EFFECTS OF POPULATION GROWTH ON ECONOMIC GROWTH IN ASIAN DEVELOPING COUNTRIES

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ABSTRACT

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Title: Effects of Population growth on Economic Growth in Asian Developing countries

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Problem: The population growth rate affects both the consumption and the productivity of a country’s economy. One more person can increase not only one pair of hands for labor but also one mouth for consumption. Especially in Asian Developing countries, where the population growth is developing more and more drastically, the economic growth therefore also changes critically over periods. Up to now, the debates about whether population growth is beneficial or detrimental to economic growth still have been discussed. As a result, it is significant to take into account the effects of population growth on economic growth in these countries, which focus on per-capita term specifically.

Purpose: We would like to first define some main factors, which lead to the increase in population growth, then analyze the positive and negative effects on economic growth. Moreover, we will interpret the result of the regression test to find out the exactly answer of the question whether the growth rate of population can increase or decrease the economic growth in Asian Developing countries. Lastly, we will make predictions about the future trend in population growth in these countries based on some given data.

Method: The paper is based on the theoretical tools of Macroeconomic Theory and Statistics for Business courses. We will apply some existing models and set up a regression test on Excel to clarify the hypotheses. Some practical data and examples will also be used to explain the ideas.

Conclusions and Results: By doing some linear regression tests, we can conclude that in Asian Developing countries, higher population growth rates can lead to a decline in economic growth, which specifically is Gross Domestic Product (GDP) per capita in this case. The main reasons for these negative effects are capital dilution, standard of living, resource shallow and age structure respectively.
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1. Introduction

1.1. Problem discussion:

In the early of twenty-first century, the world population had fluctuated around 6 billion, in which developing countries contributed to 80% of the total amount and mostly occur in Asian countries. The fact is population growth and economic growth always has a close relationship. Over periods, the arguments about positive and negative effects of population on economic development are still complicated problems for most of the economists. One of these economists is Thomas R Malthus. In his model (1826), he stated that the population growth can reduce the output per capita because population increases at a geometrical rate while production rises at an arithmetic rate so that output growth rate can not keep the same pace. Another famous economist is Rober M. Solow (1956). Unlike Malthus, he focused on the term “population growth rate” instead of the “population level”. He stated that an increase in the population growth rate can decline the capital per worker as well as the steady-state output per worker. As a result, higher population growth can bring the detriment to the productivity and economic growth. However, there are also some optimist views stated that population growth can make a positive impact on economic growth. An example is Ahlburg (1998). He believed that larger population can lead to “technology pushed” and “demand pulled” which means higher population growth can increase the needs for goods and boost the technological development. Therefore, it can increase the labour productivity, income per capita and living conditions.
This paper focuses on analyzing the impact of population growth on economic growth in Asian Developing countries where currently have one of the most critical situations in the world. By doing some research on both positive and negative sides of the impacts, we can conclude that whether an increase in population growth rate can lead to a benefit or detriment to the economic growth in these countries.

1.2. Outline of the paper:

This thesis is divided into four main sections. The first section is used to describe the two significant factors which directly affect to the population growth – mortality and fertility. This section also explains the interaction between these two elements.

Section 2 will be used to analyze and explain the positive and negative effects of population growth on economic growth. This section will be divided into two parts:

- **Part 1**: Describe the positive effects through analyzing the “Economies of Scale” phenomenon of population growth as well as the acceleration of technological progress.
- **Part 2**: Describe the negative effects by defining the Solow model then apply it to explain some negative impacts.

Section 3 will focus on interpreting the result of the Linear Regression tests with some given data of 8 Asian Developing countries from 1965 to 2010. The result in this section will help us decide whether higher population growth can make positive or negative effects on economic growth in these countries.

Section 4 will present a prediction of the population trend in future and how it can affect the economic growth in Asian Developing countries.
1.3. Aim of the research:

This thesis is focused on answering the fundamental question “Are the effects of population growth on economic growth in Asian Developing countries positive or negative?” In more details, we need to find out how population growth rate affects to GDP per capita in these countries and in which direction (positive or negative).

1.4. Limitations:

The first limitation occurred when we used the Solow model to analyze the negative effects of population growth on economic growth. This model is built on some not-so-true assumptions. First, all countries are supposed to have no kind of interrelation or in a closed economy situation. Then, the technological progress is considered an exogenous element. However, as Solow argued, “every model has some untrue assumptions but may succeed if the final results are not sensitive to the simplifications used.”

Secondly, due to the multiple regression test, collecting data becomes the most time consuming period. However, there are some data are not available before 1980 period. Thus, it makes our regression test become not so tight.

