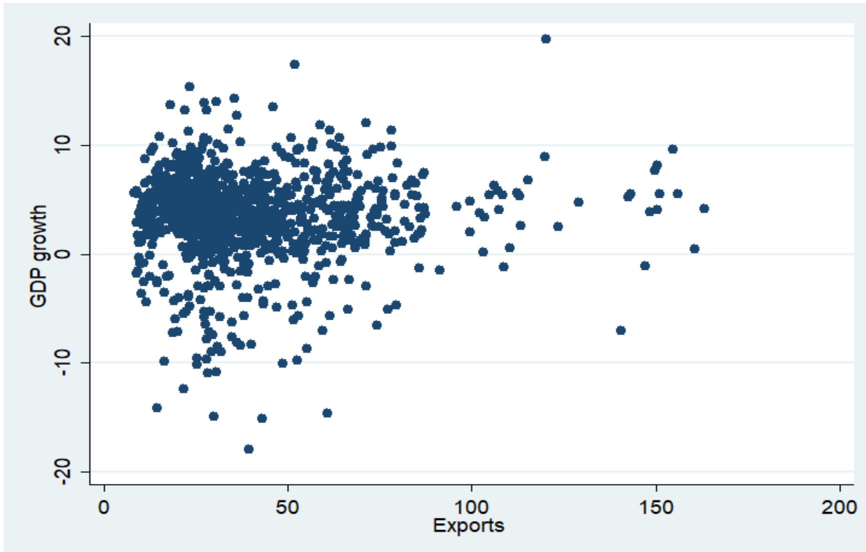

Fig. 3 shows the positive correlation between economic growth and exports. As we can see, exports increase the GDP growth also taking place. Those countries export more have higher growth rate as compare to less exports countries.

Fig. 4

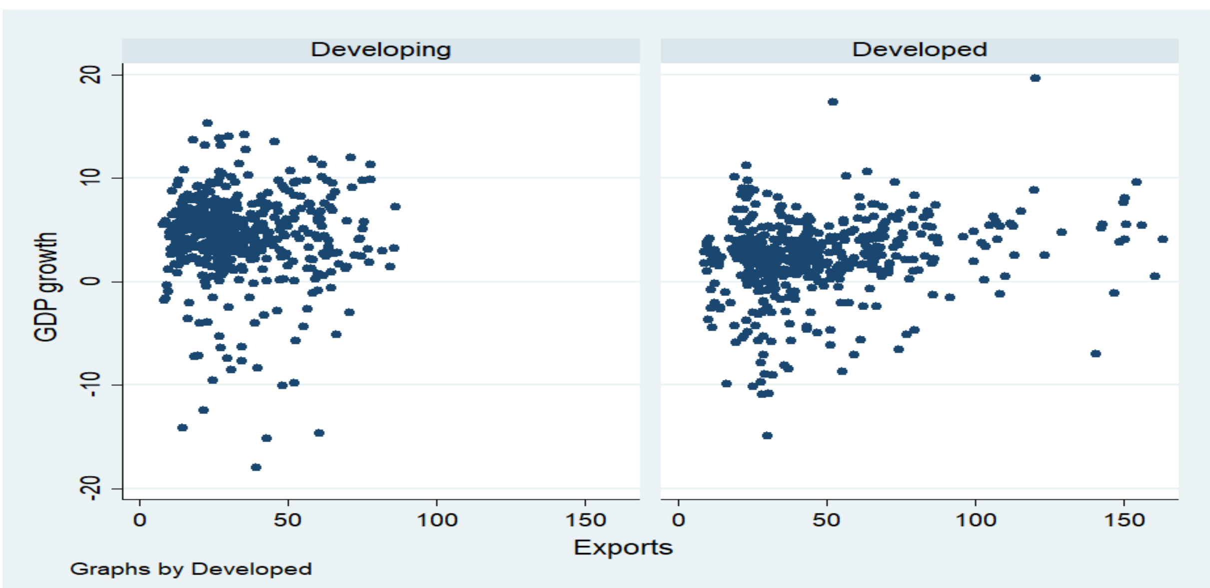

Fig. 4 shows the correlation between exports and imports for both developed and developing countries. Developing countries graph shows that growth is higher but exports are not much as compare to the developed countries. Developed countries have stable growth and highest number of exports which are further increasing.

Fig 5

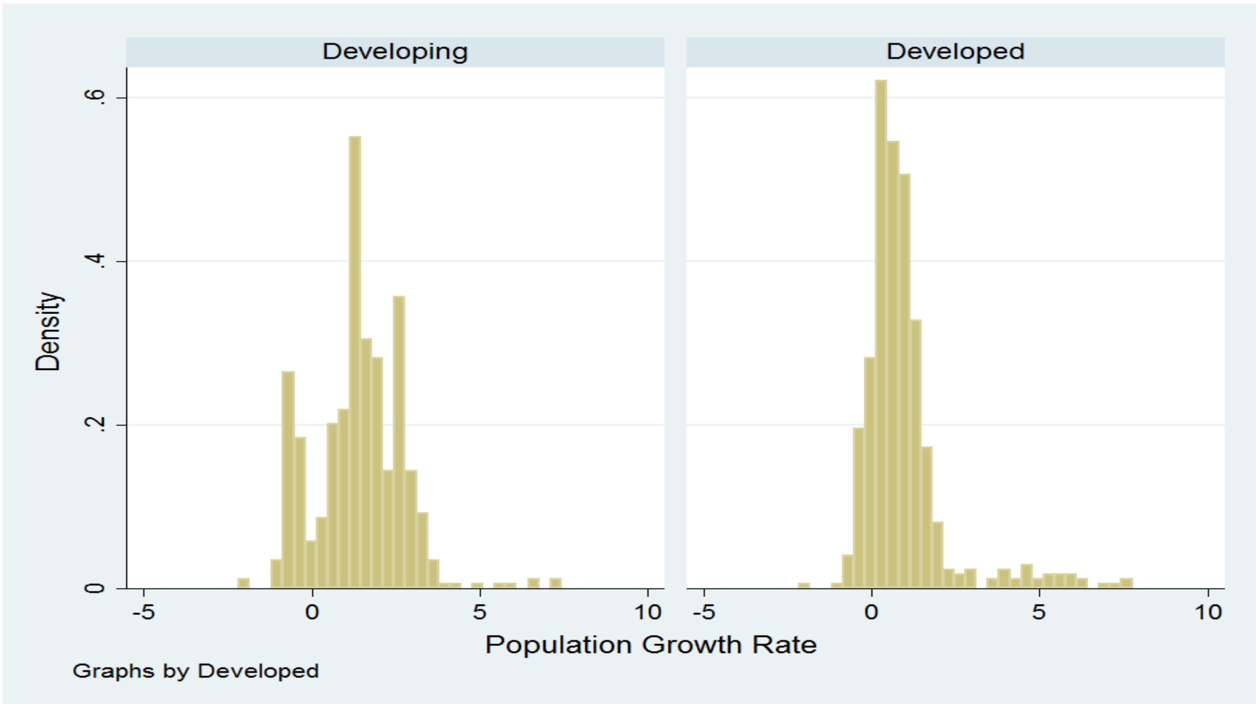

Fig 6 shows histogram for developed and developing countries. Developed countries lies in the index of 6-8 in their population growth, and the developing countries lie in the region 02 to 09 implying most of the developing countries experienced high level of population growth.

