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Analysis of the Correlation Between Population Growth and Economic Development in Asian Countries

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Abstract

Population size, as an important factor to economic growth, determines supply of human resources directly. The proportion of skilled labor to human resources exerts great influence on a nation's economy. This essay analyzes and elaborates the correlation between labor—which consists of skilled labor and unskilled labor, and economic growth based on the Solow model. This essay also analyzes factors affecting economic growth of ten Asian countries through statistical analysis of public data, elaborates the causal relationship between population growth and economic development, and puts forward corresponding suggestions.

Key words: Population growth; Economic development; Skilled labor

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INTRODUCTION

Population size exerts crucial influence on an economic entity in the long course of human history. The relationship between population growth and economic development is gaining more and more attention along with the population explosion.

It is generally believed that a larger population usually demands more food, natural resources, and living area. Therefore, a majority of people take for granted that population growth takes an adverse effect on economic development. Economists also have different views on the relationship between population growth and economic development. Thomas Malthus put forward the theory for the first time in *An Essay of the Principle of Population* that there is a negative correlation between the two factors, namely, population growth would result in lower rate of economic development.

For quite a long time afterwards, Thomas Malthus' theory was widely recognized and affected national policy-making, such as China and other Asian countries. However, with the development of global economy and innovation of economic theory, many economists proposed different theories, such as Becker, Glaeser and Murphy, who stated that population growth may affect productivity and economic development in both positive and negative sides. Economists supporting this theory argue that a nation or an area with large population has sufficient labors and a large amount of consumers, which can improve national productivity and stimulate consumption, and consequently promotes economic growth (1999).

Based on economic data of ten Asian countries, this paper aims to explain and state how population growth promotes economic development, elaborate the correlation between population growth and economic development and propose suggestions on population policy compatible with economic development for these countries.

1. LITERATURE SURVEY

Malthus (1798) proposed that population growth may lead to massive increase in demand for food, living space and natural resources, which would result in decrease of productivity, and thus hinder economic development.

Becker, Glaeser and Murphy (1999) state that population growth affects productivity and economic development in both positive and negative sides with a

simple theoretical model. On one side, they agree with Malthus that population growth may lead to decline of productivity according to the law of diminishing returns; on the other side, population growth promote increase in investment, and is conductive to further division of labor.

Thornton (2001) claims there is no significant relationship between population growth and economic development after investigation and analysis on economic condition of some Latin America economies employing Granger-type test. Dawson and Tiffin (1998) employed co-integration test investigating per capital GDP in India from 1950 to 1993 and find a similar conclusion that there is no correlation between the two factors.

Although economists above-mentioned analyze with different methods and arrive at different conclusions and unique characteristics, their researches provide us with theoretical and practical instructions for future researches, based on which this essay will then discuss the relationship between population growth and economic development in ten Asian countries.

According to the studies, I find that the approaches the economists often take in measuring the relationship between the two factors are empirical analyses and statistical analyses. Moreover, the results of the studies are not the same, and some of them even have totally different answers. Therefore, I cannot get an apparent answer to explain the relationship between population and economic development based on the studies, which means these studies are merely considered as references instead guides.

2. ANALYSIS ON RELATIONSHIP BETWEEN POPULATION SIZE AND ECONOMIC DEVELOPMENT

In this part, this essay will analyze the relationship between population size and economic development based on public data from ten Asian countries, including China, India, Indonesia, Japan, Malaysia, Pakistan, Philippines, South Korea, Thailand and Vietnam.

The methodology includes empirical analysis and statistical analysis. The author is expecting to find the relationship between population growth and economic development with Solow Model through empirical analysis, and check the validity of the conclusion with statistical analysis.

2.1 Empirical Analysis

Solow model with human capital will be adopted in the analysis. In the original Solow model theory, people are assumed as identical without human capital, which means it does not consider the difference between skilled and unskilled labor. However, the degree of productivity is determined to a great extent by the proportion of skilled labor, the influence of which, therefore, shall not be neglected.

In Solow model, the total population is the total labor force which is divided into skilled labor and unskilled labor. The influence of change of labor force on the economy represents the influence of population change on the economy.

2.1.1 Model Selection

In 1950, Robert Solow first mentioned Solow model in a published article, which later regarded as the original Solow model, stating the relationship between economic development and other correlative factors. This model probe into the relationship among total output, capital and labor force. However, this model takes the labor force as an invariant parameter, and does not distinguish between skilled labor and unskilled labor. Therefore, it is difficult to find the correlation between population growth and economic development.

Different from the Solow model, Solow model with human capital, which divides labor force into skilled labor and unskilled labor, suffice to analyze the relationship between population growth and economic development, and therefore, be adopted in this essay.