Thirdly, due to the Solow model, the investment rate has a vast effect on the economic growth. However, because of the shortage of data and times, we cannot include the investment rate data in our regression model test. Moreover, we also assume that other variables do not affect much on the result of our regression test.
1.5. Literature search and methodology:

In order to analyze the impact of population growth on economic growth in Asian Developing countries, we searched some literatures, published works and textbook concerning population growth. We also used internet sources and review several available works relevant to this problem.

This thesis bases on both theoretical and numerical data concerning population growth and economic growth. We will basically first search and review all the literatures then collect the necessary data from internet sources. In this paper, we also use Microsoft Excel to do the Multiple Regression tests for 8 Asian Developing countries from 1965 to 2010 so that we can find out whether higher population growth can bring benefit or detriment to the economy in these countries.

2. Determinants of population growth

2.1. Mortality transition

Over two centuries, from 18th century to 20th century, the level of mortality has changed dramatically in Asian countries. The demographers use life expectancy of birth, which is the average number of years that newborn baby can be expected to live, as a mean to measure the mortality level. Generally, the life expectancy of birth has increased rapidly from the beginning of 18th century.
The data was collected from 1960 to 2000 from worldbank.org, as can be seen on the graph, in seven countries, the average life expectancy in 1960 was increased nearly 1.5 times, from 48.17 up to 68.75. There are two main reasons that make the big change in mortality level. Firstly, the living standard has improved in overall; include housing and other necessities like food and water. When people have a higher level of income, they will enjoy a better nutrition and thus have more resistant to disease. For instance, in 1960, the GDP/capita in China was only around 92 USD and the life expectancy was 46.6; ten years after, in 1970, their newborn child’s life expectancy moved up to 61.97 (nearly 1.3 times) and their level of income jumped to 111.62 USD (also nearly 1.3 times). The second reason is the import of new technology from Western countries; include medical treatment, drainage system, vaccines protecting people from dangerous epidemics like smallpox, measles, etc… This also explains why the life expectancy in Asian countries is increased much faster than Western countries ones.
2.2. Fertility transition

In order to measure fertility, demographers use the total fertility rate (TFR) which is the number of children that one woman can give birth through her lifetime. In general, the total fertility rate in Asian developing countries has declined dramatically over the past three decades. According to the data of United Nations Population Division, the average TFR declined from 6.27 in 1965 to 2.47 in 2009 (decreased more than 2.5 times).

There are many factors which contribute to the decrease in birth rate in Asian developing countries. In some countries, such as China and Vietnam, the government has applied intensive family planning program to control birth rate. But in most of countries, socio-economic is a key factor of the situation. Delaying marriages, rising cost of health caring and education for children are some main factors in socio-economic case. Moreover, the income level, which increases vastly in some middle-income countries like China and Thailand, rises the opportunity cost of time spending for rearing children. Last but not least, education, especially female education, is expected to be strongly related to the fertility rate. Highly educated women have preferences for well-educated children, so it makes more difficult to have large-size families because of the children-rearing cost. Along with the tremendous development in economy, the education level has also increased in order to satisfy the need of the new emerging economy. Due to studies conducted by Cochrane(1983), he suggested that the education level has a negative impact on fertility rate.

2.3 The interaction of Fertility and Mortality

The Net rate of reproduction is considered a good mean to measure the interaction among fertility and mortality. The Net rate of reproduction (NRR) is defined as the number of
daughters that each girl who is born can be expected to give birth to (David N. Weil, 2008). The NRR is calculated by using the below formulation:

\[ \text{NRR} = \beta \times \sum_{i=0}^{T} \pi(i)F(i) \]

where \( \beta \) is the probability that the newborn child is a girl

\( F(i) \): specific fertility rate at age \( i \).

\( \pi(i) \): probability that a person will be alive at age \( i \)

As we can see in the formula above, both birth rate and mortality rate play an important role to evaluate the value of NRR. Most of the countries in our sample experience the increase in Life expectancy; however, according to United Nations Population Division, the data of NRR collected from 1970-2005 reduced all the time. The main reason is that the second variable, total fertility rate declined at a faster rate. Take India for an example, in the period of 45 years, from 1955-2000, despite of the increasing in life expectancy (from 42.6 to 62.1), the NRR slightly decreased from 1.75 to 1.43 since TFR faced a dramatic downward, from 5.92% to 3.45%.