Fig. 6

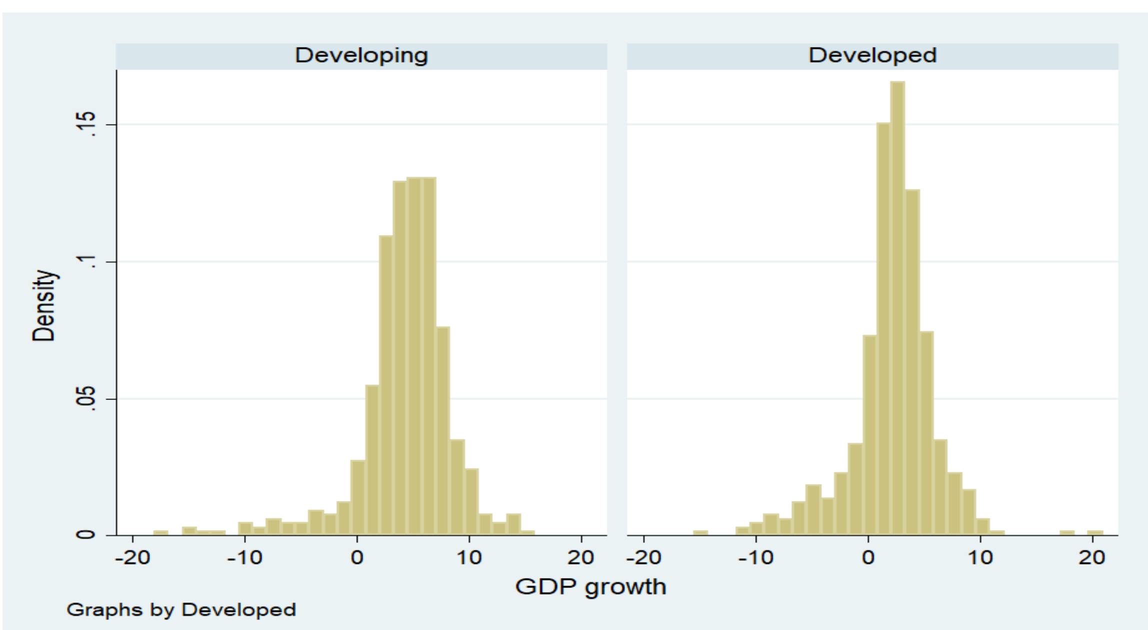

Fig. 6 shows the histogram of GDP growth rate for both developed and developing countries.

Developed countries shows the higher growth rate as its index lies between -15 to +20 and density is greater than 15 as compare to the developed countries.

Fig 7
GDP Growth Rate

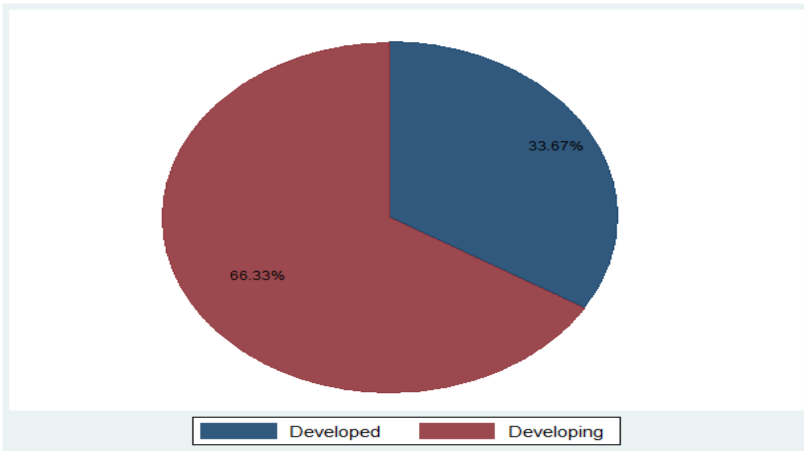

Fig 7 is a pie chart which shows majority of GDP growth is within developed countries which amounts to about 66.44% and developing countries it is 33.67%.

Fig 8
Population Growth

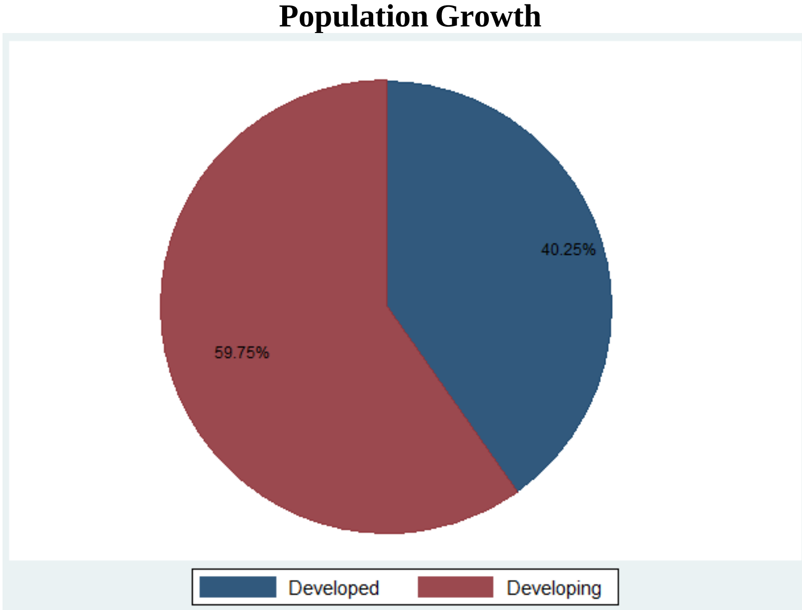

fig 8 shows the pie chart for population growth for developed vs developing countries and states that the data indicates that developed countries have lower population growth that developed countries the shares are 40.24% for developed and 59.75% for developing.

Fig 9
Infant Mortality Rate

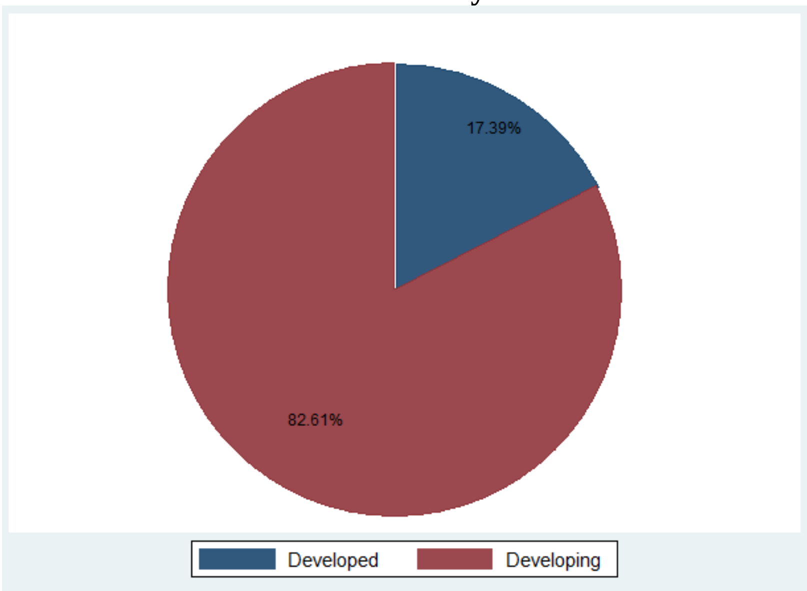

Fig 9 shows the pie chart for infant mortality rate for developed vs developing countries and states that the data indicates that developed countries have lower infant mortality rate due to the presence of better health and sanitation system that developed countries the shares are 17.39% for developed and 82.61% for developing due to poor healthcare system.