2.1.2 Model Construction

The production function of the original Solow model is:

$$Y = K^{\alpha}(AL)^{1-\alpha}.$$

The production function of Solow model with human capital is:

$$Y = K^{\alpha}(AH)^{1-\alpha}. \quad (1)$$

H means skilled labor; its relation with labor force in original Solow model is represented as $H=e^{\psi\mu}*L$; L means total labor force, also meaning total population in an economic entity;

ψ indicates the proportion of educators' annual salary increase, which is an parameter estimating level of education, and is assumed as a positive constant;

μ represents the time an individual labor spend in learning and practicing skills;

$e^{\psi\mu}$ denotes the time that skilled labor spend in training and accumulating skills;

Y refers to the total output of an economic entity;

K is the total capital of an economic entity;

A is the influence of science and technology on productivity;

α refers to the influence from the increase of capital or labor force on productivity, and the value is generally between 0 and 1.

Note that if $\mu=0$, meaning individual labor does not spend time promoting proficiency in skills, then $H=L$, indicating that there is no distinction between skilled labor and unskilled labor, which is in accordance with the original Solow model. The parameter $e^{\psi\mu}$ is a constant within a country annually. However, $e^{\psi\mu}$ is not constant in different countries at different time. This essay chooses ten countries in Asia, and supposes A, the influence of science, is a constant. This means the productivity of the ten countries is the same.

2.1.3 Formula Derivation

By taking logs and differentiating, based on the formula $\frac{d\ln(x)}{dt} = \frac{1}{x}\frac{dx}{dt} \approx \Delta\ln(x)$, we can get growth rate Equation (2)

$$\log Y = \alpha\log K + (1 - \alpha)\alpha\log A + (1 - \alpha)\alpha\log H$$
$$\rightarrow g_Y = \alpha g_K + (1 - \alpha)g_A + (1 - \alpha)g_H \quad (2)$$

g_Y, g_K, g_A and g_H are growth rates of corresponding parameters.

Equation (3) can be easily checked:

$$\frac{\partial g_Y}{\partial g_H} = 1 - \alpha > 0 \quad (3)$$

Because the value of α is between 0 and 1, meaning the first order derivative function is more than 0 in Equation (3), which means there is positive correlation between skilled labor and economic development.

In order to find out the correlation between total output and population, the first step is to raise the equation of capital accumulation.

$$\Delta K = S_K Y - \delta K \quad . \quad (4)$$

In Equation (4), S_K is the investment rate, meaning part of the total annual output Y is used for investment, and part for consumption. δ is the rate of wear, referring to abrasion of capital each year, such as abrasion and maintenance of machinery.

Then divide Equation (1) by total labor force L, the following equation will be obtained:

$$\frac{Y}{L} = \frac{K^\alpha (AH)^{1-\alpha}}{L} = \frac{K^\alpha (Ae^{\psi\mu})^{1-\alpha}}{L^\alpha} \quad .$$

Suppose y is the output of per capital, h is the time skilled labor required, and k is the capital of every individual labor, we can get the following equation:

$$y = k^\alpha (Ah)^{1-\alpha} \quad , \quad (5)$$
$$h = e^{\psi\mu} \quad . \quad (6)$$

We can get the production function after mathematical manipulation.

$$\tilde{y} = \frac{y}{Ah} = \frac{K^\alpha (Ah)^{1-\alpha}}{Ah} = \tilde{k}^\alpha \quad . \quad (7)$$

At the same time, according to the variation of capital within specific period $\dot{K} = \frac{dK}{dt}$, and growth rate formula $\omega = \frac{\dot{K}}{K}$, we suppose that the growth rate of population as well as growth rate of science and technology are as follows:

$$n = \frac{\dot{L}}{L} \quad , \quad (8)$$
$$g = \frac{\dot{A}}{A} \quad . \quad (9)$$

According to Solow model with human capital, the capital each individual takes is $\tilde{k} = \frac{K}{AL}$. By taking logs and differentiating, we can get the growth rate equation:

$$\frac{\dot{\tilde{k}}}{\tilde{k}} = \frac{\dot{K}}{K} - \frac{\dot{A}}{A} - \frac{\dot{L}}{L} \quad ,$$

$$\rightarrow \frac{\dot{\tilde{k}}}{\tilde{k}} = S_k \tilde{y} - (n+g+\delta)\tilde{k} \quad . \quad (10)$$