Moreover, the “decreasing infant mortality rate” also has a strong effect on fertility rate. Each family has its own desired fertility. If the infant death rate equal to \( \frac{1}{2} \) and the desired fertility equal to two, the family have to give birth to four children in order to ensure that two of four children will survive in future. Because the infant death rate decreases sharply overtime; take Indonesia for example, according to the United Nations Population Division, the infant death rate decrease from 201/1000 in 1950s to 27/1000 in 2005s; and the desired fertility seems to be fixed or decreased, the total fertility rate will decrease.
3. Positive and Negative effects between Population growth and Economic Growth

3.1 Positive effects

3.1.1 The “Economies of Scale” phenomenon of population growth

Despite of the Malthus’ theory of diminishing return when it comes to scarce resource like food and water, some of optimistic “population growth” economists, like Kuznets (1956), Boserup(1965) and Simon (1981), believed that population growth can really help the nation economy to turn from ineffective economy into “economies of scale” state. According to Kendrick (1977), economies of scale are an important factor to increase the productivity (increase in output per unit of labor) of one nation. A country, which has a rapid population growth, can suffer many burdens, such as capital dilution, shortage of necessity resources and the casualty could lead the whole population to poverty, famine and starvation. However, there are three arguments supported for the idea that population growth can boost the country economy by “economies of scale” phenomenon.

Firstly, a nation, which has a rapid population growth rate, means that its population size will develop with a quicker rate. The bigger the population size is, the larger the market size becomes. In order to meet the product demand of the large-size market, bigger and more effective as well as longer performance period manufacturing plants are required to develop (Simon 1994). Therefore, the producing cost and setup cost per one output have tendency to reduce.
Secondly, the large-scale of population not only have a large size market but also possess an impressive number of labors. Because of the availability of labor force, it is possible for firms to divide their labor into particular division of labor to do specific tasks. An excellent example of specialization is car assembly line in which each division just takes responsibility of installing only one part of the car such as engine or car wheels. According to Adam Smith, “division of labor has caused a greater increase in production than any other factor. This diversification is greatest for nations with more industry and improvement, and is responsible for "universal opulence" in those countries”. Moreover, through specialization, working skill of labor force is likely to improve more quickly with learning-by-doing. Since a large size of population demands a tremendous number of products, these workers have more chances to improve their working skill. As a result, the average time spending for producing one unit of output have tendency to decrease more quickly than in smaller market-size. Correlating with saving producing time, the cost per one product is also deducted and firm is more efficient through specialization.

Finally, the rapid population growth rate could cause a positive effect on communication and transportation. Transportation plays an important role in economic development. A good transportation system can help reduce transportation cost and travel time. Along with high population growth rate, the increase in population density is inevitable. A dense population is likely to pressure the government to develop more in transportation system such as railroad, highways and road. Take China as an example, according to United Nations Population Division, in 1985, its population density was 110 people/km² and the total amount of railroad was 52,000 km while in 2010, the total length of railroad is 91,000 km (increase 75%) and its population density is 141 people/km² (increase 28%).
Transportation improvement is surely a general trend for every economic development, but it is not deniable to state that the population density has a strong impact on number of construction of transportation. As Julian L. Simon stated in “The Ultimate Resource”, “population growth clearly leads to an improved transportation system, which in turn stimulates economic development”.

3.1.2 Acceleration of technological progress

The Industrial Revolution started at the beginning of 18th century and ended at the end of 19th century. This is the period when Malthusian “population growth” model was broken down and technology proved its own importance for the economic growth. In Cobb-Douglas model, \( y = A k^{\alpha}h^{1-\alpha} \); where \( y \) is output per worker, \( A \) is productivity and \( h \) is human capital per worker; technological progress, which increase the value of parameter \( A \), eventually lead to the higher output per worker with the same number of input. According to early neoclassical model of Solow (1956), the role of technological change is crucial and he emphasized that it is even more important than the accumulation of capital.

There are some theories supported for positive effect of population growth on technological growth, two most well known theories belonged to Boserup and Simon. Among in the optimistic economists in “population growth” field, Boserup is quite famous as an anti-Malthusian economist. In her theory, she argued that when the population faces a critical event like shortage of food or other necessity goods, people would find a way to overcome the situation by increasing workforces, using new method of producing or inventing new machines, tools, etc. In Simon-Steinmann Economic
growth model, Simon also shows the idea that the greater the total population, the greater the level of technological growth which eventually lead to yield greater capita income.