Fig 10
Primary School Enrollment

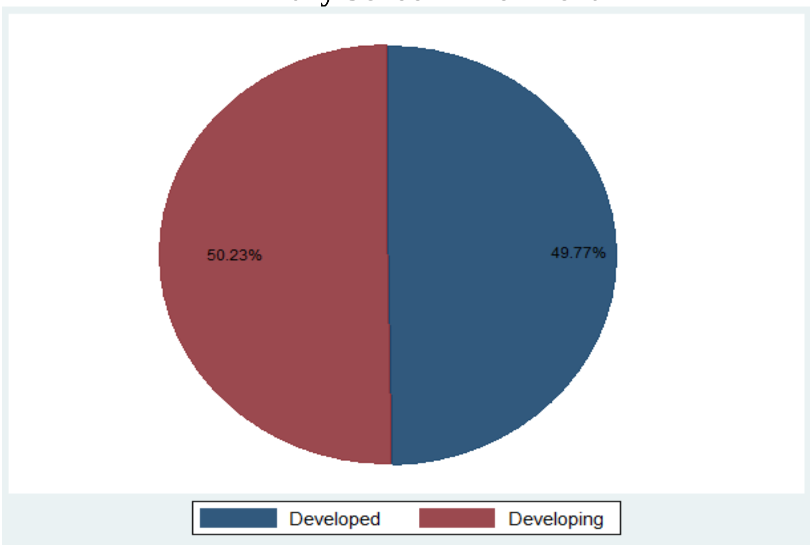

Fig. 10 shows the primary school enrollment for both developed and developing countries. Pie chart is equally divided because equal percentage of population get population education.

Fig 11
Exports

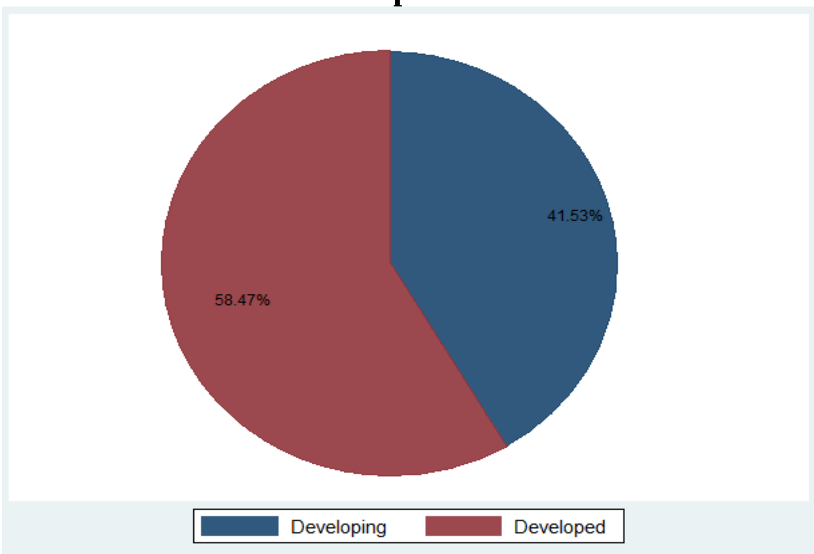

Fig. shows the percentage of exports for both developing and developed countries. Developed countries exports more as compare to developing countries.

Fig 12
Imports

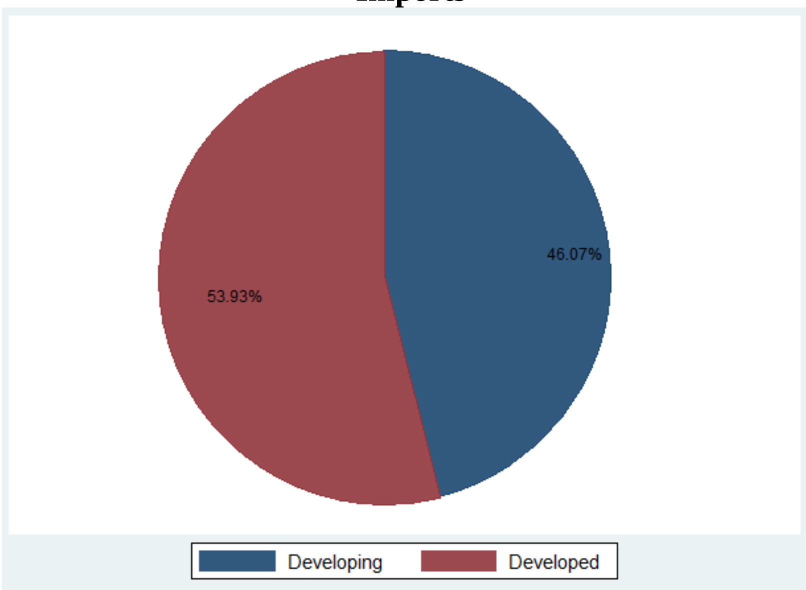

Fig. shows the percentage of imports for both developing and developed countries. Developed countries imports (53.93%) more as compare to developing countries (46.07%).

Fig 13
Fertility Rate

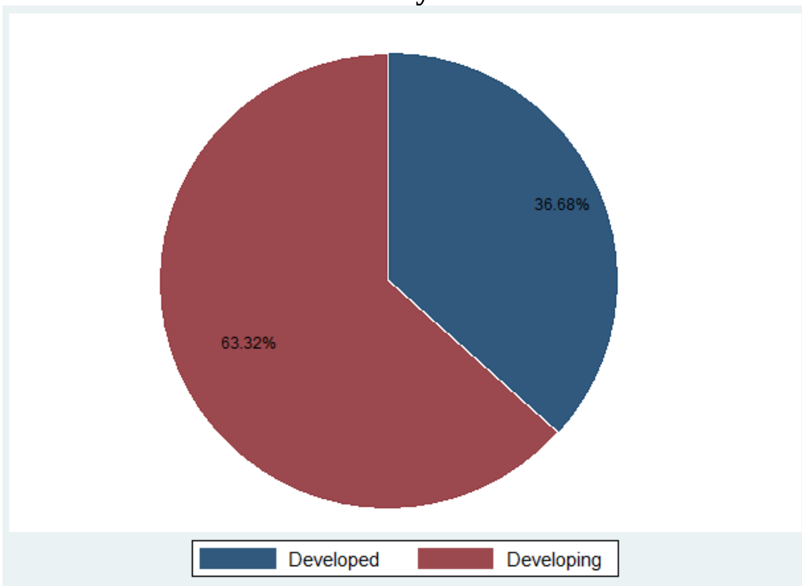

Fig 13 shows the fertility rate for developed and developing countries. Fertility rate in developed countries is 36.68% and developing countries is 63.32%. This means that developed countries less fertility rate due to the presence of one child policy and other laws.