In comparative economic statics, investment equals to depreciation, which means the growth rate of capital is 0. Based on equation (10), we can get $Sk^{\tilde{y} = (n+g+\delta)\tilde{k}}$. After mathematical manipulation, the following equation is obtained:

$$\frac{\tilde{k}}{\tilde{y}} = \frac{Sk}{n+g+\delta} \quad . \quad (11)$$

Substitute Equation (11) into equation:

$$\tilde{y} = \left(\frac{S_K}{n+g+\delta}\tilde{y}\right)^\alpha$$
$$\rightarrow \tilde{y} = \left(\frac{S_K}{n+g+\delta}\tilde{y}\right)^{\alpha/(1-\alpha)} \quad (12)$$

Based on Equation (7), Substitute Equation (12) into Equation (5):

$$\rightarrow y = \tilde{y} * hA = \left(\frac{S_K}{n+g+\delta}\tilde{y}\right)^{\alpha/(1-\alpha)} hA \quad . \quad (13)$$

Take the derivative of population growth rate n and the time unskilled labor required to become skilled labor with respect to the production equation, we can get the correlation among the change rate y, n and h.

$$\frac{\partial y}{\partial n} = \frac{\alpha}{1-\alpha}\frac{S_K}{(n+g+\delta)^2}\left(\frac{S_K}{n+g+\delta}\right)^{\frac{\alpha}{1-\alpha}} hA$$
$$= -\frac{\alpha}{1-\alpha} S_K^{\frac{\alpha}{1-\alpha}} (n+g+\delta)^{\frac{-\alpha}{1-\alpha}-1} * h * A < 0 \quad , \quad (14)$$
$$\frac{\partial y}{\partial n} = \left(\frac{S_K}{n+g+\delta}\right)^{\alpha/1-\alpha} A > 0 \quad . \quad (15)$$

All equations required are presented above.

2.1.4 Theoretical Analysis

Two conclusions can be made based on the above theoretical derivation:

a) The total output growth rate is positively affected by skilled labor growth.

The conclusion can be checked from Equations (2) and (3), as derived function is more than 0. More directly, suppose skilled labor takes certain proportion of the total population, and then the number of skilled labor grows with the increase of population, the effect of which is economic development. This argument contradicts the statement that population growth hinders economic development.

b) The output per capita is negatively affected by population growth rate, but positively affected by the time unskilled labor spent to become skilled labor.

As the derived function of (14) is smaller than 0, and that of (15) is more than 0, Equation (2) is verified. Generally speaking, total population growth is harmful to the economic development, but the growth of skilled labor benefits the economy. An elaboration of the relationship between population growth and economic development would help to better understand the conclusion. Most of Asian countries, as developing countries, have large population base which requires more resources. In this case, population growth to some extent hinders economic development.

An increase of the number of skilled labor would stimulate economic development. Providing a large amount of skilled labor, the wages would be pushed down, which makes companies be willing to employ more workers and invest in production. More importantly, skilled labor is the key factor in technological improvement. According to Solow model, science and technology have a positive effect on economy. Therefore increase of skilled labor benefits economic performance.

It suffices to say that population growth promotes economic development as long as the skilled labor takes a high proportion of the total population and the country has enough educational resources to foster skilled labor. Romer model[1] (Jones & Vollrath, 2013, p.98, 110) also demonstrates this statement that high-tech and skilled labor contributes to economic development.

2.2 Statistical Analysis

The author calculates on the public data of ten Asian countries with linear regression model to verify the conclusion above.

2.2.1 Data Exploration and Fundamental Assumption

The data, mainly collected from the World Bank Data and the Economic Watch, include GDP growth rate, growth rate of population and that received higher education, and growth rate of investment in ten Asian countries, ranging from the year of 1991 to 2012. A bachelor's degree is regarded as a criterion to distinguish skilled labor and unskilled labor. As the data is too large, it shall not be attached.

The data will be explored before analysis.

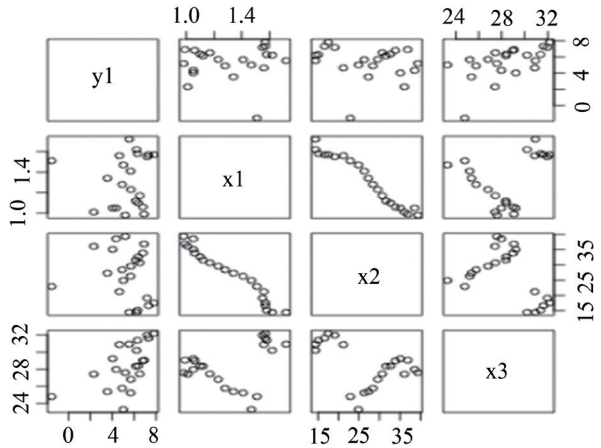

Figure 1
Correlation Matrix of Parameter

According to Figure 1, there is linear relation between dependent variable and independent variable. Therefore, linear regression model shall be employed in this essay.