A country, which has a higher population growth rate, implies that there is a rapid increase in school-age population. Instead of investing in other essential industrials to increase the overall capital accumulation, the government has to spend more public spending in schooling and educational facilities. The pressure created by massy number of school-age population also retards the general education level of the nation. However, in long run, huge investment in education in present can result in the accumulation of human capital, which is a special stock of competence, knowledge, personalities as well as the ability to produce economic value. Human capital has two effects on economic development. First, human capital can be used as a productive factor like other capitals like machine, vehicles etc. Second, human capital can directly contribute to the development of new technology which effect positively to the productivity. Hence, greater population growth tends to raise the level of technology growth.

The population growth enlarges the size of labor force, so, the average wage rate, therefore, is pushed down. In developing countries, low wage rate is considered an important factor in the progress of industrialization and modernization, which are closely related to the wealth of the nation. Moreover, instead of spending a huge amount of money to pay the labor, firm can invest more in R&D sector, which finally result in the sufficient development of new technology that leads to higher productivity. Hence, the growth of population is likely to help firms to have a better chance in competing with other foreign rival firms.
3.2 Negative effects

3.2.1 The Solow Model

Economist Robert Solow developed the Solow Model in 1956. In this model, he considered the following production function:

\[ Y = A K^\alpha L^{1-\alpha} \]

Where \( Y \) is the aggregate output, \( A \) is the total factor productivity, \( K \) is the size of manufactured capital and \( L \) is the amount of labor used overtime.

In per-worker term:

\[ y = \frac{Y}{L} = \frac{A K^\alpha L^{1-\alpha}}{L} = A \left( \frac{K}{L} \right)^\alpha \left( \frac{L}{L} \right)^{1-\alpha} = A k^\alpha \quad (1) \]

where \( y = \frac{Y}{L} \) denotes the output per worker and \( k = \frac{K}{L} \) denotes the capital per worker.

Now we assume that the quantity of labor input (\( L \)) and the production function above will not change over periods. It implies that the parameter \( A \) is a constant number. As a result, the aggregate output (\( Y \)) in this case will depend on the stock of capital (\( K \)).

On the other hand, the change in capital (\( \Delta K \)) is defined by the difference between the number of Investment and Depreciation, which is formulated as below:

\[ \Delta K = I - D \]

However, we need to focus on per-worker term. Assume that \( i \) and \( d \) are the number of investment per worker and depreciation per worker respectively. So, the formula for the change in capita per worker can be transformed into:
\[ \Delta k = i - d = \gamma y - \delta k \quad (2) \]

where \( i = \gamma y \) denotes a constant portion of output used to invest in building new capital

and \( d = \delta k \) denotes a constant portion of capital depreciating each period

Since output per worker can be rewritten as a function of capital per worker, we got the final equation:

\[ \Delta k = \gamma f(k) - \delta k \]

In steady state, the quantity of capital per worker will be considered constant and be denoted as \( k^{ss} \). It means that \( \Delta k \) will be equal to 0. Plug (1) into (2), we have the formula below:

\[ \Delta k = \gamma A k^\alpha - \delta k = 0 \Rightarrow \gamma A k_{ss}^\alpha = \delta k_{ss} \Rightarrow k_{ss} = \left( \frac{\gamma A}{\delta} \right)^{1/(1-\alpha)} \]

Plug the value of \( k_{ss} \) into (1) to find the value of \( y_{ss} = A(k_{ss})^\alpha = A^{1/(1-\alpha)} \left( \frac{\gamma}{\delta} \right)^{\alpha/(1-\alpha)} \)

From the formula of \( y_{ss} \), we may ultimately conclude about the relation between investment rate, depreciation rate and output per worker in steady state. As we can see, an increase in investment rate \( (\gamma) \) will raise the output per worker in steady state \( (y_{ss}) \) but on the contrary, a rise in depreciation rate \( (\delta) \) will decrease the output per worker in steady state \( (y_{ss}) \).
3.2.2 Negative effects

- **Capital dilution:**

The first problem caused by population growth is capital dilution. In Asian Developing countries, the total population is going up dramatically. For example, according to United Nations Population Division, in 1965, India had the total population around 497 thousands while in 2010, the total population of India is approximately 1,214 millions (increased 1.44%). Assume that the amount of capital in a country is constant, an increase in population will lead to a decrease in capital per worker (since adding more workers can lower the amount of capital at each worker’s disposal). In economic, this situation is called capital dilution. According to the Solow Model, \( y = A k^\alpha \) which means that the reduction in capital per worker \( k \) can make a decline to the output per worker \( y \) since parameter \( A \) is constant. To understand the impact of output per worker on output per capita, we need to set up a link between these two variables. According to David E. Bloom (1997), we analyze the following identity:

\[
\frac{Y}{N} = \frac{Y}{L} \cdot \frac{L}{N}
\]

where \( Y, N, L \) denotes the amount of output, total population and labor respectively.