Fig 14
Developed Countries

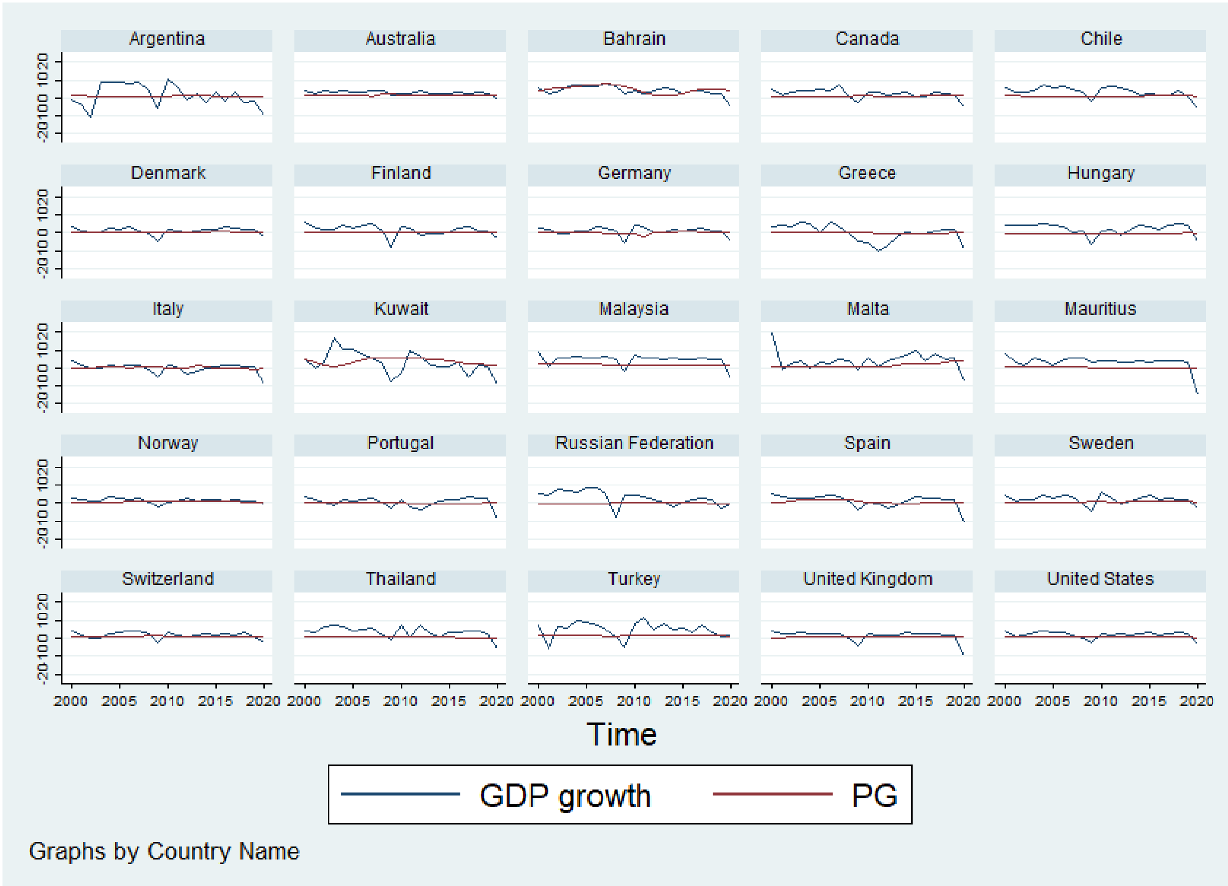

Fig 14 shows GDP growth and population growth trend hand in hand for all developed countries it shows that there was relatively direct relationship between them over time. Population growth is constant in most developed countries and GDP growth fluctuate along the population growth line. GDP growth of Argentina and Kuwait deviate more as compare to other countries.

Fig 15
Developing Countries

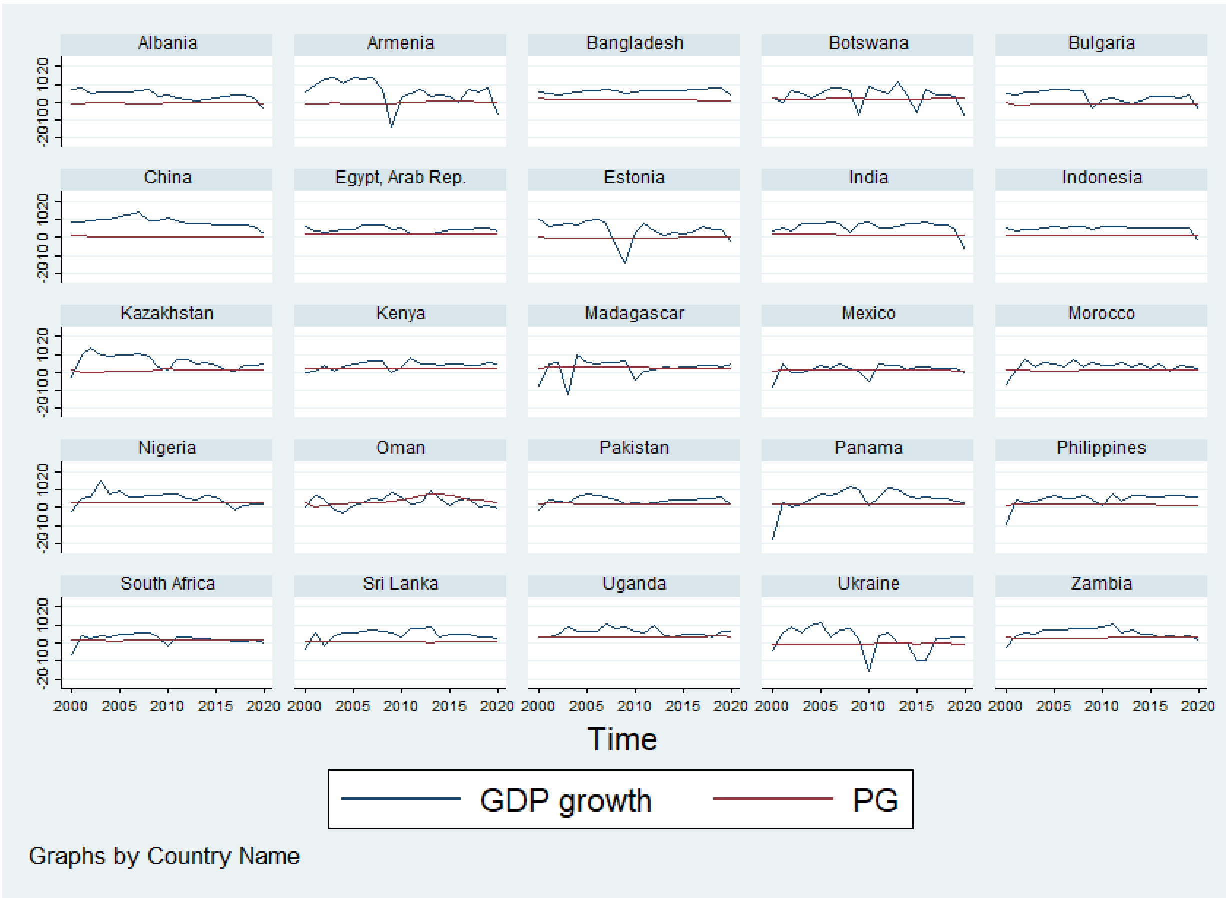

Fig. 15 indicate that GDP growth and Population growth for developing countries fluctuated over time. GDP growth of Albania and Bangladesh is greater than population growth. Population growth is greater of Oman as compare to other countries. For Pakistan, population growth is between 0% to 5% and GDP growth rate greater than population growth.