[1] In Romer Model, technology $A=\frac{\theta S_R L}{g_A}$, where S_R "is the share of the population engaged in Research and Development", and L is total population. So a large population growth will result in higher technology level.

The following fundamental hypothesis will be checked with linear regression model:

a) The expected value of random errorε is 0;
b) The variance of random error is always a constant;
c) The random error do not have serial correlation;
d) Random errorεfollows normal distribution.

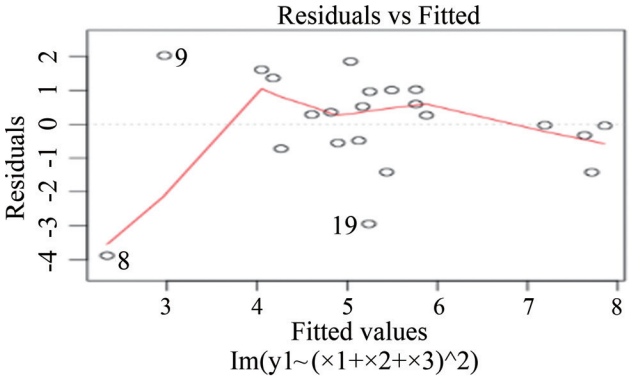

Figure 2
Residuals VS Fitted Value (Point 9 and 19 Are Deleted Due to Large Deviation)

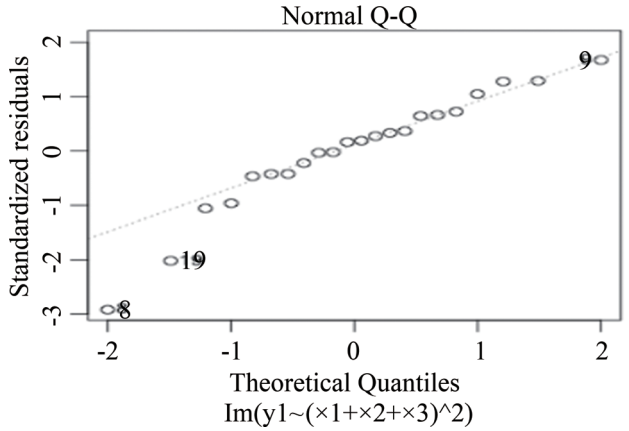

Figure 3
Empirical Quantiles & Theoretical Quantiles (Normal Q-Q plot)

The random disturbance ε mostly spread around y=0 from plot 1, which verifies that the expected value of random disturbance approximately equals to 0 (hypothesis 1), and that the variance is a constant (hypothesis 2). Because no compare can be made among data of different years from different countries, hypothesis 3 is verified that the random disturbance does not have serial correlation. The approximate straight line in plot 3 indicates the random disturbance is subject to normal distribution (Hypothesis 3). Therefore the data meet the basic requirement of linear regression analysis.

2.2.2 Model Selection

In this section, we will first check whether there is quadratic term between the average GDP growth rate and other variables. In other words, whether the quadratic term in Equation (16) should be kept.

$$Y=\beta_{00}+\beta_{11}X_1+\beta_{22}X_2+\beta_{33}X_3+\beta_{12}X_1X_2+\beta_{23}X_2X_3+\beta_{13}X_1X_1. \quad (16)$$

Table 1
Value of Parameters

	R^2	β_{11}	β_{22}	β_{33}	β_{12}	β_{23}	β_{13}	*P* value
Y	0.479							
X_1		79.450						0.458
X_2			4.072					0.266
X_3				9.740				0.251
X_1X_2					0.538			0.157
X_2X_3						-3.529		0.350
X_1X_3							-0.170	0.191

All results calculated from statistical software are included in Table 1.

In statistics, R^2 refers to the degree estimation model interpreting dependent variable, i.e. degree to which independent variable X interpret dependent variable Y. In this quadratic model, X reflects 47% of GDP growth rate. P is a value to measure the degree of significance of variable in statistics. In general, if P is smaller than 0.05, it means the variable is important and should be kept in the model. However, key variable or non-interaction terms should be kept regardless of the value of P. It makes no sense if the key variable is discarded. According to Table 1, as the P value of X_2, X_2X_3 and X_1X_3 is more than 0.05, it means the three interaction terms are not important, discard of which does not exert influence on Y. After discarding interaction terms, the equation becomes a simple equation without interaction terms, as is shown in Equation (17).