The equation above illustrates that output per capita is equal to the multiplication of income per worker and the ratio of labor to the total population. Since the Solow model assumes that the quantity of labor \( L \) will not change overtime, the increase in population \( N \) and decrease in income per worker \( \frac{Y}{L} \) can lead to the reduction in output per capita \( \frac{Y}{N} \).

As a result, it will bring detriment to the economy.
Standard of living:

Population growth also leads to higher total consumption demand for goods and services. The figure below illustrates the relationship between demand and supply curve based on quantity demanded and price:

![Graph showing demand and supply curves](image)

**Figure 2. The relationship between demand and supply**

If supply lower than demand, the goods will become scarce. Due to high demands and shortage of resources, the prices of the goods will increase, causing a shift to the left in the supply curve (as shown in the figure 2). The raise in price, however, declines the demand for goods, which causes a shift in the demand curve to the left. The decrease in demand is caused by the inadequate income per capita, which implies that people cannot afford to buy necessary goods and services required to survive. Consequently, this leads to starvation, poverty, disease as well as a decrease in economic growth.
Resource shallow:

Another negative effect of population growth on economic growth is the problem of resource shallow. Natural resources are finite and can not be produced. According to Malthusian model (1826), higher population growth can lead to a decrease in natural resources per capita, which means reduces the capital-labor ratio. According to Galor and Weil’s model (1996), there is a link between the capital-labor ratio and the gender-gap wage ratio. Labor has two dimensions, which are physical and mental. Each man is allocated with one unit of physical labor and one unit of mental labor while each woman is assigned with one unit of mental labor only. A lower capital-labor ratio in this model presents a worse compensation to mental labor concerning physical labor. As a result, the gap between women and men’s wages will be raised. In other words, lower capital-labor ratio can lead to an increment of the gender-gap wage ratio, which implies that women will prefer to stay at home and give more time to have children rather than go to work. Thus, this fact can lower the level of output per capita and increase the population growth. With this model, we can sum up that the population growth and GDP per capita have a tendency to develop in opposite ways.

Age structure:

Last but not least, we will discuss the impact of the age-structure in output per capita of a country. The demography divides population into three categorizes, which are: young age population (0-14 ages), working age population (15 - 64 ages) and old age population (over 65 ages). Amongst these three categorizes, young age and old age population can negatively affect on the output per capita for two reasons.
First, population in the ages of below 14 and over 65 belong to the group in which most people are not or stop working. In case they have no ability to work, the proportion of population participating in productive works will be reduced, which leads to a decline in the total output per capita. Let us take a practical example in China. The figure below illustrates the ratio between working-age and non working-age population.

![Figure 3. China’s Ratio of Working-Age to Non-Working-Age Population](image)

Because of the “one child policy” per household, the fertility rate in Chinese declines, which is automatically means that older population will take a larger portion than in the past. Thus, Chinese population is promptly aging. From figure 3, we can see that along with the decrease in fertility, the ratio of the working-age (15-64) to non-working-age population go up irregularly starting in the late 1970s. It reaches its peak in 2010 and is having a tendency to go down due to the increment of elder population. For example, from 1995 to 2000, the old age population growth rate in China raises from 6,01% to 6,79% while in contrast, GDP per capita growth rate decreased critically from 9,7% to 7,6%. Second, the savings rate is different depending on ages. Working-age people save the most since they can draw money from their salary as well as having encouragement to
save for retired spending. While in case of the elder and the younger, because of not working, they have no or little income (although they sometimes receive subsidy from government or family support), so they have no ability to save. If a country has a high percentage of elder and younger people, the savings rate per capita will go down. According to the Solow model, fewer saving available for investment can lead to a decline in steady state output per worker as well as bring detriment to the economy.

4. Testing the population effects hypothesis

1. Data description:

The data needed for regression test are population growth per year, GDP growth per year, GDP per capita (USD/capita), and working-age population rate (from 15-64). Our observations are eight developing countries: China, India, Thailand, Philippines, Vietnam, Iran, Indonesia, and Pakistan.

The number of real GDP/capita in the period of 1965-2005 is elaborated from the data provided by Worldbank.org and International Monetary Fund. The data in GDP/capita growth rate, which is measured in percentage, is extracted from the database of the World Resources Institute. Other data such as population growth rate (%) and working age population ratio (%) are found in the World Bank database.