6. Regressions

The following equation is used to determine the impact of population growth on the GDP per capita of a country and determine whether this impact differs between developed and developing countries.

$$GDP/C_{i,t}=\beta 0 + \beta 1(fertility)_{i,t} + \beta 2(IMR)_{i,t} + \beta 3(PG)_{i,t} + \beta 4(exports)_{i,t} + \beta 5(FDI)_{i,t} + \beta 6(PSE)_{i,t} + \beta 7(Imports)_{i,t} + e_{i,t}$$

Where:

GDP= Gross Domestic Product

Fertility= fertility rate

IMR= Infant Mortality Rate

PG= Population Growth

Exp= Exports

Imp= Imports

FDI= Foreign Direct Investments

PSE= Primary School Enrollment

E= Error Term

Table 5: Overall Regression

	(1) Fixed effects	(2) Time Fixed Effects	(3) Fixed Effects Robust
VARIABLES	**lnGDP/C**	**lnGDP/C**	**lnGDP/C**
PSE	-14.98	-12.68	-14.98
	(34.76)	(26.77)	(48.29)
Exports	73.35*	129.8***	73.35
	(40.91)	(31.65)	(102.8)
Imports	48.30	-192.0***	48.30
	(48.15)	(38.13)	(107.1)
Fertility rate	0.169	0.980	0.169
	(0.010)	(0.081)	(0.019)
FDI	-1.847	-0.244	-1.847
	(10.30)	(8.047)	(7.779)
IMR	-209.5***	280.0***	-209.5***
	(42.48)	(38.00)	(64.83)
PG	0.237***	0.148***	0.237**
	(0.035)	(0.277)	(0.093)
2001.Time		-2,648***	
		(964.5)	
2002.Time		-1,741*	
		(957.9)	
2003.Time		278.2	
		(952.8)	
2004.Time		2,340**	
		(949.0)	
2005.Time		3,780***	
		(949.6)	
2006.Time		5,330***	
		(951.9)	
2007.Time		7,775***	
		(955.7)	
2008.Time		10,042***	
		(961.6)	
2009.Time		8,032***	
		(950.9)	
2010.Time		9,023***	
		(949.9)	
2011.Time		11,584***	
		(956.9)	
2012.Time		11,722***	
		(963.4)	
2013.Time		12,332***	
		(961.5)	
2014.Time		12,255***	
		(959.1)	
2015.Time		9,993***	

		(957.5)	
2016.Time		9,774***	
		(957.2)	
2017.Time		10,767***	
		(959.6)	
2018.Time		12,212***	
		(964.3)	
2019.Time		12,050***	
		(965.4)	
2020.Time		11,263***	
		(963.6)	
Constant	11,167**	4,335	11,167
	(4,419)	(3,522)	(7,732)
Observations	1,050	1,050	1,050
R-squared	0.090	0.478	0.090
Number of Ncountry	50	50	50

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Hausman test (Overall)

	Coef.
Chi-square test value	23.97
P-value	0.0005

Ho: No difference in coefficients

H_1: Significant difference in coefficients

Figure 6 shows the Hausman test for overall regression and it can be seen that as prob>chi2 is less than 1% (0.0005) this implies that we reject the null hypothesis and fixed effect is the correct model. Then using this, table 9 results were estimated. Column 1 provides the results for fixed effect, column 2 provides the results for time fixed effect and column 3 provides result for fixed effect robust. The results in Column 1 are interpreted and they indicate that there exists a significant relationship between population growth and GDP per capita at 1% significance level. This implies that 1% increase in population growth leads to 23.07% increase in GDP per capita, holding everything else constant. This is supported by the study (Sutradhar, 2020; Pradhan, Upadhyay & Upadhyaya, 2015). Similarly, there exist a significant but a negative relationship between IMR and GDP/C at 1% significance level. This implies that 1% increase in IMR net inflows leads to $209.07 decrease in GDP per capita having ceteris paribus. This is supported by the study (Rehman, 2015; Dinh, Hong, Vo & Nguyen, 2019) Also, there exists a significant but relationship between exports and GDP at 10% significance level. This implies that 1% increase in exports leads to $73.43 increase in GDP per capita, ceteris paribus. This is supported by the study (Fatima, Chen & Ramazan, 2020). Moving to column 2, it can be seen that all the time dummies are significant as indicated by the results of time fixed effect test. The coefficients show an decrease till 2002 and then increase till 2020. This implies that there has been significant increase in GDP per capita over time till 2018 due to increase in the productivity impacting the economy positively. Moreover, the coefficient of 2020 time dummy has the highest value compared to 2005 implying a significant increase in the productivity in that year due to advancement in technology, increase in human capital and physical capital and better trade opportunities. (Boldeanu and Constantinescu, 2015)

Table 7: Time fixed effects for overall regressions

(1)	**2001.Time = 0**
(2)	**2002.Time = 0**
(3)	**2003.Time = 0**
(4)	**2004.Time = 0**
(5)	**2005.Time = 0**
(6)	**2006.Time = 0**
(7)	**2007.Time = 0**
(8)	**2008.Time = 0**
(9)	**2009.Time = 0**
(10)	**2010.Time = 0**
(11)	**2011.Time = 0**
(12)	**2012.Time = 0**
(13)	**2013.Time = 0**
(14)	**2014.Time = 0**
(15)	**2015.Time = 0**
(16)	**2016.Time = 0**
(17)	**2017.Time = 0**
(18)	**2018.Time = 0**
(19)	**2019.Time = 0**
(20)	**2020.Time = 0**

F(20, 973) =	**36.20**
Prob > F =	**0.0000**

Table 7 shows the time fixed effect for the overall regression equation of the model and it can seen as prob>F=0000is less than 1%, this implies that time dummies should be incorporated in the regression model.

Table 8: Wald test for groupwise heteroscedasticity in fixed effect regression model for overall

chi2 (50) =	**17745.59**
Prob>chi2 =	**0.0000**

H_0: sigma $(i)^2$ = sigma^2 for all $_i$

H_1: sigma $(i)^2 \neq$ sigma^2 for all $_i$

Table 8 shows the results for heteroscedasticity. As Prob>chi2 = 0.00 this implies that heteroscedasticity exists so we need to robust our regression and the robust results are in column 3 of table 5.

Table 9: Wooldridge test for autocorrelation in panel data for overall

F(1, 49) =	**631.732**
Prob > F =	**0.0000**

H_0: no first-order autocorrelation

H_1: Autocorrelation is present

Table 9 shows the results for serial correlation and as Prob>F = 0.00, we reject the null hypothesis which implies that there exists serial correlation overall in the equation.

Table 10: Regressions for Developed Countries

	(1) Fixed effects	(2) Time Fixed Effects	(3) Fixed Effects Robust
VARIABLES	**lnGDP/C**	**lnGDP/C**	**lnGDP/C**
PSE	235.4**	97.50	235.4*
	(97.19)	(63.71)	(132.4)
Exports	103.6	46.74	103.6
	(78.40)	(50.79)	(183.1)
Imports	149.0	-97.96	149.0
	(103.4)	(68.24)	(221.0)
Fertility rate	-0.135	0.871***	-0.135
	(0.028)	(0.019)	(0.054)
FDI	5.778	1.873	5.778
	(13.71)	(9.123)	(8.288)
PG	0.318***	0.225***	0.318**
	(622.5)	(410.8)	(1,295)
IMR	-1,301***	828.0***	-1,301**
	(199.0)	(155.6)	(612.1)
2001.Time		544.9	
		(1,475)	
2002.Time		2,024	
		(1,482)	
2003.Time		5,670***	
		(1,489)	
2004.Time		9,167***	
		(1,490)	
2005.Time		11,388***	
		(1,499)	
2006.Time		13,548***	
		(1,510)	
2007.Time		17,358***	
		(1,524)	
2008.Time		20,373***	
		(1,530)	
2009.Time		16,375***	
		(1,527)	
2010.Time		18,944***	
		(1,532)	
2011.Time		23,514***	
		(1,549)	
2012.Time		23,079***	
		(1,559)	
2013.Time		24,099***	
		(1,574)	
2014.Time		23,654***	
		(1,578)	
2015.Time		19,393***	