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3\,. \quad (17)$$

2.2.3 Major calculation result

a) Average value of all parameters in Asian countries (as is shown is Table 2)

Table 2
Regression Test on All Countries

	P-value	R^2	β_1	β_2	β_3	SEβ_1	SEβ_2	SEβ_3
Y	0.00379	0.4664						
X_1			-9.7431			8.3752		
X_2				0.2806*			0.2235	
X_3					0.3480***			0.2004

From calculation results through statistical software and coefficient of X_1, X_1, X_3 , β_1, β_2, β_3, we get the correlation between three parameters and GDP growth rate. As the parameter β_1 is smaller than 0, it is believed that there is a negative correlation between GDP growth rate and population growth. As parameter β_2, β_3 are more than 0, it is believed that increase of investment and of the number of skilled labor stimulate GDP growth.

In order to verify this result, data from ten Asian countries are analyzed with linear Model as shown in Table 3.

Table 3
Regression Test on Individual Countries

Country/ parameter	R^2	β_1	β_2	β_3	SE1	SE2	SE3	*P* value
China	0.45	-11.05	0.568	0.5884	4.387	0.179	0.1622	0.0107
India	0.49	-4.277	0.350	0.3545	4.834	0.1541	0.1518	0.00596
Indonesia	0.423	-24.40	0.442	0.4924	17.672	0.3605	0.1508	0.0173
Japan	0.111	0.156	0.167	0.5574	3.6586	0.1548	0.4182	0.5386
Malaysia	0.463	-12.53	0.3497	0.3449	6.4062	0.2822	0.1747	0.00932
Pakistan	0.009	-1.96	-0.37	0.0171	1.6278	0.301	0.1536	0.6148
Philippines	0.4683	0.468	0.288	0.4003	2.1979	0.3915	0.1534	0.0086
South Korea	0.4155	0.415	0.0474	0.7597	5.4493	0.0599	0.2799	0.0193
Thailand	0.4641	0.464	0.3228	0.6976	3.3922	0.1424	0.1899	0.0092
Vietnam	0.4189	0.419	0.088	0.0640	3.191	0.0895	0.0511	0.01837

b) Results of data analysis

i) Parameter model of countries with large population base like China, India and Indonesia is smaller than 0, which means population growth and increase in number of skilled labor do not promote economic development. This is because large population base brings about high natural growth rate of population. The increasing number of labor, however, does not convert into skilled labor in a large scale due to backward education. Therefore, population growth and slow increase in the number of skilled labor fail to promote economic development.

ii) In relatively developed countries like Japan, South Korea and Philippines, population growth boosts economy mainly because the education in these countries are advanced and the population increased can quickly become skilled labor. Japan has a special situation in that negative population growth promotes economic development because education is relatively advanced and the increasing population still provides the country with more skilled labor despite. However, in countries like Philippines who has relatively advanced education, population growth does not benefit the nation's economy

because education is overloaded with heavy population and fails to convert unskilled labor into skilled labor.

iii) Data of countries like Pakistan and Vietnam fail to explain the relationship between population growth and economic development because of their immature market. Take Vietnam for example, although population growth offers enough labors despite of its small population base, unskilled labor do not have sufficient education to become skilled labor. Therefore, slow increase in the number of skilled labor fails to stimulate economic development.

3. DISCUSSION AND ANALYSIS

3.1 Situation of Developing Countries With Large Population Base in Asia

Based on the above analysis, it is concluded that population growth affects the economic development in a negative way in some developing countries such as China, India and Indonesia. This is mainly because the population increased is too large due to its population base and fails to convert into skilled labor. Specifically, the situation in India and China is different.

India does not have sufficient skilled labor because of her education situation. Accordingly, the most important task for India is to improve the education level. Measures such as reduction of education expenses can be carried out.

In China, though education level is higher than that of India, unskilled labor fails to turn into skilled labor because the number of students receiving professional training does not meet the requirement of demand. Therefore, China should improve education level and increase professional training for labors. The number of labors receiving professional training should meet the social demand of professional labor. Only in this way can unskilled labor becomes skilled labor effectively.

3.2 Situation of Relatively Developed Countries in Asia

The relatively developed countries like Japan has a high proportion of skilled labor despite of negative population growth. Moreover, unskilled labor become skilled effectively. Therefore, population growth to some extent does not affect the economy.

For these countries, what they need is to keep their education level, keep steady increase of population and the number of skilled labor by encouraging fertility, so as to promote economic development.

3.3 Situations of Other Developing Countries in Asia

For other developing countries like Pakistan and Vietnam who are not steady in politics and market, they need to maintain market stability and raise the proportion of skilled labor on the total population. A steady market is a prerequisite for economic development.

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