The data of GDP growth rate in four countries: Pakistan, Iran, Indonesia and Philippines in 2010 are equal to 0. Moreover, the data about the GDP growth rate of Vietnam in the period from 1965-1980 are equal to 0 or missing. Since we cannot find any reliable information to confirm that the GDP growth rate per capita of those listed observation is
equal to zero or missing, instead of using 80 observations, we can only construct the
dataset with 71 observations.

2. Model:

We use six models of regression tests to interpret the relationship between the population
growth and the economic growth, which is the overall growth in GDP/capita. In all
models, the dependent variable is per capita GDP growth (%). In the first three models,
the independent variables are the population growth rate, the GDP/capita level and the
working-age population rate. In mathematical term, the equation of first three models will
be:

- 1st model: \(\text{GDP}_{g_i} = \beta_0 + \beta_1\text{POP}_{g_i} + \beta_2\text{GDP}_i + \varepsilon\)
- 2nd model: \(\text{GDP}_{g_i} = \beta_0 + \beta_2\text{GDP}_i + \beta_3\text{WPR}_i + \varepsilon\)
- 3rd model: \(\text{GDP}_{g_i} = \beta_0 + \beta_1\text{POP}_{g_i} + \beta_2\text{GDP}_i + \beta_3\text{WPR}_i + \varepsilon\)

Where:

\(\text{GDP}_{g_i}\): per capita GDP growth rate of \(i^{th}\) observation

\(\text{POP}_{g_i}\): population growth rate of \(i^{th}\) observation

\(\text{GDP}_i\): per capita GDP of observation \(i\).

\(\text{WPR}_i\): working-age population rate of \(i^{th}\) observation

\(\beta_1\): impact coefficient of population growth rate on GDP/capita growth rate

\(\beta_2\): impact coefficient of GDP/capita level on GDP/capita growth rate

\(\beta_3\): impact coefficient of working-age population on GDP/capita growth rate

\(\varepsilon\): error term.

Base on the “catching-up effect” theory in which there is a possibility of poorer
economies have a quicker growing rate than richer economies, so we expect \(\beta_2<0\). We
assume that the “capital dilution” effect overwhelm other positive effects of the population growth; hence, we expect $\beta_1 < 0$. For $\beta_3$, higher working-age population rate lead to a larger labor force and less dependent population (young and old population), therefore the economic state of one country could be better off. Hence, we expect $\beta_3 > 0$.

We also assume each country in our sample as specific factor that affects GDP/capita growth rate. Hence, we use dummy variables to measure the specific factor of each country.

- 4th model equation: $\text{GDP}_{gi} = \sum_{a=1}^{7} \alpha_a \delta_a + \beta_1 \text{POP}_{gi} + \beta_2 \text{GDP}_i + \epsilon$
- 5th model equation: $\text{GDP}_{gi} = \sum_{a=1}^{7} \alpha_a \delta_a + \beta_2 \text{GDP}_i + \beta_3 \text{WPR}_i + \epsilon$
- 6th model equation: $\text{GDP}_{gi} = \sum_{a=1}^{7} \alpha_a \delta_a + \beta_1 \text{POP}_{gi} + \beta_2 \text{GDP}_i + \beta_3 \text{WPR}_i + \epsilon$

where $\alpha_a$: constant for dummy variable $a$.

3. **Result:**

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.108955 (**)</td>
<td>-0.15262 (**)</td>
<td>0.021628</td>
</tr>
<tr>
<td>$\beta_1$ (POPg)</td>
<td>-2.61784 (**)</td>
<td>N/A</td>
<td>-1.84948</td>
</tr>
<tr>
<td>$\beta_2$ (GDP)</td>
<td>$-1.6 \times 10^{-5}$ (**)</td>
<td>$-2 \times 10^{-5}$ (**)</td>
<td>$-1.8 \times 10^{-5}$ (*)</td>
</tr>
<tr>
<td>$\beta_3$ (WPR)</td>
<td>N/A</td>
<td>0.003629 (**)</td>
<td>0.001254</td>
</tr>
<tr>
<td>R-square</td>
<td>0.1868</td>
<td>0.1741</td>
<td>0.1904</td>
</tr>
</tbody>
</table>

**Note:** *: the coefficient is significant at 95% confidence level.

**: the coefficient is significant at 99% confidence level.
The first model is used to show us the impact of population growth rate and GDP/capita level on GDP/capita growth rate. As can be seen on the table, all three coefficients in model 1 are very significant at 99% confidence level. The sign of the β₁ and β₂ are negative (as was expected), which prove that the population growth rate and GDP/capita level have a negative effect on economic growth.

The second model tells us about the relationship between the population structure and the economic growth. With 99% confidence level, the result support our expectation that working-age population rate effect positively to the GDP/capita growth rate.