		(1,583)	
2016.Time		19,003***	
		(1,587)	
2017.Time		21,040***	
		(1,606)	
2018.Time		23,339***	
		(1,623)	
2019.Time		22,874***	
		(1,635)	
2020.Time		21,236***	
		(1,628)	
Constant	2,561	-16,319**	2,561
	(11,505)	(7,692)	(15,741)
Observations	525	525	525
R-squared	0.168	0.670	0.168
Number of Ncountry	25	25	25

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 11: Hausman test for developed countries

	Coef.
Chi-square test value	16.30
P-value	0.0122

"Ho: No difference in coefficients"

"H_1: Significant difference in coefficients"

Table 11 shows the Hausman test for overall regression and it can be seen that as prob>chi2 is less than 1% (0.0000) this implies that we reject the null hypothesis and fixed effect is the correct model for this regression. Using the hausman test, table 5's results were estimated where column 1 provides the results for fixed effect, column 2 provides the results for time fixed effect and column 3 provides results for fixed effect robust. Column 1's results can be interpreted as there exists a positive relationship between population growth and GDP per capita i.e. as GFCF rises by 1%, GDP rises by 0.646% for developed countries and this result is statistically significant at the 1% significance level. This result is supported by (Zahir & Rehman, 2019) who fund a significant positive relationship between population growth and GDP in both long and short run. Next, fertility rate shares a negative relationship with GDP which means that as fertility rate increases by 1, GDP of developed countries tends to fall by 13.12% which is supported by several studies such as (Baldwin et al., n.d. 2018) who postulate that there is a positive significant relationship between export diversification and economic growth. Using data for 102 countries for the time frame 1961-2000, the researchers use Herfindahl index as a proxy to measure export concentration which is the opposite of export diversification thus a negative coefficient on the variable was found which means that export diversification has a positive relationship with economic growth.

Table: 12: Time Fixed effects for developed countries

(1) 2001.Time = 0
(2) 2002.Time = 0
(3) 2003.Time = 0
(4) 2004.Time = 0
(5) 2005.Time = 0
(6) 2006.Time = 0
(7) 2007.Time = 0
(8) 2008.Time = 0
(9) 2009.Time = 0
(10) 2010.Time = 0
(11) 2011.Time = 0
(12) 2012.Time = 0
(13) 2013.Time = 0
(14) 2014.Time = 0
(15) 2015.Time = 0
(16) 2016.Time = 0
(17) 2017.Time = 0
(18) 2018.Time = 0
(19) 2019.Time = 0
(20) 2020.Time = 0

F (20, 473) = 36.03

Prob > F = 0.0000

Table 12 shows the time fixed effeet for the first equation's overall regression and it can be soon that as Prob>F=0.00 is less than 1%, this implies that time dummies should be incorporated in the regression.

Table 13

Modified Wald test for groupwise heteroscedasticity in fixed effect regression model for developed countries

chi2 (25) =	**1989.39**
Prob>chi2 =	**0.0000**

H_0: sigma $(i)^2$ = sigma^2 for all $_i$

H_1: sigma $(i)^2 \neq$ sigma^2 for all $_i$

Table 13 shows the results for heteroscedasticity. As Prob>chi2 = 0.0000 this implies that heteroscedasticity exists so we need to robust our regression and the robust results are in column 3 of table 10.

Table 14: Wooldridge test for autocorrelation in panel data

F(1, 24) =	**452.423**
Prob > F =	**0.0000**

H_0: no first-order autocorrelation

H_1: Autocorrelation is present

Table 14 shows the results for serial correlation and as Prob>F = 0.00, we reject the null hypothesis which implies that there exists serial correlation developed countries in the equation.

Table 15: Regressions for developing countries

	(1) Fixed effects	(2) Time Fixed Effects	(3) Fixed Effects Robust
VARIABLES	**lnGDP/C**	**lnGDP/C**	**lnGDP/C**
PSE	-30.80**	-23.70**	-30.80
	(12.08)	(9.967)	(33.58)
Exports	7.473	51.57***	7.473
	(17.74)	(14.97)	(46.37)
Imports	-27.02	-96.25***	-27.02
	(19.20)	(16.41)	(47.08)
Fertilityrate	0.188***	0.158***	0.188*
	(0.036)	(0.031)	(0.010)
FDI	-25.45	6.122	-25.45
	(32.98)	(29.24)	(62.66)
PG	0.168***	0.107***	0.168***
	(0.017)	(0.015)	(0.032)
IMR	-153.8***	15.38	-153.8***
	(14.04)	(15.62)	(39.70)
2001.Time		-2,135***	
		(462.1)	
2002.Time		-1,957***	
		(453.1)	
2003.Time		-1,716***	
		(445.3)	
2004.Time		-1,368***	
		(441.0)	
2005.Time		-907.1**	
		(442.7)	
2006.Time		-375.3	
		(441.7)	
2007.Time		371.7	
		(448.0)	
2008.Time		1,175***	
		(450.5)	
2009.Time		1,377***	
		(442.1)	
2010.Time		947.1**	
		(434.2)	
2011.Time		1,660***	
		(436.1)	
2012.Time		2,188***	
		(442.8)	
2013.Time		2,447***	
		(442.1)	
2014.Time		2,651***	
		(440.1)	
2015.Time		2,332***	

		(436.5)	
2016.Time		2,123***	
		(435.6)	
2017.Time		2,207***	
		(436.6)	
2018.Time		2,836***	
		(439.0)	
2019.Time		3,191***	
		(440.2)	
2020.Time		3,150***	
		(438.1)	
Constant	5,047***	898.1	5,047
	(1,599)	(1,401)	(5,515)
Observations	525	525	525
R-squared	0.361	0.593	0.361
Number of Ncountry	25	25	25

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 16: Hausman

	Coef.
Chi-square test value	23.97
P-value	0.0005

“H_0: No difference in coefficients”

“H_1: Significant difference in coefficients”

The figure 16 shows the Hausman test for lower-middle income countries (LMCs). As the Prob>chi2 = 0.0005 which is less than 1% this implies that fixed effect is the correct model.

Using the results of figure 16 table 15 results have been estimated for developing countries. Column 1 shows the results for fixed effect, column 2 provides result for Time Fixed effect and Column 3 provides results for Robust Fixed effect. Interpreting the results for column 1, we can see that there exists a significant and positive relationship between population growth and GDP per capita at 1% significance level. This implies that $1 increase in population growth leads to 16.8% increase in GDP per capita, ceteris paribus. (Chowdhry, 2015) supports the relationship. There exists a negative relationship between PSE and GDP at 5% significance level. This implies that as PSE increases by 1 point, indicating equality of access to primary education among males and females, it leads to $30.13 decrease in GDP per capita, ceteris paribus. (Mahmood & Shahab, 2015) support this relationship Also, there exists a significant and positive relationship between exports and GDP at 1% significance level. This implies that 1% increase in exports leads to $7.66 increase in GDP per capita, ceteris paribus. Topcu, Altinoz and Aslan (2020) support this association. Moreover, there also exists a significant and positive relationship between imports and GDP. This implies that 1% increase in imports leads to $27.07 decrease in GDP per capita, ceteris paribus. (Gries & Redlin, 2012; Keho, 2017). Column 2 shows time fixed effect and it can be seen that 2020's coefficient has the highest value compared to 2000. This implies that in 2020 due to high productivity, GDP was higher. This can be due to better trade opportunities, higher physical and human capital, more exports and low fertility rate in developing countries (Kira, 2013). Column 3 provides the desired robust results for fixed effect.