In first three models, the value of R-square is quite low (18.68%, 17.41% and 19.04% respectively) demonstrate that there are other factors affecting the GDP/capita growth rate beside of population growth rate, GDP/capita level and working-age population rate.

<table>
<thead>
<tr>
<th></th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta₁ (POPg)</td>
<td>-1.9119 (*)</td>
<td>N/A</td>
<td>-2.0366</td>
</tr>
<tr>
<td>Beta₂ (GDP)</td>
<td>-1.6 x 10⁻⁵ (**)</td>
<td>-1.7 x 10⁻⁵ (*)</td>
<td>-1.6 x 10⁻⁵ (*)</td>
</tr>
<tr>
<td>Beta₃ (WPR)</td>
<td>N/A</td>
<td>0.002</td>
<td>-0.00023</td>
</tr>
<tr>
<td>D-China</td>
<td>0.1336 (***)</td>
<td>-0.024</td>
<td>0.1493</td>
</tr>
<tr>
<td>D-Thailand</td>
<td>0.1011 (***)</td>
<td>-0.058</td>
<td>0.1166</td>
</tr>
<tr>
<td>D-Vietnam</td>
<td>0.0836 (***)</td>
<td>-0.068</td>
<td>0.0989</td>
</tr>
<tr>
<td>D-India</td>
<td>0.0858 (**)</td>
<td>-0.072</td>
<td>0.1014</td>
</tr>
<tr>
<td>D-Iran</td>
<td>0.0922 (**)</td>
<td>-0.0706</td>
<td>0.1072</td>
</tr>
<tr>
<td>D-Philippines</td>
<td>0.0675 (**)</td>
<td>-0.0942</td>
<td>0.0828</td>
</tr>
<tr>
<td>D-Indonesia</td>
<td>0.0857 (***)</td>
<td>-0.072</td>
<td>0.1012</td>
</tr>
<tr>
<td>D-Pakistan</td>
<td>0.101 (***)</td>
<td>-0.061</td>
<td>0.1164</td>
</tr>
<tr>
<td>R-square</td>
<td>0.6259</td>
<td>0.6162</td>
<td>0.6259</td>
</tr>
</tbody>
</table>
In three models in which dummy variables are applied, the fourth model is the most noticeable one because all of the coefficients include $\beta_1$, $\beta_2$ and seven dummy variable are significant at 90% confidence level. The result of the impact of population growth rate and GDP/capita level is still the same as in the regression model 1. The higher R-square value in model 4 (R-square = 62.59%) prove that the data fit better than the first two models and our assumption that exclude of three dependent variables mentioned in our model, each countries have other specific factors effecting the GDP/capita growth are quite reasonable.

From the result derived from model 1, 2 and 4, we can conclude that the population growth has a negative impact on the economic growth.

### 5. Future population trends in Asian developing countries

Figure 4 illustrates the level of world population for the last 200 years, along with a forecast for the next 200 years. As we can see, the population in Developing Countries increased critically in the period from 1900 to 2010 and may reach its peak in 2020s. Then population growth has a tendency to slow down over the next 100 years. According to The United Nation, the world population will fluctuate around 11 billion in 2200.
There are two significant reasons for this population trend, which are age-structure and fertility.

- **Age-structure**

Many Asian Developing countries nowadays are changing quickly concerning the amount of young, working age and old population. Let us take India as a particular example. According to World Bank, in India, for the last 45 years, the percentage of young age population decreased 25% while the percentage of working age increased 15% and old age population raised 67%. Following this trend, by 2050, it is predicted that young age population will take only 20% of total population in developing countries. Because of this decline in young age population, the old age population is increasing critically. According to Mirkin and Weinberger (2000), there are 33 million oldest people (over 80 ages) are currently living in developing countries. Moreover, by 2050, the percentage of this oldest population in developing countries will take 3% of the total. With this increment aging in Asian Developing countries, the Elderly Dependency Ratio, which is the ratio between numbers of people aged over 65 and number of people aged...
15-64, can be expected to increase by around three times in the period between 2000 and 2050. On the contrary, this trend has to be placed against the reduction of Child Dependency Ratio, which is the ratio between numbers of people aged 0-14 and number of people aged 15-64. Thus, the total effect will be a decrease in population growth for the next five decades in Developing countries.