Table 17: Time Fixed effects for developing countries

(1) 2001.Time = 0
(2) 2002.Time = 0
(3) 2003.Time = 0
(4) 2004.Time = 0
(5) 2005.Time = 0
(6) 2006.Time = 0
(7) 2007.Time = 0
(8) 2008.Time = 0
(9) 2009.Time = 0
(10) 2010.Time = 0
(11) 2011.Time = 0
(12) 2012.Time = 0
(13) 2013.Time = 0
(14) 2014.Time = 0
(15) 2015.Time = 0
(16) 2016.Time = 0
(17) 2017.Time = 0
(18) 2018.Time = 0
(19) 2019.Time = 0
(20) 2020.Time = 0

F(20, 973) = 36.20

Prob > F = 0.0000

Table 17 shows the time fixed effeet for the first equation's overall regression and it can be soon that as Prob>F=0.00 is less than 1%, this implies that time dummies should be incorporated in the regression.

Table 18

Modified Wald test for groupwise heteroscedasticity in fixed effect regression model for developing countries

chi2 (25) =	**1.7e+05**
Prob>chi2 =	**0.0000**

H_0: sigma $(i)^2$ = sigma^2 for all $_i$

H_1: sigma $(i)^2 \neq$ sigma^2 for all $_i$

Table 18 shows the results for heteroscedasticity. As Prob>chi^2 = 0.0000 this implies that heteroscedasticity exists so we need to robust our regression and the robust results are in column 3 of table 16.

Table 19: Wooldridge test for autocorrelation in panel data

F(1, 24) =	**62.002**
Prob > F =	**0.0000**

H_0: no first-order autocorrelation

H_1: Autocorrelation is present

Table 19 shows the results for serial correlation and as Prob>F = 0.00, we reject the null hypothesis which implies that there exists serial correlation of developing countries in the equation.

7. Relevance and Contribution

For an issue that has been studied for so long, and with such potential import, the base of evidence regarding the economic effects of fertility (or population growth more generally) is rather weak. In some ways, this should not be a surprise. Population growth changes endogenously as a country develops. Further, factors that impact population, such as changes in institutions or culture, are also likely to affect economic growth directly, and they are poorly observed as well. Finally, the lags at which fertility changes affect economic outcomes may be fairly long. Thus, at the macroeconomic level, it is very hard to sort out the direct effects of population growth from those of other factors. Much of the current thinking about the aggregate effects of fertility decline relies on results from cross country regressions in which the dependent variable is growth of GDP per capita and the independent variables include measures of fertility and mortality, or else measures of the age structure of the population. Our goal in this paper is to quantitatively analyze the economic effects of reductions in fertility in a developing country where initial fertility is high.

Attempts to assess the effect of fertility changes on economic outcomes can be classified in two categories: Micro and Macro.

The panel Granger causality testing approach recently developed by Knya (2006), which is based on SUR systems and Wald tests with country specific bootstrap critical values, adds to the existing literature on growth by investigating the causality relationship between population growth and host country economic conditions (unemployment). By taking into account the contemporaneous connection across countries, this approach allows one to test for Granger- causality on each individual panel member separately. As a result, depending on immigration policy, it is possible to test for a causal association between immigration and host economic indicators for each country.

8. Future implications and policy

The study indicates a positive impacts of population growth on economic growth per capita of develop and developing countries. These countries should devise friendly policies to reduce the population growth because at certain extent population would be a burden on the economies. The developed countries have controlled level of population because policies to control the population. Similarly, the government of developing countries should wisely and efficiently devise policies i.e one child policy etc. to control the growing trend of population to increase economic development and mitigate poverty levels.

The government should also focus on integrated population intervention that provide social, political and economic empowerment to vulnerable groups of the society such as women, youth, etc. who have a major role in the population growth. There is a need to put in place a legislation to protect the rights of children, and women (legal age at marriage). An integrated population intervention will focus on the provision of a combination of the quality reproductive health services and education as a social empowerment measure and access to resources and technology as economic empowerment measure.

One of the primary implications of developing countries for population policies is to shift the responsibility for controlling population growth by means of family planning to reproductive health, and to other sectors of development, mainly through universal access to education, primary health care and equal employment opportunities. This highlights the progress made developed nations in linking population growth with economic growth through a more coordinated approach aimed at reaching out to the base root of population growth and ensuring a strong alliance across gender, class and geographic boundaries.

9. Conclusion

There is a large body of theoretical and empirical literature on the possible association between population and per capita income. The lack of a consensus is mainly due to the fact that some research bodies show positive impact of population growth on GDP per capita and some shows negative impacts. This is mainly due to development and under-development factor. Population positively impacts on GDP per capita in developed countries due to the availability of proper infrastructure for labor force and resources (Hajamini, 2014).

An empirically relevant question is to what extent population growth impacts the GDP per capita in developed and developing countries. To be able to answer this question, we have estimated to panel data including country and time-period fixed effects. We found that the coefficient of the population growth is positive and significant while that of the infant mortality rate is negative and significant for these three regression specifications. By contrast, the coefficient of the primary school enrolment appeared to be positive for the regressions for developed countries while negative for the developing countries. We found that the fixed effects model best described the data when these specifications of regression were tested against one another and robust also applied. Based on this model, we found that population dynamics explain 31.16 percent of economic growth in per capita GDP in developed countries and 16.31 percent of economic growth in per capita GDP in developing countries over the period 2000–2022.

There exists a positive relationship between population growth and GDP per capita i.e. as PG rises by 1%, GDP rises by 31.16% for developed countries and this result is statistically significant at the 1% significance level. This result is supported by (Zahir & Rehman, 2019) who fund a significant positive relationship between population growth and GDP in both long and short run. On the other hand, there exists a significant and positive relationship between population growth and GDP per capita at 1% significance level. This implies that $1 increase in population growth leads to 16.8% increase in GDP per capita, ceteris paribus. (Chowdhry, 2015) supports the relationship.

We also found that the exports were the major contributor to GDP per capita growth. These results corroborate Kelley and Schmidt's argument that the growth differential between the population of working age and the total population (Bloom & Williamson, 1998). Furthermore, population growth expected to have a positive effect on economic growth in India and Pakistan over the period 2005–2050, and a negative effect in China (Choudhry & Elhorst, 2010). Even though the coefficient of the old-age dependency ratio was found to be insignificant and thus ambiguous, it is the expected increase of this ratio that may be held responsible for this negative effect in China. One explanation for its insignificance is that most developed countries just reached the last phase of the population growth. Furthermore, by incorporating demographic variables would help researchers to see the clear relationship between population and economic growth in future.

10. References

Last Name, Giles, J. A., & Williams, C. L. (2000). Export-led growth: A survey of the empirical literature and some non-causality results. Part I. Journal of International Trade and Economic Development, 9(3), 261–337.