**Fertility:**

A future decrease in fertility is expected to happen rapidly in Asia Developing countries. In developing countries, from 1970 to 2005, the total fertility rate declined from 5.5 to 2.9 children per woman. The table below illustrates the level of population in 2004 together with the total fertility rate in the period 1970 – 1975 and 2000 – 2005 for developing countries.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>All Developing Countries</td>
<td>5093.60</td>
<td>5.50</td>
<td>2.90</td>
</tr>
<tr>
<td>East Asia &amp; Pacific (excluding China)</td>
<td>636.10</td>
<td>5.45</td>
<td>3.19</td>
</tr>
<tr>
<td>China</td>
<td>1307.99</td>
<td>4.90</td>
<td>1.70</td>
</tr>
<tr>
<td>South Asia (excluding India)</td>
<td>441.00</td>
<td>6.21</td>
<td>3.94</td>
</tr>
<tr>
<td>India</td>
<td>1087.12</td>
<td>5.40</td>
<td>3.10</td>
</tr>
</tbody>
</table>

**Table 1. Fertility in the Developing World**

Following this trend, the United Nation has predicted that by 2050, the fertility in developing countries will decrease until most countries are at the replacement rate, which is the total fertility rate at which newborn girls will have an average of exactly one daughter over their lifetimes. There are also some explainable reasons for the future decline in fertility, which are the increasing in contraceptive prevalence, rising women’s
ages at marriage, improvement in female education and employment as well as the urbanization in Asian Developing countries.

**The effect of future population trend on economic growth:**

With all the reasons above which explained for the decrease in future population growth over the next 200 years, it would be very interesting to take a look at how future economic growth changes responding to this trend.

According to the Solow model, we have the change in capital per worker is:

\[
\Delta k = \gamma f(k) - \delta k.
\]

In section 3.2.2 above, we already discussed the problem of capital dilution, which are the decrease in capital per worker when population growth increases. Denote \( n \) as the growth rate of labor force. In this case, the dilution due to the arrival of new workers can have the same function as depreciation:

\[
\Delta k = \gamma f(k) - \delta k - nk = \gamma f(k) - (n + \delta)k
\]

In steady-state, \( \Delta k = 0 \), we have the new equation:

\[
yf(k) = (n + \delta)k \implies \gamma A^\alpha = (n + \delta)k \quad (\text{since } f(k) = y = A^\alpha)
\]

Thus, the steady-state capital per worker can be rewritten as:

\[
k_{ss} = \left( \frac{\gamma A}{n + \delta} \right)^{1/(1-\alpha)}
\]

Plug the value of \( k_{ss} \) into the production function, we get the value of the steady-state output per worker:

\[
y_{ss} = A(k_{ss})^\alpha = A^{1/(1-\alpha)} \left( \frac{\gamma}{n + \delta} \right)^{\alpha/(1-\alpha)}
\]
Now assume that we need to compare two countries with the same values for productivity $A$, investment ratio $\gamma$ and depreciation ratio $\delta$. Let $n_i$ and $n_j$ denote the growth rates of population. Suppose that population and labor force increase at the same rate, we can get the two equations for steady-state level of output per worker in the two countries:

$$(y_{ss})_i = A^{1/(1-\alpha)} \left( \frac{\gamma}{n_i + \delta} \right)^{\alpha/(1-\alpha)}$$

$$(y_{ss})_j = A^{1/(1-\alpha)} \left( \frac{\gamma}{n_j + \delta} \right)^{\alpha/(1-\alpha)}$$

Divide these two equations for each other we have: 

$$\frac{(y_{ss})_i}{(y_{ss})_j} = \left( \frac{n_j + \delta}{n_i + \delta} \right)^{\alpha/(1-\alpha)} \quad (*)$$

We now need to compare the income per worker between two developing countries. For example, let $\delta = 5\%$, $n_i = 0.8\%$, $n_j = 2.1\%$ and $\alpha = 1/3$, the equation (*) will be:

$$\frac{(y_{ss})_i}{(y_{ss})_j} = \left( \frac{0.021 + 0.05}{0.008 + 0.05} \right)^{1/2} = 1.11$$

The implication of the result above explains that the decline in population growth can lead to an increase in output per worker by $(1.11 -1)*100 = 11\%$ in steady-state.

In summary, with Solow model, we can have a final conclusion that a future decrease in population growth of Asian Developing countries, by lower the impact of capital dilution, can raise the level of output per worker. As a result, the economic growth will be boosted.
6. Conclusion

In summary, this paper researches the impact of population growth in economic growth, specifically GDP per capita, of Asian Developing countries. By doing the multiple regression tests, we can conclude that higher population growth will lower the GDP per capita as well as pull the economy in these countries down. Furthermore, we can predict that in the near future, the population growth in Asian Developing countries will decline, along with a rise in the level of output per worker. Consequently, the economic development in these countries will be improved.
7. References


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