Greenaway, D., & Morgan, W. (1998). Trade orientation and economic development: Theory and evidence. In D. Sapsford, & J. R. Chen (Eds.), Development economics and policy, The conference volume to celebrate the 85th birthday of Professor Sir Hans Singer. New York, NY: St. Martin Press. [Chapter 9].

Grepin, K., & Klugman, J. (2013). Maternal health: A missed opportunity for development. *The Lancet, 381*(9879), 1691–1693. https://doi.org/10.1016/S0140-6736(13)60981-2.

United Nations. World Population Prospects: The 2010 Revision. [Accessed 6/4/12]; *Department of Economic and Social Affairs, Population Division, Population Estimates and Projections Section.* 2010 at ≪ http://esa.un.org/unpd/wpp/index.htm≫.

Malthus Thomas R. Edited with an introduction and notes by Geoffrey Gilbert. Oxford, UK: Oxford University Press; 1798. An Essay on the Principle of Population. Reprint 2004.

Das Gupta Monica, Bongaarts John, Cleland John. *Policy Research Working Paper 5719.* Development Research Group, The World Bank; 2011. Population, poverty, and sustainable development: A review of the evidence.

National Institute of Population Studies (NIPS) [Pakistan] and ICF International. 2013. Pakiatan Demographic and Health Survey 2012-13. Islamabad, Pakistan, and Calverton, Maryland, USA:NIPS and ICF International.

World Health Organization / UNICEF. Trends in maternal mortality: 1990 to 2013: estimates by WHO, UNICEF, UNFPA, The World Bank and the United Nations Population Division. 2014.

Coale Ansley J, H. E. (1958). *Population Growth and Economic Development in Low income countries.* Princeton, NJ: Princeton University Press.

Council, N. R. (n.d.). Working Group on Population Growth and Economic Development,Committee on Population, Commission on Behavioral and Social Sciences and Education. *Population Growth and Economic.* Washington, DC: National Academy Press.

Das , G. M., Bongaarts , J., & Cleland , J. (2011). Population, poverty, and sustainable development. *Policy Research Working Paper 5719. Development Research Group, The World Bank.*

Deaton , A. (1992). Saving and income smoothing in Côte d'Ivoire. *Journal of African Economies*, *1*(1), 1–24.

Denton , F., & Spencer, B. (1999). A simulation analysis of the effects of population change on a neoclassical economy. *Journal of Political Economy*, 356–375.

Denton Frank T, S. B. (1973). A simulation analysis of the effects of population change on a neoclassical economy. *Journal of Political Economy, 81*(2), 356–375.

Enke, S. (1971). Economic consequences of rapid population growth. *Economic Journal*, 800–811.

Kuznets, S. (1967). Population and economic growth. *Proceedings of the American Philosophical society,* (pp. 170-193).

Malthus, T. R. (1798). *An Essay on the Principle of Population.* (U. Edited with an introduction and notes by Geoffrey Gilbert. Oxford, Ed.) UK: Oxford University Press.

Simon , J. (1976). Population growth may be good for LDCs in the long run: A richer simulation. *Economic Development and Cultural Change*, *24*(2), 309–337.

Coleman, D., & Rowthorn, R. (2011). Who's afraid of population decline? A critical examination of its consequences. *PoPulation and develoPment review*, *37*, 217-248.

Golosov, M., Jones, L. E., & Tertilt, M. (2007). Efficiency with endogenous population growth. *Econometrica*, *75*(4), 1039-1071.

Ashraf, Q. H., Weil, D. N., & Wilde, J. (2013). The effect of fertility reduction on economic growth. *Population and development review*, *39*(1), 97-130.

Srinivasan, T. N. (1988). Population growth and economic development. *Journal of Policy Modeling*, *10*(1), 7-28.

Gries, T., & Redlin, M. (2012, June). Trade openness and economic growth: a panel causality analysis. In *International conferences of RCIE, KIET, and APEA, March* (pp. 16-18).

Topcu, E., Altinoz, B., & Aslan, A. (2020). Global evidence from the link between economic growth, natural resources, energy consumption, and gross capital formation. *Resources Policy*, *66*, 101622.

Chowdhry, S., Saha, S., Samadi, F., Jaiswal, J. N., Garg, A., & Chowdhry, P. (2015). Recent vs conventional methods of caries removal: a comparative in vivo study in pediatric patients. *International journal of clinical pediatric dentistry*, *8*(1), 6.

Hafeez, M., Shahab, S., & Tariq, M. (2015). Exchange Rate-Economic Growth Nexus under Different Political Regimes and Structural Shocks: Evidence from Pakistan. *Hafeez, M., Shahab, S., & Mahmood, MT (2017). Exchange Rate-Economic Growth Nexus under Different Political Regimes* *and Structural Shocks: Evidence from Pakistan. Journal of Contemporary Management Sciences*, *1*(2), 93-106.

Mushtaq, Z., Asghar, H. N., & Zahir, Z. A. (2021). Comparative growth analysis of okra (Abelmoschus esculentus) in the presence of PGPR and press mud in chromium contaminated soil. *Chemosphere*, *262*, 127865.

Dinh, T. T. H., Vo, D. H., The Vo, A., & Nguyen, T. C. (2019). Foreign direct investment and economic growth in the short run and long run: Empirical evidence from developing countries. *Journal of Risk and Financial Management*, *12*(4), 176.

Sutradhar, S. R. (2020). The impact of remittances on economic growth in Bangladesh, India, Pakistan and Sri Lanka. *International Journal of Economic Policy Studies*, *14*(1), 275-295.

.

.

11. Appendix

Developed countries	**Developing countries**
Argentina	Albania
Australia	Armenia
Bahrain	Bangladesh
Canada	Botswana
Chile	Bulgaria
Denmark	China
Finland	Egypt, Arab Rep.
Germany	Estonia
Greece	India
Hungary	Indonesia
Italy	Kazakhstan
Kuwait	Kenya
Malaysia	Madagascar
Malta	Mexico
Mauritius	Morocco
Norway	Nigeria
Portugal	Oman
Russian Federation	Pakistan
Spain	Panama
Sweden	Philippines
Switzerland	South Africa
Thailand	Sri Lanka
Turkey	Uganda
United Kingdom	Ukraine
United States	Zambia

Overall

VARIABLES	(1) lnGDP
PSE	0.0617***
	(0.0174)
Exports	0.0425**
	(0.0190)
Imports	0.000545
	(0.0213)
Fertilityrate	-0.901**
	(0.364)
FDI	0.000351
	(0.00575)
PG	-0.0180
	(0.174)
IMR	0.125***
	(0.0185)
Constant	-4.894**
	(1.901)
Observations	1,050
Number of ncountry	50

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Developing Countries

VARIABLES	(1) lnGDP
PSE	0.0513**
	(0.0206)
Exports	0.0551**
	(0.0274)
Imports	-0.00221
	(0.0311)
Fertilityrate	-1.136***
	(0.439)
FDI	0.199***
	(0.0616)
PG	-0.142
	(0.286)
IMR	0.123***
	(0.0213)
Constant	-3.491
	(2.341)
Observations	525
Number of ncountry	25

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Developed Countries

VARIABLES	(1) lnGDP
PSE	0.0160
	(0.0285)
Exports	0.0411*
	(0.0227)
Imports	-0.0151
	(0.0251)
Fertilityrate	1.027
	(0.660)
FDI	0.000770
	(0.00536)
PG	0.0218
	(0.177)
IMR	0.205***

	(0.0435)
Constant	-3.760
	(3.149)
Observations	525
Number of ncountry	25

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1